The dental workforce in Kentucky: current status and future needs

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Abstract

Objectives: This study assessed the geographic distribution of dentists in Kentucky, determined socioeconomic correlates of practice location, estimated the future availability of dental providers, and made policy recommendations that could improve access to oral health care in Kentucky and other rural states.
Methods: Dentists' addresses were mapped using a geographic information system. Poisson regression modeling and geospatial analyses were conducted using SAS v9.1 (SAS Institute, Cary, NC, USA) and ArcGIS v9.2 (Environmental Systems Research Institute Inc., Redlands, CA, USA), respectively. Data on the number of dentists ($n = 2{,}391$) per county ($n = 120$) were used for the regression models. Explanatory variables included: per capita income, 2006 intercensal population estimates, percent adults with six or more teeth removed, percent population uninsured, physician-to-population ratios, and region type. A simulation model was used to project dentist-to-population ratios to the year 2016.
Results: The dental workforce analysis revealed disparities in the distribution of dentists between rural, urban, and Appalachian Kentucky counties. Dentists were more likely to be found practicing in areas with higher income and higher physician-to-population ratios. Compounding this geographic maldistribution, our projections suggest that the number of dentists per unit population will decrease over time in the near future, likely widening this disparity in rural and underserved areas.
Conclusions: These results show present and widening workforce disparities in rural and socioeconomically depressed counties in Kentucky. Understanding the geographic distribution of dentists and the socioeconomic correlates of their practice locations may inform workforce development and reimbursement policies for the goal of improving access to oral health care in these areas.

Introduction

A large proportion of the rural population in the United States has poor access to oral health care, due in part to a limited supply of dentists (1-3). Kentucky is a typical example of this phenomenon; in 2005, 99 of the state's 120 counties had a dentist-to-population ratio lower than the American Dental Association's (ADA) estimated national average of 6.0 : 10,000 (4,5). People with lower incomes and those living in rural areas often have difficulty accessing oral health-care services, and frequently bear significant travel burdens to access these services. This results in low utilization rates of dental services in these populations (6-9). Access to dental care is particularly concerning for Kentuckians, especially for those living in the Appalachian and other rural regions of the state. Nearly 30 percent of Kentuckians live in Appalachian-designated counties; these areas contain some of the poorest populations in the United States, contributing to the acute condition of dental care access issues in the region (10).

Oral health indicators in Kentucky are not very encouraging. According to the 2001 Kentucky Children's Oral Health Survey, children with the greatest oral health needs are the very same who have the least access to oral health care (11).

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Results from the 2002 Kentucky Adult Oral Health Survey show that unmet dental needs among adults were high with those enrolled in Medicaid, with the lowest income group also reporting low utilization rates of dental services (12). In 2004, 41 percent of Kentucky dentists billed Medicaid for services rendered. During this time, only 33 percent of Medicaid and Kentucky Children's Health Insurance Program (KCHIP) eligible recipients under 21 years of age received any form of dental care. A 2004 report proposed several reasons for this: too few dentists accepting Medicaid; long drives to see a dentist; a lack of pediatric dentists; high costs of dental care; and discrimination against patients based on their Medicaid status (13).

Low dentist-to-population ratios, geographic maldistributions of their practice locations, and the low percentage of dentists who accept Medicaid are likely contributing factors to the 2006 Behavioral Risk Factor Surveillance System finding that, in Kentucky, only 37 percent of individuals making less than $15,000 per year and 42 percent of those making between $15,000 and $24,999 per year visited the dentist within the past year for any reason (14). This is further compounded by the relative paucity of oral health components in local health departments and community-based health centers (15).

Previous studies assessing the distribution of dentists using a geospatial mapping system have found higher dentist-to-population ratios in urban areas (5,16-19). Population density and per capita income are strong predictors of dentists' practice location (20,21), with rural areas tending to have smaller numbers of dentists than urban areas (9,19,22). A recent report commissioned by the Kentucky Cabinet for Health Services revealed fewer dentists in rural and Appalachian Kentucky as compared with urban areas in Kentucky (5).

In spite of Kentucky's poor oral health outcomes, significant access issues, and low dental care utilizations rates (13), a thorough analysis of the distribution of dentists and workforce trends has yet to be completed. This study assesses the distribution of Kentucky dentists across geographic space and time through spatial and statistical analyses and workforce projection simulations. We believe that a better understanding of the dentist workforce capacity and distribution in a rural state such as Kentucky has national implications for informing interventions and policy changes in other rural states.

Methods

Geospatial analyses

Because of the nature of the project and data to be utilized, the University of Kentucky Institutional Review Board waived the requirement for review. Data on dentist practice locations by physical address, county, and zip code were obtained from the Kentucky Board of Dentistry (23). Locations of dentists with a business address in the state ($n = 2{,}391$) were geocoded by zip code to each county ($n = 120$) in Kentucky using an Internet-based batch geocoding application (24). Dentists licensed but not practicing within the state (e.g., dentists with business addresses in other states) and non-active dentists (e.g., retired) were excluded from the sample. The resulting locations were mapped using ArcGIS v9.2 geographic information system (GIS) (Environmental Systems Research Institute Inc., Redlands, CA, USA). GIS allows for exploring, interpreting, and visualizing geographic data to reveal relationships and trends in the form of maps (25). The Kentucky county basemap shapefile used in these analyses was downloaded from the Kentucky Division of Geographic Information. The maps were prepared using color schemes generated from ColorBrewer (26).

Counties were classified in three groups: non-metropolitan non-Appalachian (rural); metropolitan non-Appalachian (urban); and Appalachian counties using a combination of the most recent Appalachian Regional Commission (ARC) area designation (10) and the 2003 Rural-Urban Continuum Codes (RUCC). RUCCs are a system of classification developed by the Department of Agriculture Economic Research Service that classifies counties from urban to rural, where codes 1-3 are assigned to urban counties and codes 4-9 to rural counties (27). Appalachian counties were classified using the ARC designation. The four counties with both an ARC designation and an urban RUCC (i.e., metropolitan Appalachian) were grouped with the other Appalachian counties in these analyses, as the urban Appalachian counties of Kentucky are generally considered to be more similar to their adjacent rural Appalachian counties with respect to socioeconomic conditions than to the other rural non-Appalachian counties in Kentucky (10). A similar methodology was incorporated in a GIS study of Ohio dentists (16).

Poisson analyses

The unit of analysis for the regression modeling was the county ($n = 120$). The following data were collected and included in our regression modeling from a 2007 Kentucky Institute of Medicine report (KYIOM): the percentage of adults 18 or older with six or more permanent teeth removed because of tooth decay or gum disease (data from 1997 to 2004 were used by the KYIOM to form an aggregated estimate); per capita personal income (2007); percentage of population under 65 years old who are uninsured (2007); and the primary care physician-to-population ratio (2006) (13,28). Population estimate and projection data were obtained from the Kentucky State Data Center (29). County population characteristics were included in the model as

measures of socioeconomic status. The physician-to-population ratio variable was included because we were interested in testing whether there was a link between physician- and dentist-to-population ratios. If we found no statistically significant association between the physician-to-population variable and the distribution of dentists, we could then encourage physicians to provide anticipatory guidance for oral health care to their patients. Poisson regression analyses were performed using SAS v9.1 (SAS Institute, Cary, NC, USA) using PROC GENMOD, with model options of a log link, deviance correction for overdispersion, and the population estimate variable as the offset term. In addition to those listed above, the explanatory variables used in the modeling also included the region type (urban, rural non-Appalachian, and Appalachian) described previously. The dependent variable for all models was the number of dentists in a county, which was standardized by the population variable used as an offset term (where its beta coefficient was locked to the value of one during estimation) (30). This means that although the dependent variable to be modeled is the number of dentists, the model output is understood to be controlled for population size, rendering the dependent variable interpretation as dentists per unit population. Poisson regression models were first performed individually with each explanatory variable, and only significant variables ($P \leq 0.05$) were further tested and included in the multivariate model. The models' beta coefficients were interpreted as adjusted relative risks and 95% confidence intervals (CIs) were estimated.

Simulation modeling

Based on data from the Kentucky Dental Workforce Provider Analysis, the number of practicing dentists for the time period 2007-16 was calculated using system dynamics modeling (31) (iThink, iSee Systems, Version 9.1, 2008). Data from the simulation model were compared with population estimates and projections from the US Census Bureau to determine the ratio of dentists-to-population for the time period 2007-16 (32).

Results

As of September 12, 2007, there were 3,152 dentists licensed to practice in Kentucky. Of those, 2,391 (75.9 percent) had a business address in one of Kentucky's 120 counties. Most general dentists (1,305 or 66 percent) and pediatric dentists (57 or 75 percent) had an address in an urban (metropolitan non-Appalachian) county. Table 1 presents a comparison of the variables of interest across the three region types. Of the three region types, the Appalachian region had the lowest median dentist-to-population ratio (2.93) and the intermediate median physician-to-population ratio (4.29). As expected from the known socioeconomic conditions in the Appalachian region, this region had the highest median percentage of uninsured population under 65 (18 percent), the lowest per capita personal income ($18,982), and the largest percentage of adults with 6 or more teeth removed (42 percent).

Figure 1 shows the number of dentists by individual county and region type. A large number of dentists are concentrated in three particular areas (circled in Figure 1): Boone and Kenton counties (151 dentists), Fayette county (343 dentists), and Jefferson county (687 dentists). These four counties accounted for 1,181 dentists or almost 50 percent of the total number of dentists in Kentucky in 2007, leaving the other 50 percent of dentists to serve 116 counties. In large, there are lower numbers of dentists in Appalachia when compared with the two other regions.

Figure 2 presents a detailed listing of the dentist-to-population ratios at the county level for urban, rural, and Appalachian Kentucky. The ratios were grouped into five classes/categories based on the Jenks natural breaks optimization algorithm (33). The Appalachian region has 52.9 percent of its counties in the bottom two classes (0.0-1.8 and 1.9-3.2), the rural region has 52.6 percent whereas the urban region has 41.9 percent. There are markedly different dentist-to-population ratios both between and within regions.

According to the simulation model output, the number of dentists retiring (82 per year) will exceed the number of

Table 1 Comparison of Variables and Distribution of Dentists' Practice Type by Region, 2007

	Regions			
	Rural	Urban	Appalachian	State
Total number of dentists (% of state total)	315 (13.2%)	1,629 (68.1%)	447 (18.7%)	2,391 (100%)
Number of general practice dentists (% of state total)	277 (14%)	1,305 (66%)	396 (20%)	1,978 (100%)
Number of pediatric dentists (% of state total)	6 (7.9%)	57 (75%)	13 (17.1%)	76 (100%)
Median dentist-to-population ratio (1.0 : 10,000)	3.18	4.10	2.93	3.24
Median physician-to-population ratio (1.0 : 10,000)	3.71	4.86	4.29	4.29
Median percentage uninsured population under 65	13%	12%	18%	14%
Median per capita personal income	$22,965	$27,098	$18,982	$21,968
Median percentage of adults with six or more permanent teeth removed because of tooth decay or gum disease	36%	30%	42%	38%

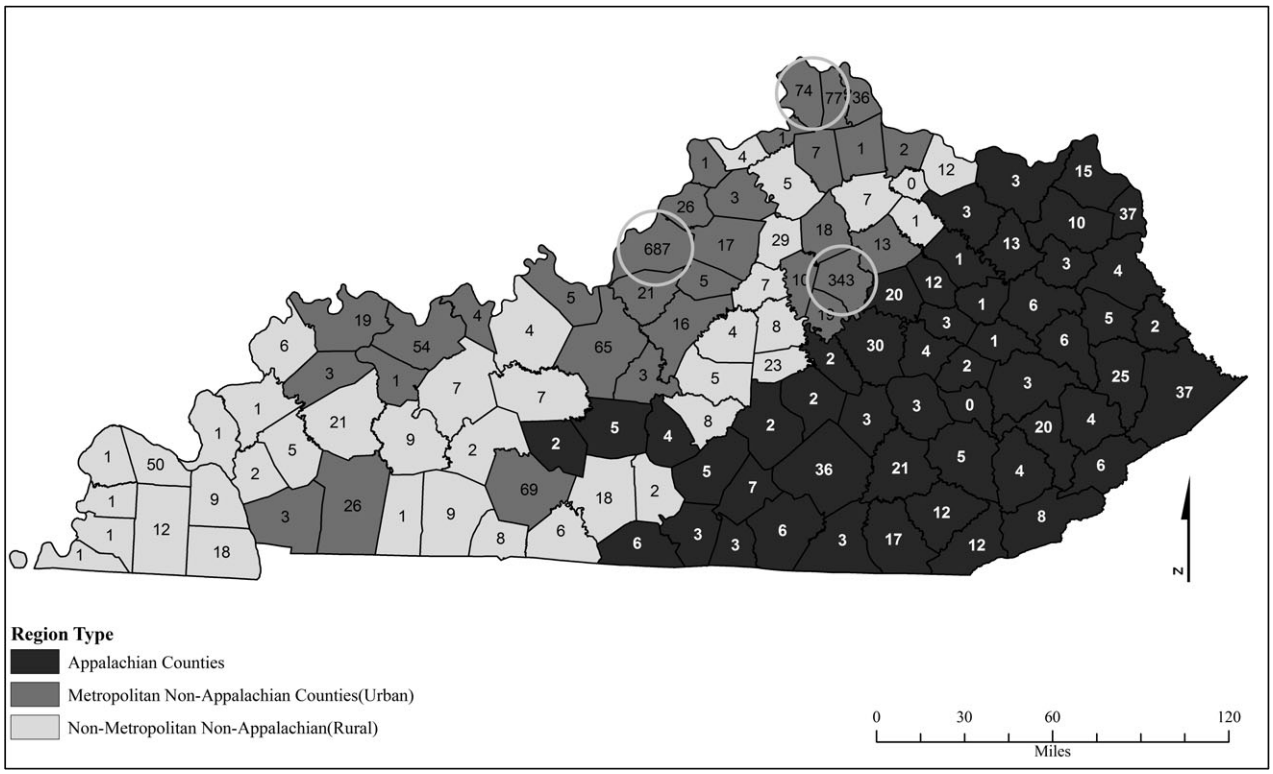

Figure 1 Count of dentists across rural, urban, and Appalachian Kentucky. The three circled areas account for four counties, which contain 1,181 dentists, or almost 50% of the total number of dentists in Kentucky in 2007.

incoming dentists (55 per year). Given the concurrent projected growth of the population as compared with the declining dentist-to-population ratio, we estimate the dentist-to-population ratio in Kentucky to change from 5.50: 10,000 in 2007 to 4.74: 10,000 in 2016 (Figure 3).

The Poisson regression analysis output (Table 2) shows variables that were significantly associated (at $P \leq 0.05$) with the number of dentists per unit population during initial testing of each variable independently. Only per capita personal income [relative risk (RR) = 1.37, 95% CI 1.11, 1.68] and physician-to-population ratio (RR = 1.09, 95% CI 1.06, 1.11) were statistically significant after controlling for the other variables in the multivariate model. The model showed that for every increase of $10,000 in per capita income by county, the number of dentists increased by 37 percent or 1.37 times and by a factor of 1.09 (or by 9 percent) for every unit increase in the physician-to-population ratio (e.g., a gain from 3.0: 10,000-4.0: 10,000). An additional Poisson regression was performed (Table 3) with explanatory variables not highly correlated ($r < 0.5$) to best address the issues of multicolinearity within the Poisson regression model shown in Table 2. After removing variables that were highly correlated (e.g., percentage uninsured population and percentage of adults with 6+ teeth removed), results similar to those in Table 2 were found. Table 3 shows that both per capita personal income (RR = 1.42, 95% CI 1.22, 1.66) and the physician-to-population ratio (RR = 1.08, 95% CI 1.06, 1.10) maintained significance ($P \leq 0.05$) to the number of dentists per county after controlling for the region.

Neither the Appalachian nor rural region variables were significantly associated to the number of dentists per county after controlling for the other explanatory variables (Table 2). However, when examining these region variables in a separate Poisson regression model without the other explanatory variables in the model, the number of dentists in the rural region was 0.56 times than that of the urban region (RR = 0.56, 95% CI 0.44, 0.73) and the number of dentists in the Appalachian region was 0.53 times than that of the urban region (RR = 0.53, 95% CI 0.42, 0.66) (results not shown in table). Finally, a Poisson regression model (results not shown in table) using only per capita income as an explanatory variable while including the population offset was performed to show the correlation of dentists with higher income areas. The model showed that for every increase of $10,000 in per capita income by county, the number of dentists increased by 101 percent or 2.01 times.

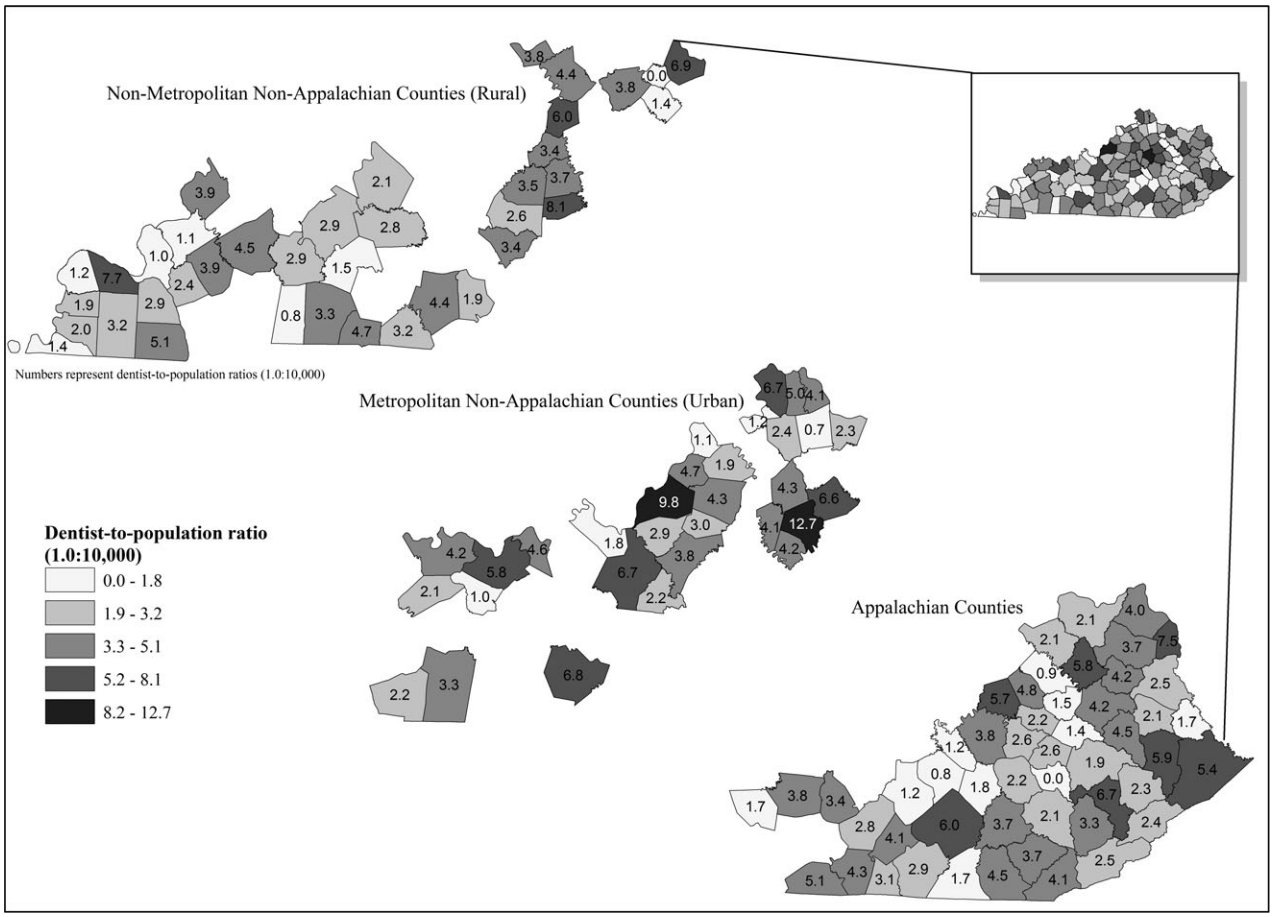

Figure 2 Ratio of dentists-to-population in rural, urban, and Appalachian Kentucky.

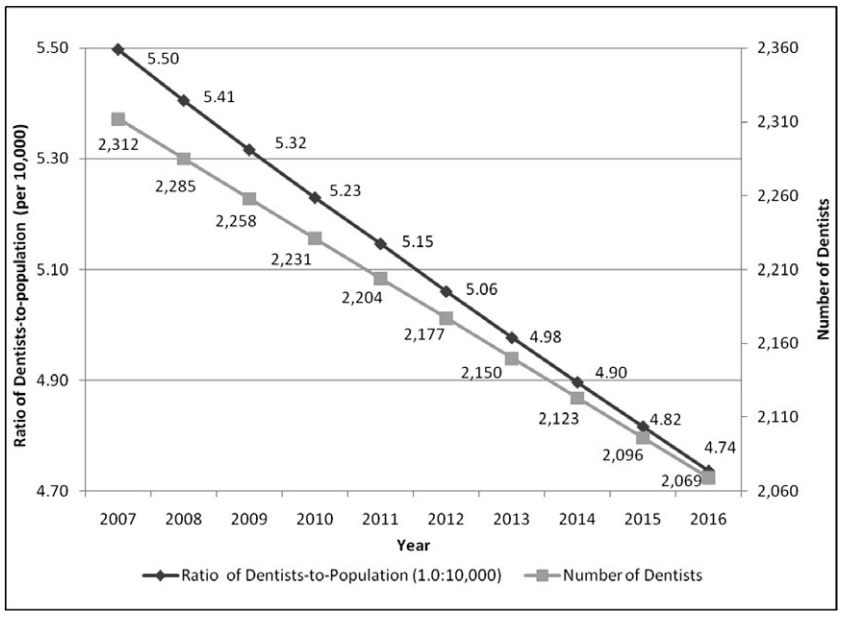

Figure 3 Number of dentists and ratio of dentists-to-population for Kentucky: 2007-2016.* *Data calculated by the authors based on data from the Kentucky Dental Provider Workforce Analysis 2007 (5) and the U.S. Census Bureau.

Table 2 Poisson Regression Model

Parameter	Relative risk	95% Conf. interval	χ^2	*P*-values
n = 120 observations				
Dependent variable = number of dentists per county				
Per capita personal income (for every $10,000 increase)	1.37	(1.11, 1.68)	8.83	0.0030
Percentage uninsured population under 65	0.99	(0.96, 1.02)	0.41	0.5239
Physician-to-population ratio (for every unit increase in ratio; i.e., 1.0 : 10,000 to 2.0 : 10,000)	1.09	(1.06, 1.11)	68.69	<0.0001
Percentage of adults with six or more permanent teeth removed because of tooth decay or gum disease	1.00	(0.99, 1.01)	0.01	0.9102
Rural region (reference = Urban)	1.04	(0.86, 1.25)	0.16	0.6858
Appalachian region (reference = Urban)	1.04	(0.85, 1.26)	0.14	0.7058

Overall chi-square test significant at $P \leq 0.05$. Before scaling by using the deviance divided by the degrees of freedom as an estimate of the dispersion parameter instead of 1.0 (i.e., not assuming that the variance and mean are equal), there was minor evidence of overdispersion (variance > mean).

Discussion

As expected, the GIS and Poisson regression analyses revealed disparities in the distribution of dentists in Kentucky, with deficits most notably found in nonmetropolitan non-Appalachian (rural) and Appalachian counties. Similar to the studies by Knapp and Hardwick and Mertz and Grumbach (2,9), our study found a lower number of dentists (by both count and per capita rates) in lower income and rural areas pointing to a regional-based inequality among dentist availability. Our results also agree with Susi and Mascarenhas' (16) findings in that there were "obvious disparities" in the rural and Appalachian regions. The statistical and geospatial analyses showed the extent to which dentists are located in high income areas. These findings agree with Beazoglou *et al.* and Bailit and Beazoglou, who concluded that per capita income was a good predictor of dentists' location (20,21).

Our study also found a statistically significant association between the physician-to-population ratio variable and the number of dentists per county. Though there was an association, we find many areas in Kentucky with few dentists, and accordingly we encourage physicians to provide anticipatory guidance for oral health care to their patients.

Given that Kentucky's number of dentists is projected to decline (Figure 3), improving access to oral health care will require a multifaceted approach. The National Rural Health Association recommends improving access to oral health care in rural areas by: increasing loan repayment opportunities by the National Health Service Corps and state governments; creating dental school externship requirements in underserved communities for students; and advising dental and dental hygiene programs to orient the admissions process to encourage applications from students with rural backgrounds and/or those with demonstrated service to underprivileged and minority populations (22). Implemented concurrently, these recommendations may significantly improve access in rural and underserved areas like many of Kentucky's counties.

The Kentucky Dental Provider Workforce Analysis (KDPWA) (2007) estimated there being 2,069 dentists in the year 2016; a loss of 243 dentists compared with 2007 (5). As documented by Osborne and Haubenreich, the likelihood of dentists establishing private practices in areas sparsely populated and with a depressed economy – like in rural and Appalachian Kentucky – is low (34). In order to maintain the current level of provider availability, the number of retiring dentists should be equal to the number of incoming replacements. According to KDPWA, from 2002 to 2006, only half of Kentucky dental school graduates originally from Kentucky remained in the state (5). Our analyses show that Kentucky not only faces a problem of a geographic maldistribution (Figures 1 and 2), but also a steady decline in the number of dentists over time (Figure 3). Given that most dental care is provided by private practitioners, any strategy to improving

Table 3 Final Poisson Regression Model

Parameter	Relative risk	95% Conf. interval	χ^2	*P*-values
n = 120 observations				
Dependent variable = number of dentists per county				
Per capita personal income (for every $10,000 increase)	1.42	(1.22, 1.66)	20.39	<0.0001
Physician-to-population ratio (for every unit increase in ratio; i.e., 1.0 : 10,000 to 2.0 : 10,000)	1.08	(1.06, 1.10)	83.97	<0.0001
Rural region (reference = Urban)	1.04	(0.87, 1.25)	0.21	0.6458
Appalachian region (reference = Urban)	1.02	(0.85, 1.22)	0.04	0.8513

Overall chi-square test significant at $P \leq 0.05$. Before scaling by using the deviance divided by the degrees of freedom as an estimate of the dispersion parameter instead of 1.0 (i.e., not assuming that the variance and mean are equal), there was minor evidence of overdispersion (variance > mean).

access will require their participation. Only about one in four dentists see at least 100 Medicaid patients per year nationally (35). In 2004, only 41 percent of Kentucky dentists billed Medicaid for services (13). Adjusting Medicaid fees to commercial or near-to commercial levels may attract additional providers and address disparities in access for the Medicaid population as has been the experience in several states (36).

Further evidence that increasing Medicaid rates improves access to oral health care comes from a report by the National Academy for State Health Policy (NASHP) (37). It examined six states that increased their Medicaid rates and found that provider participation in Medicaid increased by at least one-third and sometimes more than doubled in the first 2 years after the Medicaid rate increases. The NASHP study also found that states saw an increase in the number of patients treated as a result of these payment rate increases. Medicaid rate increases, however, were found to be necessary but singularly insufficient in improving overall access to oral health care. They suggest that increasing Medicaid rates alone may not be as effective as coupling the increase with easing Medicaid administrative processes and involving state dental societies as partners in program improvements. States should, however, take into account the financial feasibility of a Medicaid rate increase given the current national economic situation.

Though economic reasons may prevent Kentucky and similar states from increasing Medicaid rates, increasing access to oral health care may also be achieved through the development of a new type of dental care practitioner. The introduction of mid-level dental providers has been controversial in the United States in spite of their success as a means of improving access to care in other countries with similar dental provider disparities as Kentucky (38). Though the development of mid-level providers has been criticized for potentially offering a substandard level of care, research has shown otherwise (39,40). Mid-level providers could address the needs of underserved populations or individuals living in areas too small or isolated to attract and support dentists. For example, Minnesota recently became the first state to pass legislation to provide a training option for a mid-level dental provider in order to expand the dental workforce and increase oral health-care services offered to underserved populations (41). Accordingly, we encourage Kentucky and other states with similar workforce disparities to create a mid-level provider in hopes of reducing the dental workforce disparity so often found between rural and urban areas and improve access to oral health care.

Our analysis has several limitations. This study is susceptible to issues related to ecological studies in that some variables are not necessarily descriptive of the whole county; they are a summary of the county, and may not truly reflect what is happening in different parts of the county. Additionally, the dentist-to-population ratio is not a sufficient measure (given that there is no known acceptable ratio) by itself, but can be used to make comparisons within Kentucky and to other states.

The Poisson regression model in Table 2 has issues of multicollinearity. Many of the explanatory variables were not independent; e.g., per capita income is associated with the percentage of adults with six or more teeth removed and the percentage of the population under 65 who are uninsured. However, even after removing all the variables that were correlated, it was still found that per capita income and the physician-to-population ratio were predictive of dentists' location. Finally, the methodology in this study assumes that populations within counties stay within those county boundaries when they visit a dentist, which may not be the case.

Understanding the distribution of dentists across geographic regions can help policymakers determine where additional resources are required. Increased reimbursement rates in the Medicaid program, introduction of mid-level dental providers as a part of the dental team, and the creation of incentive programs to attract dentists to rural and Appalachian areas in Kentucky and in other rural areas of the United States are likely solutions to improve access to oral health care.

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