# Geographic access to dental care varies in Missouri and Wisconsin

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## Abstract

**Objective:** To examine geographic access to dental providers for the general population and children with public insurance in Missouri and Wisconsin.
**Methods:** Using a newly constructed dentist office database from the American Dental Association master file and other sources, we use the two-step floating area catchment area method to calculate population to provider ratios at the census block group level. These ratios are used to determine potential geographic dentist shortage areas. We utilize street network data to estimate travel times and catchment areas between population centers and dental offices. This methodology accounts for the actual spatial distribution of dental providers and potential dental patients.
**Results:** Within and across Missouri and Wisconsin, there is some variation in geographic access to dental offices for the general population and publicly insured children. More than 90 percent of publicly insured children have access to dental providers within 30 minutes. Among the states examined, Missouri has more geographic disparities to dental care.
**Conclusion:** The Health Resources and Services Administration, which designates dental health professional shortage areas, relies on administrative boundaries to calculate population to dental provider ratios. These boundaries may not reflect actual or "real-time" dental care markets. The methods employed in this paper may give policymakers a template to better determine geographic dentist shortage areas.

## Introduction

The Health Resources and Services Administration (HRSA) designates Health Professional Shortage Areas (HPSAs) for medical, dental, and mental health services (1). For each service, HRSA determines an HPSA based on geographic areas, population groups, and facilities. The criteria for a dental geographic HPSA is that the area is rational, have a population to full-time- equivalent (FTE) ratio of 5,000:1, or have a population to FTE ratio of 4,000:1 in areas of unusually high need. According to HRSA, a rational service area is "a county, or a group of several contiguous counties whose population centers are within 40 minutes travel time of each other" (2). Population group HPSAs are in rational service areas and consist of low-income minority groups with significant access barriers to care. A facility HPSA is a correctional or public/nonprofit facility that serves underserved individuals or has insufficient capacity to treat patients (2). Many have criticized HRSA's HPSA designation methodology. The Government Accountability Office concluded that HPSAs do not reflect realistic market boundaries (3). Others have concluded that HRSA needs to modernize and make more transparent its HPSA designation methodology (4).

Recent studies attempted to determine the link between dental HPSAs and dental care utilization, often with conflicting results. Among Medicaid-enrolled children in Iowa, it was found that those who lived in dental HPSAs were less likely to receive dental care (5). Another study of Medicaid-enrolled children in nine states found no relationship between residence in a dental HPSA and dental care utilization (6). Despite having fewer dental HPSAs than Utah, Wisconsin had higher rates of emergency department use for dental services (7).

 

HRSA determines rational service areas to be individual counties or contiguous counties whose populations centers are 40 minutes travel time from each other. Based on these rational service areas, HRSA designates HPSAs (2). However, county boundaries are often drawn arbitrarily, may be too aggregate and may not accurately reflect dental care markets (8). Current methods employed by HRSA may not accurately depict the ability of individuals to receive care across administrative boarders (9,10).

In order to measure access to dental care, researchers need to consider spatial access factors, which include travel time and distance, and nonspatial access factors which include income, age, race/ethnicity, high healthcare needs, and sex (11). Spatial and nonspatial factors can further be divided into four categories (potential spatial access, potential nonspatial access, revealed spatial access, and revealed non-spatial access) (12). Revealed accessibility measures actual use of healthcare services while potential accessibility measures possible access to healthcare services (11-14). Using travel time, a spatial factor, we focus on measuring potential spatial access for dental care services, particularly among low-income public insurance enrollees. In this paper, we do not focus on analyzing nonspatial access, although previous research used factor analysis to determine the most important nonspatial characteristics (age, income, high healthcare needs) that determine healthcare access (15). We do not use factor analysis to explicitly assess nonspatial characteristics that determine access to dental care. We leave that to future research. However, we do assess spatial access to dental care for low-income children enrolled in public insurance programs.

With the availability of detailed street network data and improved geo-analytic software to calculate travel times, HRSA's HPSA methodology can be significantly improved on. A common tool employed by researchers to identify geographic medical shortage areas is the two-step floating catchment area (2SFCA) method (16). The 2SFCA method uses two catchments, one around offices and another around population centers, in order to calculate population to provider ratios at a geographic level such as a census tract or block group. Previous studies applied the 2SFCA method to measure spatial accessibility to primary care physicians in Chicago (17) and Illinois (15). To our knowledge, no one has applied the 2SFCA method to analyze access to dentists in the United States. This is the focus of our paper. Specifically, we analyze the geographic proximity of publicly-insured children to dental care providers participating in public programs. We use an alternative methodology to identify geographic dentist shortage areas, particularly among low-income publicly insured children.

A number of states have network adequacy standards for HMO, managed care, and Medicaid plans. Illinois, Kentucky, and Minnesota require that primary care services be within 30 minutes of an enrollee's place of residence (18). In its managed care program, Maryland requires that there be at least one Medicaid dental provider within 10 minutes from an enrollee in an urban area and within 30 minutes of an enrollee in a rural area. Georgia's network adequacy standards require there to be one dentist accepting Medicaid within 30 miles or 30 minutes in urban areas (45 miles or 45 minutes for rural areas) (19). For its Medicaid population, Maryland mandates a 500:1 Medicaid enrollee to dentist provider ratio (20). New Jersey mandates a 2,000:1 Medicaid enrollee to dentist provider ratio in its Medicaid program (21). These are the upper and lower bounds for Medicaid network provider standards that we could identify through our literature review and key informant inquiry.

We focus on two states: Missouri and Wisconsin in our analysis. Missouri and Wisconsin have a balanced mix of rural and urban regions. Although dental care utilization increased significantly in most states among Medicaid enrolled children from 2005 to 2013, Missouri and Wisconsin experienced some of the smallest gains in dental care utilization in relation to other states (22). Poor geographic access to dental care services could be one reason why dental care use among low-income children did not increase as much in Missouri and Wisconsin in comparison to other states. We determine geographic shortage areas for the overall population and low-income children enrolled in Medicaid or the Children's Health Insurance Program (CHIP). Missouri, and Wisconsin operate separate Medicaid and CHIP programs (23).

## Data and methods

### Source data

We used data from several sources to construct a dentist office database. These sources include the October 2014 American Dental Association (ADA) master file, which is the primary source of business addresses in the database. Other sources include the National Provider Identifier dentist registry, data from dental management service organizations, Medicaid dental provider data from Insure Kids Now (IKN), and street address data from HRSA on Federally Qualified Health Centers (FQHCs). For more details on the construction of the office database, please see Appendix A. All addresses in the office database were geocoded with verified latitude and longitude values by Melissa® Data Services. Insure Kids Now does a good job of identifying dentists and offices that participate in pediatric Medicaid or CHIP programs, but does not do a good job of placing dentists at specific locations (24). Hence, we assumed that if an office is listed in IKN, each dentist located at that office participates in these pediatric public insurance programs. We considered all FQHCs where we could identify a practicing dentist to be Medicaid offices, even if the FQHC was not listed in IKN. We limited our

 

**Table 1** Percent of Population by Population to Dentist Ratio

| State | Population to dentist ratio | 15 minutes catchment area | 30 minutes catchment area |
|---|---|---|---|
| Missouri | <2,500:1 | 44.6% | 49.5% |
| | 5,000:1-2,500:1 | 33.9% | 35.4% |
| | >5,000:1 | 14.5% | 14.4% |
| | Outside catchment | 7.1% | 0.7% |
| Wisconsin | <2,500:1 | 59.2% | 67.1% |
| | 5,000:1-2,500:1 | 27.6% | 28.6% |
| | >5,000:1 | 10.1% | 4.2% |
| | Outside catchment | 3.0% | 0.2% |

Note: Percentages derived from two-step floating catchment area method.
Source: 2014 ADA Office Database. 2010-2014 American Community Survey (25).

analysis to offices where general practicing dentists and pediatric dentists are located, since these are the type of offices a person is likely to visit first in order to get preventive care.

We used StreetMap® Premium for ArcGIS® to determine travel times. It is a highly accurate street network data set that includes traffic history and details on street restrictions that allow for a better representation of the reality of modeling travel time.

At the census block group level, we downloaded population data from the 2010-2014 American Community Survey (25). The census block group is the smallest level of aggregation at which estimates of insurance coverage by age exist. For each census block group, we utilized estimates of total population, total number of children under age 18 and total number children under age 18 with public insurance coverage. Unfortunately, the American Community Survey is unable to provide separate estimates of the number of children enrolled specifically in Medicaid or CHIP. This is a limitation in our study. We used these population estimates to determine the percentage of individuals in geographic dentist shortage areas. There are 4,506 census block groups in Missouri and 4,475 census block groups in Wisconsin.

# Methodology

## Travel time

Based on established network adequacy standards in Georgia, Illinois, Kentucky, Maryland, and Minnesota (18,19), we estimated the percentage of the overall population and people under 18 years old within 5, 15, and 30 minutes travel time from a dental office. We also estimated the percentage of children under age 18 with public coverage within 5, 15, and 30 minutes from a Medicaid participating dental office.

Census block groups contain multiple census blocks, which are the basic census unit. Utilizing underlying census block data from the 2010 United States Census (26), we determined the population weighted mean center of each census block group. At the census block group level, we utilized estimates of total population, total population under age 18 and total number of children with public insurance. We derived 5, 15, and 30 minutes travel time buffers around each dental office. If a population mean center of a census block group was within 15 minutes of a dental office, we assumed that the entire population of the census block group was within 15 minutes travel time from a dental office. We applied similar logic to determine the percentage of publicly insured children within 5, 15, or 30 minutes from a Medicaid dental office. The following equation determines the percentage of a state's population within a certain travel time to a dental office

$$\%\ \text{Within Travel Time Buffer} = \frac{\sum_{k\in\{t_{kj}\le t_0\}} P_k}{\sum_{k=1}^{N} P_k} \quad (1)$$

where a buffer with travel time to a dental office less than or equal to a threshold, $t_0$ (5, 15, 30 minutes), was drawn around each dental office and encompasses any number of census block group population centers, $P_k$, in a state with $N$ census block groups. Any census block group's population, $P_k$, is included in the numerator of Equation (1) if its travel time to a dental office, $t_{kj}$, is less than or equal to the threshold, $t_0$.

## Shortage areas

We implemented the 2SFCA method to determine geographic shortage areas in Missouri and Wisconsin. We estimated shortage areas by generating 15 and 30 minutes travel time catchment areas around population mean centers and dental offices. First, we defined the number of FTEs in a dental office based on the number of offices a dentist works at and the age of the dentist(s) working at that office. HRSA applies an age adjustment when calculating dentist FTEs (2). We also applied age weights based on the age distribution of the dental workforce and the average number of hours worked per week by a dentist, but derived these weights based on data from the 2014 ADA Survey of Dental Practice, a nationally representative survey of practicing dentists in the United States. Younger dentists have larger weights because they typically work more hours than older dentists (Appendix Table A1). We applied the following formula to calculate FTEs for a dentist

$$\text{FTE} = \frac{\text{Age Weight}}{\text{No. of Offices Dentist is Located}} \quad (2)$$

We derived $\text{FTE}_j$ for office $j$ by summing the FTEs of each dentist located in office $j$.

 

The 2SFCA is implemented in two steps (15-17). First, for each dental office, *j*, we calculated a FTE to population ratio

$$R_j = \frac{\text{FTE}_j}{\sum_{k\in\{t_{kj}\le t_0\}} P_k} \quad (3)$$

where a catchment area with travel time to a dental office less than or equal to a threshold, $t_0$, was drawn around each dental office and encompasses any number of census block group population centers, $P_k$. Any census block group's population, $P_k$, is included in the denominator of Equation (3) if its travel time to a dental office, $t_{kj}$, is less than or equal to the threshold, $t_0$ (15 or 30 minutes). In step two, for each population center of a census block group, we drew 15 and 30 minutes travel time catchment areas. We summed $R_j$ for all dental offices that were within these catchment areas and generated access scores (aggregate FTE to population ratios), $A_i$, for each census block group.

$$A_i = \sum_{j\in\{t_{ij}\le t_0\}} R_j \quad (4)$$

### General access measures

We defined geographic shortage areas based on all dental providers and population within a state. HRSA's criteria for a geographic dental HPSA is that the area be rational and have a population to FTE ratio of 5,000:1 (2). We applied this same cutoff, taking into account all dental providers and population within a state, in order to determine geographic dental shortage areas derived from the 2SFCA method. Areas beyond travel time thresholds were considered geographic shortage areas.

We also defined separate geographic shortage areas based solely on Medicaid dental providers and estimates of the number of children with public insurance. To our knowledge, there are no Medicaid network adequacy standards established in Missouri and Wisconsin. Hence, we rely on standards established in New Jersey (21) to designate geographic shortage areas for publicly insured children. We designate a dentist shortage area when there are more than 2,000 Medicaid enrollees per Medicaid provider within the catchment area or when there are no Medicaid dentists within the catchment area. We do not define separate population to provider ratios for each state included in the study. All analysis was performed using the ARC GIS network analyst tool in ARC Map 10.3.

## Results

### Dental offices in Missouri and Wisconsin

In Missouri, we successfully mapped 1993 dental offices, 367 of which participate in Medicaid (18.4 percent). Wisconsin has 2014 dental offices, 574 of which participate in Medicaid (28.5 percent). All participating Medicaid dental providers from Missouri and Wisconsin listed in IKN also participate in CHIP.

**Table 2** Percent of Pediatric Publicly Insured Population by Publicly Insured Population to Medicaid DDS Ratio

| State | Pediatric publicly insured population to Medicaid dentist ratio | 15 minutes catchment area | 30 minutes catchment area |
|---|---|---|---|
| Missouri | <500:1 | 24.2% | 23.7% |
| | 2,000:1-500:1 | 46.0% | 59.6% |
| | >2,000:1 | 9.0% | 12.4% |
| | Outside catchment | 20.7% | 4.3% |
| Wisconsin | <500:1 | 55.7% | 73.3% |
| | 2,000:1-500:1 | 32.6% | 24.9% |
| | >2,000:1 | 2.1% | 1.0% |
| | Outside catchment | 9.7% | 0.8% |

Note: Percentages derived from two-step floating catchment area method.
Source: 2014 ADA Office Database. 2010-2014 American Community Survey (25).

### Travel time to dental offices

As shown in Appendix Table A2, among Missouri residents, 67.3 percent are within 5 minutes of a dental office, 92.4 percent are within 15 minutes of dental office, and 99.1 percent are within 30 minutes of a dental office. Among Missouri children, 66.6 percent are within 5 minutes of a dental office, 92.6 percent are within 15 minutes of dental office, and 99.2 percent are within 30 minutes of a dental office. About 38.4 percent of publicly insured children under age 18 are within 5 minutes of a dental office. Approximately 95.6 percent of publicly insured children are 30 minutes from a dental office.

In Wisconsin (Appendix Table A2), 73.2 percent of the population is within 5 minutes of a dental office, 97.1 percent of the population is within 15 minutes of a dental office and 99.9 percent of the population is within 30 minutes of a dental office. Among Wisconsin children, 73.8 percent are within 5 minutes of a dental office, 97.3 percent are within 15 minutes of dental office, and 99.9 percent are within 30 minutes of a dental office. Among publicly insured children in Wisconsin, 65.4 percent are within 5 minutes of a Medicaid dental office, 89.8 percent are within 15 minutes of a Medicaid dental office and 99.2 percent are within 30 minutes of a Medicaid provider.

### Geographic dentist shortage areas

Table 1 summarizes geographic proximity to dental offices taking into account the population to provider ratio within the catchment area. Assuming a 15 minute travel time threshold and a 5,000:1 population to provider cutoff, about 21.5 percent of the population in Missouri lives in a geographic

 

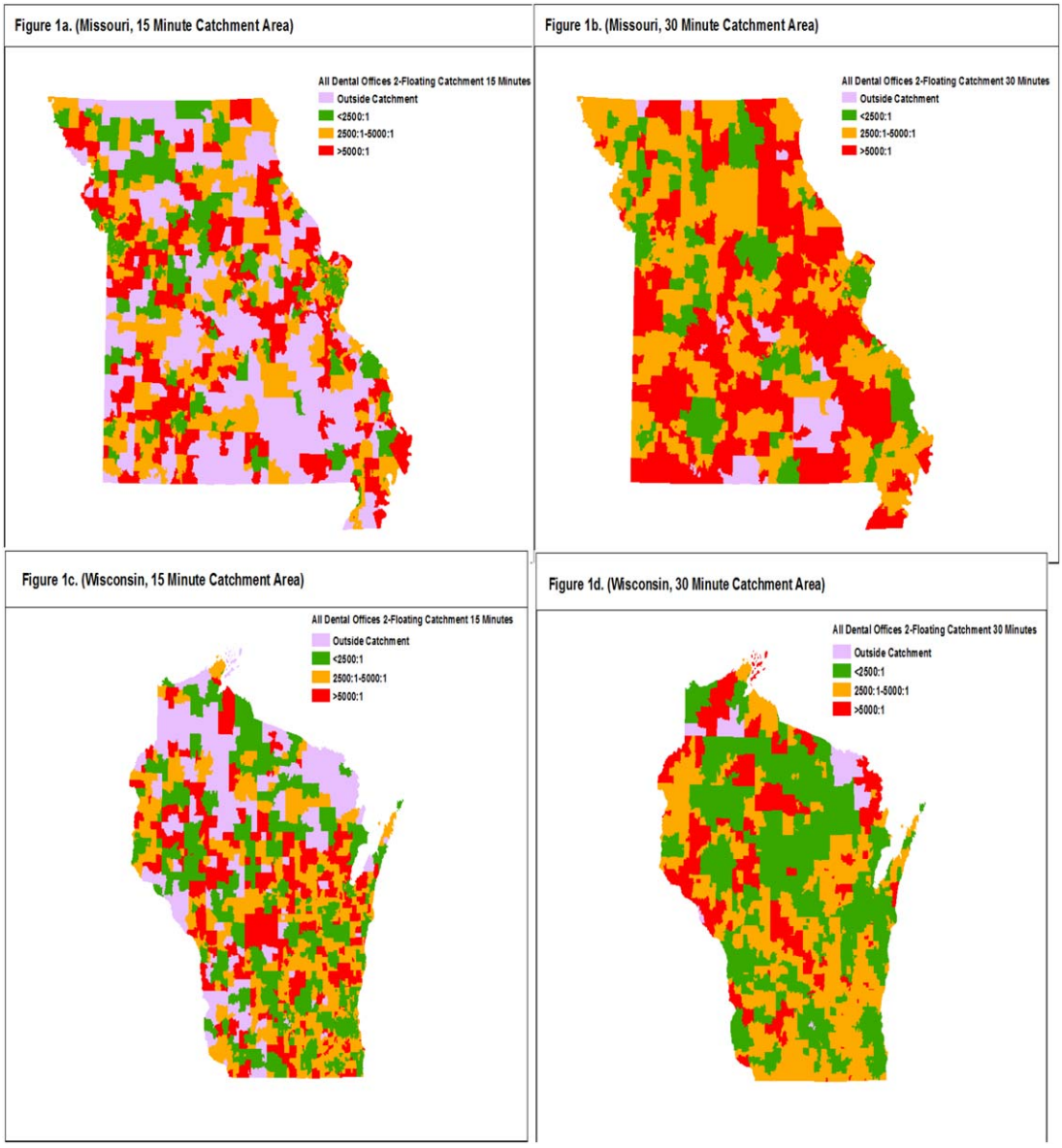


**Figure 1** (a-d) 2SFCA maps. Population to dentist ratio by census block group. Fifteen- and thirty-minutes catchment areas. Note: Population to provider ratios determined using 2SFCA Method. Source: 2014 ADA Office Database. 2010-2014 American Community Survey (25).

dental shortage area. When one assumes a 30 minute travel time threshold, 15.1 percent of the population in Missouri lives in a geographic dental shortage area. Geographic dental shortage areas in Missouri are clustered in the south-central and rural portions of the state (Figure 1a,b). In Wisconsin, if one imposes a 15 minute travel time threshold, 13.1 percent of the population is in a geographic shortage area. When the travel time threshold is expanded to 30 minutes in Wisconsin, 4.4 percent of the population lives in a geographic dental shortage area. Geographic shortage areas are clustered near Lake Superior, along the border with Michigan, and in central Wisconsin (Figure 1c,d).

In Missouri, children with public coverage that are outside a 15 minute travel time to a Medicaid dental provider are clustered in the south-central portion of the state. Publicly insured children in large Missouri cites (St. Louis, Kansas City, Springfield, Columbia) are within a 15 minute travel time from a Medicaid dental office (Appendix Figure A1a and Appendix Figure A2a). By contrast, most areas in Wisconsin are within a 15 minute travel time to a Medicaid office (Appendix Figure A1b and Appendix Figure A2b). Census block groups in northern Wisconsin have higher percentages of children with public coverage. Some of these areas are not within a 15 minute travel time to a Medicaid office.

 

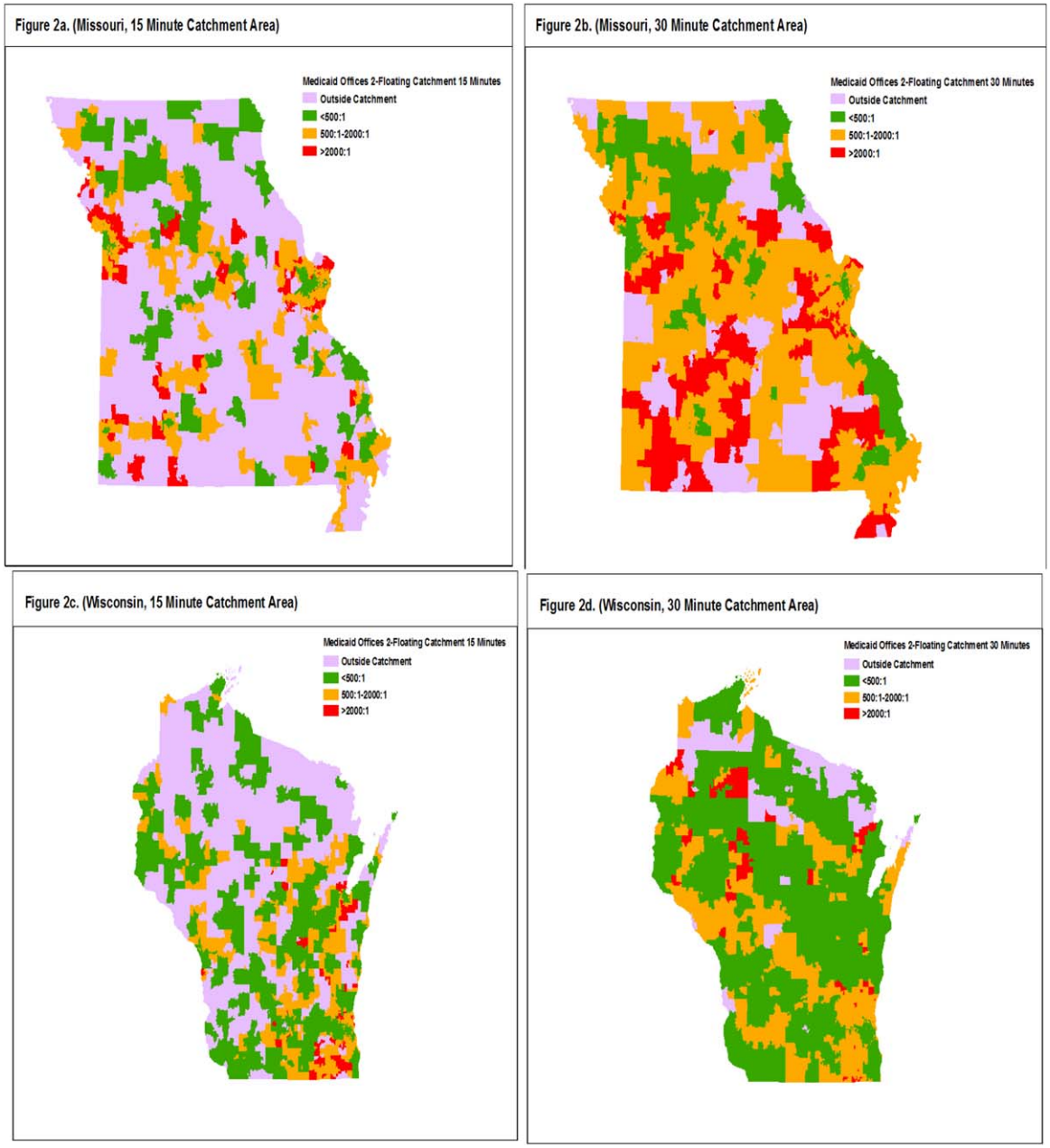


**Figure 2** (a-d) 2SFCA maps. Publically insured children to Medicaid dentist ratio by census block group. Fifteen- and thirty-minutes catchment areas. Note: Population to provider ratios determined using 2SFCA Method. Source: 2014 ADA Office Database. 2010-2014 American Community Survey (25).

Figure 2a,b summarize geographic dental shortage areas in Missouri for publicly insured children assuming a 15 and 30 minute travel time threshold. The areas of shortages are mostly clustered in rural Missouri, outside the larger metropolitan regions of the state. Assuming a 15 minute travel time threshold and a cutoff of 2,000 publicly insured children per Medicaid participating provider, 29.7 percent of publicly insured children live in a geographic dental shortage area. When one expands the travel time threshold to 30 minutes, 16.7 percent of publicly insured children in Missouri live in a geographic dental shortage area (Table 2). Geographic dental shortage areas for the pediatric Medicaid population exist in rural northern Wisconsin (Figure 2c,d). Under a 15 minute travel time threshold, 11.8 percent of publicly insured children in Wisconsin live in a geographic dental shortage area. When the travel time threshold is increased to 30 minutes, the percentage of publicly insured children in Wisconsin living in a geographic dental shortage areas drops to 1.8 percent

 

(Table 2). Compared to Missouri, publicly insured children in Wisconsin have more geographic access to Medicaid dental providers.

## Discussion

Significant variation in geographic access to dental care exists in Missouri and Wisconsin. Compared to Wisconsin, in Missouri a higher percentage of the general population as well as publicly insured children live in geographic dental shortage areas. Conversely, individuals in Wisconsin have more geographic access to dental providers.

In 2015, 26.0 percent of Missouri's population and 13.8 percent of Wisconsin's population lived in a dental HPSA (27,28). Based on the 2SFCA method employed in our analysis and assuming a 30 minute travel time threshold, the percentage of the population in a geographic dental shortage area is lower in Wisconsin and Missouri.

Over the past decade, rates of dental care utilization among low-income publicly insured children increased significantly (29). In addition, Medicaid expansion under the Affordable Care Act will bring a significant inflow of Medicaid adults with dental benefits in many states (30). Now is the time to re-examine the way in which policy makers conceptualize and measure access to dental care providers, especially for the publicly insured. This analysis serves as a proof-of-concept that can be applied to other states to better inform policymakers of potential geographic access barriers to dental care.

A number of avenues exist for future research. First, the analysis could be extended to consider nonspatial factors such as dental care need. As done in previous research (15), factor analysis could be carried out to account for nonspatial characteristics that influence access to dental care. Future research should also assess the impact of travel time to a dental office on dental care utilization. Geographic access to dental care among adult Medicaid enrollees also needs to be examined.

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## Appendix A: Construction of Dental Office Database

The October 2014 American Dental Association (ADA) master file, which includes a census of all professionally active dentists in the United States, was used as the primary source of business addresses for the dentist office database. These addresses are provided to the ADA via the ADA distribution of dentist file, the ADA survey of dental graduates, state dental societies and local dental associations. Along with business addresses, the ADA master file includes name of dentist, dental specialty, birth date, gender, year of graduation, and the dental school from which a dentist graduated from. We supplemented the office database with data from the National Provider Identifier (NPI) dentist registry, which includes the NPI for each dentist and a business address. The NPI registry is maintained by the Department of Health and Human Services' (HHS) Centers for Medicare and Medicaid Services (CMS) for all healthcare providers who submit insurance claims electronically (31).

We also included data from dental management service organizations (DMSOs). These entities provide compliance, accounting, billing, supply, inventory, and management services to dental practices (32). The identity of DMSOs is based on a list provided by the Association of Dental Support Organizations (33). From September to early December 2014, we collected dentist office data from each ADSO member website. This data included dentist name and office address. Using exact and fuzzy matching methods, we merged dentist name, business address and NPI from the NPI registry and DMSO tables to the office database. We also received dental provider data from Insure Kids Now (IKN), a website that identifies dentists that participate in pediatric public insurance programs in the United States. These pediatric public insurance programs include Medicaid or CHIP. The IKN website is maintained by the Centers for Medicare and Medicaid Services (34). The purpose of the IKN website is to help families in each state locate Medicaid dental providers for their children. For each state, HRSA provided a full roster of Medicaid providers in August, October, and November of 2014. We removed duplicate observations and used exact and fuzzy matching methods to merge IKN records to the office database. In some cases, IKN only provides the address of an office participating in Medicaid or CHIP but no dentist information. In those instances, we consider all dentists working at that address as public insurance providers. Finally, we received street address data from HRSA on Federally Qualified Health Centers (FQHCs) provider sites in September 2014 (35). Based on dentist address data in the ADA masterfile, NPI dentist registry, DMSO tables, and IKN database, we were able to map dentists into specific FQHCs.

**Table A1** Age Adjustment Weights Used in Calculation of FTEs

| Age bracket (years) | Weight |
|---|---|
| 20–54 | 1.04 |
| 55–59 | 1.03 |
| 60–64 | 0.96 |
| 65 and Older | 0.82 |

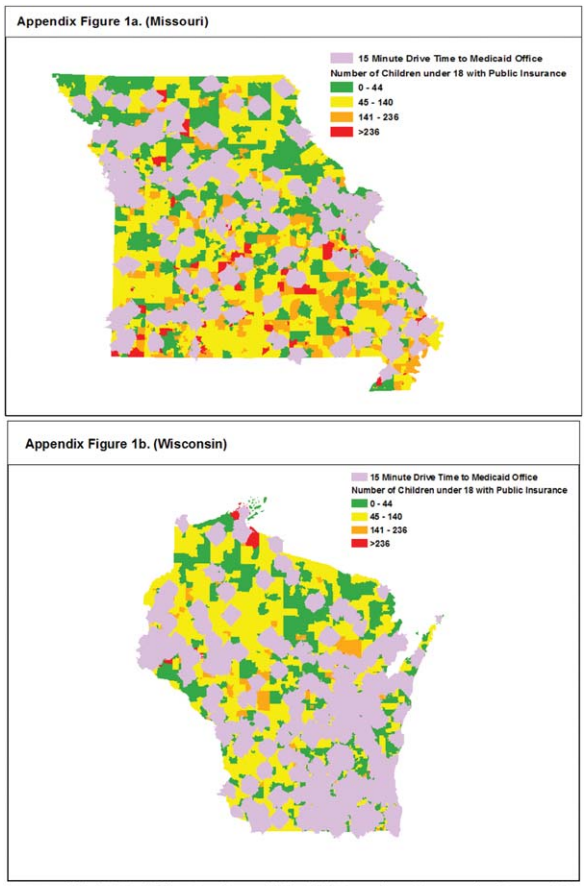
Age weights derived from the 2014 ADA Survey of Dental Practice. Weights based upon the average number of hours per week a typical dentist works.
FTE, Full Time Equivalent.

**Table A2** Percent of Population within Certain Travel Time of a Dental Office

| State | Drive time (minutes) | All population, all dental offices (%) | All children less than 18 years old, all dental offices (%) | Publically insured children less than 18 years old, Medicaid and CHIP dental offices (%) |
|---|---|---|---|---|
| **Missouri** | 5 | 67.3 | 66.6 | 38.4 |
| | 15 | 92.4 | 92.6 | 78.5 |
| | 30 | 99.1 | 99.2 | 95.6 |
| **Wisconsin** | 5 | 73.2 | 73.8 | 65.4 |
| | 15 | 97.1 | 97.3 | 89.8 |
| | 30 | 99.9 | 99.9 | 99.2 |

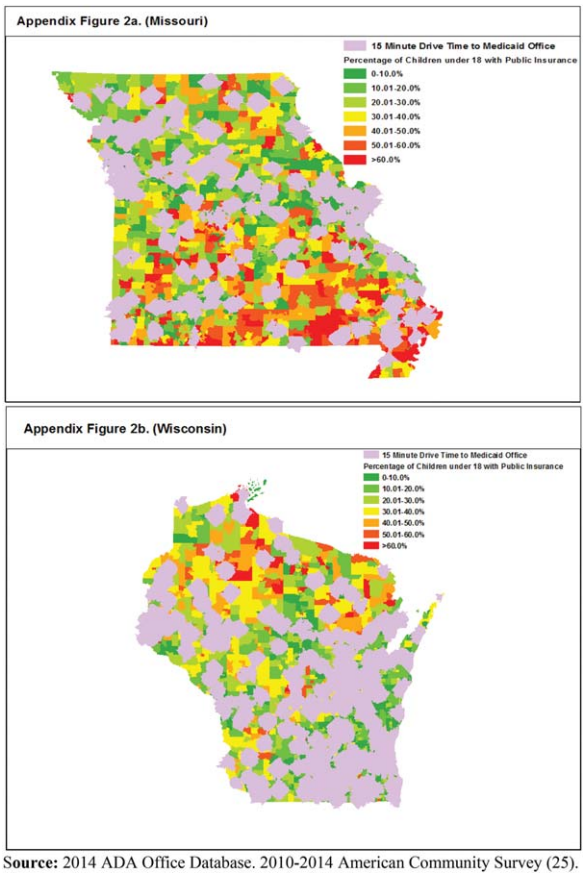
CHIP-Children's Health Insurance Program.
Source: 2014 ADA Office Database. 2010–2014 American Community Survey (25).




**Source:** 2014 ADA Office Database. 2010-2014 American Community Survey (25).

**Figure A1** Number of Children with Public Coverage Overlaid by 15 Minute Drive Time Coverage Areas to Medicaid OfficesSource: 2014 ADA Office Database. 2010-2014 American Community Survey (25).




**Source:** 2014 ADA Office Database. 2010-2014 American Community Survey (25).

**Figure A2** Percentage of Children with Public Coverage Overlaid by 15 Minute Drive Time Coverage Areas to Medicaid Offices. Source: 2014 ADA Office Database. 2010-2014 American Community Survey (25).