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Health care service disparity: Factors associated with the distribution of primary care physicians

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Health Care Service Disparity:

Factors Associated with the Distribution of Primary Care Physicians

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Abstract

Primary care physicians operate on the front lines of health care. Although primary care physicians play a critical role in improving health outcomes, workforce trends in the United States show a growing shortage of primary care physicians as demand for primary care rises. In conveying the importance of primary care physicians, the worsening physician shortage, the inequitable distribution of providers, and the lackluster institutional response thus far, this paper calls into question the effectiveness of current indicators used to identify underserved areas and provide appropriate government assistance. Through the use of data from the 2010 census and American Medical Association Master File, Spearman's rho tests were conducted to determine factors associated with the distribution of primary care physicians in Virginia and North Carolina. In Virginia, population density was positively correlated with physician quantity and percent elderly population was negatively correlated with physician quantity. In North Carolina, population density and median household income were positively correlated with physician quantity. Race was not significantly associated with physician quantity in either state. Following analysis of the findings in each state, this paper concludes by raising concern regarding the use of income and elderly population in the designation of underserved areas, recommending greater emphasis on consistently supported indicators of underserved areas like population density, and calling for additional research into other potential indicators.

Introduction

Health care issues have been at the forefront of the systemic agenda for decades in the United States. Policymakers and health services research often frame the innumerable health care issues confronting the American health care system within one or more issue areas, such as access, quality, and cost. Given that these issue areas are frequently interconnected in their effect on health care outcomes, inadequate focus on the part of policymakers for any single component can negatively affect the broader health care system. Unfortunately, in the pursuit of improving access to care, policymakers have largely focused their efforts on improving citizens' financial means of accessing care while overlooking the worsening supply of primary care physicians.

Although the American Academy of Family Physicians defines a primary care physician as "a generalist physician who provides definitive care to the undifferentiated patient at the point of first contact," this paper more narrowly conceptualizes primary care physicians as those who identify as practicing pediatrics, internal medicine, general practice, and obstetrics and gynecology (Primary Care, 2015). Despite the literature consistently finding that greater primary care physician to population ratios result in improved health outcomes (Macinko et al., 2007), workforce trends in the United States reveal a surplus of specialists yet a growing shortage of primary care physicians (Starfield et al., 2005). The insufficient supply of primary care physicians is worsened by their inequitable distribution, causing some areas to experience the growing primary care physician shortage more profoundly than others (Petterson et al., 2012; Green et al., 2004; Shi and Starfield, 2001).

Due to this inequitable distribution, intermittent attempts by policymakers to address the physician shortfall have produced mixed results. For example, the Patient Protection and Affordable Care Act (PPACA) attempted to remedy projected primary care physician shortfalls through numerous provisions designed to increase physician training, improve productivity, and address inequitable geographic distribution (Heisler, 2013). Specifically with respect to the geographic distribution of primary care physicians, the PPACA increased the quantity of National Health Service Corps (NHSC) providers serving in shortage areas, further encouraged physician training in shortage areas, and directed Health and Human Services (HHS) to revise the criteria used to determine Health Professional Shortage Areas (HPSAs) and Medically Underserved Populations (MUPs) (Heisler, 2013). However, these initiatives have not reversed the physician supply trend due to the PPACA's corresponding increase in health care utilization, as well as population growth and aging (Petterson et al., 2012).

The proposed revision of the criteria used to determine HPSAs and MUPs is particularly important because HPSA/MUP designation grants eligibility for federal programs designed to address physician shortages. In order to receive HPSA designation, an area, population group, or facility must have "a full-time equivalent primary care physician ratio of at least 3,500 patients for each primary care physician or has a ratio of at least 3,500 patients for each primary care physician and has a population with high health care needs" (Heisler, 2013). MUP designation, as well as the similar Medically Underserved Area (MUA) designation, considers available health care services and population characteristics (Heisler, 2013). The Government Accountability Office has criticized the strict and outdated HPSA/MUP criteria because of its potential to designate areas with serious physician shortages as ineligible for applicable federal assistance (Heinrich, 2001). Although Section 5602 of the PPACA requires that a final rule for a revised HPSA/MUP methodology be published by July 1, 2011, a final rule has not yet been published (Heisler, 2013).

As a result, current policies that use HPSA/MUP designation to identify areas with low numbers of primary care physicians are not effectively allocating limited, essential resources. The misallocation of resources is further exacerbated by the numerous problems associated with the current state of Critical Access Hospitals (CAHs). CAH certification provides cost-based Medicare reimbursement as opposed to the standard fixed reimbursement rates in order to strengthen the financial health of hospitals in underserved areas, but the Office of Inspector General has found that over sixty percent of CAHs would be ineligible for CAH status if they were required to re-enroll in Medicare (Minich et al., 2013). In other words, most CAHs do not meet the location requirements to become a CAH in the first place, meaning that hundreds of millions of taxpayer dollars are allocated to hospitals that are in close enough proximity to another hospital to call into question whether the area they serve is truly underserved (Minich et al., 2013).

It is evident that current indicators used to identify underserved areas and provide appropriate relief are inadequate. As the quantity of physicians continues to shrink relative to population size and geographic inequities in physician distribution persist, the inadequacy of tools currently used to identify underserved populations and direct appropriate resources is becoming increasingly visible and unacceptable. Furthermore, when one considers the lower political capital needed to revisit these indicators relative to that of comprehensively addressing the supply-side of the primary care physician problem, it is clear that now is the appropriate time for reevaluation. As such, this paper seeks to identify factors associated with the distribution of primary care physicians.

In order to identify factors meaningfully associated with the distribution of primary care physicians, this paper first establishes a thorough understanding of relevant literature and workforce trends. The subsequent section provides a comprehensive analysis of trends in the workforce, important findings in the literature, and theoretical support for the variables discussed throughout the rest of this paper. Following a brief discussion of this paper's methodology, statistical analyses are conducted for the two states examined as case studies: Virginia and North Carolina. Using the findings presented in the Virginia and North Carolina sections, this paper proceeds to compare and contrast these findings in order to arrive at meaningful conclusions regarding factors associated with the distribution of primary care physicians. Lastly, this paper provides concluding remarks regarding previous findings, implications for future research, and implications for policymakers.

Literature Review

Workforce Trends

Unquestionably, the issue of health care plays a prominent role in national discourse. The inequitable distribution of primary care physicians is particularly notable because these physicians operate on the front lines of health care. The American Academy of Family Physicians asserts that primary care physicians coordinate "the use of the entire health care system to benefit the patient" by functioning as many people's point of first contact for any health care need (Primary Care, 2015). However, recent and continuing trends in the workforce serve as a significant source and amplifier of disparities in the distribution of primary care physicians. Consequently, examination of current trends in the physician workforce is essential in order to identify and understand the problem of physician distribution inequity.

According to a 2003 report published by the National Center for Health Statistics, office visits to general practitioners remained statistically similar from 1992 to 2000 (Bernstein et al.). However, the rate of office visits to internists, a practice within primary care, increased from 400 per 1,000 population in 1992 to 458 per 1,000 population in 2000 (Bernstein et al., 2003). This data by the CDC suggests that demand for primary care physicians remained relatively stable during the 90s. Going into the 21st century, however, research has consistently indicated that the demand for physicians is outpacing the quantity of physicians.

The Council on Graduate Medical Education, authorized by Congress in 1986 to analyze physician workforce trends, reported in 2005 that there will be a 24% increase in the supply of practicing physicians from 2000 to 2020, but the rate of population growth will exceed the growth in physician numbers by 2015. They arrived at their conclusions by utilizing the Physician Supply Model, which predicts the supply of physicians by type. In the case of this report, they looked at projections for generalists and non-generalists with full-time equivalent (FTE) physicians acting as the unit of observation (Council on Graduate Medical Education, 2005). Overall, the methodology for this report is sound, and the report produced significant findings regarding the impending physician shortage that later literature builds upon.

In fact, a 2006 article by Salsberg and Grover supports the Council on Graduate Medical Education's claims of a physician shortage. Salsberg and Grover claim that physician shortages are largely the result of medical school enrollment patterns (2006). Medical school enrollment doubled in the 1960s and 1970s, but has stagnated since the 1980s, which helps explain why the shortage is expected to significantly worsen as a large portion of the physician workforce approaches retirement (Salsberg and Grover, 2006). This mirrors the Council on Graduate Medical Education's findings and conclusions regarding the physician shortage, however, they acknowledge that their findings cannot take into account enhancements in productivity resulting from technology advances that could lessen the impact of a significant physician shortage (2005).

Regardless, additional research since the mid-2000s has continued to build upon and support previous literature, thereby demonstrating that trends in the physician workforce continue to pose a significant threat to the accessibility and availability of health care services in the United States. By 2008, the quantity of research on primary care physician workforce trends began to skyrocket as the problem of health care provider scarcity became more visible. Using similar methods as the Council on Graduate Medical Education's research in 2005, a 2008 report published by the Bureau of Health Professions of the Health Resources and Services Administration claims that the primary care physician supply will experience an 18% increase by 2020 from 2005 (US Department of Health and Human Services, 2008). They conclude that an 18% increase is not enough to keep up with population growth (US Department of Health and Human Services, 2008). Furthermore, the report warns that if an increased public expectation for coverage or an increased public ability to pay for care occurs, "then a significant shortfall of physicians could develop over the next 15 or more years in the absence of increased output from U.S. medical schools, increased recruitment of foreign-trained physicians, or both" (US Department of Health and Human Services, 2008, p. 73).

Unsurprisingly, following the passage of the Affordable Care Act, an avalanche of new research has emerged assessing the impact that health care reform will have on the physician workforce and preexisting health care disparities. Updating previous workforce projections made by the Association of American Medical Colleges Center for Workforce Studies to include provisions of the ACA, Kirch et al. found that projected physician shortage for 2020 increased from 64,100 pre-ACA to 91,500 post-ACA (2012). Their projections have the same flaws as previous projections in that they cannot account for technological or productivity increases, but the researchers suggest the difference is significant enough to warrant an increased emphasis on addressing physician scarcity (Kirch et al., 2012).

Although a comprehensive analysis of the implications of the ACA on the physician workforce is beyond the scope of this paper, the consensus in the literature is that the ACA brings with it new and unique challenges for policymakers seeking to address the inequitable distribution of primary care physicians. The provisions with the most significant impact on the supply of primary care physicians include the expansion of "Medicaid to all individuals in families earning less than 133 percent of the federal poverty level (FPL)," and the availability of "subsidies to uninsured lower-income Americans (133 to 400 percent of FPL) without access to employer-based coverage to purchase insurance in new exchanges" (Hofer et al., 2011, p. 70). Using the Medical Expenditure Panel Study, state-level information of the quantity of uninsured individuals, and a regression model of annual primary care utilization, Hofer et al. conclude that 4,307-6,940 additional primary care physicians will be needed to accommodate the increase in insured individuals by 2019 (2011).

Interestingly, Cunningham claims that the effects of health care reform on primary care physicians will vary by state. States with the lowest numbers of primary care physicians relative to their populations will experience the greatest increase in demand for medical care because those states typically have many uninsured individuals above the poverty line who were not eligible for Medicaid (Cunningham, 2011). The opposite is true for states with the highest numbers of primary care physicians relative to their populations (Cunningham, 2011). Overall, the growing nationwide scarcity of physicians has a disproportionate impact on certain segments of the population. As a result, preexisting disparities in the accessibility of health care services have worsened. The workforce trends mentioned previously indicate that this problem will continue until the segments of the population being disproportionately impacted are identified and addressed with appropriate policy solutions.

Income and Race

Yao et al. found that, despite decreases in white infant mortality rates over the past two decades, there remain significant disparities between Appalachian counties compared to non-Appalachian counties with respect to infant mortality (2012). They analyzed data from 1,100 counties in 13 Appalachian states and used reliable Area Resource File data to produce county and city infant mortality rates, as well as numbers of physicians per 1,000 residents (Yao et al., 2012). Their sound results were produced through multiple regression analyses for the time periods of 1976-1980 and 1996-2000 (Yao et al., 2012). Most interestingly, these researchers presented several factors that increase the risk of infant mortality, such as low income, a greater proportion of minority residents, and rural residence (Yao et al., 2012).

Yao et al. claim that low-income areas typically have higher infant mortality rates for several reasons, one of them being “lowered access to quality health care” (2012, p. 175). Similarly, Shi and Starfield, using the popular Gini coefficient to measure income inequality, found “that state-level income inequality and primary care physician supply were significantly associated with population health indicators” (2001, pp. 1246, 1248). This finding suggests that increased access to primary care may mitigate some of the negative effects income inequality has on health outcomes. However, remedying the problem of physician disparity between low-income and high-income areas has proved challenging.

Bodenheimer and Pham point out that public and non-profit organizations known as community health centers often serve the health care needs of low income populations (2010). They claim that the federal government has been placing growing emphasis on community health centers to address problems relating to the accessibility of primary care (Bodenheimer and Pham, 2010). Unfortunately, a study by The Robert Graham Center asserts that there are simply not enough physicians willing to staff a large expansion of community health centers' capacities, and that “Staffing a rapidly enlarged health center network will likely require incentives to shift currently practicing physicians…into these settings” (2009, pp. 45-46). Although this study by the Robert Graham Center provides insightful conclusions regarding health disparities resulting from income, they are very transparent in stating that their lack of access to the AAMC Matriculation Survey Questionnaire limited their ability to provide data on race (2009).

With respect to race, Yao et al. claim nonwhite populations often have fewer high-quality healthcare facilities and supportive community services, and these populations typically have higher infant mortality rates (2012). Similarly, Collins et al., in their analysis of data presented in the Commonwealth Fund 2001 Health Care Quality Survey, assert that minorities more often believe they lack options in where they receive their care, and they are less likely to have a regular doctor (2002). Specifically, only 15% of whites believe they lack options in where they receive their care, whereas 28% of Hispanics believe they lack options in where they receive their care (Collins et al., 2002). Even more shocking, 80% of whites have a regular doctor, whereas only 57% of Hispanics have a regular doctor (Collins et al., 2002). Therefore, it is evident that a significant disparity exists between minority populations and white populations with respect to their access to health care services.

In addition, providing health care to minority populations often creates unique challenges for primary care physicians. Looking at the findings from the Commonwealth Fund 2001 Health Care Quality Survey, Collins et al. report that 15% of African Americans, 13% of Hispanics, and 11% of Asian Americans believed that they would have received better care if they were a different ethnicity or race (2002). Furthermore, “One of three Hispanics and one of four Asian Americans have problems communicating with their doctor,” which indicates that not only must there be an adequate supply of physicians for minority populations, but that supply of physicians must also have the cultural competence to properly serve the health care needs of minority populations (Collins et al., 2002, p. v).

Allison also examines health care accessibility for minorities, but does so in a more in-depth, state-focused analysis. Through a compilation of past research, Allison assesses many factors impacting the ability of Arizona minorities to access health care services, including transportation, health insurance, and Health Provider Shortage Areas (2005). The number of primary care physicians stagnated or decreased throughout Arizona from 1997 to 2001, which resulted in an inability for the supply of primary care physicians to keep pace with population growth (Allison, 2005). Allison reveals that Health Provider Shortage Areas, which designate areas in which the supply of health care providers is not keeping up with demand, exist in all 15 counties of Arizona (2005). In fact, Allison claims that sixty-seven percent of Native Americans in Arizona reside in Health Provider Shortage Areas (2005).

However, Yao et al. suggest that race often interacts with other variables, such as income, to impact access to health care services and outcomes (2012). Interestingly, Allison's research suggests that race, although a significant variable, cannot solely account for disparities in the distribution of primary care physicians. Allison incorporates the previously discussed variables, income and race, as well as the most widely discussed and supported variable in the literature: population density.

Population Density and Elderly Population

Contemporary research regarding disparities in the distribution of primary care physicians usually claim that rural areas, or areas with lower population densities, suffer from poor accessibility to health care services that extends beyond physician scarcity. For example, Allison identifies transportation as a contributing factor in worsening accessibility to health care services in areas with low population densities (2005). These areas with low population densities most commonly exist in rural America, where longer distances between health care facilities pose unique challenges for providers of emergency care. Allison identifies some factors impacting transportation issues related to health care, including the expense of travel, the lack of transportation options for individuals too sick or injured to travel by conventional means (wheelchair accessible vans, for instance), and poor weather conditions in some circumstances (2005).

In addition to the practical challenges associated with accessing health care in rural America, statistics illustrate that rural communities have a growing need for health care services but diminishing choices with respect to health care providers. Gamm et al. utilize a variety of scholarly and reputable sources to provide policy suggestions on how significant rural health priorities should be addressed. Gamm et al. assert, "Only about 10 percent of physicians in America practice in rural areas despite the fact that one-fourth of the U.S. population lives in these areas" (2003, p. 45). Their report clearly demonstrates the striking disparity in physician supply between rural and urban areas.

Analyzing data in the 2001 Urban and Rural Health Chartbook, Hartley goes beyond the data presented in Gamm et al. to claim that health patterns of rural populations exhibit a "rural culture" of negative health behaviors (Hartley, 2004, p. 1675). Hartley points out that the Chartbook claims individuals living in rural areas typically "smoke more, exercise less, have less nutritional diets, and are more likely to be obese than suburban residents," but he claims this is often correlated with variables such as education, income, and physical environment (Hartley, 2004, p. 1676). Hartley suggests that we must address regionally diverse risk factors rather than focusing on access to care (2004). Consequently, Hartley's article is largely a critique of the traditional focus of rural health research on issues relating to accessibility.

In contrast, Rabinowitz et al. focus entirely on the supply and retention of primary care physicians in rural areas. The fact that rural residents are sicker, older, and more likely to be uninsured makes them "one of the largest underserved US populations" (Rabinowitz et al., 2001, p. 1041). Rabinowitz et al. argue that encouraging medical school graduates to work as rural primary care physicians is an extremely challenging policy problem, especially when less than three percent of those medical school graduates say they plan to practice in an area with low population density (2001). This traditional emphasis on accessibility as the core rural health problem instead of public health is in stark contrast to Hartley's conception of the rural health problem.

Rabinowitz et al. proceed to identify factors that increase rural primary care physician supply through an analysis of the Physician Shortage Area Program of Jefferson Medical College. A large sample size of 3414 Jefferson Medical College graduates, including 220 Physician Shortage Area Program graduates, was utilized to increase the generalizability of the findings (Rabinowitz et al., 2001). Rabinowitz et al. found that being in the Physician Shortage Area Program, among other less controllable factors (such as being male), successfully resulted in medical school graduates choosing to practice primary care in rural areas (2001). This research demonstrates to policymakers seeking to address physician distribution disparities that increasing the quantity of medical school graduates in activities and programs designed to encourage practicing rural primary care is a potentially viable policy solution to such disparities.

Given the well-established literature on the subject of encouraging physicians to practice in underserved areas, this paper opts to address the inadequacy of tools currently used to identify underserved populations and direct appropriate resources. Successful implementation of health care policies intended to remedy physician scarcity and distribution problems requires accurate indicators of underserved populations. Key factors associated with the distribution of primary care physicians must be identified and verified. This section has already identified several factors associated with the distribution of primary care physicians in the literature, and the following section takes the next step by outlining this paper's methodological approach.

Methodology

This section outlines the methods used to determine factors associated with the distribution of primary care physicians, including variable conceptualization, operationalization, and appropriate summary statistics. Statistical analyses were conducted using Virginia and North Carolina as case studies due to their unique population characteristics and geopolitical units, thus offering greater generalizability for consistently significant relationships. The four independent variables (population density, income, elderly population, and race) and dependent variable (physician quantity) were all continuous, but the dependent variable was non-normal for both the Virginia and North Carolina data. Non-normal continuous data directed toward the use of Spearman's rho rather than Pearson's r. Although Spearman's rho assumes a monotonic relationship rather than a linear relationship, lines of best fit were plotted on scatter plots to improve visualization of directionality.

Measures

A primary care physician was conceptualized as a physician who identifies as practicing pediatrics, internal medicine, general practice, and obstetrics and gynecology. Although the literature has utilized a wide variety of methods to assess spatial accessibility, physician to population ratios are the most widely used measures because "they are highly intuitive, the data sources are readily available…they do not necessarily require GIS tools and experience…[and] are good for gross comparisons of supply between large geopolitical units" (Guagliardo, 2004,

p. 4). For both Virginia and North Carolina, primary care physician supply was operationalized as the number of primary care physicians per 100,000 population in a given locality. Localities in Virginia were operationalized as counties and independent cities, whereas localities in North Carolina were only operationalized as counties due to the absence of independent cities in the state.

In order to evaluate the effect that rurality has on primary care physician supply, population density was conceptualized as the number of people in a given area. Population density was further operationalized as the number of residents per square mile of land area in a given locality. Each county constituted an observation in North Carolina, and each county and independent city constituted as an observation in Virginia.

The income variable was conceptualized and operationalized as median household income instead of average family income because the former is a more comprehensive measure that includes one person households. Average family income is also employed less frequently than median household income in the literature because it can produce inflated income levels. Similar to all other variables, median household income was assessed for each county in North Carolina and each county and independent city in Virginia.

The elderly variable was conceptualized as individuals ages 65 and over. Elderly population was operationalized as the percent of total population in a given locality comprised of individuals ages 65 and over. Percent elderly population was assessed for each county in North Carolina and each county and independent city in Virginia.

Lastly, the race variable was conceptualized as an individual's self-identified race or ethnicity. In order to determine the existence of a relationship between race and primary care physician supply, the race variable was operationalized as percent white population in a given locality. Race was operationalized as percent white population due to the inherent challenges associated with identifying and evaluating underserved minority groups, as well as concerns regarding insufficient population size depending on minority group and locality. The methodological challenges associated with this variable are discussed in greater depth throughout the statistical analyses and comparative analysis.

Methods

Table 1

Summary Statistics

Variable	Mean	Standard Deviation
Primary Care Physician #		
Virginia	85	89
North Carolina	63	44
Population Density		
Virginia	845	1,534
North Carolina	195	260
Income		
Virginia	51,189	18,478
North Carolina	40,848	7,696
Elderly Population		
Virginia	16	4
North Carolina	16	4
Race		
Virginia	75	18
North Carolina	72	18

The sole dependent variable, primary care physicians per 100,000 population, was derived from the American Medical Association Master File and was assessed as the number of physicians practicing pediatrics, internal medicine, general practice, and obstetrics and gynecology per 100,000 population in a given locality. Only 2010 data was used so that statistical analyses could be conducted with the dependent variables, all of which use 2010 census data. For both the Virginia and North Carolina data, it was continuous but informal normality tests, including skewness (VA: 2.72; NC: 2.45) and kurtosis (VA: 9.46; NC: 9.58), produced unacceptable values indicating strong positive skewness and leptokurtic shapes. Failure to meet the assumption of normality directed toward the use of a nonparametric relationship test: Spearman's rho.

Similar to the dependent variable, all four of the independent variables were continuous. The population density, income, elderly population, and race variables were all derived from 2010 census data. Informal normality tests for income, elderly population, and race for both Virginia and North Carolina data produced acceptable skewness and kurtosis values. However, skewness (VA: 2.98; NC: 3.5) and kurtosis (VA: 10.74; NC: 14.97) values were unacceptable for the population density variable, thus precluding the use of statistical tests that assume a normal independent variable. Despite some normally distributed independent variables, the presence of a non-normal dependent variable, as well as continuous independent and dependent variables, directed toward the use of Spearman's rho to test all of this paper's hypotheses.

Virginia

Context—Independent Cities

Before a statistical analysis of demographic factors affecting the distribution of primary care physicians in Virginia can be undertaken, it is important to first understand some of the state's unique characteristics that may play a role when comparing the results of this state with those of the other state this paper examines: North Carolina. Since this section aims to assess factors associated with the distribution of primary care physicians through county level data, a fundamental understanding of Virginia's geopolitical units is essential. In the context of Virginia, the presence of independent cities creates pockets of high population that have the potential to significantly affect the data and results.

Local government in Virginia is unique in that the state constitution grants all incorporated cities administrative and political independence from surrounding counties (Peaslee & Swartz, 2013). These cities have been formally known as "independent cities" since being codified in the Constitution of 1971 (The Hornbook of Virginia History, 2014). Due to the existence of administratively and politically independent cities in Virginia, counties and cities are included in the data as separate but equal units of analysis. For example, if a hypothesis seeks to determine whether a relationship exists between population density and physician quantity in Virginia, then data on these variables for an independent city will be separate from the data for surrounding counties. This is in contrast to North Carolina, for which county data includes cities encompassed by county jurisdiction.

Hypotheses

Four independent variables pertaining to various demographic characteristics of Virginians, along with one dependent variable, are considered in order to address the broader research question regarding factors affecting the distribution of primary care physicians. The sole dependent variable, the number of primary care physicians per 100,000 people, is an essential metric through which the impact of the four independent variables on the distribution of primary care physicians can be assessed. The first independent variable, population density per square mile, is the most supported variable associated with inequitable physician distribution in the literature: "One of the more entrenched physician workforce concerns in the United States has been the limited number of physicians in rural communities" (Salsberg and Forte, 2002, p. 169). The second independent variable, median household income, which includes the income of all individuals in a given residence above the age of 15, has moderate support in the literature. For example, Guzick and Jahiel examined a similar variable, median area income, and found "a strong, positive association," but their analysis focused more narrowly on urban neighborhoods rather than counties (1976, p. 469). The third independent variable, the percent of the population over 65, likely influences the distribution of primary care physicians due to that demographic's comparatively higher demand for medical advice and attention relative to other age groups. Lastly, the percentage of the population comprised of minorities serves as an interesting independent variable that often only receives peripheral discussion, mixed support, or an emphasis on quality rather than access in the existing literature. The inclusion of percent minority population as an independent variable ensures a comprehensive approach whereby the assertion in the literature that income plays a greater role than race can be empirically tested (Bach et al., 2004). Based on relevant literature examining these relationships in the past, I believe that a strong relationship exists between population density and physician quantity, a moderate relationship exists between median household income and physician quantity, a moderate to weak relationship exists between elderly population size and physician quantity, and a very weak relationship exists between the size of minority populations and physician quantity.

H_1: There is a positive relationship between population density and physician quantity in Virginia.

H_2: There is a positive relationship between median household income and physician quantity in Virginia.

H_3: There is a positive relationship between percent elderly population and physician quantity in Virginia.

H_4: There is a positive relationship between percent white population and physician quantity in Virginia.

Presentation of Results

Table 2

Summary of Results

Hypothesis	Significance	Correlation
H_1: Population Density	.000	.629
H_2: Income	.486	.062
H_3: Elderly Population	.020	-.206
H_4: Race	.084	-.153

H_1: As seen in Table 2, this is a statistically significant relationship with a Spearman correlation of .629, suggesting a strong positive correlation between population density per square mile and the number of primary care physicians per 100,000 population. Furthermore, the r-squared value is .396. Therefore, 39.6% of the variability in the number of primary care physicians can be accounted for by population density.

H_2: As seen in Table 2, the p-value (.486) falls above the .05 threshold for significance, resulting in acceptance of the null of no relationship. This is reflected in the weak Spearman correlation of .062. In addition, the r-squared value of .004 indicates that only .4% of the variability in the number of primary care physicians can be accounted for by median household income.

H_3: As seen in Table 2, this is a statistically significant relationship with a Spearman correlation of -.206, suggesting a weak to moderate negative correlation between the percent of the population that is over 65 years old and the number of primary care physicians per 100,000 population. The r-squared value is .042. Therefore, only 4.2% of the variability in the number of primary care physicians can be accounted for by the size of the elderly population.

H_4: As seen in Table 2, the p-value (.084) falls above the .05 threshold for significance, resulting in acceptance of the null of no relationship. The weak Spearman correlation (-.153) and r-squared value (.023) reflects this, indicating that only 2.3% of the variability in the number of primary care physicians can be accounted for by white population size.

Discussion of Results

All of the hypotheses' correlations were overestimated, but the results for H_1 most closely align with the initial prediction based off the previous literature. Undoubtedly, population density plays a significant role in the quantity of primary care physicians among Virginia's localities. A cursory examination of Figure 1 reveals that the strong positive correlation between population density and physician quantity is not the product of the most populous localities at the far right of Figure 1. These outliers' population densities, namely the city of Alexandria and the county of Arlington, outpace their per capita physician count. However, many independent cities have above-average numbers of physicians relative to their population density, and most of the counties with the largest numbers of physicians relative to their respective population densities essentially ride the coattails of adjacent independent cities. Indeed, it is the scarcely populated counties and cities that force the correlation to a relatively high .629. The incredibly dense grouping of counties on the far-left of Figure 1 from the southern and western regions of the state with abysmally low population densities significantly affect Virginia's average

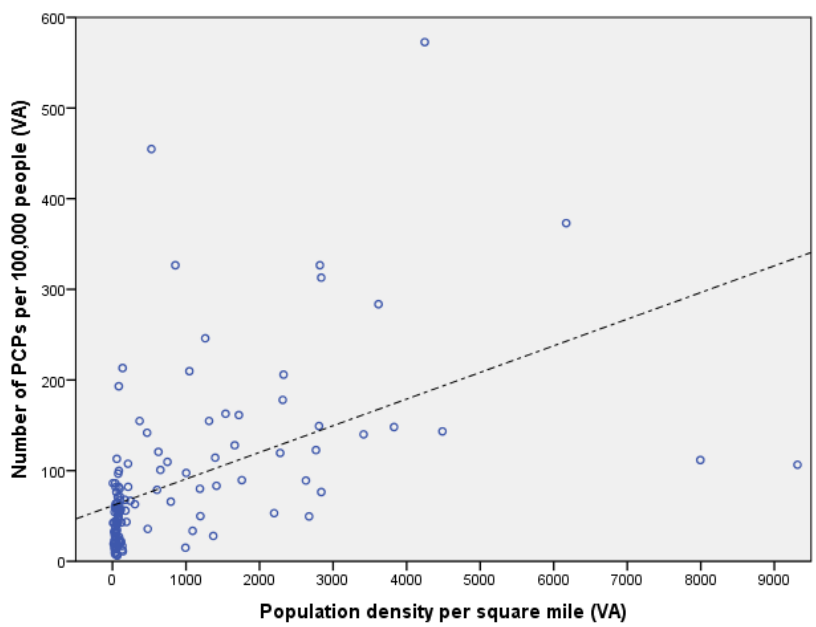

Figure 1

per capita physician count.

In contrast to H_1, the results of H_2 fail to reflect the literature with respect to the correlation between income and physician quantity. Although the results produced a positive correlation, it is weak and statistically insignificant. In addition, what little positive correlation exists is likely the result of high-income individuals frequently residing in counties and cities with high population densities. At the same time, Figure 2 shows that many localities with low median household income enjoy above-average physician numbers. It is possible that high concentrations of low-income households in some densely populated cities negated the impact of higher incomes from surrounding counties and lower incomes from rural communities further from the cities. If this is the case, then these unexpected results may be a consequence of Virginia's socioeconomic distribution by geography, which may not be shared by other states.

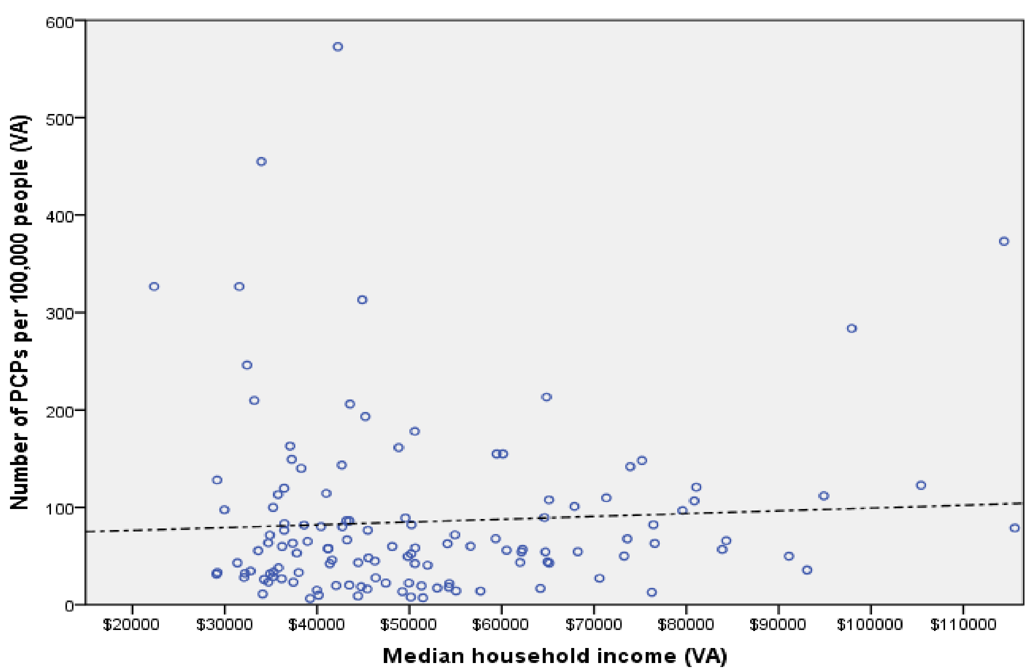

Figure 2

The results of H_3 are particularly interesting because they show a statistically significant relationship that is negative rather than positive. Although this does not precisely align with the initial hypothesis, it does still align with the literature in that it can be explained through an examination of demographic trends and the results of H_1. As Johnson points out, “net migration to and from rural areas has always been age selective…the incidence of migration is highest for young adults,” which has resulted in a proportional increase in the elderly population in many rural areas (2006, p.11). As rural communities lose population density, the percent of their populations comprised of the elderly increase. Therefore, the weak to moderate negative correlation between percent elderly population and physician quantity is buttressed by the strong relationship between population density and physician quantity. The opportunity cost of practicing in rural areas rather than urban or suburban areas outweighs the increasing demand for medical services by a proportionately large rural elderly population.

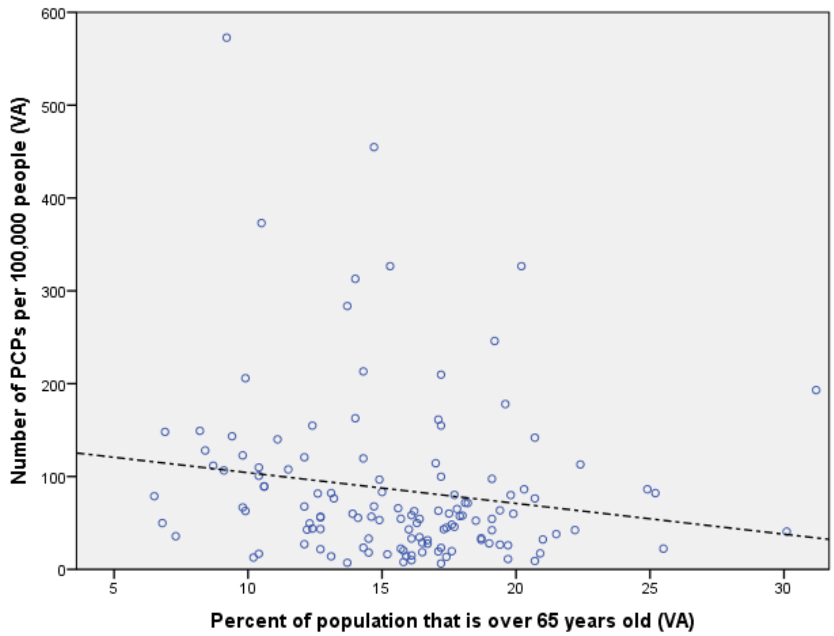

Figure 3

Lastly, the results of H_4 are not particularly surprising given its weak support in the literature. More importantly, any possible relationship between race and access to primary care physicians would likely be the result of income inequality or geographic location, particularly in the context of Virginia, to a far greater extent than race itself. Any statistically significant relationship found outside the context of Virginia should consider the various disadvantages inherent to being in a minority group individually.

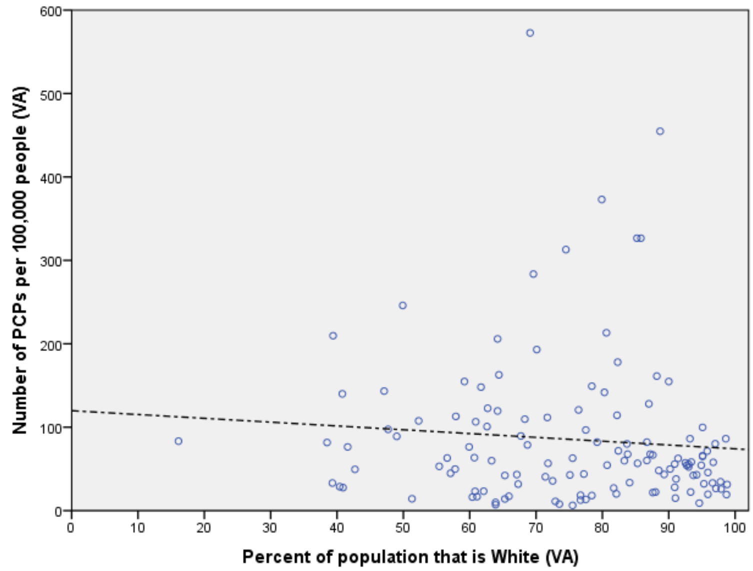

Figure 4

In summary, the results presented thus far provide an interesting glimpse into the validity of commonly held assumptions regarding factors associated with the distribution of primary care physicians. There is a strong positive relationship between population density and physician quantity. As seen in Figure 5, most localities feature a population density per square mile under 1000, most localities with a population density under 200 also have less than 100 primary care physicians per 100,000 people, and no locality with a population density under 1000 has more than 500 primary care physicians per 100,000 people. Similarly, there is a statistically significant relationship between elderly population and physician quantity. However, the relationship between elderly population and physician quantity is negative rather than positive, indicating that physician quantity decreases as percent elderly population increases. Significant interaction between the population density and elderly population variables is probable. Lastly, the income and race variables did not produce statistically significant results. Although the latter is not surprising given its mixed support in the literature and difficultly in accurately measuring, the former notably conflicted with extant literature. The concentration of wealth, population, and physician quantity in northern Virginia localities likely contributed to acceptance of the null hypothesis. A significant relationship between median household income and physician supply is still possible in the context of a state with less wealth concentration in areas with high population density. The following section will discuss the unique characteristics of North Carolina relative to Virginia, present findings using identical variables, and discuss the results.

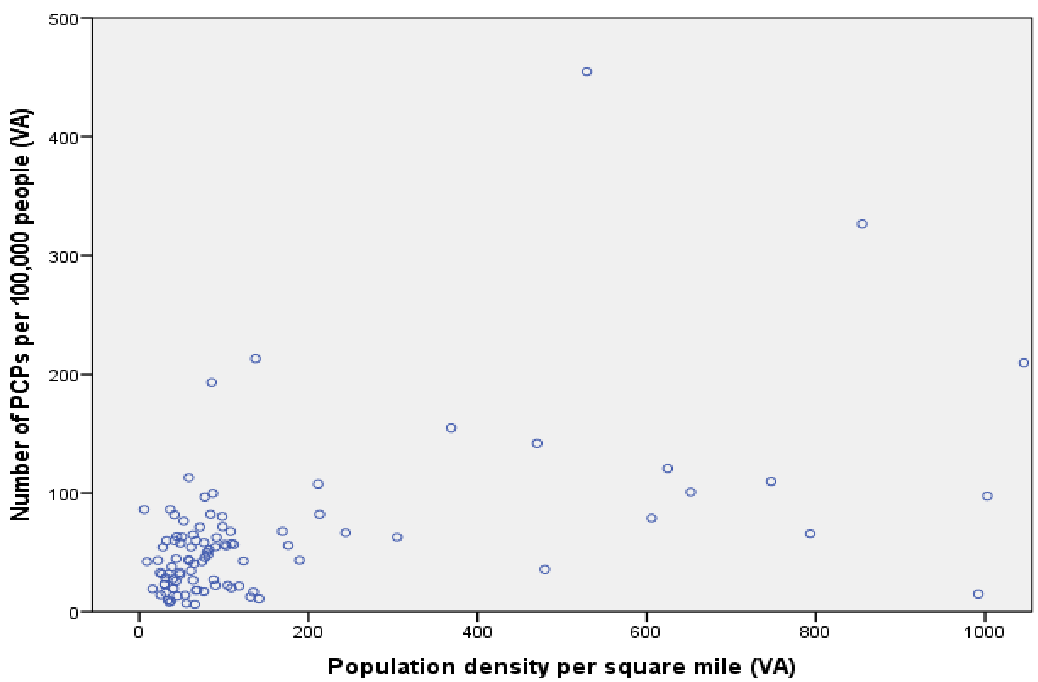

Figure 5

North Carolina

Context—Sprawl and the Absence of Independent Cities

The previous section examined several hypotheses regarding factors associated with higher or lower numbers of primary care physicians. Two of the presented hypotheses produced statistically significant relationships. First that a strong positive correlation exists between population density and physician quantity, and second that a weak to moderate negative correlation exists between percent elderly population and physician quantity. However, in order to strengthen the generalizability of this paper's findings it is necessary to test these hypotheses in the context of a state with notably different characteristics, yet similar enough to still make meaningful comparisons. Unlike Virginia, North Carolina does not have independent cities and features relatively greater sprawl.

Local units of government in North Carolina are distinguished from those in Virginia in the absence of independent cities. Unlike Virginia, North Carolina does not feature city and county separation (Peaslee & Swartz, 2013). More specifically, cities in North Carolina are not considered politically independent general-purpose local governments (Peaslee & Swartz, 2013). For example, Charlotte, the most populous city in North Carolina (U.S. Census Bureau, 2015a), is considered a part of Mecklenburg County, whereas Virginia Beach, the most populous city in Virginia (U.S. Census Bureau, 2015b), does not fall under the jurisdiction of surrounding counties. Consequently, this section's unit of observation will not include any cities, but rather the counties they fall under the jurisdiction of.

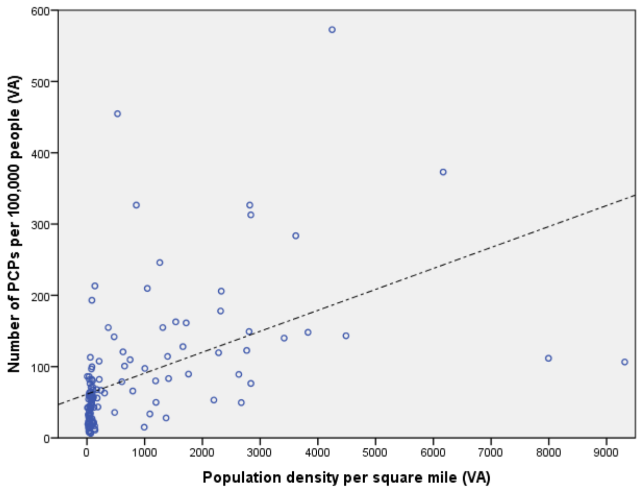

Figure 1

The absence of independent cities will undoubtedly influence results regarding factors affecting the distribution of primary care physicians in North Carolina. In the previous section, the disproportionately large populations of independent cities relative to surrounding counties increased the likelihood of statistical outliers and the clumping together of data points as seen in Figure 1. In addition, as evidenced by the two states' urbanized areas in the 2010 census seen in Figure 6 (U.S. Census Bureau, 2013), Virginia features less urban sprawl. Charlotte serves as an excellent example of sprawl in North Carolina, as its urban area grew by 44% during the 1990s (Alig et al., 2004).

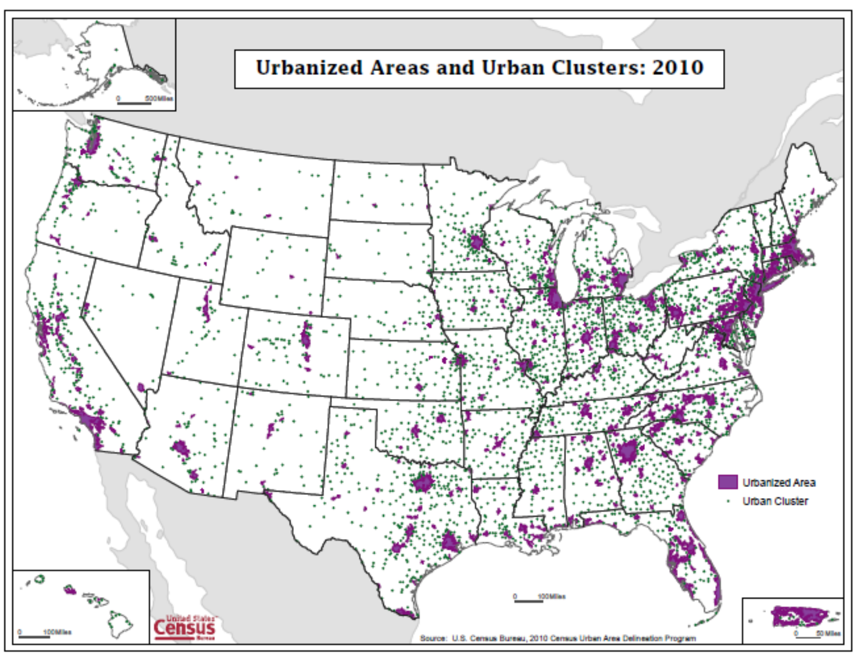

Figure 6—(U.S. Census Bureau, 2013)

With more urban sprawl and no independent cities to serve as pockets of urban areas, the North Carolina data will likely produce less outliers. With less outliers, other hypotheses that were shown to not have statistical significance in the previous section, such as the relationship between income and physician quantity, might produce p-values closer to the threshold of statistical significance.

Since this paper's statistical analyses are based on a comparison of general-purpose units of local government, the distinctions in the characteristics of local government between Virginia and North Carolina laid out thus far could significantly impact the results. The impact of such differences on the results are more thoroughly evaluated in the subsequent comparative analysis section.

Hypotheses

This section considers the same four independent variables examined in the previous section in order to address the broader research question regarding factors affecting the distribution of primary care physicians. The significance of these independent variables are assessed through their relationship with the sole dependent variable, the number of primary care physicians per 100,000 people. The first independent variable, population density per square mile, receives the most support in the literature and was shown to be statistically significant within Virginia. Guzick and Jahiel found "a strong, positive association" between median area income and the location of physicians' practices (1976, p. 469), but the previous section failed to find a statistically significant relationship between median household income, the second independent variable, and physician quantity. The third independent variable, the percent of the population over 65, did produce a statistically significant relationship with physician quantity. However, contrary to the positive relationship initially predicted by H_3 due to higher demand for medical services among the elderly population, the results showed a negative relationship. This suggests that the opportunity cost of practicing in rural areas rather than urban or suburban areas, as evidenced by the strong positive correlation between population density and physician quantity, outweighs the inherently higher demand for medical services among disproportionately large elderly populations in rural areas (Johnson, 2006). This section's hypothesis regarding the relationship between percent elderly population and physician quantity reflects the previous section's findings with respect to the directionality of the relationship. Lastly, the fourth independent variable, percent White population, seeks to determine whether a relationship exists between the size of minority populations and physician quantity. Percent White population is used as the independent variable rather than percent minority population in order to avoid methodological problems associated with defining, distinguishing, and unintentionally excluding less prevalent racial and ethnic groups. The previous section did not find a statistically significant relationship, however, the hypothesis remains the same in this section as it is unclear how and to what extent greater sprawl and the absence of independent cities in North Carolina will affect the data and results for this relationship.

H_5: There is a positive relationship between population density and physician quantity in North Carolina.

H_6: There is a positive relationship between median household income and physician quantity in North Carolina.

H_7: There is a negative relationship between percent elderly population and physician quantity in North Carolina.

H_8: There is a positive relationship between percent white population and physician quantity in North Carolina.

Presentation of Results

Table 3

Summary of Results

Hypothesis	Significance	Correlation
H_5: Population Density	.000	.436
H_6: Income	.047	.201
H_7: Elderly Population	.343	-.041
H_8: Race	.178	.137

H_5: As seen in Table 3, this is a statistically significant relationship with a Spearman correlation of .436, suggesting a moderate to strong positive correlation between population density per square mile and the number of primary care physicians per 100,000 population. The r-squared value of .19 indicates that 19% of the variability in the number of primary care physicians can be accounted for by population density.

H_6: As seen in Table 3, this relationship is statistically significant and features a Spearman correlation of .201, suggesting a weak to moderate relationship between median household income and the number of primary care physicians per 100,000 population. The r-squared value of .04 indicates that 4% of the variability in the number of primary care physicians can be accounted for by median household income.

H_7: As seen in Table 3, the p-value (.343) falls above the .05 threshold for significance, resulting in acceptance of the null of no relationship. This is reflected in the weak Spearman correlation of -.041. In addition, the r-squared value of .002 indicates that only .2% of the variability in the number of primary care physicians can be accounted for by percent elderly population.

H_8: As seen in Table 3, the p-value (.178) falls above the .05 threshold for significance, resulting in acceptance of the null of no relationship. The weak Spearman correlation (.137) and r-squared value (.019) reflects this, indicating that only 1.9% of the variability in the number of primary care physicians can be accounted for by white population size.

Discussion of Results

The results produced by H_5 are similar to those produced by H_1. With a p-value well below the threshold for significance, it is evident that a statistically significant relationship between population density and physician quantity exists

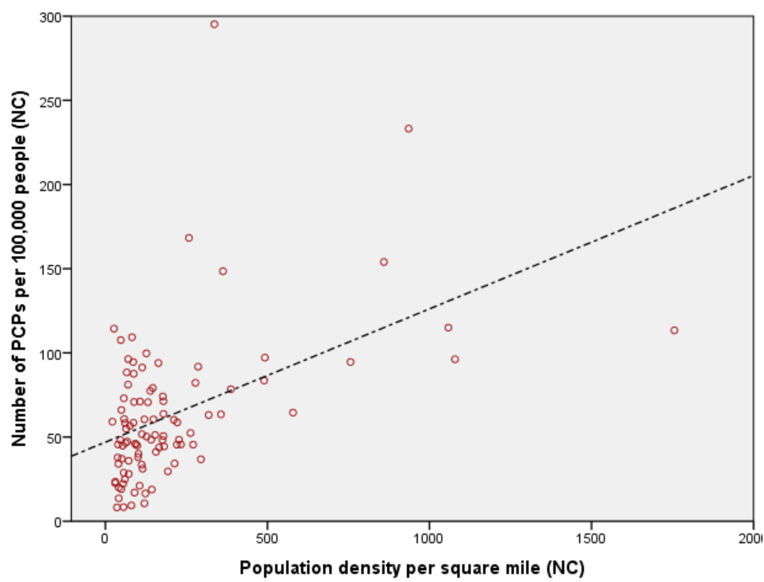

Figure 7

within North Carolina. The fact that this relationship maintains such a high level of statistical significance despite the absence of independent cities to serve as concentrated pockets of population density is a testament to its validity. Figure 8 provides additional insight into the distribution of primary care physicians according to population density.

The scatter plot seen in Figure 8 is grouped by population density range, which aids in distinguishing the concentration of data as well as identifying trends in the association between population density and the quantity of primary care physicians. The highly variable number of primary care physicians per 100,000 people among counties with population densities below 100, and even under 200, demonstrates that an estimation of approximate physician count relative to population density among the least populous counties cannot be consistently determined. A more consistent relationship between physician quantity and population density for any given county does not manifest until population density surpasses 300. At this threshold, Figure 8 illustrates a consistently high quantity of physicians relative to population density when compared to most counties with lower population densities. The consistency with which counties in North Carolina with higher population densities feature high physician quantities provides additional credence to the claims of urban-rural health care disparity frequently espoused in the literature (Rosenblatt & Hart, 2000).

Unlike H_2, H_6 achieves statistical significance, rejecting the null of no relationship. There is a statistically significant positive relationship between median household income and physician quantity in North Carolina. This finding conforms with the assertion made by most scholarly literature that health care professionals are drawn to affluent areas due to the potential for higher earnings

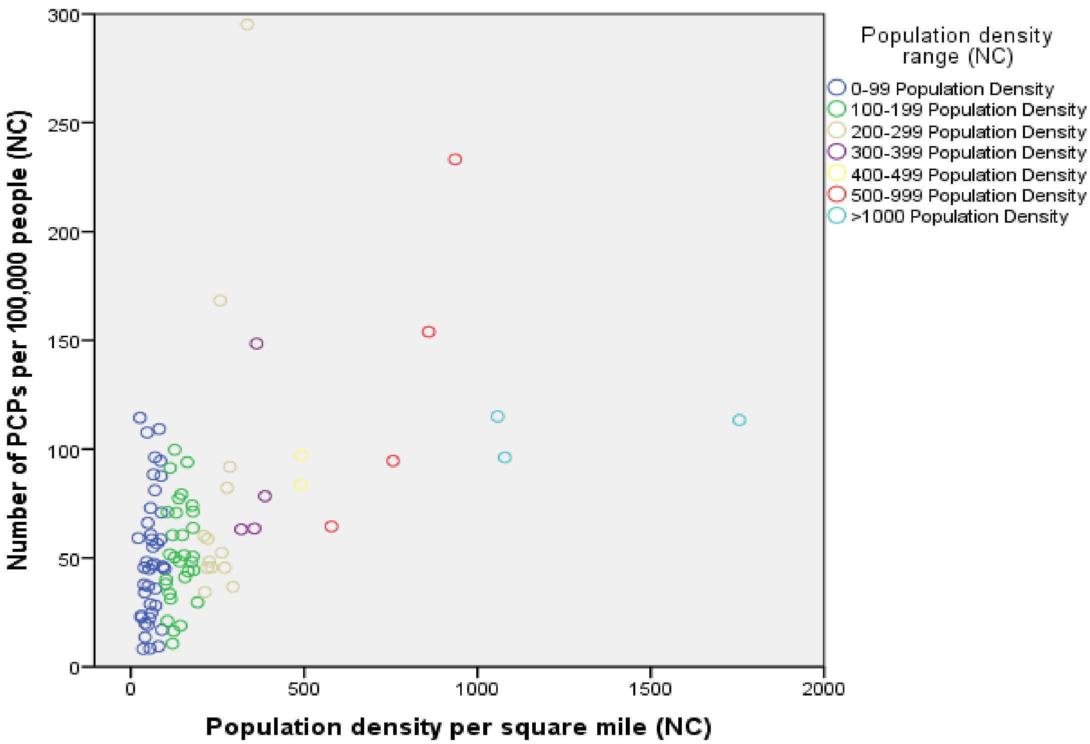

Figure 8

(Rosenblatt & Hart, 2000). As mentioned in the previous section, the concentration of wealth, population, and physician quantity in northern Virginia localities contributed to acceptance of the null hypothesis for H_2. Figure 10 conveys the relative absence of wealth concentration in areas with high population density in

North Carolina. Indeed, if physicians increasingly move from less affluent areas, often inner-city neighborhoods, to more affluent areas, often suburban areas with less population density, this relationship will strengthen in the future (Thomas, 2014). H_6

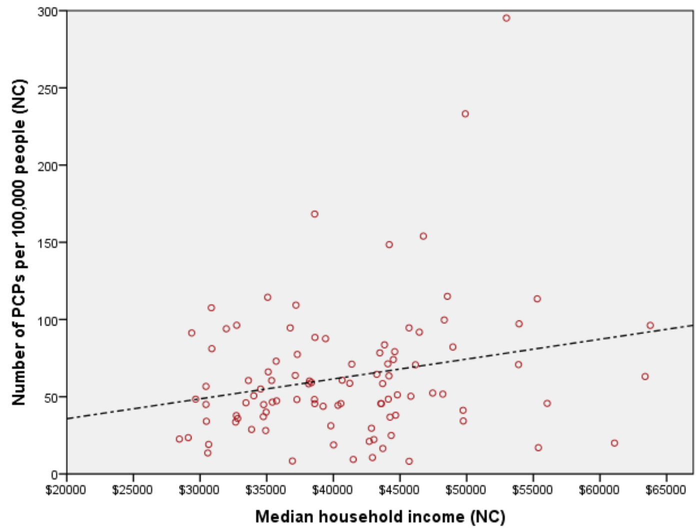

Figure 9

highlights the importance of possessing data able to distinguish between

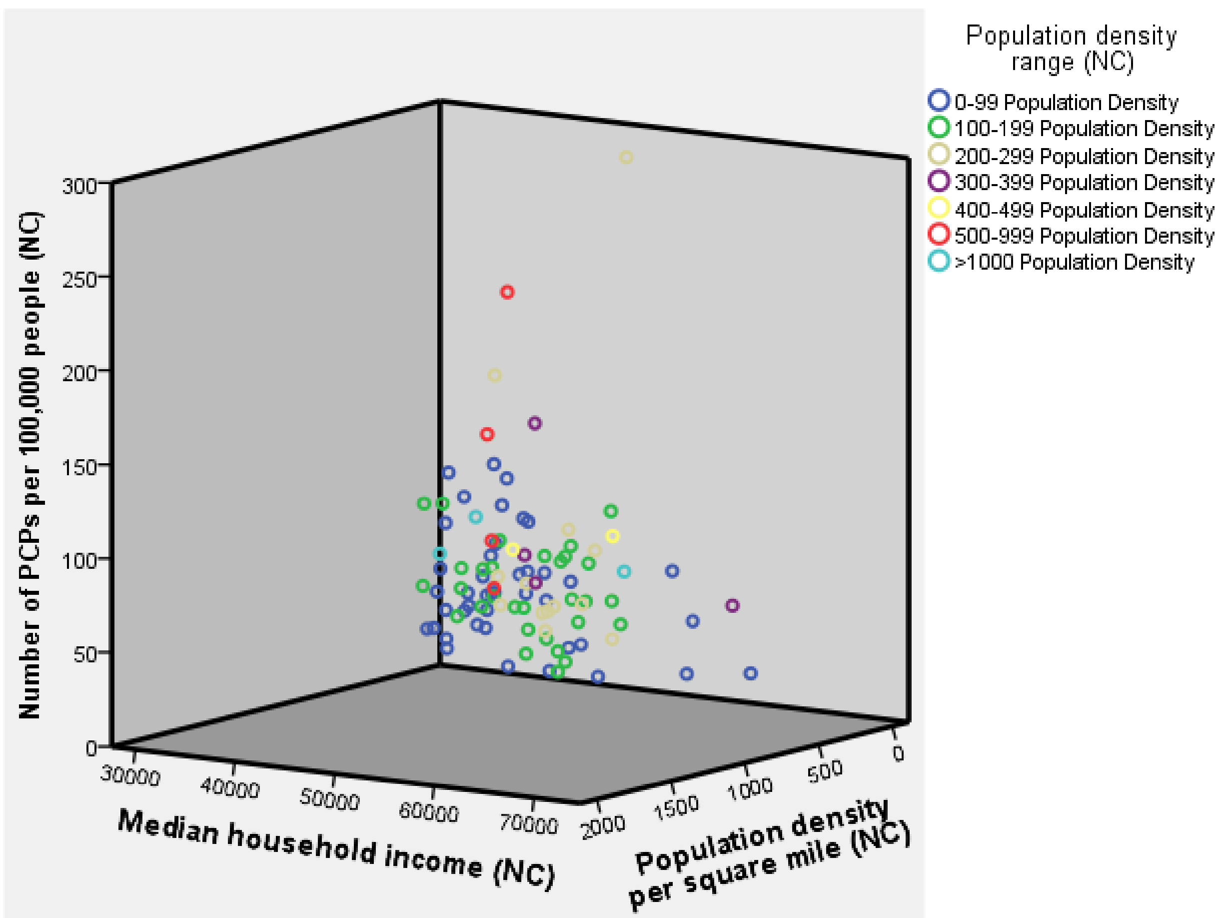

Figure 10

affluent/poor and urban/rural communities. The subsequent comparative analysis section provides additional insight into H_6 through a discussion of sprawl, relevant descriptive statistics, and the impact of this paper's methodological approach.

In contrast to the nearly identical results produced by H_1 and H_5, the results of H_7 represent a marked shift from those of H_3. H_7 fails to reject the null, indicating that there is no statistically significant relationship between percent elderly population and physician quantity in North Carolina. This is particularly surprising given the similar age distributions and associated elderly population characteristics between North Carolina and Virginia. A cursory examination of Figure 12 reveals that the overwhelming majority of counties with elderly populations greater than 20% also feature population densities under 200, and counties with the smallest elderly populations are among the most populous localities in the state. Although the direction of the relationship remains negative, providing little reason to believe that any association found outside of these states would feature positive directionality, any correlation between percent elderly population and physician supply likely features some interaction with population

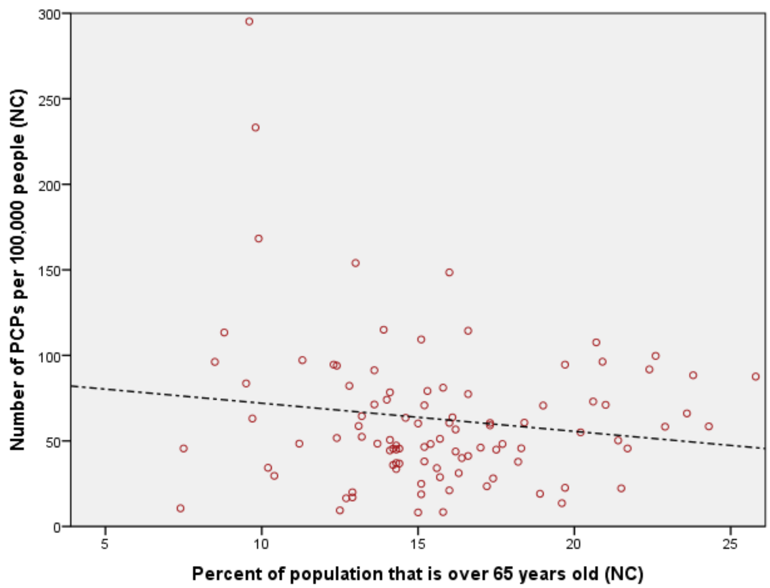

Figure 11

density. As migration from rural communities continues to be age selective (Johnson, 2006), increasing the percent of their populations comprised of the elderly, it will only become more difficult to delineate the effects of elderly population and population density.

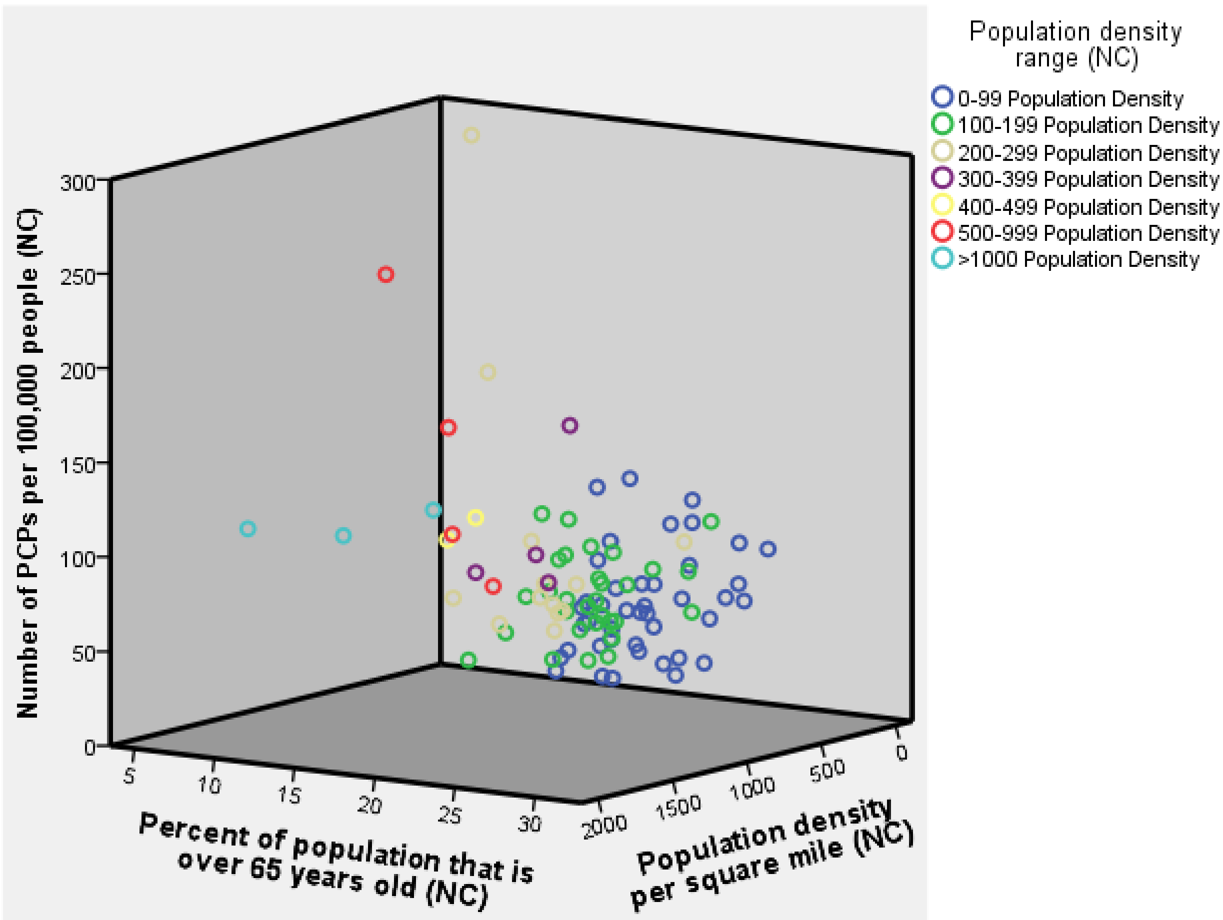

Figure 12

Lastly, H_8 maintains the statistical insignificance of H_4. Undoubtedly, it is difficult to empirically demonstrate a relationship between race and the distribution of primary care physicians. This is not due to the absence of well documented disparities in care among minority groups, of which there are plenty (Newacheck et al., 1996; Fiscella et al., 2002), but rather due to the complicated, multifaceted nature of the challenges inherently faced by such groups. Although the literature supports the claim that minorities disproportionately face difficulties with respect to health care access, quality, and availability (Newacheck et al., 1996; Fiscella et al., 2002), dissecting the underlying linguistic, cultural, and economic barriers and their relationship to the distribution of primary care physicians is beyond the scope of this paper (Scheppers et al., 2006). Therefore, it is possible that the statistical insignificance of H_8 is the product of the independent variable's insufficient specificity. Furthermore, a smaller unit of observation, such as a comparison of neighborhoods rather than counties, would likely produce more useful results with respect to H_4 and H_8.

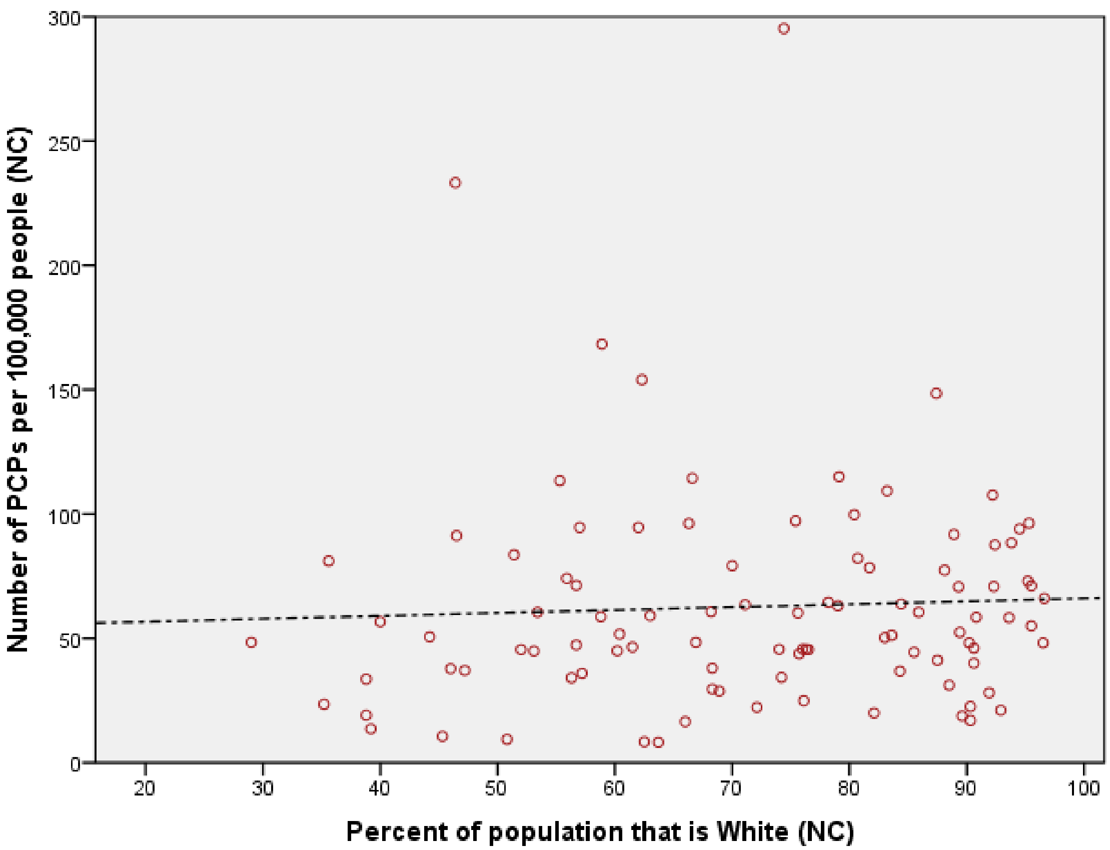

Figure 13

In summary, the results presented in this section offer additional insight into the findings of the previous section as well as the broader research question this paper seeks to answer. Nearly identical to the Virginia findings, there is a strong positive relationship between population density and physician quantity in North Carolina, providing additional credence to claims of urban-rural health care disparity. However, the income and elderly population variables produced results inconsistent with those of the Virginia section. The relationship between median household income and physician quantity shifted toward significance, whereas the relationship between elderly population and physician quantity shifted toward insignifiance. In the case of the former, not only does the North Carolina data have lower average median household income, but it also features less wealth concentration in areas with high population density. More evenly distributed income levels by population density increased the validity of median increased the validity of H_6. In the case of the latter, the North Carolina results realize the concerns expressed in the previous section that significant interaction between elderly population and population density limits the validity of percent elderly population as an accurate indicator of underserved areas. Lastly, the race variable remained consistent in its finding of no relationship between percent white population and physician quantity. Similar to Virginia, it appears that the unit of observation lacks sufficient specificity to accurately measure any association between race and the distribution of primary care physicians. The following section expands upon the analysis of these findings through additional comparative evaluation, important descriptive statistics, and discussion of the effect that sprawl and other characteristics unique to each state have on several variables.

Comparative Analysis

Table 4

Summary of Findings

Virginia	H_1: Pop. Density	H_2: Income	H_3: Elderly Pop.	H_4: Race
Significance	.000*	.486	.020*	.084
Correlation	.629	.062	-.206	-.153
North Carolina	**H_5: Pop. Density**	**H_6: Income**	**H_7: Elderly Pop.**	**H_8: Race**
Significance	.000*	.047*	.343	.178
Correlation	.436	.201	-.041	.137

* indicates statistical significance

Population Density

Through an examination of county-level data for both Virginia and North Carolina, this paper finds that the relationship between population density per square mile and the quantity of primary care physicians per 100,000 people remains statistically significant in both states. Moreover, these levels of significance remain the highest among all of the other tested hypotheses for both states, surpassing the more stringent threshold of $p<.01$. There are two components to this finding: (1) that physician shortages are more likely to occur in rural areas and (2) that this relationship remains true despite variable sociodemographic factors and units of observation.

The first component aligns with longstanding evidence highlighting the problem of insufficient rural physician supply (Laditka et al., 2009; Rosenblatt and Lishner, 1991). Although the literature indicates that supply disparity is more profound with respect to subspecialty physicians (Rosenblatt and Lishner, 1991), this finding provides more credence to the claim that primary care physician disparity by population density is similarly prevalent. However, concern has also been raised regarding insufficient numbers of primary care physicians in some urban areas (Institute of Medicine, 1996). If that is the case, one would expect a curvilinear relationship in which moderately populated observations, such as predominately suburban localities, feature the highest physician quantities whereas lowly and highly populated observations suffer physician scarcities. The positive Spearman correlations and overall scatter plot distributions produced by H_1 and H_5 do not reflect the curvilinear relationship suggested by such literature.

Several factors contribute to the data's fit to a monotonic rather than a curvilinear model. Most notably, the use of county-level data is not specific enough to detect the type of relationship suggested by literature claiming that some urban areas experience physician shortages similar to those of rural areas. Previous literature examining urban physician supply employ units of observation smaller than counties and independent cities, such as neighborhoods (Walker et al., 2010). When evaluating physician supply exclusively within densely populated cities, however, inequity in primary care physician supply has been found to be more

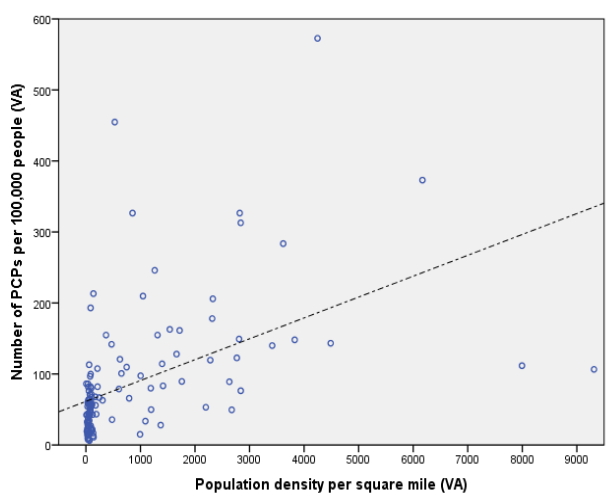

Figure 1

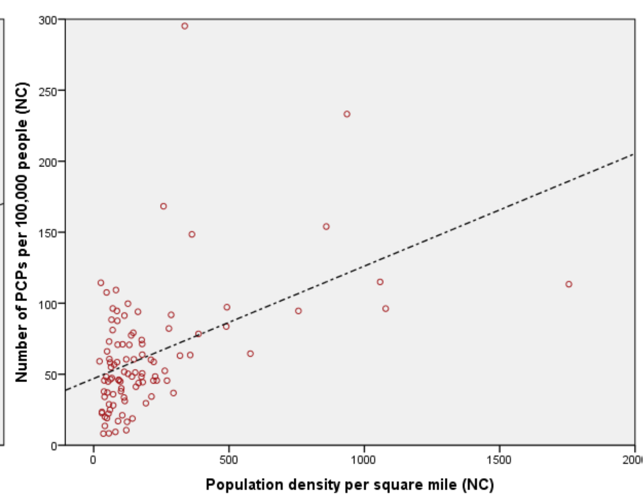

Figure 7

accurately associated with income and minority population than population density (Rosenblatt and Lishner, 1991).

Regardless, lower than expected physician quantities in cities and counties with extreme population densities—those beyond two standard deviations from the mean—allude to a relationship in which densely populated areas experience physician scarcity comparable to sparsely populated areas. As seen in Figure 7, the three observations with the greatest population densities exhibit this phenomenon to some extent. These outliers, which include New Hanover County, Wake County, and Mecklenburg County, exhibit lower numbers of primary care physicians than what one would expect for such populous counties. The Virginia data presented in Figure 1 provides a more noticeable example of this phenomenon due in large part to the lesser degree of sprawl in Virginia relative to North Carolina. The two observations with the greatest population densities, Arlington County and Alexandria City, possess physician quantities relative to their populations similar to those of significantly less populous jurisdictions. This paper cannot arrive at any conclusions regarding the threshold at which population density becomes negatively associated with primary care physician quantity—or even whether such a relationship exists—due to the previously mentioned unit of observation limitation and an insufficient sample size of densely populated observations.

Figure 1 and Figure 7 provide greater insight into the more novel second component of this paper's finding concerning the relationship between primary care physician quantity and population density. The concentration of observations seen in Figure 1 is more than likely a product of Virginia's cities constituting subdivisions of the state independent from surrounding counties, which not only creates more observations but also creates many jurisdictions without the population density boost provided by encompassing nearby cities. On the other hand, observations are more evenly distributed in Figure 7 due to a combination of the absence of independent cities as geopolitical units of observation and greater sprawl. Figure 14 overlays these scatter plots, provides lines of best fit, and crops out extreme outliers to improve readability. The exclusion of many of the previously mentioned extreme outliers provides greater clarity, thus highlighting the similar distribution of observations with low population densities for both states. In both Virginia and North Carolina the overwhelming majority of counties and cities with

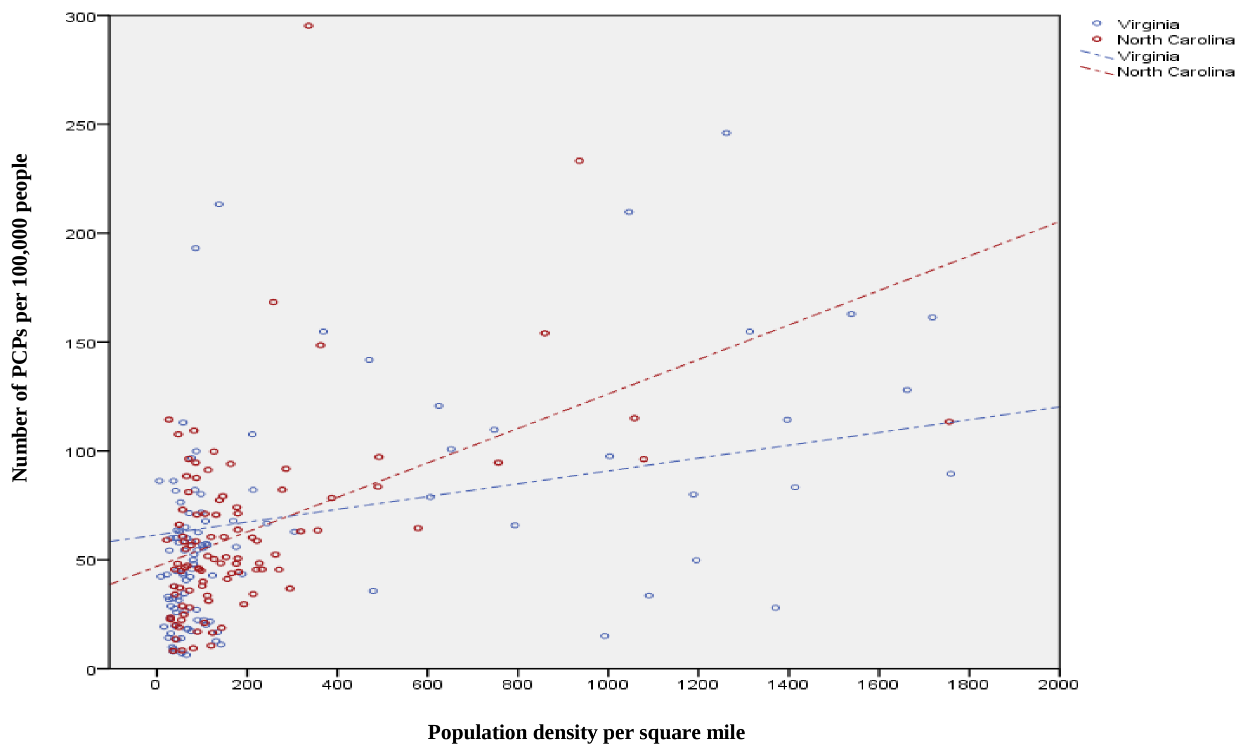

Figure 14

low population densities possess fewer than 100 primary care physicians per 100,000 people. The strength of this relationship's statistical significance in both states despite striking differences with respect to sprawl and the presence of independent cities is a testament to its generalizability and scholarly acceptance as an accurate tool to identify where public policy intended to relieve physician scarcity should be directed.

Income

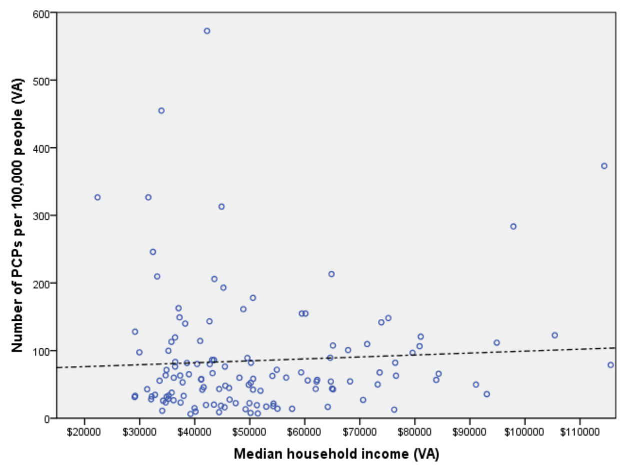

Figure 2

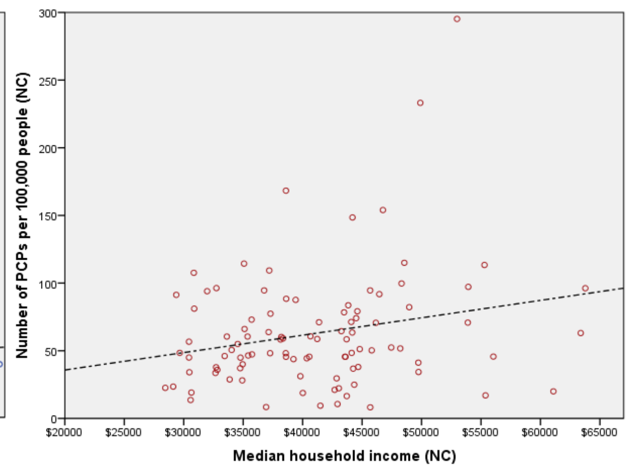

Figure 9

Unlike H_1 and H_5, this paper does not find the hypothesized relationship between median household income and the quantity of primary care physicians per 100,000 people to maintain statistical significance in both Virginia and North Carolina. Rather, the p-value changes from a large value of .486 in Virginia to .047 in North Carolina, meeting the $p<.05$ threshold for statistical significance. Similarly, the Spearman correlation increases from .062 in Virginia, suggesting a very weak positive correlation, to .201 in North Carolina, indicating a weak to moderate positive correlation. The vast difference in statistical significance and correlation between H_2 and H_6 establishes median household income as one of the most compelling and seemingly volatile independent variables examined in this paper.

Despite the remarkable shift in statistical significance, an analysis of the scatter plots for H_2 and H_6 reveals a similar explanation for the differing observation distributions as in the previous analysis of H_1 and H_2. Indeed, the Virginia data is characterized by greater variability, both in terms of median household income and the supply of primary care physicians, compared to the North Carolina data. Greater economic opportunity present in independent cities and counties in northern Virginia relative to the rest of the state heavily influences the income distribution observed in Figure 15. This suggests that variation in median

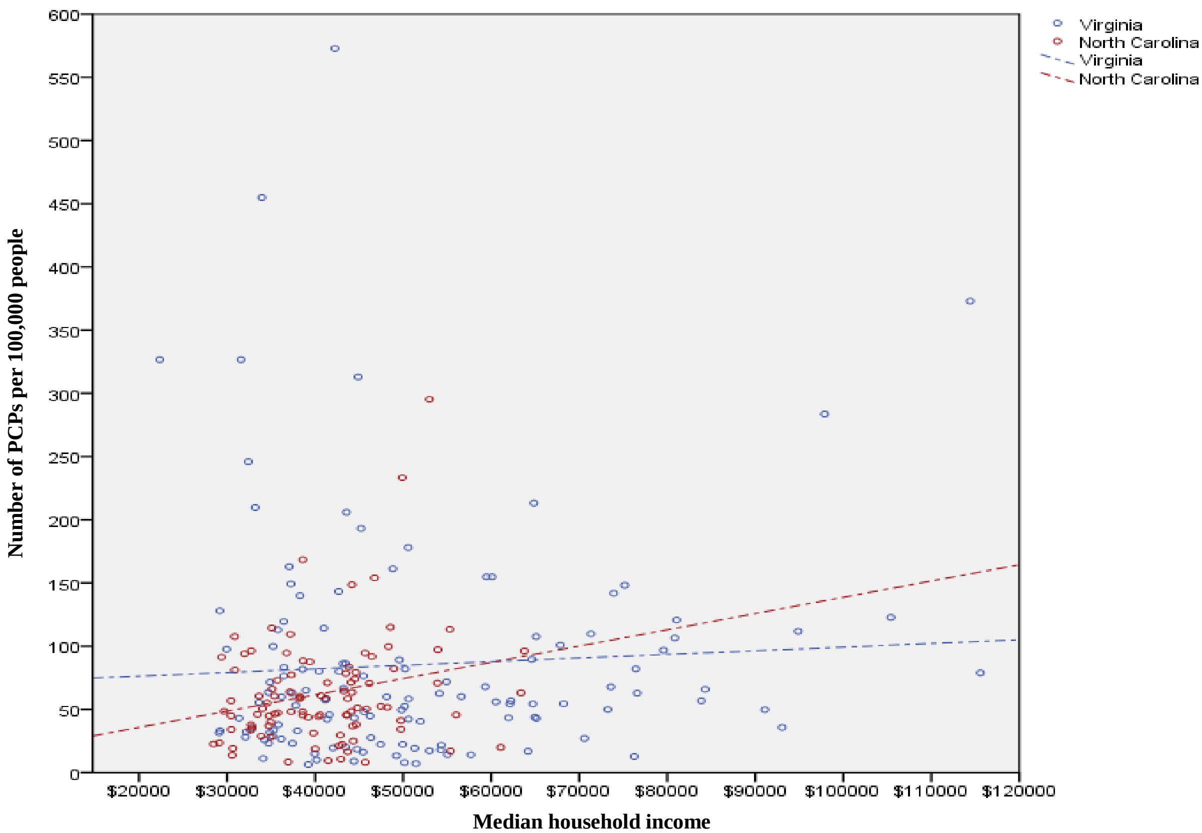

Figure 15

household income is largely dictated by population, however, such an understanding of the relationship between income and physician quantity is potentially misleading and inaccurate given the failure of H_2 to ride on the statistically significant coattails of H_1, so to speak.

The conflicting results produced by H_2 and H_6 are better understood through an examination of relevant descriptive statistics rather than a cursory examination of scatter plots. Virginia's counties and independent cities feature a mean median household income of $51,189 with a standard deviation of $18,478, whereas North Carolina's counties feature a lower mean median household income of $40,848 with a standard deviation of only $7,696. In conjunction with a lower mean median household income and less variance, median household income is positively associated with primary care physician quantity in North Carolina due to the incorporation of low-income urban populations with surrounding high-income suburban populations.

Furthermore, the overwhelming majority of Virginia observations at the lower end of the median household income spectrum featuring high concentrations of primary care physicians are comprised of independent cities with moderate population densities, such as Galax and Fredericksburg. These independent cities often provide the only accessible major hospital for surrounding rural areas—or at least the hospital with the most comprehensive medical services in the region, as is the case with Mary Washington Hospital in Fredericksburg. Consequently, the failure of H_2 to reject the null is a sociodemographic and methodological problem unique in several respects to Virginia. H_6 is likely generalizable in the context of states where cities are not considered county equivalents.

Elderly Population

Similar to H_2 and H_6, this paper does not consistently support the hypothesized relationship between percent of population over age 65 and the number of primary care physicians per 100,000 people. In contrast to the hypotheses evaluating the association between income and physician supply for which statistical significance was found in North Carolina but not Virginia, the hypotheses testing the association between percent elderly population and physician supply achieved statistical significance in Virginia but not North Carolina. Both H_3 and H_7 produced negative correlations indicating that localities with larger elderly populations are associated with lower numbers of primary care physicians. Given the states' similar age distributions, the associated causes and implications are more difficult to diagnose than H_2 and H_6.

A cursory examination of relevant descriptive statistics reveals that the percent elderly populations in Virginia and North Carolina are more similar than any other tested independent variable. The mean percent of the population over the age of 65 is 15.6% in both states, which is unsurprising under the assumption that health care services and lifestyle choices are sufficiently similar for adjacent states to the extent that average life expectancy is not reasonably expected to change. In contrast, the median percent elderly population in Virginia is 16.1% with a standard deviation of 4.4 whereas the median percent elderly population in North

Carolina is 15.2% with a standard deviation of 3.8. Prior to any visual evaluation of the distribution of observations, it is evident that the Virginia data features stronger outliers than the North Carolina data once again.

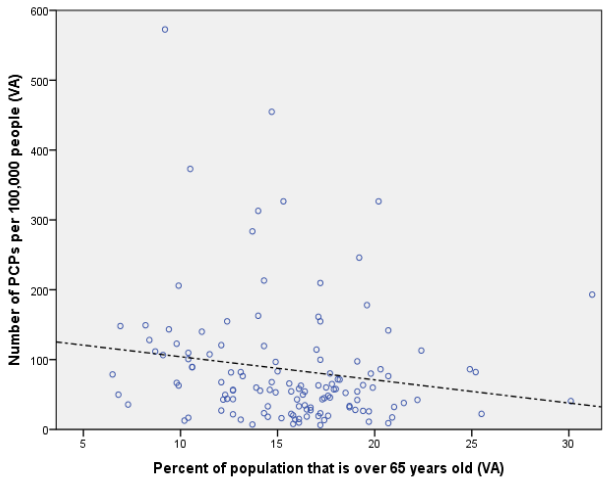

Figure 3

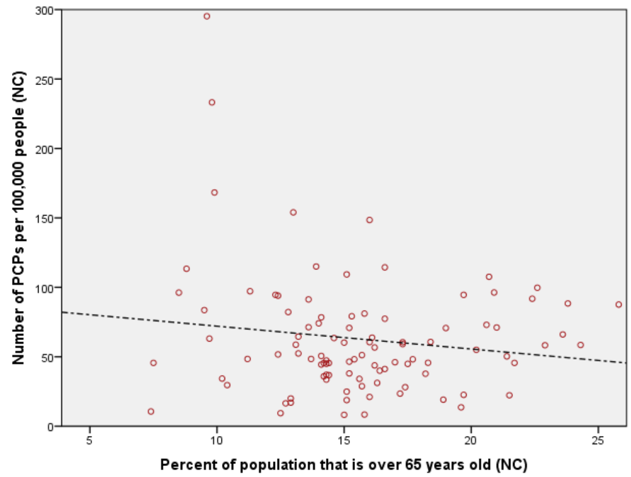

Figure 11

Figure 3 and Figure 11 illustrate the distribution of observations for Virginia and North Carolina, respectively. Given the close similarity of the Virginia and North Carolina percent elderly data, an overlaid scatter plot does not provide the same degree of insight for this variable as it does with others. Figure 11 demonstrates that greater sprawl combined with fewer concentrated pockets of non-elderly individuals due to the absence of independent cities results in more tightly distributed observations with a weaker correlation. On the other hand, Figure 3 shows many of the rural areas seen clustered together in Figure 1 now situated below the line of best fit between 10 and 20 percent elderly population. In addition, many of the independent cities with low median household income and high physician supply in Figure 15 are now mirrored in Figure 3. In conjunction, these characteristics unique to Virginia push H_3 over the $p<.05$ threshold for significance despite a weak correlation of -.206. Therefore, the generalizability of H_3 is questionable outside of the context of Virginia.

Race

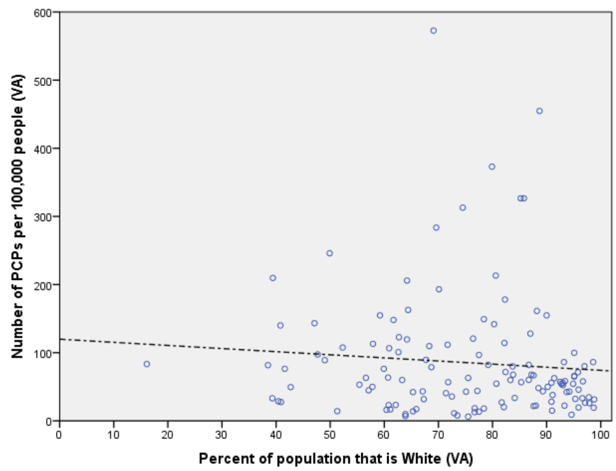

Figure 4

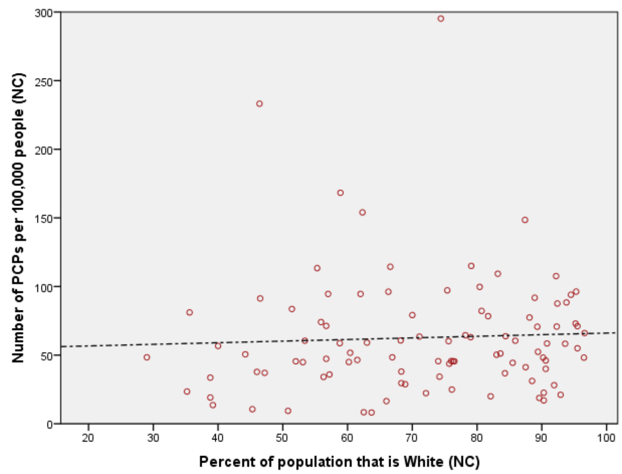

Figure 13

Lastly, this paper does not support the hypothesized relationship between percent white population and quantity of primary care physicians per 100,000 people in either Virginia or North Carolina. This is the only independent variable for which both hypotheses fail to reject the null. In fact, the p-value increases from .084 for H_4 to .178 for H_8, and the Spearman correlation decreases and changes directions from -.153 for H_4 to .137 for H_8. As discussed in the Virginia and North Carolina sections, reasons for the failure of H_4 and H_8 to reject the null include inherent operationalization challenges and units of observation lacking the necessary specificity.

In most cases failure to find a statistically significant relationship in and of itself constitutes a finding, but in this case the hypotheses' failure to reject the null is the result of a concept that is challenging to operationalize with sufficient methodological rigor: minority population. The use of percent white population as the independent variable rather than percent minority population avoids the methodological minefield that is operationalizing what constitutes a minority group. This involves delineating race, ethnicity, culture, and other competing notions of what constitutes a minority group. Even after such a thorough operationalization, questions still remain regarding capturing adequate sample sizes and accounting for the inevitable interference of numerous socioeconomic variables.

Unfortunately, the methodological rigor demanded by the complicated, multifaceted notion of a minority population is beyond the scope of this paper. Despite literature indicating that minority communities are typically underserved (Walker et al., 2010), this paper's statistical analyses did not find a statistically significant relationship between race and physician supply at least in part due to the insufficient specificity of the unit of observation.

In summary, this section conveyed the difficultly of conclusively identifying factors associated with the distribution of primary care physicians. The income and elderly population hypotheses were not consistently supported, and the race variable was assessed in a manner that could not accurately detect meaningful relationships. Only the hypotheses regarding population density found support in both Virginia and North Carolina. The following section summarizes the findings presented thus far, provides concluding remarks regarding these findings, and presents implications for researchers, policymakers, and public administrators.

Conclusion

Primary care physicians operate on the front lines of health care. They serve as generalists at the first point of contact and function as gatekeepers, providing referrals to specialists when appropriate. Although primary care physicians play a critical role in improving health outcomes (Macinko et al., 2007), workforce trends in the United show a growing shortage of primary care physicians as demand for primary care rises (Starfield et al., 2005; Bernstein et al., 2003). Despite attempts by the PPACA to remedy the projected primary care physician shortfall through numerous provisions designed to increase physician training, improve productivity, and address inequitable geographic distribution (Heisler, 2013), such provisions have failed to reverse the physician shortfall trend due to population growth, aging, and the corresponding increase in health care utilization (Petterson et al., 2012).

In conveying the importance of primary care physicians, the worsening physician shortage, the inequitable distribution of providers, and the lackluster institutional response thus far, this paper has called into question the effectiveness of current indicators used to identify underserved areas and provide appropriate government relief. Strict and outdated HPSA/MUP criteria can potentially designate areas with serious physician shortages as ineligible for applicable federal assistance, increasing the likelihood of policies ineffectively allocating limited, essential resources. Furthermore, most CAHs do not meet the location requirements to become a CAH in the first place, resulting in the allocation of hundreds of millions of taxpayer dollars to hospitals in close enough proximity to another hospital to call into question whether the area they serve is truly underserved (Minich et al., 2013). As the quantity of physicians continues to shrink relative to population size and geographic inequities in physician distribution persist, it is of growing importance that policymakers reevaluate theoretical underpinnings and commonly held assumptions regarding the distribution of primary care physicians. What factors should policymakers consider when attempting to identify underserved areas? More specifically, what factors are associated with the distribution of primary care physicians?

The findings presented in this paper highlight the difficultly of conclusively answering this question. This paper found a statistically significant positive relationship between population density and physician quantity in both Virginia and North Carolina, meaning that localities with higher population densities are associated with higher physician quantities and those with lower population densities are associated with lower physician quantities. Consistently significant results across both states strengthen this relationship's generalizability and provide further credence to claims in the literature of urban-rural health care disparity. However, the hypotheses pertaining to income and elderly population demonstrated varying degrees of significance across both states.

Whereas the hypotheses evaluating the association between income and physician supply found statistical significance in North Carolina but not Virginia, the hypotheses testing the association between percent elderly population and physician supply achieved statistical significance in Virginia but not North

Carolina. On one hand, the correlation between median household income and physician quantity was positive in Virginia and North Carolina, meaning that localities with lower median household income are associated with lower physician quantities and those with higher median household income are associated with higher physician quantities. On the other hand, the correlation between percent elderly population and physician quantity was negative in Virginia and North Carolina, meaning that localities with smaller elderly populations were associated with greater physician quantities and those with larger elderly populations were associated with lower physician quantities. Although this paper's findings with respect to directionality align with the literature, failure to support the hypothesized relationships in both states undermines their generalizability.

Indeed, these findings call into question the validity of income and elderly population as accurate indicators of underserved areas. This is cause for particular concern given their prominent role in determining where essential government assistance is allocated. For example, the MUA designation process employs the Index of Medical Underservice (IMU) to determine whether an area is underserved, and two of the four variables used to determine an area's IMU score are income and elderly population (Health Resources and Services Administration, 1995; Heisler, 2013). If the income and elderly population variables exhibit consistent negative directionality across different states yet inconsistent significance, policymakers and public administrators run the risk of misallocating resources to adequately served areas, or worse, not recognizing truly underserved areas.

Lastly, this paper did not find a statistically significant relationship between race and physician quantity. This does not raise as much concern as the findings pertaining to income and elderly population because race does not currently serve as a significant determinant in the designation of underserved areas. That is not to say that race is definitively ruled out as a variable associated with the distribution of primary care physicians, as the challenges disproportionately faced by minorities with respect to health care access are well documented (Newacheck et al., 1996; Fiscella et al., 2002; Scheppers et al., 2006), but inadequate methodological rigor necessitated by the scope of this paper produced insignificant results inconsistent with much of the literature. The failure to identify an association between race and physician quantity was likely a product of inherent operationalization challenges and units of observation lacking sufficient specificity. Researchers, policymakers, and public administrators should still consider formal and informal accessibility barriers associated with certain ethnic groups, as well as any interaction with income and geopolitical location.

Based on these findings it is evident that additional research must be conducted, and future research should examine indicators of underserved areas individually and on a national scale to increase their validity. This is particularly true for variables that require thorough conceptual understanding and smaller units of observation to accurately measure, such as race. Researchers, policymakers, and public administrators should also reevaluate the methods used to designate underserved areas. Weak and potentially spurious associations between physician quantity and variables such as income and elderly population weaken the effectiveness of programs using them as indicators of underserved areas. Consequently, programs that use an HPSA, MUA, or MUP designation to identify areas with low numbers of primary care physicians risk ineffective allocation of limited, essential resources.

Regardless, this paper's findings pertaining to the association between population density and primary care physician quantity demonstrate the relationship's generalizability and reinforce its scholarly acceptance as an accurate indicator of where public policy intended to relieve physician scarcity should be directed. When asking what factors are associated with the distribution of primary care physicians, and by extension what factors policymakers should consider when identifying underserved areas, population density is the only variable in the literature and in this paper for which there is consistent support. As demand for primary care continues to increase due to population growth, health care reform, and an aging population, it is essential that policymakers and public administrators possess the tools and knowledge to effectively respond to inequitable physician shortages.

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