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Primary Care Providers: Relationships in Practice Locations

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Researchers and policymakers in the United States have recognized for decades that a geographical maldistribution of primary care providers exists that disproportionately affects residents of rural and inner-city areas (1). The persistent disparities between the urban and rural distribution of health care providers calls for innovative research, the results of which support programs designed to alleviate access barriers. We initiated this project to examine the distribution of primary care dentists, pharmacists and physicians in Iowa. We analyzed practice locations to determine if a spatial pattern or heterarchy exists. For communities looking to recruit and retain health care providers, a keystone provider may be required before they can attract different types of providers.

In addition to personal motivators such as family and local ties to communities, professional relationships can be powerful motivators for practice location. Physicians place a high priority on proximity to hospitals, and study findings have shown that professional interactions are important for job satisfaction (2-4). It is reasonable to assume that similar factors motivate dentists and other health care providers. Although urban practitioners may have ample opportunities for professional interaction with other health care providers, peers can be relatively scarce in rural areas. Consequently, in small communities, interactions between different types of health care providers may become more important.

Geographers developed central place theory in the 1930s to explain the distribution of retail goods and service industries across the landscape (5). According to the principles of this theory, goods and services appear in market areas on the basis of minimum populations required to support them. This location theory also predicts that basic services will be found more commonly and more specialized services will be found less frequently (5). Researchers have applied the hypothesis that goods and services are found in hierarchical patterns in communities to health services research, including evaluations of the physician workforce and provision of hospital services (6,7).

Lawlor and Reid (6) found that primary care providers were the most common medical provider in U.S. counties. They also identified a pattern of increasingly specialized physicians' (for example, dermatologists' and allergists') being located in larger counties in

which there was a full range of basic medical providers (for example, general practitioners, internists and general surgeons). In a study of hospital specialization, Berry (7) identified services that appeared to be basic and ones that were more complex, which were added by hospitals in a predictable order as the facilities increased in size and number of beds. We hypothesize that a similar ordering of services may occur among primary care providers in Iowa.

Research findings have demonstrated that the supply of physicians in a county is correlated positively with the supply of dentists (8). Knapp and Hardwick⁹ found that primary care physicians and dentists were the most common pairing of primary care providers at the zip code level in the United States. The results of our previous investigations suggest that a county-level relationship also may apply to dentists and pharmacists (unpublished data, 2007). This coincident geographical relationship is intuitive: communities require primary care providers to meet local demand for health services. We designed the current study to examine whether a heterarchical relationship existed among dentists, physicians and pharmacists in Iowa. If primary care providers are found to colocate in communities in a predictable pattern, recruitment efforts can target communities with favorable conditions. Although individual providers may be motivated by different factors in selecting practice locations, central place theory offers a conceptual framework that facilitates a community-level analysis of the relationships between multiple provider types.

The objectives of this study were to map the distribution of primary care dentists, physicians and pharmacists in Iowa in the year 2000; evaluate the spatial relationships between the practice locations of these providers; and examine changes in these relationships after a 10-year period. We hypothesized that pharmacists or physicians were keystone providers and that dentists would be found more often in cities and towns with these other health care providers than in communities without them.

METHODS

Study Population

We designed this study to evaluate the distribution of primary care providers in Iowa so that we could identify potential heterarchical relationships with respect to their spatial distribution. Primary care providers of interest included dentists, physicians and pharmacists. For this study, we defined primary care dentists as general or pediatric dentists in private practice. Primary care physicians included those engaged in private practice of the following specialties, as designated by The Iowa Health Fact Book: family practice, internal medicine, pediatrics and obstetrics/gynecology (10). We excluded dentists and physicians practicing in community health centers (CHCs). CHC providers often are supported by state and federal incentive programs to serve in shortage areas, and their presence in a community may not be supported adequately by local demand alone. We defined community pharmacists as independent practitioners and practitioners employed by chains, including practitioners sponsored by hospitals. We excluded hospital-based pharmacists and those in academic settings. We obtained main practice addresses for primary care providers engaged in active practice in Iowa during 2000 and 2010.

Source of data

We obtained information about health care providers from the Iowa Health Professions Tracking Systems (11). Although participation in the tracking systems is voluntary, this data set captures information pertaining to almost 100 percent of Iowa's practitioners (12). We analyzed practice locations at the city level by using shapefiles delineating the boundaries of incorporated areas in Iowa. Incorporated areas include all census-recognized cities, towns and villages (hereafter referred to as "cities"). Shapefiles provide vector coordinates for geographical features (13). We obtained these shapefiles from the U.S. Census Bureau (14). We also analyzed practice locations at the county level by using shapefiles obtained from the U.S. Census Bureau (14).

We linked city-and county-level demographic data from the 2000 and 2010 U.S. Census to provider locations. Demographic data included total city and county population size in 2000 and 2009–2010 and mean household income in 1999. We described county urbanicity by using U.S. Department of Agriculture Rural-Urban Continuum Codes (RUCCs) (15). RUCCs provide information about the metropolitan status of a county, population within each county and proximity of each county to an urban area (16). For this study, we examined the urban character of Iowa counties by categorizing them as urban (RUCCs 1–3), less urban (RUCCs 4–7) and completely rural (RUCC 8–9) (17).

Data analysis

We geocoded practice addresses from 2000 and 2010 by using ArcMap 10.0 software (Esri, Redlands, Calif.). The process of geocoding involves the assignment of geographical coordinates to data and allows researchers to study information in a spatial context (18). For this study, we geocoded provider locations to the street level and then aggregated them to the city and county levels for analysis.

Using geocoded practitioner data, we identified the types of primary care providers in each city in Iowa for 2000 and 2010. We created a modified Guttman scale to analyze the heterarchical relationships between the three types of health care providers in practice locations. Guttman scales were developed to predict test responses (19). Investigators order test items on the basis of levels of increasing difficulty; the assumption is that a correct response to a difficult question predicts a correct response to an easier question. Investigators can use these scales to determine whether a spatial ordering exists among health care providers or health care activities (6,7). Each provider's rank in the scale is based on whether each type is found in a city. If a heterarchical relationship exists, the provider found least often should be in areas in which the other two types of providers are found.

For this study, we generated a matrix that categorized cities on the basis of the types of primary care providers present in each year: no providers of any type, providers of one type only (for example, pharmacists), providers of two types (for example, pharmacists and physicians) or all three provider types. We also examined changes in the presence of primary care providers per city for 2000 and 2010. Using the city/provider matrix, we tabulated changes between categories. We evaluated the collective movement of dentists, physicians and pharmacists across the 10-year period. We compared the changes in city

categorization from 2000 to 2010 and summarized them in Table 1. This table shows longitudinal changes for the entire sample of cities.

We generated maps by using ArcMap to show the locations of primary care providers throughout the state. Cities are indicated by their geographical centroids. We included selected maps to highlight the colocation of provider types in Iowa.

The institutional review board at the University of Iowa approved this study.

RESULTS

In 2000, slightly fewer than 3 million people lived in Iowa, with 1,108 primary care dentists (hereafter “dentists”), 1,691 primary care physicians (“physicians”) and 1,656 community pharmacists (“pharmacists”). This translates into a dentist to population ratio of 1:2,641, a physician to population ratio of 1:1,731 and a pharmacist to population ratio of 1:1,767. By 2010, the state’s population had increased by 4 percent to slightly more than 3 million people. The numbers of all three provider types increased marginally during the 10-year period. Provider to population ratios improved minimally for physicians and pharmacists (1:1,691 and 1:1,758, respectively), but the ratio declined for dentists (1:2,656).

Geocoding resulted in successful matching for more than 97 percent of dentist, physician and pharmacist locations in 2000 and 2010 (Table 2). shows the effective total provider population sizes for the subsequent analyses. Effective population sizes are smaller than the total number of providers per group owing to losses from geocoding, as well as to losses that occurred when providers practiced outside of incorporated areas. We identified 954 incorporated places (“cities”) in Iowa. For our analyses, we included only those primary care providers found within city limits.

In 2000 and 2010, physicians were the largest group of primary care providers in Iowa. However, even though we identified through geocoding 568 more physicians than dentists, these providers were located in only five more cities than were dentists in 2000 (Table 2). By 2010, physicians outnumbered dentists by 629 but were located in nine fewer cities than were dentists. Of all three provider types, pharmacists were located in the greatest number of cities in 2000 and 2010, despite having a smaller workforce than that of physicians. In 2000, dentists were located in 222 cities (Table 2). Physicians and pharmacists were located in slightly more cities than were dentists in 2000. By 2010, fewer cities had primary care providers practicing within their boundaries.

In cities with any primary care providers in 2000, the most common scenario was for all three provider types to be found together. In cities with two types of providers, physicians and pharmacists were the most likely combination, followed by pharmacists and dentists and then physicians and dentists. Cities in which only one type of primary health care provider practiced ($n = 64$) were more likely to have a pharmacist than any other type of provider. Cities with no primary care providers had the smallest mean population in 2000 (Table 3). Cities with all three provider types had mean population sizes in 2000 that were similar to those in cities with a physician and pharmacist only. The mean annual household income per city increased minimally as the number of provider types increased.

Table 1 provides detailed information about the changes in city categorizations during the 10-year study period. For example, in 2000, 664 cities had no primary care providers. By 2010, the number with no primary care providers had decreased to 651. Between 2000 and 2010, most cities experienced no change in the types of providers found within city limits: 855 of 954 cities (90 percent) were in the same category in 2010 as in 2000 (Table 1).

Table 4 provides information about county urbanicity and Iowa's population distribution. Of the 99 counties in Iowa, 20 are categorized as urban on the basis of RUCCs, 58 are less urban and 21 are completely rural. Figure 1 shows the distribution of cities with all three provider types in 2000 along with county urbanicity. Twenty-five cities had a physician and pharmacist but no dentist in 2000 (Figure 2). Nine of these cities were located in completely rural counties. By 2010, three of these most rural cities had added a dentist; only one of these cities was adjacent to a metropolitan county.

DISCUSSION

In 2000 and 2010, most cities in Iowa lacked any primary care dentist, physician or community pharmacist. A pharmacist was the most common single type of health care provider in a city, and a physician and pharmacist were the most common pairing of provider types. We should point out that among cities that had any primary care providers, the most common scenario was to have all three types (Table 3).

Pharmacists were the most widely available health care provider at the city level in Iowa in 2000 and 2010. Even though physicians outnumbered pharmacists in both years, they were the second most commonly found provider according to city in 2000, and they were the least commonly found provider according to city in 2010. Finally, dentists were the smallest of these workforces in the state and were located in the fewest cities in 2000. Our study findings show that by 2010, dentists were located in more cities than were physicians. That pharmacists formed the basis of a primary care heterarchy is supported by the changes in provider distribution from 2000 to 2010. A greater number of cities without dentists lost physicians than lost pharmacists during the 10-year period, indicating that pharmacists may offer the most basic and widely used services that can be supported by the smallest population.

Only about 7 percent of Iowa's population lives in completely rural counties. In 2000, cities within these counties were less likely to have all three provider types compared with more urban counties. The differences in mean population per city in 2000 were the most dramatic between cities with no provider or one provider type versus cities with two or three provider types. These similarities may indicate that larger communities with two types of primary care providers may be able to offer a third type of health care provider with the infrastructure and population necessary for sustainability.

The results of this study offer more specificity than does previous research of its kind. We included only active practice providers and were able to definitively identify practice locations. A major strength of this study is that the Iowa Health Professions Tracking Systems offer current, detailed information pertaining to almost 100 percent of Iowa's

practitioners. Our study was based on the city level, unlike previous studies in which researchers have examined data according to zip codes or counties (6,9). City level analysis may provide a more realistic description of health care provider availability than does an analysis of zip codes, the coverage areas of which may be too small to represent service areas accurately, or of counties, which may be too large.

Our purpose in conducting this study was to identify whether there was a keystone provider in a city that increased the likelihood of a primary care dentist practicing there. Instead, our results indicate that these three types of health care providers most often are found practicing together in a city. Communities with at least one physician and pharmacist but no dentist may be able to offer new or relocating dentists a competitive opportunity for practice. Similarly, communities with at least one physician and one dentist, or one pharmacist and one dentist, may represent competitive practice locations for a new community pharmacist or primary care physician. Analyzing local providers from a community level, as we did in this study, may offer additional information about the existing population support for health care services that an analysis based primarily on population size may not reveal.

The results of the Guttman scale analysis are affected by the geographical scale used; for this study, we analyzed health care provider distribution across incorporated places (that is, towns and cities). Investigators can use a similar analysis to analyze the distribution of other types of health care providers, such as medical and dental specialists, at the county level. The use of incorporated places as the geographical unit of analysis posed certain challenges; some health care providers may serve a community but locate their practices outside the city borders. As populations move to newer developments outside of cities, primary care providers may follow them. Our analyses did not enable us to account for these providers, and we could not account for satellite, part-time practice locations.

CONCLUSIONS

This study represents the incorporation of geographical information systems analysis with a workforce analysis. A similar study that incorporates data about variations in local need or demand for dental services could provide enhanced results. The relationships between primary care provider locations may be changing. The results of a recent study show that the number of independently owned retail pharmacies declined rapidly in rural communities between 2003 and 2010 (20). If pharmacists are leaving rural areas in response to economic pressures and changing demand patterns, the same factors may soon have a similar effect on physicians and dentists in these communities. Although local pharmaceutical services can be augmented by mail order delivery of medications, medical and dental services require direct provider care.

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Figure 1.
Cities with three primary care provider types (dentist, physician, & pharmacist) – Iowa, 2000

Figure 2.
Cities with physicians and pharmacists only (no dentists) – Iowa, 2000

Table 1

Changes in city categorization based on the presence of primary care provider types – Iowa, 2000 – 2010

Baseline city type (2000)	10-year city type (2010)							
	No providers	Physician only	Dentist only	Pharmacist only	Pharmacist & Dentist	Physician & Dentist	Physician & Pharmacist	All 3 types
No providers	651	2	7	3	0	0	0	1
Physician only	7	10	1	0	0	0	1	0
Dentist only	3	0	15	0	2	0	0	1
Pharmacist only	9	0	0	11	0	0	4	0
Pharmacist & Dentist	1	0	5	1	9	0	0	2
Physician & Dentist	1	3	0	0	0	3	1	3
Physician & Pharmacist	2	1	0	7	1	0	9	5
All 3 types	0	0	1	1	9	4	10	147
Total	674	16	29	23	21	7	25	159
								954

Table 2

Geocoded primary care providers and distribution by city – Iowa, 2000 and 2010

Provider	2000		2010	
	Total providers (n)	Cities with each provider (n)	Total (n)	Cities with each provider (n)
Dentist	1096	222	1125	216
Physician	1664	227	1754	207
Pharmacist	1625	239	1689	228

Table 3

Characteristics of cities categorized by the presence of primary care provider types – Iowa, 2000

Cities with...	Cities (%)	Mean population	Mean household income
No providers	664 (69.6)	751	\$34,991
Pharmacist only	24 (2.5)	1,100	34,830
Dentist only	21 (2.2)	1,399	36,155
Physician only	19 (2)	1,158	33,784
Physician and Pharmacist	25 (2.6)	9,337	36,101
Pharmacist and Dentist	18 (1.9)	1,228	35,042
Physician and Dentist	11 (1.2)	1,641	38,313
All 3 types	172 (18)	8,267	36,595
Total	954		

Table 4Rural-Urban Continuum Code (RUCC) descriptions[†] and Iowa population by RUCC, 2000 and 2009

RUCC	Description	Iowa counties per category	Total population, 2000 (%)	Total population, 2009(%)
Urban counties:				
1	Counties in metro areas of 1 million population or more	0	0	0
2	Counties in metro areas of 250,000 to 1 million population	9	760,100 (26%)	850,110 (28.3)
3	Counties in metro areas of fewer than 250,000 population	11	806,884 (27.6)	856,617 (28.5)
Less urban counties:				
4	Urban population of 20,000 or more, adjacent to a metro area	3	131,161 (4.5)	131,127 (4.4)
5	Urban population of 20,000 or more, not adjacent to a metro area	5	202,753 (6.9)	193,794 (6.4)
6	Urban population of 2,500 to 19,999, adjacent to a metro area	25	453,637 (15.5)	436,636 (14.5)
7	Urban population of 2,500 to 19,999, not adjacent to a metro area	25	370,186 (12.6)	350,899 (11.7)
Completely rural:				
8	Completely rural or less than 2,500 urban population, adjacent to a metro area	10	115,743 (4)	108,083 (3.6)
9	Completely rural or less than 2,500 urban population, adjacent to a metro area	11	87,720 (3)	80,590 (2.7)
Total		99		

[†] RUCC descriptions were obtained from the USDA Economic Research Service (available at: <http://www.ers.usda.gov/Briefing/Rurality/RuralUrbCon/>)