LOCATION THEORY AND THE SUPPLY OF PRIMARY CARE PHYSICIANS IN RURAL AMERICA

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ABSTRACT

The dire state of rural health and the continuing trend of geographic and specialty maldistribution among physicians inform the need for urgent efforts to recruit primary care physicians (PCPs) to rural America. Whereas many studies have analyzed personal characteristics, traits and aspects of medical training that may encourage rural location among medical students and recent graduates, the methodology has been causally weak and important exogenous factors are overlooked. Location theory presents a more generalizable and consistent approach to understanding the location decision of physicians. It considers physicians as economic beings with the purpose to maximize income or utility in selecting a practice location. In the first study to analyze this issue using the primary care service area (PCSA) as unit of analysis, I test the following hypotheses of location theory: that a location's population size is the primary determinant of the likelihood that a primary care physician is present there; that the growth rate of primary care physicians is greater in locations that previously were unserved by a primary care physician than in locations that had at least one member of this specialty. I aim to demonstrate the importance of spatial economics theories in understanding the varying supply of PCPs in rural locations.

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BACKGROUND

Specialty and Geographic Maldistribution of American Physicians

On March 23, 2010, President Barack Obama signed into law the Patient Protection and Affordable Care Act (PPACA), the culmination of a long and arduous process of sensitizing the American public to the urgent need for comprehensive reform in health care. Toward its ambitious objective of providing quality, affordable health care for all Americans, this law emphasizes expanding access to primary care, defined as "the provision of integrated accessible health services by clinicians who are accountable for addressing a large majority of personal health care needs, [for] developing a sustained partnership with patients, and [for] practicing in the context of family and community."[1] Primary care medicine is broadly distinguished from other medical specialties, termed *subspecialties*: the former is usually the first contact with a patient, provides ongoing care over time and attends to all but uncommon problems, while the latter focus on particular aspects of the anatomy or medical care, short-term consultations for diagnosis and long-term referral for management of unusual conditions (L. Chen et al., 2004). Medical specialties under the umbrella of primary care include: pediatrics and adolescent medicine, family medicine, general practice and internal medicine, obstetrics and gynecology.

The emphasis on strengthening primary care is not baseless; an effective system of patient-centered care has significant effects on quality and equity in health for the entire American population. From their analysis of articles on primary care from the PubMed database, Macinko et al. (2007) estimate that an increase of one primary care physician per 10,000 population was associated with an average mortality reduction of 49 persons per 100,000 people per year. In a nationwide study of patients, primary care clinicians were the most common clinician type accessed by disadvantaged populations of adults, seniors and reproductive-age women (Ferrer, 2007). According to the American

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[1] [1] *Patient Protection and Affordable Care Act*. Public Law 111-148, 111th Congress. http://www.gpo.gov/fdsys/pkg/PLAW-111publ148/pdf/PLAW-111publ148.pdf. 12/16/2010. Stat. 515

College of Physicians, Medicare expenditures are lower per beneficiary in states that have a higher generalist-to-population ratio than in those with fewer generalists and more specialists per capita.[2] Starfield et al. (2005) conclude that having a good primary care source is associated with an earlier detection of breast cancer, colon cancer, cervical cancer and melanoma. Hence, a stronger system of primary care would deliver amplified benefits in efficiency and equity of health care pervading all sections of the American population.

The main obstacle to providing needed primary care to all sections of the American populace is twofold: the maldistribution of doctors with respect to specialty and to geographic location. Between 2001 and 2005, slightly more than a third of practicing physicians were doing so in primary care, but a recent national survey found that only 2% of medical students were interested in general internal medicine careers, 4.9% in family medicine, and 11.7% in general pediatrics, the dominant specialties of primary care.[3] This finding supports a decade-long trend of decline in primary care specialty choices highlighted in Jeffe et al. (2010), a study of medical students that graduated between 1997 and 2006. As a result, the field of primary care has become more reliant on international medical graduates, who are also increasingly avoiding primary care and pursuing subspecialty training (Bodenheimer & Pham, 2010).

In addition to shunning primary care specialties, physicians tend to prefer metropolitan and suburban locations to rural practice. The distribution of doctors in the US is very heterogeneous, and national or state statistics mask significant locational disparities. In 1993, when the national physician-to-population ratio was 208 per 100,000, metropolitan areas had an average ratio of 226 per 100,000,

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[2] *The Impending Collapse of Primary Care Medicine and and Its Implications for the State of the Nation's Health Care: A Report from the American College of Physicians (January 30, 2006).* http://www.acponline.org/advocacy/events/state_of_healthcare/statehc06_1.pdf. 12/16/2010. p. 4

[3] *Specialty and Geographic Distribution of the Physician Workforce: What Influences Medical Student & Resident Choices?* Robert Graham Center (American Academy of Family Physicians Center for Policy Studies). p. 13 http://www.graham-center.org/online/etc/medialib/graham/documents/publications/mongraphs-books/2009/rgcmo-specialty-geographic.Par.0001.File.tmp/Specialty-geography-compressed.pdf. 12/16/2010.

while nonmetropolitan areas had an average of 118 physicians, slightly over half of the proportion in urban locations. In Pennsylvania, which contained the largest rural population of any state in the country in 1999, almost half the physicians in the state were located in three urban and suburban counties—Philadelphia, Allegheny and Montgomery—although the remaining 64 counties had almost three-quarters of the state's population (Rabinowitz, Diamond, Hojat, & Hazelwood, 1999). In 2007, 75% of physicians in patient care were practicing in urban areas.[4] However, a substantial number of Americans, up to 20%, remains in rural areas, where only 9% of physicians practice (Geyman, et al., 2000).

There is a link between the specialty and geographic maldistribution of physicians in the US. Maudlin et al. (2010) infers that the more highly specialized physicians are, the less likely they are to practice or settle in rural areas. There is "a population threshold" below which specialist physicians find it unfeasible to practice, and many rural areas fall short of it (p. 723). In other words, as physicians continue to shun general primary care specialties for subspecialties, fewer doctors are likely to practice in rural areas. Physician maldistribution by specialty feeds inequality by geography and results in gaps in access to care.

The trends of geographic and specialty maldistribution that foster the dearth of primary care coverage in rural areas arise because of the arduous logistics of rural health, that make practicing primary care here much more demanding than in urban or metropolitan locations.

Logistics of Primary Care in Rural America

From the 2000 Census, 21.1% of the American population lived in nonmetropolitan counties (NMCs), defined by the Office of Management and Budget (OMB) as not having a city with a population of 50,000 or more and not having a metropolitan population of up to 100,000. NMCs

[4] *Occupational Outlook Handbook, 2010-11 Edition: Physicians and Surgeons*. Bureau of Labor Statistics. http://www.bls.gov/oco/ocos074.htm. 12/16/2010.

formed 26.4% of Midwestern counties, 24.2% of Southern counties, 14.1% of Western counties and 9.9% of Northeastern counties. 14.6% of the population in NMCs was 65 years of age or older, compared to 11.8% in large central metropolitan counties. NMCs had 50% more whites (83.3% of the NMC population), less than half the blacks (9.1% in NMCs), and about a quarter of the number of Hispanics (4.8% in NMCs) in large central metropolitan counties[5]. In 1999, more than 75% of US counties designated by the federal government as medically underserved areas (MUAs) or health professional shortage areas (HPSAs, defined as an area with less than one primary care physician per 3,500 population) were rural. The crux of rural health problems is in small rural areas, "rural communities with fewer than 10,000 people and not adjacent to a metropolitan area" (Geyman, Hart, Norris, Coombs, & Lishner, 2000, p. 57). These are the most isolated rural locations where many of the challenges described below manifest and, hence, where very few doctors practice.

Compared to urban locations, rural areas of the US are characterized by smaller populations, greater dispersion, and more geographic access barriers, with considerable travel distance and transportation problems to tertiary health facilities. The lower population in very rural areas may not be adequate to sustain a lucrative practice. Moreover, NMCs have a higher percentage of their population living below the federal poverty threshold than in metropolitan counties. Rural residents also have higher rates of the uninsured and underinsured and usually have fewer benefits in their coverage than urban residents. This may reduce the magnitude of reimbursement physicians receive for services and procedures (Regan, Schempf, Yoon, & Politzer, 2003).

With respect to arduousness of practice, rural areas generally have more elderly residents and a greater number of patients with chronic medical conditions than non-rural areas (Regan, et al., 2003).

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[5] The Department of Health and Human Services's (DHHS) Urban Rural Health 2001 Chartbook. Using the Office of Management and Budget taxonomy, this study classifies American counties broadly into metropolitan and nonmetropolitan counties. Metropolitan counties are further divided among large central (counties in large metro areas that contain all or part of the largest central city and have population of 1 million or more), large fringe (remaining counties in large metro areas with population of 1 million or more) and small (counties in metro areas with less than 1 million population). Nonmetropolitan counties are classified into those with a city (of 10,000 or more population) and those without a city.

NMCs also have worse outcomes for health behaviors, risk factors, mortality, health care access and use. There are only 110.4 physicians per 100,000 population in NMCs, and more than double that rate in large fringe (223.5), small (227.7) and large central (308.5) metropolitan counties. (Rabinowitz, et al., 1999; Regan, et al., 2003). These outcomes may be the result of the shortage of physicians practicing in rural areas, but the severity of these conditions and the effort they require to manage serve as a further deterrent to prospective physicians.

In addition, the nature of rural primary care is very demanding, as physicians who live in the community may have to entertain frequent house calls and may be required to provide out-of-hours care. Visiting patients may involve traveling long distances, especially when there are very few physicians serving in a large expanse. A low number of nearby tertiary health care centers reduces the ability of PCPs to run complex tests for diagnoses.

There are other factors that reduce the attractiveness of rural practice to new physicians and hamper the retention of practicing PCPs in rural communities. Isolation from urban locations limits the range of social activity, entertainment and amenities available to doctors practicing in rural communities. Poor city neighborhoods are perceived as having underfunded facilities, high crime, and lack of professional support.

Some implications of geographic and specialty maldistribution of physicians for residents of rural locations include lack of access to a usual source of ongoing care and to primary care providers, inadequate female and minority physician representation to cater to women and minorities, poor supply of non-physician providers for secondary care and minor health problems, and avoidable hospitalizations. Rural residents are less likely than urban residents to obtain preventive services such as cholesterol and colon cancer screening, Pap smears, mammography and clinical breast exams (Regan, et al., 2003). They result in avoidable hospitalizations and may require additional monitoring and checkups of patients. The need to monitor patients regularly translates into more frequent on-call demands and out-of-hours care responsibilities for rural doctors.

The potential income disparity between serving in rural areas and in urban areas is another important consideration in a physician’s decision of practice location. Chirayath (2006) describes the population of Americans that participate in Medicaid (41 million) and the medically uninsured (45 million) as the medically indigent. Physicians that take on such care, which is largely uncompensated, face low reimbursement, fear of litigation, administrative costs of providing care and difficulties in referring and hospitalizing the patients. Higher proportions of the medically indigent American population are present in rural areas than in urban locations (Holleman et al., 1991; Komaromy et al., 1995; Chaudry et al., 2003). This, in effect, reduces the effective number of beneficiary clients for primary care physicians practicing in rural locations.

Finally, out-of-hours care is also a frequent characteristic of rural health practice, with important implications for physicians and their families. Being on call after working hours or attending to patients at this time could be particularly onerous, because restrictions are imposed on the physician and their families to be within a certain distance from the hospital or critical patients. The primary stressors induced by out-of-hours care are lack of time off, restrictions on family life and constant interruptions to social life (Cuddy, Keane, Murphy, 2001).

Recruitment to Rural Practice

In academic research, studies addressing recruitment to rural primary care practice focus on current medical students and recent graduates surveying them for their preferences regarding specialty selection and future practice location. They aim to create a profile—background, traits and training—of the medical student who is most likely to practice primary care in rural areas, which are mostly underserved. Unlike studies on retention, studies on recruitment usually focus on students at a specific medical school or in a group of medical schools in contiguous states. Although it may seem that sampling from suggests low external validity, recruitment studies from across the nation highlight very similar factors that they cite as strong determinants of rural practice in incoming medical students.

In a systematic review of the PubMed and Medline databases for quantitative articles analyzing recruitment of primary care physicians to rural areas from 1990 to 2000, Brooks et al. (2002) classify factors prevalently associated with rural practice in three contexts: pre-medical-school, medical school, and residency. Pre-medical-school factors describe background influences that strongly predispose an individual to rural practice. The traits consistently associated with rural practice include rural background, older age and male sex. In a study of 1,609 medical graduates serving in rural Pennsylvania, Rabinowitz et al. (1999) identifies growing up in a rural area as the most important independent predictor of medical practice in a rural setting ($p<0.001$). Medical students with a rural background were 3.9 times more likely to have settled into rural practice than their counterparts without a similar background.

This predilection to rural practice of medical students with rural backgrounds may be explained by the social and geographic familiarity students may feel towards places similar to where they had lived before, as well as desires for sense of place and self-actualization (Hancock, Steinbach, Nesbitt, Adler, & Auerswald, 2009; Tolhurst, Adams, & Stewart, 2006). Horner, Samsa & Ricketts (1993) found that the mean age of nonfederal North Carolina primary care physicians serving in rural areas (31.7) was slightly higher than that for counterparts in urban areas (30.1) ($p<0.001$). In fact, this is the trend nationally, but may simply be explained by the younger age at which medical students are entering practice and probably selecting urban locations to settle (Kindig, Schmelzer, & Hong, 1992). As there are more men than women in the medical workforce, there would practically be more male physicians than female doctors in rural areas. However, as a proportion of their sex cohort, female physicians are less likely to practice in rural areas than their male counterparts (F. Chen, Fordyce, Andes, & Hart, 2010; D'Elia & Johnson, 1980; Rosenblatt, Whitcomb, Cullen, Lishner, & Hart, 1992). In 1999, of all female physicians, only 8.9% were in rural practice (Frank, Lutz, 1999). In the Northwest US, female physicians were half as likely as their male counterparts to practice in rural locations (West, Norris, Gore, Baldwin, & Hart, 1996).

Medical school factors discuss characteristics of one's medical training that influence the practice location decision. Brooks et al. (2002) cite the following factors associated with rural practice: attending a publicly owned medical school or one in a rural state, participation in a specialized medical program dedicated to staffing rural areas or for students with rural background, less student debt load, rural experience, commitments to service, and primary care training. The authors report that medical schools that implemented rural curricula and rotations recruited a higher proportion of their students to rural practice than schools that did not have these systems in place, rural recruitment increasing with the intensity of community experience. Pursuant to medical school, the residency years provide another platform to stoke interest in rural practice. Residency programs that are very successful at recruiting doctors to medical practice are characterized by rural mission and location (Brooks, Walsh, Mardon, Lewis, & Clawson, 2002).

On the national scale, results from this research have been employed by stakeholders in forming policy to recruit physicians to rural areas. Financial incentives, like the National Health Service Corps scholarship program, have been the primary focus behind national policies regarding physician recruitment and retention in rural areas. Incepted in 1972, the National Health Service Corps (NHSC) scholarship program is "the most ambitious" federal mechanism established to supply physicians to medically underserved areas and to promote long-term retention (Cullen, Hart, Whitcomb, & Rosenblatt, 1997, p. 272). It combines scholarships and loan repayment incentives for medical students and fully trained physicians in return for primary care service obligations in HPSAs.

The program pays tuition, fees and a living stipend to medical students who, upon graduation, serve as primary care providers for 2-4 years in a high-need health professional shortage area (HPSA), many of which are in remote rural locations. For seasoned health professionals and recent graduates of medical programs, $60,000 is contributed towards student loans in exchange for two years of service in an HPSA community-based site. The scheme also manifests preferential consideration of minority applicants for its scholarships, to increase the number of minority health care providers serving in these areas (Pathman & Konrad, 1996, p. 440). At present, the NHSC has 7,500 clinicians serving in over 10,000 medically underserved sites and providing health access to more than seven million people in the US.[6]

The NHSC program exploits research showing that exposure to rural practice in the course of medical training is an important factor in recruiting medical students to serve in these areas (Geyman, et al., 2000). It also tackles a major problem that medical students face after completing their training: debt. Although lower debt is associated with rural practice, student debt seems a crucial factor motivating medical students to focus on medical subspecialties as against primary care. In contrast to other subspecialties, primary care physicians will have expenses that exceed earnings in the first three to five years following residency (Palmeri, Pipas, Wadsworth, & Zubkoff, 2010). Hence, the offer of debt forgiveness and immediate employment extended by the NHSC may sway some medical graduates that were initially bent on pursuing more lucrative specialties or settling in urban areas. Despite these merits, the success of the NHSC program as regards retention of physicians in rural areas is not tenable. In a 1998 survey of alumni of the program, Porterfield et al. (2003) convey that only 52.5% of respondents remained working in an underserved area, with training as a student or resident involving care with underserved populations positively associated with retention. Pathman et al. (1992), in a longitudinal study of physicians working in rural clinics, find that NHSC physicians were

[6] NHSC website. http://nhsc.hrsa.gov/about/. 12/16/2010.

much less likely than non-NHSC physicians to have remained in their index practice, in their original communities, or in any rural county at resurvey, after ten years (p. 1554).

In response to the need for more primary care physicians in rural areas, medical schools are also responding to research that links rural exposure in medical training to the probability of rural practice. One of the formidable introductions to graduate medical education is the one-two rural training track (RTT) residency program, where medical graduates spend their first year of residency in a large urban teaching center and the second and third years at a rural site. Developed in the late 1980s, these programs have placed 76% of graduates between 1988 and 1997 in rural practice, with 61% working in HPSAs. In a recent survey of graduates of an RTT, 39% of respondents worked near their hometown, and 45% were located near the community where they completed training (Rosenthal, McGuigan, & Anderson, 2000). Admissions committees are also considering local origins in selecting new medical students, as they strive to meet local workforce needs (Pretorius, Lichter, Okazaki, & Sellick, 2010).

Methodology of Research on Recruitment

In the absence of randomized and controlled trials in the literature, the strongest studies in the Brooks et al. (2002) review were cohort studies with control groups and multivariate analyses. In this design, a body of medical students is divided into two groups based on practice location (rural or urban), and explanatory factors—demographic or elements of training in medical school or residency—are analyzed to determine which ones independently and significantly predict the desired outcome, or rural practice. The theory is that important demographic or training variables will manifest in markedly different forms among the two groups. These variables may be identified by chi-square analysis if categorical, or by analysis of variance if continuous. Multiple logistic regression may also be used to determine factors that are independently predictive of rural practice by controlling for confounding factors. The binary dependent variable is the eventual location in rural practice or not, and continuous or categorical variables may be included as controlling regressors.

An example of a study that demonstrates this methodology is Rabinowitz et al. (1999) which profiles members of twenty graduating classes of the Physicians Shortage Area Program (PSAP) based at the Jefferson Medical College of Thomas Jefferson University in Pennsylvania. The program focuses on bolstering the rural physician workforce and has been praised for raising the number of family physicians practicing in rural parts of the state. The authors sought to identify, among graduates of the program, factors individually related to rural practice. For this purpose, they tapped the vast information resources on students of the school maintained in the Jefferson Longitudinal Study (JLS) of Medical Education, a database of demographic, educational and economic information on all students. Univariate analyses identified the variables predictive of rural practice: raised in a rural community, attending an undergraduate college in a rural location, and father having no college education, as examples. Ten variables univariately predictive of rural practice were then entered in a multiple logistic regression model to identify those that were independently predictive of rural practice, after controlling for other variables. Growing up in a rural area emerged as the most important independent predictor of practice in a rural area. Odds ratios were also computed to determine the relative probability of rural practice for different categories of predictor variables.

This research design has also been employed in studies focused on retention of physicians in rural practice. An earlier study, Horner, Samsa & Ricketts (1993) examined data on all nonfederal primary care physicians who registered in North Carolina between 1981 to explain the selection of a rural versus urban practice location and length of tenure in the selected location based on demographic, practice, and training characteristics. Wilcoxon and chi-square tests compared the levels of variables of interest between urban and rural physicians, and multiple logistic regression identified practice factors as strong predictors of tenure. Physicians in office-based practices or in a professional association setting showed less risk of dropping out of rural practice than doctors in other practice settings.

These studies attempt to address a causal question: what factors make a medical student elect to practice in a rural area? The ‘gold standard’ for answering this question is the prospective randomized controlled trial: to assess their effect on selection of rural practice, the treatment variables of interest, including demographic and economic variables, must be randomly assigned to incoming medical students, and the outcome measured for different combinations. Although the randomized, controlled trial is not feasible, the cohort-with-controls design remains untenable for a number of reasons.

Pathman, Konrad & Agnew (1994) bemoan the weak methodology of most research papers focused on the retention of rural physicians, but the review in Brooks et al. (2012), which also studies retention, affirms that the methodology in these lines of research are very similar. Cohort studies may present misleading findings when they have poor internal validity, due to insufficient sample size, due to analysis techniques that do not identify relationships attribute solely to chance, and due to inadequate controlling for confounding variables. The authors assert that cohort studies are helpful in supporting claims of causal studies by demonstrating persistent association for causal factors, but this design may not be used to identify causal relationships independently.

Another important feature of research into the recruitment of primary care physicians to rural care is that the studies have been subjective and focused on the physician, to identify his/her needs and preferences regarding practice location decisions or to recognize the factors that encourage and retard her work. Whereas this research has proven useful to the federal government and medical schools, policymakers at the rural level would be at a loss in using this information to attract and retain female primary care physicians to their locations. No analysis has been conducted on the community level to analyze how the characteristics of a rural location influence the supply of primary care physicians there. Analysis at the community level could take various forms and serve many useful functions.

Firstly, such an analysis could identify how the various features related to the economy, demography and medical work conditions in different rural locations vary with the supply of primary care physicians in these areas. It could test if factors mentioned in the literature to causally influence physician supply significantly predict the dependent variable. Other relevant and significant factors, which from other research and intuition may affect physician supply, may also be identified. If data is available on these locations over time, this analysis could also explain how changes in the aforementioned variables correlate with changes in female primary care physician supply in rural areas. These results would be particularly useful to policymakers at the rural level to learn the particular features of their locations that are significant in attracting female primary care physicians to them and to understand how changes they make in these features would affect the physician supply.

In addition, one could compare factors related to the economy, demography and medical work conditions in rural locations that experience growth in the population of these physicians with the same factors in locations that do not see any increase in the number of female primary doctors serving there or that experience a decrease in their population of these physicians. If there are fundamental and systemic differences, locations that have been successful in retaining these doctors a comparison that have been successful in retaining these physicians for an extended period of time. Such an analysis,

The factors these studies associate with retention and withdrawal are sometimes conflicting (whereas they may promote retention in one area, they encourage withdrawal in others). Although this may be expected, the researchers do not give details of characteristics of their locations that prompt a certain factor to produce results opposite to what has been observed and published in another location.

Location Theory

Indeed, factors other than personal preferences and medical training do influence physicians' location decisions. Especially, characteristics of the practice location considered by doctors are largely ignored in studies focusing on recruitment of doctors to rural care. If locational characteristics are significant predictors of physician location, this finding could call into question the stance of the federal government in wooing primary care physicians to rural areas using financial incentives as a stand-alone strategy.

Standard edconomic loction theory was initially applied to predict choices of profit-maximizing firms in locating production (Newhouse et al., 1982). It outlined that demand for services and costs of production were the fundamental factors considered in locational decisions. The theory was extended to research on the supply of medical personnel in the early 1980's by Joseph Newhouse of the Division of Health Policy, Research and Education at the Harvard Medical School. In his opinion, the explanations for the geographical maldistribution of doctors were lacking a "well-articulated theory" (p.207). Hypotheses supporting the preferential location of doctors in urban areas or the uneven dispersion among medical specialties focused unduly on personal tastes and motivations without considering supra-personal economic factors.

The premise of location theory is that physicians behave as economic agents in deciding practice location, and market forces are the key determinant of physicians practicing in a particular location (Schwartz et al, 1980). The theory asserts that the presence of a physician of a particular specialty in a given location depends on the total number of physicians in that specialty and the population of residents in that location, who create a demand pool for medical services. The physician is rational and would choose to practice where demand for the services he/she provides is relatively high in order to realize a high income. As the supply of medical personnel in a specialty grows over a fixed population, new doctors disperse to unserved areas where there is demand, and the proportion of residents per doctor decreases. In this way, the number of doctors increases at a higher rate in unserved areas (usually from zero to higher numbers), while the same number increases only gradually in areas with an existing supply. There is, thus, a necessary correlation between growth of a medical specialty and diffusion of its members into previously unserved areas.

There are important assumptions required for location theory to explain the distribution of physicians:

- all towns have equal demand for health services among consumers and have equal amenities: as this may not hold in reality, we can represent the excess demand in a town as higher population. Since towns also differ in amount of amenities, the assumption is modified to read that new cohorts of physicians have similar location preferences as previous cohorts, so changes in amenities do not influence the decisions of the first or later cohorts;
- those living farther from a physician of a given specialty demand less of the physician's care
- physicians have perfect information on demand for their services and on the professional and personal amenities available in each town;
- the population surrounding each town is proportional to the town's population;
- various medical specialties do not compete with each other;
- the ratio of residents to doctors must be equal in adjacent towns.

The mechanism for location theory is simple: in a hypothetical County A, let us assume that there are 3 towns with population 10, 000, 5,000, and 1,000 equidistant from one another. If we assume that there are 3 PCPs in the county, there may be 2 physicians in the first town, 1 in the second town, and none in the third. This ratio is the result of a simple proportion calculation: if we assume that the third town has a doctor, the resident-physician ratio must be 1,000:1 requiring 16 doctors in the county, by the sixth assumption.

Location theory is valuable to policymakers and health stakeholders in analyzing the nationwide distribution of physicians because it shifts the determinants of practice location from the capricious personal factors of the doctors, which are exogenously unpredictable, to three key macro variables: the total number of physicians, the professional and environmental attributes of communities, and the geographic distribution of the demand for care (Schwartz, Newhouse, Bennett, & Williams, 1980). These are variables that health stakeholders have access to readily. They can inform the decisions of policymakers on the specific characteristics of communities that draw or repel physicians. Unlike personal characteristics of doctors, these variables can be used to predict and analyze supply at the local, regional and national levels.

Based on location theory, there are major conclusions outlined in Schwartz et al. (1980):

1. the likelihood that a specialist of a given type will be present increases with the population size of the location under study:
2. the greater the demand for services of a particular type of specialist, the smaller the size of town that will be likely to have such a specialist: physicians who provide a general range of services, such as primary care doctors, will serve the smallest towns
3. physicians who remain in large metropolitan cities and refuse to diffuse to unserved areas would earn less than their counterparts in nonmetropolitan areas: the former, who concentrate in a large city, will have fewer residents per doctor and, in effect, less revenue

Standard economic location theory refutes the notion that doctors are geographically maldistrbuted. Doctors are not found in specific locations simply because the population of that town does not meet the benchmark population—termed the *critical town size*—for ready access to a physician or because there are not enough members of a medical specialty to diffuse to a town with that population size (Newhouse, 1990).

Population of a Town and Presence of a Medical Specialty

Location theory asserts that the key characteristic of a location that determines the presence of a physician of a given or any specialty is the population of residents in that location. The residents create a demand pool equivalent to financial return for the rational physician. Research based on location theory has produced some important conclusions. Newhouse et al. (1982) asserts that "other things being equal, the larger the town, the more likely the town is to have a given type of specialist". In other words, the probability of a physician being present in a town is dependent on the town's population. Using logistic regression to calculate the town size at which there was a 50% chance of finding a physician, the authors ascertained that the benchmark population size was 2,500 for any type of physician in 1979. For primary care physicians specifically, only towns with population less than 20,000 were lacking access to at least one PCP mostly because they lacked a hospital.

Schwartz et al. (1980) expound on these results in a study investigating the geographic distribution of board-certified physicians. Their analysis showed that differences in the distribution of specialists across four regions of the country studied are small but significant. There was greater diffusion of medical specialists into smaller towns in the Northeast region than in other regions. To explain this phenomenon, the authors infer that physicians may choose to settle in larger towns where they may be an already existing supply of counterparts (and hence, lower demand for the physician's services) instead of dispersing to smaller unserved locations. The motivation is to locate in an attractive area with sophisticated amenities, even if this may mean settling for a lower income. In other words, physicians would settle in large cities of the West, Central, and Midwest regions instead of diffusing to smaller towns for the purpose of settling close to amenities that may be lacking in smaller towns in these regions. Conversely, smaller towns in the Northeast region may have amenities lacking in similar-size towns of other regions; thus, physicians are motivated to disperse without sacrificing access to the valued amenities or forgoing higher demand.

Unserved Status of a Town and Rate of Growth of Physicians

Newhouse et al. (1980) also proposes a secondary hypothesis: the rate of growth of physicians will be greater in locations that previously did not have a physician of a given specialty than in locations that had at least one member of that medical specialty, provided there is an overall increase in the number of members of that medical specialty. As the ranks of the members of a medical specialty increase, competition ensues as each physician tries to cater to the maximal population possible. Physicians would first settle in densely-populated cities where they have access to high demand. As their numbers increase, the population per physician shrinks, and the rational physician would decide to diffuse into previously unserved areas where the population per physician may be greater than is available in an urban location. In these previously unserved areas, the number of physicians jumps from zero to a positive number, making for an exponentially large real growth rate. In areas that previously had a physician of that specialty, the real growth rate would be lesser as the increase in the number of physicians is divided by a larger denominator to calculate the real rate of growth. Hence, a rise in the ranks of a medical specialty will force outward diffusion resulting in physician coverage of previously unserved locations. This prediction holds irrespective of the nature of population growth and ignores the demographic changes in age, sex, and insurance status brought on by the population surge (Schwartz et al., 1980).

This study will test these principal hypotheses of location theory on the supply of primary care physicians in rural America using the primary care service area as unit of analysis.

Justification of Unit of Analysis: PCSAs as Geographic Taxonomy

The geographical classification employed as the unit of analysis of the hypotheses of location theory in this paper is the primary care service area. Primary Care Service Areas (PCSAs) are an aggregation of zip code tabulation areas (ZCTAs) developed primarily for the measurement of primary care resources, utilization and outcomes. They were created by Goodman, Mick et al. (2000) of the Dartmouth Medical School and the Virginia Commonwealth University, funded by a grant from the Health Resources and Services Administration of the Department of Health and Human Services. The authors developed this new geographic classification based on 1997 Medicare claims data, 2000 Census data, and ZCTAs developed by the US Census Bureau. PCSAs describe utilization-based service areas for the United States that reflect where the plurality of primary care is delivered to beneficiaries, with benchmarks for geographic contiguity, minimum population and service localization.

1999 area ZIP code files were used as the primary building block of the PCSA system. PCSAs were created by assigning each residential code to that code providing the plurality of primary care for Medicare beneficiaries, adjusting to ensure that all PCSAs are geographically contiguous. Three requirements were imposed upon created PCSAs: firstly, PCSAs must have a total population of at least 1,000, the minimum population judged necessary to support a primary care clinician. Secondly, the Medicare beneficiaries must seek more of their primary care from within their residence PCSA than from any other. Thirdly, at least 35% of the primary care of the beneficiaries must be delivered by providers within the same PCSA.

Ideally, all residents of a PCSA receive their primary care services from a provider within the Area. PCSAs are modeled to be geographic markets of primary care derived from patients' travel patterns for primary care services. The initial published results in Goodman et al (2003) divided the country into 6102 PCSAs: a substantial proportion (47% of PCSAs) had four or more ZIP codes; with a minimum population size of 1,000, the median population was 17,276. As such, PCSAs extend across geopolitical borders including county and state lines. The proportion of beneficiaries in the United States with the plurality of their utilization occurring within the PCSA was 0.63. This proportion, known as the Preference Index, was negatively related to the extent of urbanization.

Compared to other methods of area definition employed in medical studies, PCSAs have "moderately high localization of primary care services and are generally small enough to provide locally detailed information about populations, primary care resources and their use" (Goodman et al., 2003). The PCSA is an ideal unit of analysis for the purpose of this study, to investigate if market forces expounded by location theory are at play in rural locations. PCSAs are specially designed by public health experts for analysis of primary care services at the lowest level. State-level and county-level calculations of per capita utilization tend to mask communities with low or high supply of primary care physician resources. PCSAs are created particularly to locate where primary care services are delivered to a specific group of beneficiaries. This makes them very useful for evaluating and comparing primary care physician resources in different communities and for tracking changes in primary care health providers at various locations.

Although they were introduced less than ten years ago, PCSAs have been taken up very quickly by researchers pursuing objectives similar to this study's. Goodman (2005) uses PCSA-level data to track recent dynamics in the number, composition and distribution of pediatricians and to predict an increase of 50% in the number of pediatricians per child over the following twenty years (Goodman, 2005). To examine how access to outpatient medical care varies with local primary care physician densities across the rural Southeast, Pathman, Ricketts, Konrad (2006) survey over four thousand residents of 298 PCSAs (Pathman, Ricketts, & Konrad, 2006). Compared to counties, PCSAs were "a better level of geographic aggregation for a study examining people's health care access and care seeking behaviors" (p. 81-2). Cull, Chang, Goodman (2005) employed PCSA-level data to profile the characteristics of areas that graduating pediatric students target in their job searches and to explore whether residents applying to primary care markets with high pediatrician supplies experience job-search difficulty (Cull, Chang, & Goodman, 2005). Parchman et al (2005) studied changes in the supply and distribution of primary care physicians in Texas from 1990 to 2000. PCSA geography was utilized, as opposed to county boundaries, "to produce findings that reflected actual health-service areas rather than administrative conventions" (p.1). From their work, they deduced that "county-level analysis obscures the variation and change in primary care physician distribution across true market areas for primary care" (p. 35)[7].

Furthermore, PCSAs have important advantages over other commonly applied rural taxonomies. Hart, Larson & Lishner (2005) details characteristics and merits of these systems. County Rural-urban commuting area codes (RUCAs) form a classification system that uses the standard Census Bureau Urbanized Area and Urban Cluster definitions in combination with work commuting information to categorize census tracts as rural or urban. It was developed by Drs. Richard Morrill, John Cromartie and Gary Hart with funding from the Office of Rural Health Policy in the Health Resources Service Administration (HRSA) and the Department of Agriculture's Economic Research Service (ERS)[8]. This system, because of the use of work commuting data in creating it, differentiates rural areas according to their economic integration with urban areas, and not by their primary care utilization. Moreover, it is difficult to apply health data to RUCAs as the information is usually collected at county or zip code area levels, or more recently at PCSA level. RUCAs do not remain stable over time because economic integration of rural areas with urban areas is dynamic. This makes comparison of RUCA data across our period of interest inconvenient without making modifications for adjustments in classification. On the other hand, there were no changes in PCSA boundaries between 2000 and 2006, so each state maintained the same number of PCSAs between both periods.

[7] http://www.uthscsa.edu/rchws/Reports/GIS1.pdf

[8] More information on the description of RUCAs, RUCA files available for download, current and future projects utilizing RUCA classification and mapped versions of RUCA categorization may be found at: http://depts.washington.edu/uwruca/

METHODS

Following the methodology of Newhouse et al. (1982), this study tests the hypotheses of location theory concerning the supply of primary care physicians in rural areas of the US. In this analysis, however, we employ the primary care service area (PCSA), instead of geographical borders, as unit of analysis and adopt a static definition of rurality. The theory of population size as the major determinant of the probability of physician location in a given location is tested using a series of logistic regression models of the binary dependent variable, physician presence. To test the hypothesis that the growth rate of physician population is higher in locations that were previously unserved than in locations that previously had a physician, we employ multiple linear OLS regression models on the relationship between growth rate of physician population and unserved status of a rural location.

HYPOTHESIS 1: The likelihood that a given location would have one or more physicians of a medical specialty increases with the population size of the location.

This hypothesis, the crux of location theory, asserts that population is the principal market force driving physician location. The number of people in a given location represents the demand pool for a PCP's services, and the rational PCP would settle in a location to maximize demand – where population size is greatest. The logistic regression model of the relationship between the likelihood of physician location in a PCSA and population size is:

$$\Pr(PCP{=}1 \mid Population) = F(\beta_0 + \beta_1(Population)) = 1/(1 + e\text{^-}(\beta_0 + \beta_1(Population)),$$

where *PCP* is a binary variable coded 1 if a given PCSA has at least one primary care physician and coded 0 if there is no PCP there. *Population* is the population size of the PCSA. *F* is the cumulative standard logistic distribution. As we will be controlling for confounding variables (discussed later in DATA section), we may expand the model thus:

$$\Pr(PCP{=}1 \mid Population, \ldots, X_j) = \Phi\,(\beta_0 + \beta_1(Population) + \ldots + \beta_j(X_j) + u,$$

for additional regressors, X_2 - X_j. To confirm this hypothesis, we expect that β_1 remains consistently positive and significantly different from zero while controlling for confounding effects.

HYPOTHESIS 2: If the population of physicians of a given specialty increases, the growth rate of physicians will be greater in locations that were previously unserved than in locations that had a physician presence prior to the surge.

Pursuant to Hypothesis 1, location theorists propose that PCSAs without a PCP will acquire them at a greater rate than PCSAs that previously had a PCP, as the overall number of PCPs increases. Therefore, the growth rate of PCPs in previously unserved towns will be a factor greater than that in PCPs that previously had at least one physician. Taking into account the effect of growth in population size on number of physicians, also:

$$\frac{PCP_{i,t} - PCP_{i,t-1}}{PCP_{i,t-1}} = \beta_0 + \beta_1 \frac{Population_{i,t} - Population_{i,t-1}}{Population_{i,t-1}} + \beta_2\,(Unserved_{i,t-1}) + u_{i,t},$$

where PCP is the total number of physicians in a PCSA, *i* indexes PCSA, and the denominators index the time elapsed between measurements. The quotient on the left side illustrates the real growth rate of PCPs over the two periods under study, *t* and an earlier time, *t-1*. *Unserved* is a binary variable coded 1 if the PCSA did not have a PCP at time *t-1* and coded 0 if the PCSA had at least one PCP at that time.

A PCSA is called unserved in 2000 if there was no PCP located there at first measurement. For such a location, $PCP_{i,t-1}$ equals zero. Let us assume there is a subsequent increase in the PCP population of this PCSA at second measurement in 2007. The growth rate of PCP population, or the result for the left side, is an exponentially large number, owing to zero in the denominator, that is computationally unmanageable. We may infer that the growth rate of physicians in a previously unserved PCSA tends to infinity as the number of PCPs in that location increases. For these instances, a model manipulation may approximate the growth rate of PCP supply in a more manageable manner. If we replace the zero in the denominator with 1 for PCSAs that were previously unserved, the growth rate calculated on the left side of the equation becomes the nominal increase in the number of physicians in the location. For example, in a previously unserved location that subsequently has 5 PCPs in 2007, the new growth rate will be (5 – 0) / 1 = 5. This growth rate is high and directly proportional to the increase in the number of PCPs. Yet, it is computable. As this problem of computation applies only to PCSAs that were unserved in 2000 and gained physicians in 2007, I modified the model thus in these instances alone:

$$\frac{PCP_{i,t} - 0}{1} = \beta_0 + \beta_1 \frac{Population_{i,t} - Population_{i,t-1}}{Population_{i,t-1}} + \beta_2 (Unserved_{i,t-1}) + u_{i,t},$$

$$PCP_{i,t} = \beta_0 + \beta_1 \frac{Population_{i,t} - Population_{i,t-1}}{Population_{i,t-1}} + \beta_2 (Unserved_{i,t-1}) + u_{i,t},$$

In simple parlance, this model suggests that the population increased five-fold, using the example above, although the actual growth rate is exponentially larger. Here, the coefficient β_2 represents the effect of unserved status, compared to served status (PCSAs that previously had a physician), on the growth rate of PCP supply in a location. For previously unserved towns, the growth rate of PCP population will be β_2 greater than in towns that had a physician previously, controlling for growth rate in resident population size.

DATA

The Health Resources and Services Administration (HRSA) has released two waves of the PCSA National Database in 2003 and 2007. The datasets contain nationwide data on US primary health care resources, populations and utilization at the PCSA level (N=6542) collected in 1999-2001 and 2005-2007 respectively. Each dataset is an agglomeration of sub-classes of variables at the PCSA level: physician characteristics; physician workforce and Medicare utilization data; data on health professional shortage areas (HPSAs) and medically underserved areas/populations (MUA/Ps) (only available in 2007); physician inventory information; and population, poverty and insurance estimates. PCSA boundary definitions are consistent in both editions.

Physician characteristics are derived from the 2000-1 American Medical Association Physician Master File (AMA MF) in the 2003 database and from the 2006 AMA MF in the 2006 database. This data details the number and composition of clinically active primary care physicians (family physicians, general internists, and pediatricians), specialists and obstetricians/gynecologists at the ZCTA and PCSA levels. Variables provided include: the number of federal, non-federal, domestically-trained, internationally-trained and Canada-trained physicians of various medical specialties in each PCSA; the number of physicians less than and equal to or older than fifty years of age in the specialties; the number of female and male physicians clinically active in these specialties; and, the crude rate (clinically active physicians per 100,000 census population) for primary care and other specialties.

The Center for Medicare and Medicaid Services (CMS) provides data on physician workforce and Medicare utilization data with variables measuring the health visits, discharges, reimbursements and deaths of Medicare beneficiaries per PCSA. Variables include: the Medicare beneficiary population, total number of medical visits (primary care, ambulatory and ob-gyn visits) by beneficiaries, total number of discharges and patient days, total value of medical reimbursements for resident Medicare beneficiaries and total number of Medicare deaths in each PCSA. Standard errors, crude rates (value of each variable per 100,000 census population) and rates adjusted for age, sex, and race are also provided for these statistics.

The third portion of HRSA PCSA data, prepared in collaboration with the Robert Graham Center for Primary Care Studies, provides markers of medical underservice at the PCSA level. It details the number and proportion of the population of a PCSA living in health professional shortage areas (HPSAs) for primary care, dental health and mental health, and the number and proportion of the population living in medically underserved areas (MUAs). For a geographic designation, the ratio of population to providers must be at least 3,500:1 as criterion for HPSA status[9]. A Medically Underserved Area (MUA) is defined as "a rational service area with a demonstrable shortage of primary healthcare resources relative to the needs of the entire population within the service area". Primary medical care HPSAs are designated if there is an established shortage of primary care physicians for the population.

Like the first division, the fourth class of data in the PCSA database, the National Physician Inventory, also provides primary care physician supply by PCSA based on the AMA Physician Masterfile. The focus here is however on the characteristics of the PCSA population, not the physicians. This batch provides the following information: population of PCSA (by age group, sex, race, civilian and non-civilian status), economic variables (median household income, population below poverty level), population living in HPSAs and MUAs, and the number of primary care physicians per 100,000 civilian population.

For simplicity, we classify the data from the 2003 database as 2000 data, since variables to be used are extracted largely from Census 2000 tables in the database. The second wave of data is classified in this study as from year 2007 since this is the latest year of data collection for variables in the set.

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[9] http://www.michigan.gov/mdch/0,4612,7-132-2945_47514-176068--,00.html

MEASURES AND VARIABLES

Dependent Variables

To test Hypothesis 1, the dependent variable *PCP* measures the likelihood of at least one nonfederal primary care physician locating in a PCSA. Federal physicians are not included because they are recruited to rural practice by governmental directive, through programs such as the NHSC. This effort represents an intrusion on the freedom of market forces to match demand with supply. We cannot expect that the independent variables that we are testing as principal market forces would predict the location of federal physicians. Hence, we analyze only nonfederal physicians practicing in the country's PCSAs. *PCP* is a binary, coded 1 for PCSAs that have at least one clinically active PCP in the location. The AMA MF table in the PCSA databases record the total number of nonfederal primary care physicians in each PCSA, and this figure is a composite of clinically active family physicians, general internists and pediatricians registered with the AMA. The variable is coded 0 if the PCSA does not have a PCP at the location. For Hypothesis 2, the dependent variable is the growth rate of nonfederal primary care physician supply, $((PCP_{i,t} - PCP_{i,t-1})/ PCP_{i,t-1})$ or the nominal increase in the supply of nonfederal PCPs, for PCSAs that were previously unserved. The two time periods of the PCSA database, years 2000 and 2007, are indexed *t-1* and *t* respectively.

Primary Independent Variables

The primary independent variable in the logistic regression model of Hypothesis 1 is *Population* – the total population of residents in a PCSA. For hypothesis 2, the primary independent variable is the change in physician presence in the PCSA. $Unserved_{t-1}$ is a binary variable coded 1 if the PCSA did not have a PCP at time *t-1* (year 2000) and coded 0 if the PCSA had at least one PCP at that time.

Controlling Variables

In testing the effect of population on physician location in Hypotheses 1 or the effect of unserved status on physician population growth rate in Hypothesis 2, we include other regressors as controls. These are variables cited in the literature as potentially influencing the nominal supply of physicians in rural locations:

Region

The supply and growth of PCP clearly varies by the location of a PCSA in the country. From description of the state of rural health in Regan et al. (1993), health outcomes were better in the Northeastern region, which incidentally had the highest number of clinically active physicians in its rural locations, than in other locations. In operationalization, binary dummy variables were created for each of the five US regions: Northeast, Midwest, Pacific, South, and West. The Northeast variable is omitted in regressions to avoid multicollinearity. Including binary variables for regions in regression models controls for variation in the likelihood of physician location in various PCSAs (Hypothesis 1) or for variation in the number of practicing PCPs in particular geographic locations (Hypothesis 2). We expect that coefficients for included regions are significant and negative, indicating that the likelihood of physician location is highest in the Northeast and varying regionally.

Presence of Health Centers

Rural hospitals and clinics provide employment, equipment, camaraderie, publicity of services, research funds, continuing education and other benefits that increase utility for PCPs. These community-based health centers are also critical safety net providers providing primary care to the homeless, public housing residents, families of migrant and seasonal farm workers and school-aged children (Regan, et al., 2003). In 2006, there are a total of 3,528 federally-qualified health centers recorded in the Physician Workforce and Medicare Utilization data. 1,134 (32.14%) of them are located in PCSAs with greater than 50% of the population identified as rural. The presence of rural health centers and federally-qualified health centers as regressors controls for their effect in drawing PCPs to rural locations. These regressors also reduce bias in the variables since they have predictive power on the presence of PCPs and are also correlated with PCSA population – we can expect more health centers in rural areas with larger population—and unserved status. PCSAs that are unserved do not have clinically active primary care physicians and are thus less likely to have a staffed health center. This variable is simply operationalized as the nominal amount of rural health centers or federally qualified health centers in a PCSA at a point in time. It is expected that the coefficient will be significant and positive, implying that more PCPs may locate in rural towns with one or more health centers. For testing Hypothesis 2, the nominal increase in the amount of rural health centers in each PCSA is added as a regressor.

Median Household Income

Dionne, Langlois & Lemire (1987) used average income as a proxy of demand factors that are not taken into account by mere population size. Health care is not an inferior good, and the latent demand for health services in a PCSA's population is actualized only when the residents have funds to pay for the PCP's services. Although health insurance may be available for the medically indigent in a rural location, the rate of use of a physician's services and the variety demanded may increase with the purchasing power of the residents. To operationalize, a log variant, *ln(Income)*, of median income provided in the PCSA database was created to control the variation inherent in calculations with large monetary values. A ladder of powers confirms that this variant is normally distributed. The coefficient is expected to be significant and positive.

Urban Proportion

This is operationalized by dividing the PCSA population living in defined urbanized areas according to Census 2000 classification by the total PCSA population. As this variable is derived from census statistics, it is not available in Wave 2 (2007) of the PCSA database. There is a strong correlation between population and urbanization, since metropolises tend to have a higher population than small rural locations. By location theory, physicians would settle first in large cities before diffusing to rural areas. Hence, the coefficient of this variable should be positive, indicating that the probability of finding a PCP is higher in urbanized locations.

Proportion of Population Below Poverty Level

Closely opposite to median income, this variable is provided directly in the PCSA database and describes the proportion of PCSA population with income below the federal poverty level. This proportion may be high in inner-city settings where residents are close to a large city and thus have access to PCP services. In other cases, the proportion may be high in very rural, isolated and underserved locations. The sign on the coefficient may depend on the greater of these two effects. For testing Hypothesis 2, the nominal increase in the proportion of population below poverty level in each PCSA is added as a regressor.

Error Term/Residuals

Other aspects of the health care environment that are not available in our data but could influence the availability of PCPs in a PCSA include payer oversight versus physician autonomy, paperwork burden, risk of being sued, and the cost of malpractice insurance (Bennett & Phillips, 2010).

FINDINGS

Description of Rural PCSAs

4,480 (69%) of the 6,542 primary care service areas (PCSA) are rural by Census 2000 classification. The total population living in rural PCSAs grew by 4% from 2000 (56.7 million) to 2007 (59 million), but still accounted for less than 20% of the total American population in both years. The mean population of a rural PCSA was 13,166 in 2007. Although there are slightly positive relationships between the population of a state and its land area, the states with the highest population and land mass do not necessarily have the highest number of PCSAs., Florida, with 16 million people in 2000, has only 165 PCSAs. On the other hand, Pennsylvania has 287 PCSAs with only 12.3 million residents in 2000. As expected, more PCSAs exist in states with larger land area, but the relationship between square miles and number of PCSAs is not definite. Montana and New Mexico, the states with the second- and third-most land area, are each more than twice the size of New York (46,080 sq. miles) but each have less than a quarter of the number of New York PCSAs. Unlike general measures of area definition such as counties, PCSAs are not created based solely on land area and population, but mainly to reflect the market of demand for primary care services.

Table 1 shows demographic information on residents in rural and non-rural primary care service areas. Rural PCSAs are evidently less populated, less wealthy and have access to much fewer clinician services than urban counterparts.

Table 1: Demographic characteristics of residents in rural and non-rural PCSAs in 2000

	RURAL PCSAs (n=4,480) Mean (SD)	NON-RURAL PCSAs (n=2,062) Mean (SD)	p-value of *t* test for equality of means
Population	12,649 (166)	108,979 (2693)	p=0.00
Land Area (sq. mi.)	461.15 (11.65)	350.55 (19.73)	p=0.00
Clinically Active Primary Care Physicians	88.05 (2.47)	7.25 (0.12)	p=0.00
Population per PCP	2,025 (27)	1,652 (29)	p=0.00
Proportion of Population >=65 yrs.	15.48% (0.07%)	12.76% (0.11%)	p=0.00
Median Household Income	$34,852 ($134)	$46,475 ($362)	p=0.00
% Population Below Poverty Level	13.91% (0.10%)	11.98% (0.18%)	p=0.00

Overview of Primary Care Physician Population

The total number of primary care physicians nationwide increased from 214,061 in 2000 to 229,151 in 2007, equivalent to 7.05% increment or an average of 2,515 primary care doctors per year over six years. The general increase in the number of primary care physicians masks changes in the composition of individual primary care specialties. The population of internal medicine doctors increased by 14.48% (from 78,249 in 2000 to 89,576 in 2006) and the number of clinically active pediatricians rose by 15.66% (to 47,234 from 40,840 within the same period). These statistics buoyed the 2.77% decrease in the number of family practice physicians (from 94,972 to 92,341 between 2000 and 2007). Nonfederal physicians formed 98% of the PCP workforce in 2000 and 97% in 2007.

Despite the nationwide growth in the number of active PCPs, the disparity in PCP supply between rural and non-rural PCSAs is striking. The average number of nonfederal PCPs in a rural PCSA was 7.3 in 2000 and reduced slightly to 6.9 in 2006. Conversely, the means are 86.3 and 93.0 in 2000 and 2007 respectively for non-rural PCSAs. 50% of rural PCSAs have 4 PCPs or less in 2007. For all nonfederal specialists, the average rural PCSA has 6.3 physicians, while the counterpart average non-rural PCSA houses 180.6 specialists.

Nevertheless, the trend suggests that primary care physicians locate more in rural areas than members of other specialties. Table 2 shows that there are more primary care physicians per 100,000 population in the smallest rural PCSAs in both years of study. As population grows, however, the number of specialists in each location increase, a sign of geographic maldistribution.

Table 2: Location of Primary Care Physicians and Specialists in 2000 and 2007

Location	**Physicians per 100,000 Population in 2000**		**Physicians per 100,000 Population in 2007**	
	Primary Care Physicians	Specialists	Primary Care Physicians	Specialists
Rural PCSAs				
Less than 10,000 population	4.96	1.65	4.10	1.59
10,000 - 25,000 population	5.64	3.80	5.22	4.01
25,000 - 50,000 population	6.04	6.82	5.89	7.06
Metropolitan PCSAs				
Less than 50,000 population	8.16	13.15	8.08	13.72
50,000 -100,000 population	7.66	14.06	7.53	13.96
100,000 - 500,000 population	8.04	15.65	8.24	16.36
500,000 – 1 million population	7.74	15.32	7.79	15.87
Over 1 million population	7.63	13.24	8.28	13.82

HYPOTHESIS 1: The likelihood that a given location would have one or more physicians of a medical specialty increases with the population size of the location.

Location theory implies that there is a critical town size above which all PCSAs have a physician of a given specialty and below which no PCSA has that physician within it (Newhouse et al., 1980). The likelihood that a physician would be present in a PCSA thus depends on the population size of the PCSA, reflecting the pool of demand for the doctor's services.

91.24% of all PCSAs have at least one PCP (*PCP*=1). Among rural PCSAs, 12.48% do not have a PCP (*PCP*=0). Table 2 shows the results of the logistic regression of presence of at least one PCP in a PCSA on the primary independent variable, population size, for all rural PCSAs in 2000. The base model, shown in the second column, estimates a coefficient of 0.0005 for population size, indicating that a surge of 10,000 in PCSA population is associated with an increase of 5 in the log-odds of that PCSA having a physician. By multiplying the logit coefficient with the variance of the binary dependent variable, an increase in population of 10,000 residents in a PCSA is associated with an increased probability of 0.5% that the PCSA has a PCP. Although significant at the 5% level, the coefficient is small because the majority of rural PCSAs have a PCP (*PCP*=1). Increases in population cannot raise the likelihood of finding a PCP in them further. Moreover, the coefficient is subject to omitted variable bias.

In agreement with the prediction of location theory, the size of the coefficient of population size remains consistent, with little variation, as controlling variables are added to the logistic regression model. Through the seven specifications modeled, the coefficient remains significant at the 1% level. In Model 2, we cannot reject at the 1% level that the relationship between likelihood of physician location and population size in a PCSA has quadratic properties. This is significant to show that the increase in likelihood of physician location with population size is not uniform or linear for all values

Table 3: Results of Logistic Regression Modeling of Likelihood of Physician Location on Population Size in 2000 and 2007

DV = *PCP*, binary variable coded 1 if at least one nonfederal physician is present and 0 otherwise								
Regressor / Year	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*	*2000*	*2007*
	MODEL 1	**MODEL 2**	**MODEL 3**	**MODEL 4**	**MODEL 5**	**MODEL 6**	**MODEL 7**	**MODEL 8**
Population	0.0005** (0.00003)	0.0007** (0.00004)	0.0006** (0.00003)	0.0006** (0.00004)	0.0006** (0.00004)	0.0006** (0.00004)	0.0005** (0.00004)	0.0004** (0.00003)
Population^2		-1e-08** (7.33e-10)						
West			-1.12** (0.26)	-0.96** (0.27)	-0.98** (0.27)	-0.93** (0.27)	-0.98** (0.27)	-0.19 (0.22)
Pacific			0.95 (1.01)	0.89 (1.02)	0.91 (1.02)	0.93 (1.01)	0.92 (1.03)	2.27* (1.00)
Midwest			-0.81** (0.24)	-0.61* (0.25)	-0.59* (0.24)	-0.60* (0.24)	-0.58* (0.24)	-0.13 (0.19)
South			-1.39** (0.24)	-1.21** (0.25)	-1.21** (0.26)	-1.13** (0.25)	-1.19** (0.24)	-0.70** (0.20)
Federally Qualified Health Centers				-0.12 (0.12)				-0.05 (0.09)
Rural Health Centers				-0.41** (0.05)	-0.41** (0.05)	-0.41** (0.05)	-0.40** (0.05)	-0.07* (0.04)
Median Household Income (log)					-0.002 (0.27)			-1.24** (0.36)
% of Population below Poverty Level						-0.01 (0.01)		-0.04** (0.01)
Urban proportion of population (in 2000)							1.61** (0.46)	1.97** (0.33)
constant	-0.93** (0.12)	-1.15** (0.12)	-0.02 (0.25)	0.14 (0.26)	0.13 (2.83)	0.26 (0.27)	0.18 (0.26)	13.13** (3.89)
N	4480	4480	4480	4480	4480	4480	4480	4480
Pseudo-*R*^{2}	0.35	0.36	0.37	0.39	0.39	0.39	0.39	0.37
Number of completely determined successes (failures)	280(0)	-	313(0)	358(0)	357(0)	357(0)	314(0)	102(0)
P-values testing the hypothesis that the population coefficients on the indicated regressors are all zero:								
Population^2=0		p=0.00						
West=Pacific= Midwest=South=0			p=0.00	p=0.00	p=0.00	p=0.00	p=0.00	p=0.00
FQHC = RHC				p=0.02				p=0.77
Median Household Income = 0					p=0.99			p=0.00
% of Population below Pov. Level = 0						p=0.13		p=0.00
Urban Prop = 0							p=0.00	p=0.00

Notes: Heteroskedasticity-robust standard errors are given in parentheses under estimated coefficients, and *p*-values are presented for postestimation tests. Coefficients are individually statistically significant at the *5% and **1% levels.

of population. The negative sign indicates a parabolic relationship that sees the effect of rising population on physician location diminish as population increases. Because of the infinitesimal size of the coefficient and the increase in the predictive power of the model, as measured by pseudo-R^2 is minimal, the variable *Population*^{2} is not retained in later models.

The regression model also confirms the significance of regional differences in the probability of a PCSA having at least one PCP. This likelihood reduces for PCSAs in the West, Midwest and South regions compared to the Northeast, but is not significantly different between the Northeast and Pacific regions. *Ceteris paribus,* two PCSAs with similar characteristics but differing only in location would see differences in the log-odds of having a physician if they are based in the Northeast and West regions, for example. A joint test of the region variables confirms that they are jointly significant at the 1% level.

Table 4: Population Size at which a PCSA has Likelihood of Having a PCP in 2000 and 2007

	Population Size at which a PCSA has a chance of having a PCP in 2000				
PCP	***Midwest***	***Northeast***	***Pacific***	***South***	***West***
50%	1,059	1,006	1,447	1,162	1,504
75%	1,728	1,006	1,447	1,500	3,476
99%	8,026	7,063	5,588	9,668	9,415
	Population Size at which a PCSA has a chance of having a PCP in 2007				
50%	1,032	1,096	1,391	1,116	1,417
75%	1,586	1,108	1,391	2,890	3,580
99%	10,987	8,972	6,199	12,137	11,508

Models 4 and 8 from Table 3were used to calculate the lowest PCSA population size for each of the specified values of PCP. Results show the lowest PCSA population size for the respective value of the dependent variable.

Table 4 highlights regional differences in physician location by showing the minimum population size for various likelihoods of physician location using predicted values of *PCP* from the logistic regression in Model 4for 2000 data and Model 8 for 2007 data. The Northeast has the smallest critical town size for a 50% chance of locating a PCP in a PCSA in 2000, while the South has the highest value. This implies that Northeastern PCPs are diffusing away from large cities into unserved areas more readily than in other regions, as illustrated by the negative coefficients on other regional dummy variables. For the Northeast and Pacific regions, the critical town size for 50% and 75% probability of physician location are the same, implying that every town in both regions has at least a 75% likelihood of physician location. The equivalent town size for 75% probability of physician location is more than double both figures (Northeast and Pacific) for PCSAs in the West (3,476). The trend of regional disparity in physician location continues in 2007, with very high critical town sizes for 75% probability of physician location in the Southern and Western regions. In fact, the critical town size for a PCSA in the West or in the South to have a 75% probability of housing a physician increased from 2000 to 2007. This suggests that PCPs may have withdrawn from previously served rural PCSAs in these regions for larger markets elsewhere.

Unexpectedly, rural health centers show negative influence on physician location in rural PCSAs. The coefficient on this variable remains consistent and significant even after controlling for other regressors. In effect, the presence of one rural health center in a PCSA is associated with a decrease of 0.41 log-odds (or 4.5% decrease in the probability) of the PCSA having a PCP. Federally qualified health centers show a similar but insignificant effect. In the 559 PCSAs that do not have a PCP, the average number of rural health centers is 1.18, compared to 1.03 in the rural PCSAs with *PCP*=1. A possible explanation may be that this model for data in year 2000 has not captured the effect of policies creating rural health centers in unserved areas. Indeed, in the 2007 model (final column), the coefficient on rural health centers is less negative, indicating that the probability of finding a physician in PCSAs with these centers increased from 2000.

The last column of Table 1 shows the results of fitting the model with all regressors to 2007 PCSA data. From 2000 to 2007, the proportion of rural PCSAs with at least one PCP dropped from

87.52% to 83.06%. This decrease in the dependent variable is also reflected in the lower coefficient for population size in the 2007 model. Nevertheless, the coefficient remains positive and significant with low standard error. This model also reflects a surge in the probability of a Pacific PCSA having a physician. There are only 28 rural Pacific PCSAs in 2007 and 27 of them have at least one PCSA (*PCP*=1). The expected value of *PCP* in other regions ranges from 0.80 in the West (463 of 577 PCSAs) to 0.89 in the Northeast (476 of 532 PCSAs). Hence, for two PCSAs with similar characteristics, the probability of locating a PCP in the Pacific PCSA is 2.27 log-odds (or probability of 32%) greater than for a PCSA in the Northeast region. This association is significant at the 5% level. A PCSA in the South is 9.8% less likely to have a PCP than a Northeast PCSA, *ceteris paribus*.

In the 2007 model, the influence of rural health centers on physician location in a PCSA is less negative. This may support the hypothesis expressed earlier that rural health centers helped draw more physicians to rural PCSAs between 2000 and 2007. In effect, the probability of physician location in a PCSA with a rural health center in 2000 increased by 4.6% seven years later. Although this effect may seem small, we must recall the expected value of *PCP* is 0.83 in 2007 – 83% of rural PCSA's have at least one PCP. For the average rural PCSA, two additional rural health centers raise the expected value of *PCP* to 0.91, controlling for other variables.

Surprisingly, higher median income of a PCSA is associated with a lower possibility of finding a PCSA in a rural location, controlling for other variables. The negative coefficient on the log variant of median household income indicates that an increase in income of 1% is associated with a 0.01 decrease in log-odds of physician location in the PCSA, controlling for other variables. This is equivalent to 0.17% decrease in the probability of *PCP*=1. Although the coefficient in the 2000 model is not significant, the 2007 coefficient is much more negative. The average of median household income among rural PCSAs decreased from $41,403 to $34,851 in 2007, as the overall probability of physician location in the average PCSA decreased during the same period. Urbanization was positively associated with probability of physician location, but the probability decreased with proportion of PCSA population living below the federal poverty level.

Controlling for influencing regressors, the coefficient on PCSA population size remained significant and positive through several model iterations. The most parsimonious model, considering pseudo-R^2 values, for 2000 data is Model 4 which predicts the likelihood of physician location based on population, regional variables and rural health centers and has similar predictive power as subsequent models. These results affirm population size of a PCSA as a principal market force determining physician location in the area, as proposed by location theorists.

HYPOTHESIS 2: If the population of physicians of a given specialty increases, the growth rate of physicians will be greater in locations that were previously unserved than in locations that had a physician presence prior to the surge.

Location theory predicts the real growth rate of physicians will be greater in locations that did not previously have any doctors than in locations that housed physicians at an earlier time. The condition is that there is overall growth in the corps of the medical specialty under study. As the supply of doctors increases nationally, competition drives diffusion of new members into smaller communities which may not have had a physician presence before. As less doctors are added to the urban ranks and as more settle in rural areas, there are two possibilities: some rural areas may not receive a physician if their population remains below the critical size for physicians in that specialty. If the population of a location matches or exceeds this town size, physician supply grows from zero to a positive number. The nominal increase is the new number of physicians in the location, but the real growth rate is:

$$\frac{\textit{Number of Physicians}_{t} - \textit{Number of Physicians}_{t-1}}{\textit{Number of Physicians}_{t-1}}$$

In previously unserved locations, where *Number of Physicians*$_{t-1}$ is zero, the quotient is computationally impossible, but very high. In other words, as long as there is an increase of even only one physician in a previously unserved PCSA, the growth rate as calculated above will be exponentially large, tending toward infinity. For locations that have a positive non-zero value in the denominator, that is locations that have at least one physician at first measurement, the growth rate reduces with the size of this original number (the denominator), tending toward zero as the original number of physicians in a location increases. As explained in the Methods and Variables section, I increased the denominator for unserved towns from zero to one so that the rate of growth for previously unserved PCSAs equals the nominal increase in the number of physicians in the location.

Nationally, the total supply of PCPs rose from 210,050 to 222,703 from 2000 to 2007, an increase of 6.02% that satisfies the condition for this hypothesis. Physician supply in the average PCSA increased by 1.93 between 2000 and 2007. In actuality, changes in physician supply ranged from -209 to +1271, with standard deviation of 21.8 PCPs . The median value for change in physician supply was 0, indicating that half of PCSAs nationwide gained at least one PCP, and the other half lost at least the same amount. Among rural PCSA's there is much less variance in change in the number of PCPs between 2000 and 2007. The average change in the supply of PCPs in these locations is -0.25, with standard deviation of 3. The greatest loss of physicians was 34, and the largest gain was 32. Among PCSAs unserved in 2000, the greatest increase in physician population was from 0 in 2000 to 8 in 2007. The average gain in PCPs in the same population was 0.43 per PCSA.

Table 5: Results of Multiple OLS Regression Modeling of Growth Rate of PCP Population on Unserved Status of a PCP in 2000

DV = *growth rate of PCP supply*							
Regressor	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
Growth Rate of Population	0.85** (0.16)	0.98** (0.13)	0.95** (0.14)	0.99** (0.13)	0.99** (0.13)	1.00** (0.13)	0.95** (0.13)
Unserved in 2000 (binary)		1.55** (0.07)	1.55** (0.08)	1.55** (0.07)	1.55** (0.07)	1.55** (0.07)	1.63** (0.08)
West			0.04 (0.04)				
Pacific			0.08 (0.10)				
Midwest			0.01 (0.03)				
South			0.04 (0.03)				
Change in Number of Rural Health Centers				0.04** (0.01)	0.04** (0.01)	0.03** (0.01)	0.03** (0.01)
Growth Rate of Median Income					-0.28 (0.19)		
Change in % of Population below Poverty Level						0.01 (0.01)	
Urban Proportion of Population (in 2000)							0.34** (0.04)
constant	-0.03* (0.01)	-0.09 (0.01)	-0.11** (0.03)	-0.10** (0.01)	-0.05** (0.04)	-0.12* (0.02)	-0.19* (0.02)
N	4,071	4,071	4,071	4,071	4,071	4,071	4,071
R^2	0.01	0.18	0.19	0.19	0.19	0.19	0.20
Adjusted R^2	0.01	0.18	0.18	0.19	0.19	0.19	0.20
P-values testing the hypothesis that the population coefficients on the indicated regressors are all zero:							
Unserved in 2000=0		p=0.00	p=0.00	p=0.00	p=0.00	p=0.00	p=0.00
West=Pacific=Midwest=South=0			p=0.60				

Notes: Heteroskedasticity-robust standard errors are given in parentheses under estimated coefficients, and *p*-values are presented for postestimation tests. Coefficients are individually statistically significant at the *5% and **1% levels.

Table 4 shows the results from fitting multiple OLS regression models to study the effect of prior-unserved status on the growth rate of PCPs within a rural PCSA between 2000 and 2007. The base model in the second column is a simple linear regression of the growth rate of PCPs between 2000 and 2007 on the growth rate of population within the same period. The resulting positive and significant coefficient on population growth rate affirms Hypothesis 1 and indicates that higher growth rate of population between 2000 and 2007 is associated with a higher growth rate of PCP population in the same location. Specifically, 1% increase in population is associated with 1.5% increase in physician population over the same period. The model, however, has very low predictive value.

Adding the predictor, unserved status in 2000, explains more of the variance in PCP growth rate and raises the adjusted R^2. In Model 2, the coefficient on unserved status indicates that the growth rate of PCP population is greater by 1.55 in PCSAs that were previously unserved in 2000 than in PCSAs that had at least one PCP then. The coefficient is significant at the 1% level. This result supports location theory: unserved status should raise the PCP growth rate of a PCSA compared to served locations. The coefficient of unserved status remains positive and significant through various model iterations. Because the value of the coefficient stays approximately within one standard error of its values, we may infer that it is not biased by omission of confounding variables.

The models also show that growth rate of PCPs does not vary significantly across regions. The effect of the regional dummy variables is not significant at the 10% level and their retention does not raise predictive power. The presence of rural health centers is emphasized again as an important factor encouraging physician location in a PCSA. An increase of one rural health center between 2000 and 2007 in a PCSA is associated with an increase in 0.03 in the real growth rate of physician population, controlling for other variables. Surprisingly, income growth in rural PCSAs is not associated significantly with increase in growth rate of PCP population.

Including the regressor, urban proportion of population in the final model highlights an important trend affecting the growth rate of PCP population in rural PCSAs. The positive and significant coefficient indicates that the higher the urban proportion of a PCSA's population in 2007, the higher the growth rate of PCPs it will experience through 2007, *ceteris paribus*. For example, PCSAs with 50% of the population classified as urban in 2000 are predicted to have approximately 10% more PCPs than PCSAs with 20% urban population, holding other factors constant. In essence, physicians are increasingly attracted to urbanized areas. Even though the growth rate of PCP supply is higher in previously unserved PCSAs, we must remember that this is largely a factor of dividing by zero as denominator. That is why a previously unserved PCSA that adds one physician will have a growth rate of PCP supply tending toward infinity, but a served PCSA may add many more physicians without a high growth rate.

DISCUSSION

The topic of geographic maldistribution of primary care physicians is a stormy one that has been approached in various strains of research. Mainly, studies have focused on the individual physician to create a profile of background, traits, orientation and training that is highly predictive of rural location. This school of thought identifies practice location as an individual decision made at the personal level and largely avoids analysis of important exogenous variables that clearly inform the decision. Location theory presents a more systematic viewpoint that situates the practice location decision away from the physician to the potential host location and its market characteristics. Location theory assumes that the physician is rational, like a profit-maximizing firm, and will aim to maximize demand or utility in selecting a practice location, regardless of his/her background, traits and orientation. The principal criterion in the decision, therefore, is the population size of the intended location, a proxy for demand of the physician's services.

Location theory proposes that the geographic maldistribution of physicians is not an issue of market failure but is rather a manifestation of market forces at work. The rational physician will prefer to diffuse to an unserved location where he can maximize demand—and income—to competing with colleagues situated in a large city. This will happen only when the critical population size of the unserved town reaches a benchmark that the physician cannot attain in a larger location. Hence, location theorists assert that towns that are presently unserved by a physician will gradually gain physicians, even at a faster rate than larger counterparts, as their population size increases. The primary condition is that the number of medical specialists continues to rise.

In my analysis, I have tested these two principal hypotheses using a novel unit of analysis, the primary care service area, a geographic construct based on actual markets for primary care services, and using a new static definition of rurality that combines demographic components used in similar research. Results of fitting various iterations of linear models confirm that population is a major determinant of the likelihood of locating a primary care physician in a given location. I also showed that the growth rate of physician supply is significantly higher among locations that were unserved by a doctor of that specialty at an earlier time, even after controlling for other strong influences on PCP supply.

The confirmation of these hypotheses suggest that the geographic maldistribution of physicians is a temporary situation that will cease as population increases in rural parts of America. However, we cannot ignore some disturbing trends noticed in the results that are not explained fully by pure location theory. Significant differences exist in the likelihood of locating a physician across US regions, even after controlling for population size. Rural regions in the South, especially, showed significantly lower likelihood of physician location than other regions. In addition, the higher growth rate of PCP supply is not the same as nominal increase in PCPs in these areas: the growth rate is large mainly because of a mathematical manipulation, but only the presence of additional PCPs (nominal increase) may translate to better health outcomes for residents of rural areas.

Moreover, it is not guaranteed that the population of rural areas will continue to rise, as it did in this sample. In this case, location theory presents a bleak picture of inevitability: physicians may continue to locate away from rural areas until the population they cater to in urban areas decreases to the point where they are forced to diffuse. At the policy level, it behooves health officials to act as a guiding hand in this otherwise free market by enticing PCPs to rural practice with funds, such as in the NHSC, with construction of more rural health centers, or by encouraging medical schools to target applicants with characteristics suggestive of rural practice.

The low predictive value of estimation equations hints at the mystery surrounding the practice location decisions of primary care physicians. Location theory contributes some, but not all understanding to this complex issue. It may require a combination of reasoning from location theory and theories of profile to fully understand it.

LIMITATIONS

There are important limitations to the inferences outlined in analysis. Most limitations discussed stem from the nature of data collected and the boundaries of analysis possible with variables provided. Firstly, I analyzed the population and supply of primary care physicians as a composite specialty without checking for equal trends among the unit specialties: family medicine, general medicine, and pediatrics. As discussed briefly in the Findings section, the three specialties underwent varied changes in location and number over the seven years of the study. For the sake of simplicity, these statistics are presented as a composite in the PCSA database, although individual specialty data is also provided. Because this analysis focused on the supply of nonfederal physicians and because the PCSA provides data on the nonfederal composition of primary care physicians as a whole, I was constrained to analyze the specialties together.

With regard to unit of analysis, there are limitations to the use of PCSAs for this analysis. The design of PCSAs relies heavily on Medicare utilization by beneficiaries that are 65 years of age or older. Thus, PCSAs capture the utilization of primary care services by Medicare beneficiaries well, but preference indices are lower for child and non-elderly adult groups. The demographic of Medicare beneficiaries, however, does not form the bulk of the population in PCSA's or in small rural PCSA's. In 2000, the mean proportion of Medicare beneficiaries in the population of PCSAs was only 14.62% for PCSAs in general and 16.46% for small rural PCSAs. These proportions were 14.98% and 17.00% respectively in 2007. Moreover, as this study purposes to analyze the supply of PCP services, and not utilization, the emphasis on the senior population in defining PCSAs may not affect this analysis. Unlike using geographical counties or towns, PCSAs are designed for primary care to reflect where clinicians actually deliver primary care services, and this is essential to examine the characteristics of areas where these providers are lacking.

The definition of rurality employed for the paper shows results in accordance to literature on the demographics of rural America, but the methodology has not been field-tested or employed in other literature. In addition, the operationalization of rurality in this paper constrains PCSAs to remain in an urban or rural status through the seven years of study. While it is likely that some PCSAs may have changed in the demographics underlining this definition of rurality, the absence of census data in the 2007 wave of PCSA data does not allow me to modify rurality in such cases. It is therefore possible that analysis of rural PCSAs in 2007 may include some locations that are wrongly classified as rural, although the likelihood is that this over-counting would not be significant given the relatively short span of time between measurements (actually 2000 – 2005 for some variables).

Location theory does not exclude the possibility that some doctors may independently choose to settle in rural areas, without consideration of demand for their services (Schwartz et al., 1980). This personal predilection is in line with the results of cross-sectional and cohort studies on recruitment studied earlier. Essentially, the decision of practice location is taken at the personal level. The failure of the studies critiqued in this paper is in their limiting analysis of this decision to personal traits solely. Phenomena such as attribution effect show that people are subtly motivated by factors outside of their control or knowledge even when they presume that they are fully in control of their decisions. Location theory makes up for this error by extending the discussion on factors influencing the practice location decision to variables that apply beyond the doctor involved and that cannot be easily ignored.

In analysis of the growth rate of PCP supply using linear regression models, random sampling is encouraged to fulfill the conditions of the model. Attempts to comply with this condition resulted in inclusion of only a small proportion of the originally low number of rural PCSAs that were unserved in 2000, and the coefficient on unserved status was biased downward. This necessitated including the complete number of rural PCSAs in analysis.

Finally, other factors that influence location decisions were not provided among the variables provided in the PCSA database. These include exogenous variables such as litigation rates for medical malpractice and quality of PCSA schools for children of married physicians.

CONCLUSION

In summary, my analysis confirms two principal hypotheses of location theory using data on rural American primary care service areas between 2000 and 2007: the likelihood of a location having a primary care physician increases with population size; the growth rate of primary care physician population is greater in primary care service areas that were previously unserved than in locations that had at least one member of the specialty. This study demonstrates the value of community-level analysis in addressing questions related to the varying supply of primary care physicians in rural America locations. Research is encouraged on methodology merging the principles of location theory with other qualitative and qualitative approaches to better understand the complex location decisions of primary care physicians and, ultimately, improve health outcomes of rural Americans.

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