PREDICTORS OF PRIMARY CARE PHYSICIANS PRACTICING IN MEDICALLY UNDERSERVED AND RURAL AREAS OF INDIANA

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ABSTRACT

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Purpose: This study examines whether Indiana physicians' choices to practice in medically underserved and rural areas of Indiana are associated with select physician characteristics. **Methods:** Physician data were gathered from the American Medical Association Physician Masterfile. Analysis was limited to primary care physicians currently practicing, whose birth city and/or state were known (if American born) and whose current practice location could be matched to an Indiana ZIP Code. The underserved and rural areas and physician data were mapped using ArcGIS. Chi square and logistic regression analyses were performed to identify significant associations between the physician characteristics and choice of practice location. **Results:** In instances where a physician was born in a county that fell below its state's median income level in the decade of birth, there is a significant likelihood of future choice to practice in underserved and rural areas. Attending a medical school in the Midwest and region of birth (subdivided by state) were proven to have no predictive value. **Conclusions:** This result, when compared with other studies that have found physician hometown to be a predictive factor, seems to confirm and strengthen the argument that factors in a physician's past, including social and economic setting of his or her upbringing, influence choice to practice in underserved and/or rural areas.

Jeffrey Wilson, Ph.D., Chair

TABLE OF CONTENTS

Nathan Bellinger

Introduction 1

Research Purpose 4

Background 4

Methods 9

Physician Data 9

Location Data: Underserved and Shortage Areas 12

Location Data: Rural Classification 17

Statistical Analysis 20

Results and Conclusions 22

Chi Square Test Results 22

Logistic Regression Results: Dataset 1 23

Logistic Regression Results: Dataset 2 27

Discussion 30

Appendices 34

Appendix A: Crosstab Tables 34

Appendix B: Regression Model Predictor Variable Coding 40

References 41

Curriculum Vitae

Introduction

From early detection and treatment of serious chronic disease to the complete prevention of these illnesses, access to primary care is of utmost importance. Cancer, heart disease, and diabetes are the leading causes of death and disability in the United States, accounting for 70% of all deaths or approximately 1.7 million each year [1]. These diseases are also responsible for some type of medication use, procedure or limitation/lifestyle change in the daily lives of nearly 1 out of every 10 Americans (roughly 25 million people) [1]. The Center for Disease Control (CDC) states, in discussion about chronic disease prevention, "although chronic diseases are among the most common and costly health problems, they are also among the most preventable" [2]. The American Cancer Society, American Heart Association and American Diabetes Association all agree that among other preventative measures, regular visits to primary care physicians are the most effective means of reducing the negative effects of these chronic diseases [3]. Further, the Council on Graduate Medical Education (COGME), in its 19th report to Congress, states that a growing body of research shows the United States is facing an increasing shortage of primary care physicians and specialists over the next 20 years [4].

The cost of medical care in the US topped $2.4 trillion in 2008 (about $7,900 per person) and accounted for 17 percent of the US gross domestic product (GDP) [5]. Without substantial change in our health care system, health care spending in the US is expected to increase, reaching an estimated $4 trillion by 2015, or 20 percent of US GDP [6]. Most of these costs are passed along to consumers in a variety of forms, including increased insurance premiums, higher bills at each office visit, and increased state and federal taxes to pay for hospital, ambulance and 911 services. Routine primary physician care helps Americans lower their medical costs by decreasing the need for future services and preventing avoidable hospitalizations and emergency services [7, 8, 9]. However, as of 2006, about 20 percent of the US population resided in places, both rural and urban, that were considered medically underserved areas (MUAs) as defined by the US Department of Health and Human Services [10].

Starfield [1] has shown that greater access to health care, expressed in terms of primary care physician to population ratios, is a positive predictor of health outcomes. As of the year 2000, the US Department of Health and Human Services estimated there were 238,734 primary care physicians (PCPs) in America [11]. That ratio is approximately 85.4 PCPs for every 100,000 Americans (or 1:1,171) [11], which actually exceeds the minimum recommended federal guideline set forth by the Public Health Service Act of 1978 for physician to population ratio (1:3,500 for specified geographic areas, and 1:3,000 for specified population groups) [12]. This guideline is the basis for defining the 'rational service area' concept for determining health professional shortage areas (HPSAs), and continues to serve as the baseline at the time of this study [13]. The fact that some geographic areas are known to be medically underserved or lack an adequate population of health professionals shows that a simple ratio of PCPs to population aggregated at the national level is not sufficient to evaluate actual PCP need. This phenomenon is also known as maldistribution, and is a major focus of health care workforce research [14].

Recently, several studies have focused on the spatial distribution of PCPs. These include examination of distance to nearest provider [15], travel patterns and paths to providers [16], physician shortages in Minnesota [17], health care center service area analysis [18], and new algorithms used in assessing these issues [19, 20]. Wade et al. [21] studied the influence that a rural hometown may have on choice of practice locations of family physicians trained at the Indiana University School of Medicine (IUSM). The study explored IUSM graduates from 1988-1997 who were native to Indiana and remained in Indiana to practice. The US Department of Agriculture (USDA) Urban Influence Codes (1993) were utilized to classify hometown and practice location as either metro or non-metro (for purposes of statistical analysis), and organized the results into a 4 category subset of large metro, small metro, non-metro adjacent to metro, and non-metro non-adjacent. One of its primary aims was to influence IUSM admissions policies to increase supply of physicians in Indiana MUAs by increasing enrollment of students likely to practice in these areas. Wade et al. found that family physicians from non-metro (rural) hometowns were about four times more likely to practice in a non-metro (rural) area compared to those from metro hometowns.

Research Purpose

The purpose of this study was to examine physician characteristics as potential predictors of primary care practice in geographic areas defined as medically underserved, which include MUAs, HPSAs and some rural areas of Indiana. It is important to note that not all rural areas are "underserved", and as such, this research does not focus solely on rural geographic locales.

Background

Physician workforce shortages and geographic maldistribution have been studied extensively in the past several decades. There is little consensus among researchers regarding workforce shortage, with some contending that there may even be an *oversaturation* of physicians (specialists, most notably) in some geographic areas [25]. While it is generally accepted that there are some populations in the US that do not have adequate access to primary care, *why* that continues to be the case has not yet been answered. The current study will contribute to the literature on physician distribution by examining selected variables, readily available through the AMA and US Government databases, as potential predictors of physician choice to practice in areas classified as MUAs, HPSAs and/or rural areas.

Wade et al. [21] examined age at graduation and gender in relation to practice location and concluded these variables were not significant predictors for practice in "rural" areas among physicians graduating from the Indiana University School of Medicine. However, coming from a rural hometown was shown to be predictive of physician choice to practice in rural locations. The current study expands on the work of Wade et al. in part, to consider age at graduation and gender of physicians trained both in and out of the state as possible predictors of practice location choice. Examining different classifications of physician hometown may give a different perspective than looking at hometown alone.

Ellsbury et al. [26] studied year of graduation, physician specialty, practice type, medical school and medical school location to determine gaps in rural practice by gender. That study focused on physicians who graduated from US medical schools from 1988 through 1996. Limiting the study by graduation date allowed Ellsbury et al. to make projections about future trends without skewing the results by including older physicians who may have had cultural biases regarding gender in the profession. The Ellsbury study found that male family physicians and general practitioners were more likely to practice in rural areas than females. Additionally, the study found that just 17 schools (of 122 identified in the AMA Masterfile), produced more than 25% of general practitioners who went on to practice in a rural location, and that medical schools on the east and west coasts tended to graduate higher numbers of female rural physicians. Gender variations in rural generalist populations were also noted in the COGME 10th report [27]. Ellsbury et al. concluded that a dearth of rural female physicians may in fact exist, which may contribute to the problem of maldistribution.

While the Wade and Ellsbury studies only considered physicians who were from the US, the current study also considered foreign-born physicians. The current literature on the role international medical school graduates (IMGs – defined as physicians who graduated from a medical school outside of the US) play in rural physician workforce is mixed. Baer et al. [28] studied all PCPs listed in the AMA Masterfile who were IMGs. They identified rural and underserved areas using combinations of HPSAs and whole counties in their research. They concluded that IMGs comprised a larger percentage of physicians practicing in rural, underserved areas than US medical school graduates. They did temper this conclusion somewhat by indicating that this distribution varied from state to state and may be influenced by individual state policies aimed at reducing physician shortage, rather than showing a predisposition of IMGs to practice in such places. There is also some indication that changes in federal laws in allowing greater access by international medical students, via the J-1 visa waiver program, may have had some effect on outcomes, but Baer draws no specific conclusions, as the program was relatively new, and most international graduates had not taken part in the program. Fink et al. [29] studied a similar cohort using HPSAs for their definition of underserved and classified any area occurring outside of a Metropolitan Statistical Areas as rural. They concluded that, overall, IMGs were no more likely to practice in rural underserved areas than were US trained physicians. There were, however, distinctions between foreign-born, internationally trained, and domestic-born but internationally trained physicians. They found that foreign-born IMG internists were three times more likely to work in rural underserved areas, and foreign-born IMG pediatricians were two times more likely. However, US-born IMG internists were just as likely as US-born, US-trained internists to practice in rural underserved areas. US-born IMG pediatricians were less likely than their US-born, US trained counterparts to do so. This suggests that country of *origin* may be a better predictive factor to underserved practice location than country of training when considering the effect of international physicians. The current study will examine the role that foreign-born PCPs play in medically underserved areas of Indiana by including US-born vs. foreign-born as an independent variable.

Rabinowitz et al. [30] conducted a study of graduates from Jefferson Medical College (which specifically recruits students to become rural family physicians) to determine the effect of their recruitment efforts in supplying and maintaining physicians in rural, medically underserved areas. The Rabinowitz study classified a physician as practicing in a rural area if they were not located in a Metropolitan Statistical Area (MSA). Among other variables, Rabinowitz et al. considered the graduates' economic situation, including expected post-graduate income and medical school debt, in their analysis. Although they found that growing up in a rural area was a significant predictor of practicing in a rural area, they ruled out the economic factors as predictors. Rabinowitz et al. questioned whether the rising debt incurred by graduates will have an effect on practice location in the future. Therefore, the current study also considers an economic predictor variable. Whereas the Rabinowitz study considered future economic prospects of the graduates, the current study examines the economic status of the county of origin of the practitioner. The county of origin (i.e., the county in which the physician was born) is an imperfect variable to determine a student's hometown; however it is the only indicator available from the AMA Masterfile to establish the hometown. The US Census Bureau provides historical data of mean income through the 1950's. This study will examine the county in which the PCPs were born to determine whether that county had a mean income above or below the state and national median income. Using these variables may reveal influences of the economic background of the graduates.

A recent study by Phillips et al. [31] distributed by The Robert Graham Center considered many of the factors previously mentioned in conjunction with practice location, and complemented them by considering economic factors such as debt level at graduation, scholarship and pre-enrollment funding, and income differences by specialty. That study found that likelihood of practicing in a rural area increases modestly as debt level rises. Both the Rabinowitz' and Phillips' studies indicate economic factors, both in background and in the future prospects of a physician, are predictive of geographic selection of practice location.

Methods

Physician Data

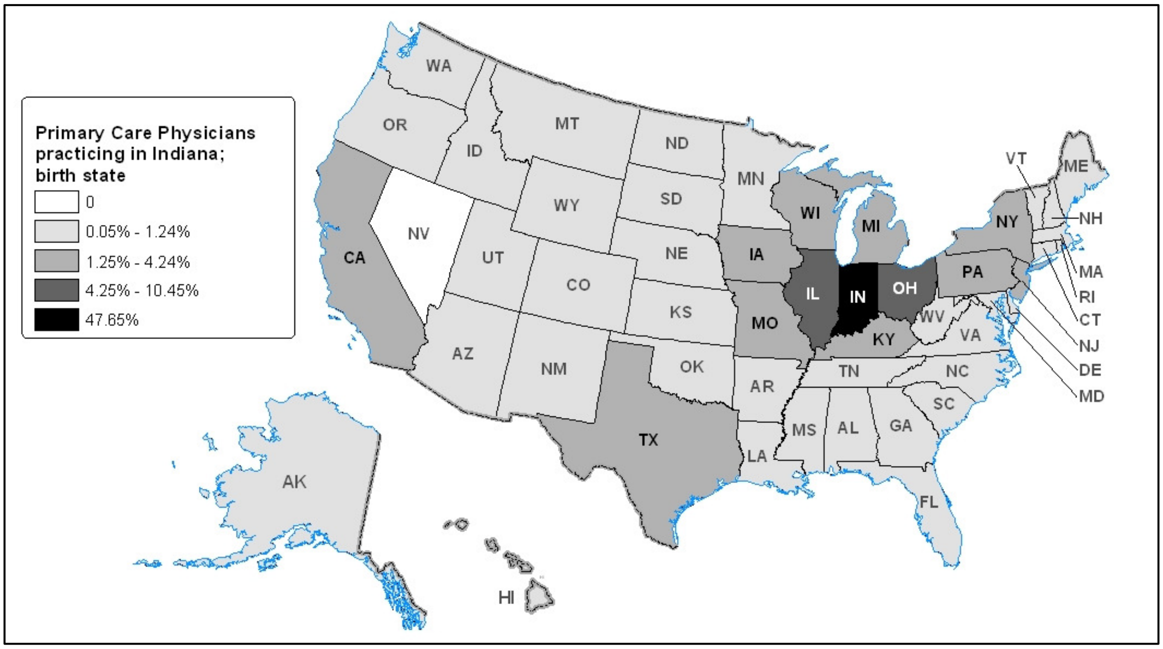
The AMA Masterfile provides information about all physicians who are United States residents and who have met the educational requirements for physicians. The file includes doctors who are not members of the AMA as well as internationally trained physicians. Data in the Masterfile are collected primarily from medical schools (a record is created for each student entering an accredited institution) and continuously updated via surveys [32]. The Masterfile has been a primary source of data for studies on physician supply in the US [33, 34, 35]. From the initial listing of all 16,181 Indiana physicians, those whose primary practice address was not in Indiana were excluded (9,166) leaving 7,015. Physicians whose country of origin, birth city or state was unknown were excluded (1,096), leaving 5,919 records. Physicians were next limited by their primary specialty to include only physicians who are primary/preventative care practitioners (excluded 3,270). Of the remaining 2,649, physicians whose Primary Type of Care was not identified as direct patient care in the Masterfile were excluded (322 records), leaving 2,327 physician records for analysis (Table 1).

Table 1: Detail of physician records excluded from AMA Masterfile for use in this study

Physician records remaining	Explanation of Exclusions
16,181	Initial AMA Masterfile dataset, containing records of living physicians with a current address in Indiana
7,015	After excluding records where address type was not listed as the physicians' professional address
5,919	After excluding records where country of origin (if not United States) was not known, or if a US physician, the birthplace city or state were not known
2,649	After excluding records where physician primary specialty, as indicated by the Masterfile, was not one of the selected codes chosen to determine a PCP
2,327	After excluding records of physicians who were coded as anything other than direct patient care as their primary type of practice

The US Census Bureau has published income data for each Decennial Census [22] since the 1950's. Physician birthplaces from the Masterfile were matched with Census data at the county level and the median income for that county in the corresponding decade was matched to each physician. The earliest data available from the Census Bureau is the 1960 Decennial Census data (covering the decade of the 1950's), and in all such cases where the doctor was born prior to 1950, 1959 income data were used. The median income for each county was then compared to the state and national median income levels for the corresponding decade and noted as falling above or below for each physician. Figure 1 represents birth state of the physicians identified for this study.

Figure 1: Indiana primary care physician's birthplaces



This study follows the 2006 HRSA paper "Physician Supply and Demand: Projections to 2020" [36] and others [1, 21] in defining a primary care physician as one whose specialty is Family Medicine, General Internal Medicine, General Preventative Medicine, Public Health & General Preventive Medicine, or General Pediatrics. The following designations were chosen from the AMA Masterfile to match this definition: FM (Family Medicine), GP (General Practice), GPM (General Preventative Medicine), IM (Internal Medicine), PD (Pediatrics), and PHP (Public Health & General Preventative Medicine). The variables from the Masterfile (referenced in Table 2) were chosen to establish a wide array of background characteristics that collectively create a profile for each individual.

Table 2: Independent variables identified for use in multivariate research, 2006 data

Variable	Description
Foreign-born	Born outside of United States
Gender	Gender of the physician
Age at graduation	Age of the physician at time of graduation from medical school
Medical School in Indiana	State in which the medical school is located (Indiana or all other)
Medical School in the Midwest	State in which the medical school is located (classified as Midwest or all other regions defined by US Census Bureau official Census Regions [37])
Birth state region	State in which physician was born (Northeast, South, Midwest and West –regions defined by US Census Bureau official Census Regions [37])
County of origin above/below STATE median income level	Indicates whether physicians' county of birth was below the state median income level in the decade of birth of the physician (for those born after 1959, the earliest data available)
County of origin above/below NATIONAL median income level	Indicates whether physicians' county of birth was below the national median income level in the decade of birth of the physician (for those born after 1959, the earliest data available)

Location Data: Underserved and Shortage Areas

The Public Health Service Act of 1978 enabled the Department of Health and Human Services to designate geographic areas as 'underserved' or 'shortage' areas, based on certain criteria [38]. The two designations on which this research focuses are MUAs and HPSAs [39]. Geographic areas may be designated as MUAs or HPSAs when they request such status from the Health Resources and Services Administration (HRSA). HRSA defines a MUA by applying an Index of Medical Underservice to certain geographic areas (whole counties, census tracts or minor civil divisions), resulting in a score for each area [40]. Any geographic area given a score of 62 or less (0 being underserved, and 100 being appropriately served) is designated as an MUA. HRSA determines how the Index of Medical Underservice is calculated. HPSAs are defined for primary care, mental health, and dental care disciplines. For the purpose of this study, only areas carrying the HPSA designation and criteria for primary care were examined. Primary care HPSAs are determined by the fulfillment of 3 criteria; 1) the area must be a 'rational' area for delivering medical services (comprised of complete parts of either whole counties, census tracts, block numbering areas or minor civil divisions) [41], 2) the 'rational area' has a primary care-to-population ratio of at least 1:3500, or less than 1:3500 but greater than 1:3000 along with a higher than usual need for PCPs, or an 'insufficient capacity' of existing PCPs in the area and 3) PCPs in adjoining geographic areas to the 'rational area' are "over utilized, excessively distant or inaccessible" [42]. It is significant to note that areas become MUAs or HPSAs only when they request to have such status.

Both MUA and HPSA designations are used as initial criteria for disseminating federal funds to health care institutions to improve access to medical care for the general population. Furthermore, while some MUAs and HPSAs overlap, many do not and are distinct geographic areas, which inspire individual study. Studies that limit their research to only MUAs or only HPSAs may not provide a complete picture of health care shortage because they do not account for patients who may travel from one adjoining area to another for health care. Analyzing both MUAs and HPSAs may better represent patient access across geographic boundaries. For the current study, HPSA's are also analyzed as a stand-alone dependant variable.

The HRSA Bureau of Health Professions National Center for Health Workforce Analysis [10] provides data on MUAs and HPSAs for use by the public. The use of MUAs and HPSAs has been criticized for being too unwieldy and not precise enough to suitably analyze emerging trends, including geographic distribution of health professionals [12]. While a replacement system has been proposed and discussed [12], improved methods for tracking areas of underservice have not yet been adopted by the federal government. Data from 2006, including MUA and HPSA score for each block group, census tract, and county, were compiled from the HRSA [10, 11, 38, 39]. These data were combined with the US Census Bureau's TIGER/Line files [43], using ESRI's ArcGIS 9.2 software, to code each physician record as in or out of an MUA and HPSA and to visualize the distribution of the MUAs/HPSAs, along with the practice location of the PCPs in Indiana. Figure 2 illustrates the MUAs and HPSAs in Indiana in 2006 used in the analytical portion of the current study.

The AMA Masterfile contains self-reported ZIP Codes of physician practice locations. To link physician practice location to MUAs/HPSAs, these ZIP Codes were cross-referenced to MUA/HPSA locations [10, 11, 38, 39] using the ZIP Code driven address matching tool in ArcGIS and each physician was categorized as "0" (does not practice in a MUA/HPSA) or "1" (practices in a MUA/HPSA). If any part of that ZIP Code overlapped with an MUA/HPSA, the entire ZIP Code was considered part of the MUA/HPSA. Figure 3 illustrates the ZIP Codes classified in this manner. This same process was also used to estimate if the practice coincided with HPSAs.

Figure 2: Officially designated MUAs and HPSAs in Indiana

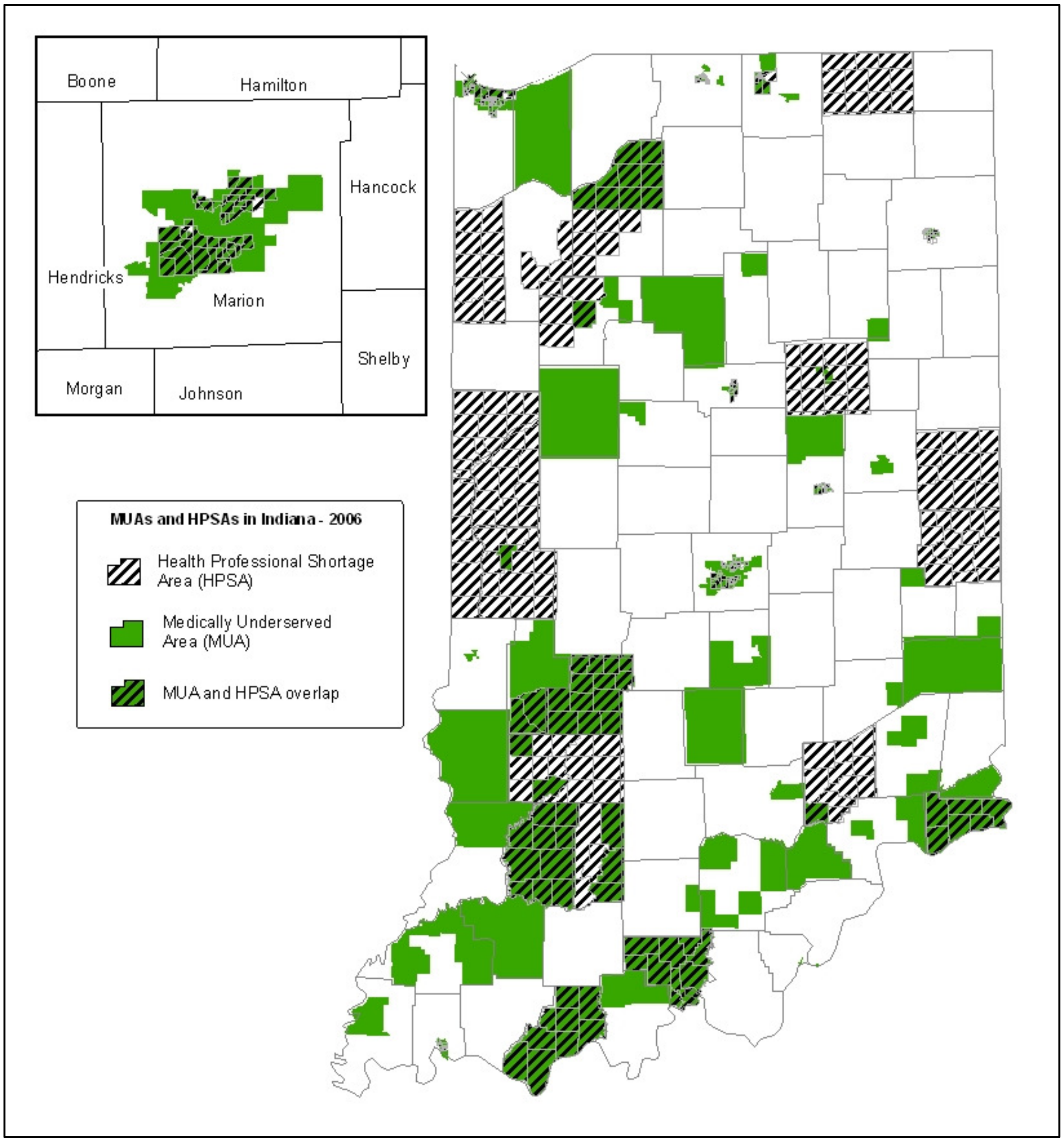
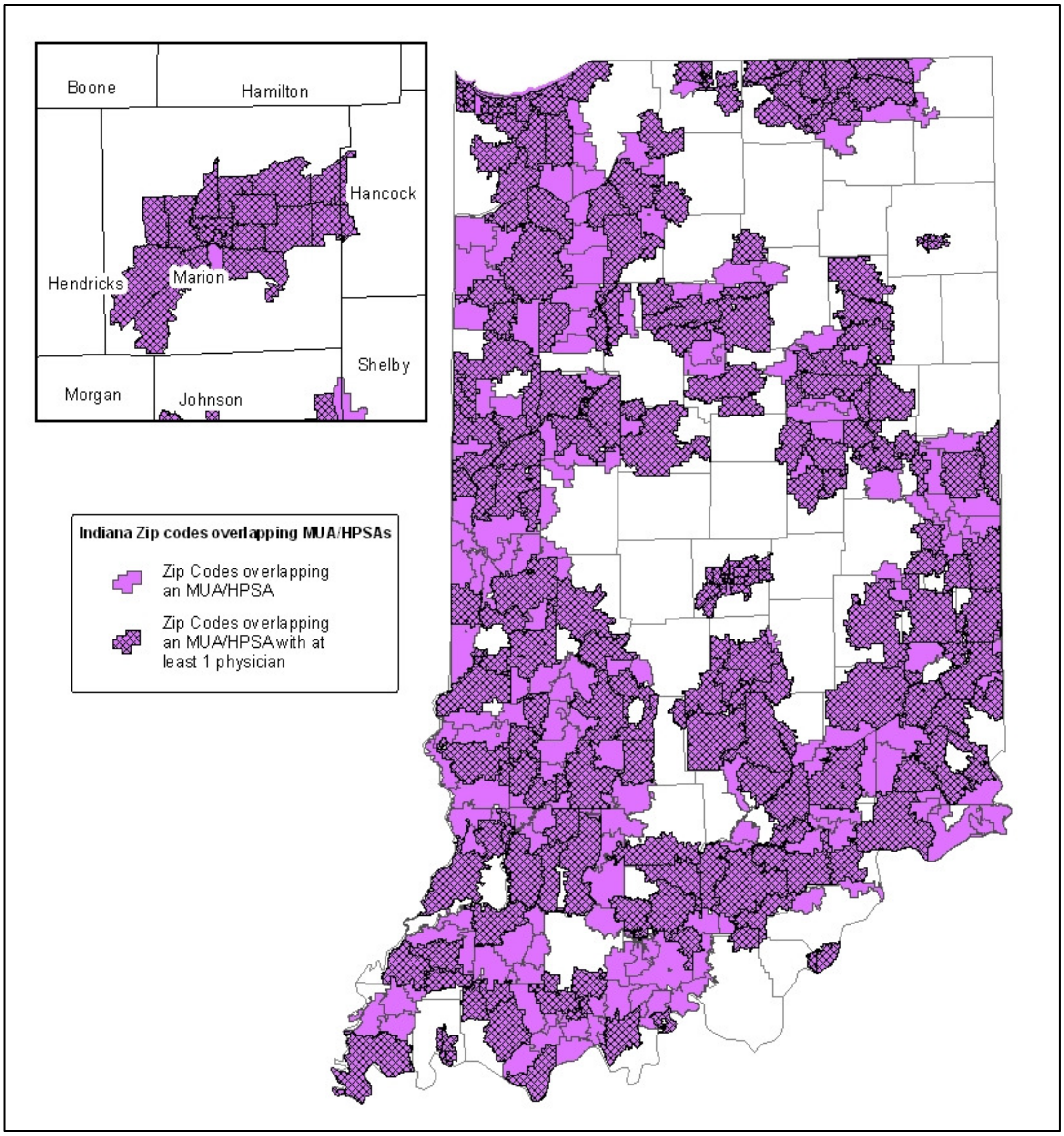


Figure 3: ZIP Codes classified as MUA/HPSA



Location Data: Rural Classification

The USDA uses Rural-Urban Continuum Codes as one method for determining the rural/urban status (also called “rurality” by the USDA) of a given area [44]. Each county is designated with a Code, ranging from 1 to 9, in an effort to classify metropolitan areas by population size, and non-metropolitan areas by level of urbanization. Table 3 lists the Rural-Urban Continuum Codes along with their detailed description. These Codes have been used in other studies on physician maldistribution to identify areas as rural [45, 46]. The USDA updated the Codes in 2003, based on changes made by the US Census Bureau in its methods for defining rurality [44]. For this study, Codes 6 through 8 were classified as rural (there are no counties in Indiana classified as 9 by the USDA). ArcGIS was used to define each physician record based on its corresponding county Rural-Urban Continuum Code. Figure 5 illustrates the counties classified as rural, along with ZIP Code centroid locations of the physicians.

Table 3: 2003 Rural-Urban Continuum Codes

Code	Description
Metro counties:	
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
Non-metro counties:	
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999, not adjacent to a metro area
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

Figure 4: Indiana counties classified as rural based on Rural-Urban Continuum Codes

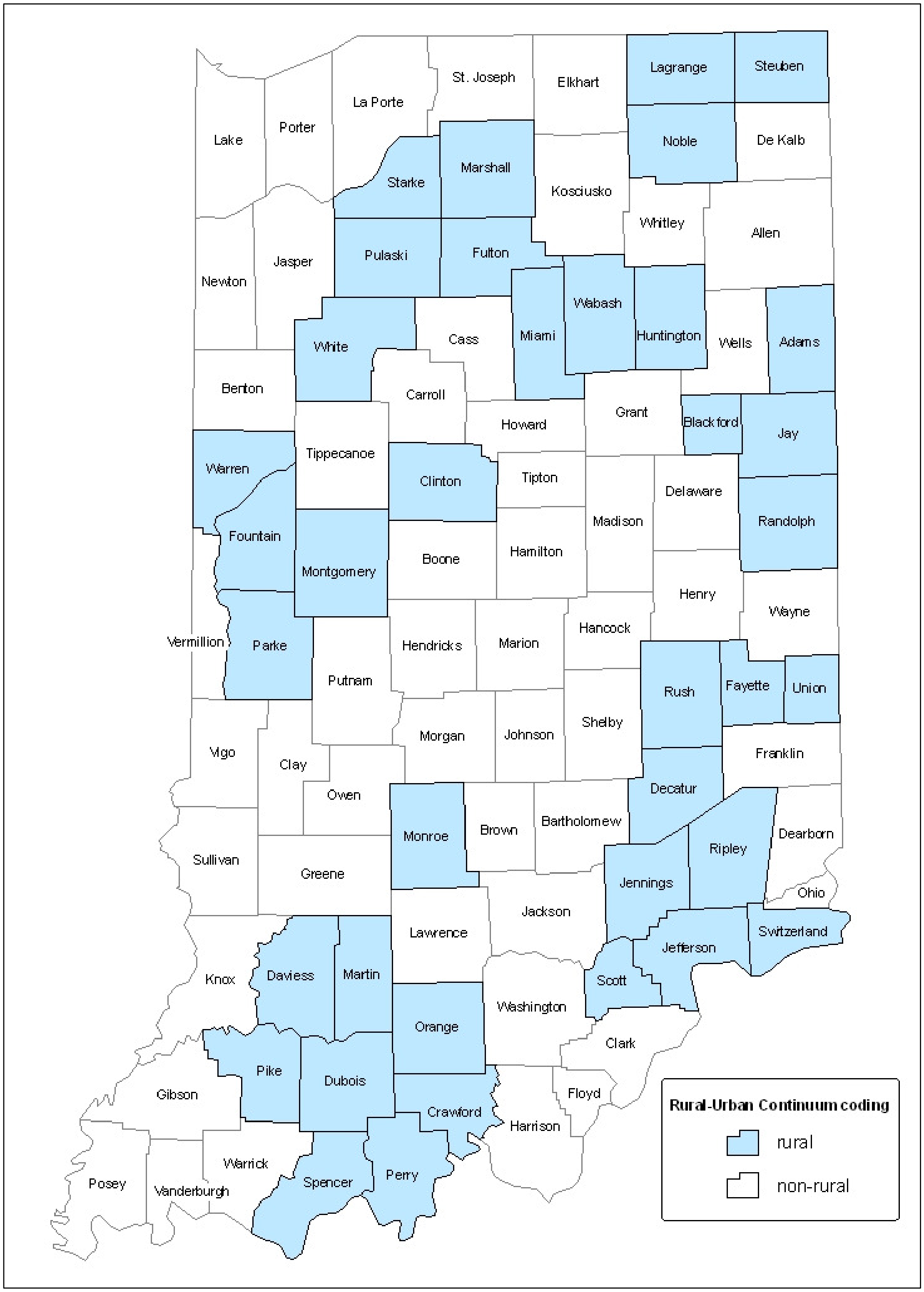
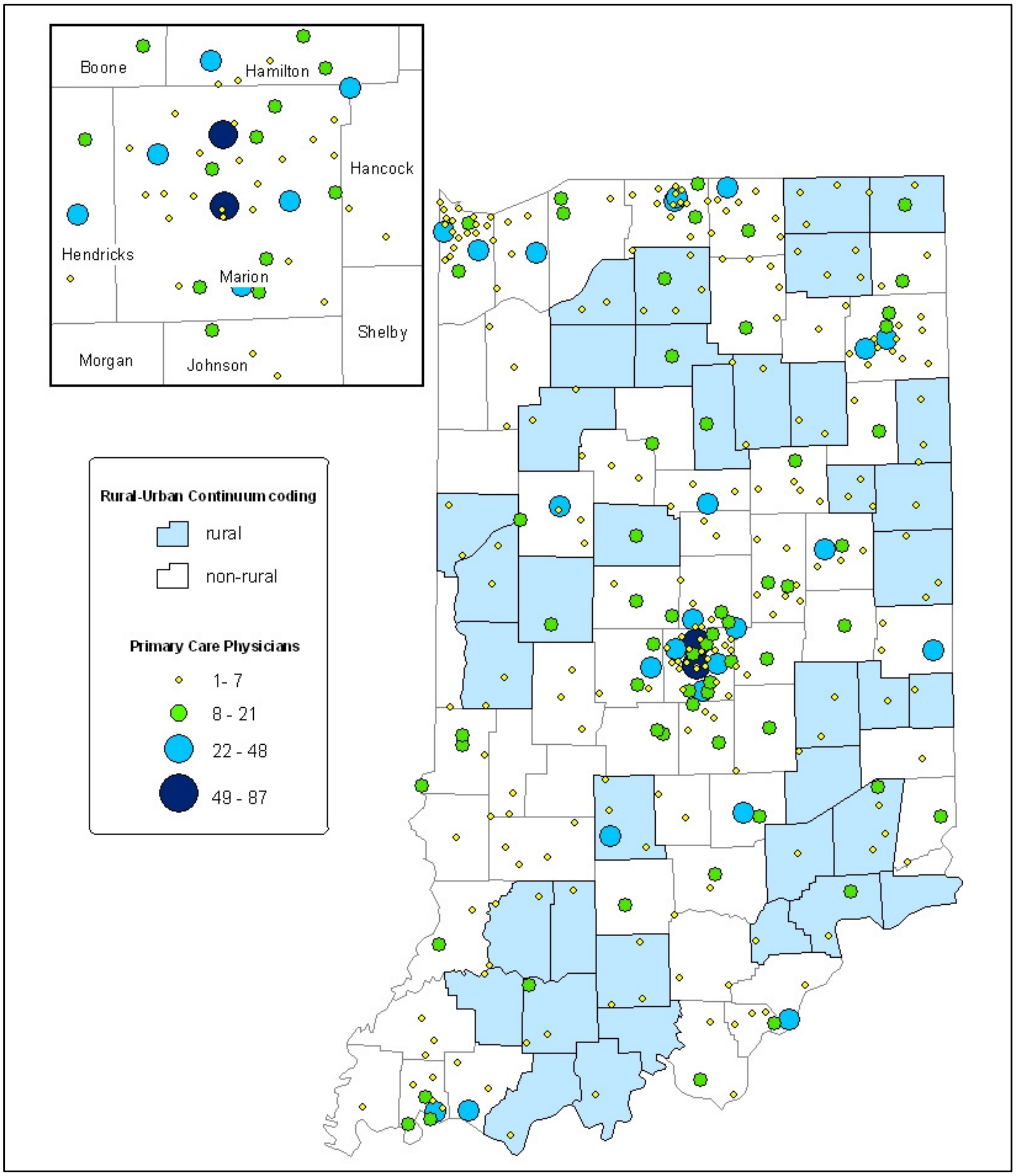


Figure 5: Primary care physician practice locations and counties classified as rural



Statistical Analysis

The predictor variables listed in Table 2 represent the independent variables in this study. The response, or dependent, variables in this study are whether or not a given physician's practice location is within or proximal to an MUA/HPSA, an HPSA alone, or classified as rural (which was determined using USDA Rural-Urban Continuum Codes). Because all variables in this study are categorical, the chi square test for independence and binary multiple logistic regression models were used to analyze the data. All statistical analyses were performed using SPSS (PASW Statistics) 17.0.2 software.

In order to determine whether associations were present between gender and response variables, foreign-born and response variables, and above/below median income (state and national levels) and response variables, the chi square test for independence was performed. This test is used to determine whether a statistical relationship exists between a given categorical (predictor) variable and a single response variable. Continuity corrected p-values less than 0.05 were considered statistically significant. The data (classified as counts that fall into each category) were arranged in a contingency table with each category of the predictor variable in rows and each category of the response variable in columns. The chi square test requires that at least one-half of the cells have a minimum of 5 observed cases. Only variables meeting this criterion were analyzed.

Binary multiple logistic regression was used to determine the impact of the potential predictor variables on the study outcomes (dependent variables). Before beginning the regression analysis, the data were split into two discrete sets. Dataset 1 includes all records for both US-born **and** foreign-born physicians (i.e., the initial 2,327 physician records shown in Table 1). Dataset 2 excludes records for foreign-born physicians (a net of 2,024 records). This separation of datasets was necessary because foreign-born physicians lacked data on birth state and median income of birthplace.

P-values less than 0.05 were considered statistically significant. Because the data were split into two datasets, analysis was performed separately for each response variable. The analysis conducted on Dataset 1 (US and foreign-born physicians) excluded the variables birth state and above/below state and National median income levels, which were not available for the foreign-born physicians. Dataset 2 (US-born physicians only) was analyzed using all variables other than foreign-born. Results from the chi square and logistic regression analyses were used to identify which predictor variables increased the probability that a physician will practice in an underserved or rural area.

Results and Conclusions

Chi Square Test Results

The results of the chi square test comparing predictor variables with practice location are shown in Table 4. Of the 2,327 physicians analyzed in this study, 1,088 (46.7%) were practicing in areas designated as MUA/HPSA, 589 (25.3%) in HPSAs only, and 305 (13.1%) in areas classified as rural (see Appendix A). The results showed some variance by response variable – i.e., as the definition of the geographic area changed, the significant predictors changed as well.

Table 4: Chi square test results

MUA and HPSA					
Independent variables		Total	#	%	p-value
Foreign-born	Yes	1088	160	52.8%	0.028
	No		928	45.8%	
Gender	Male	1088	806	47.9%	0.092
	Female		282	43.9%	
Birth county below state median income	Yes	926	383	49.5%	0.011
	No		543	43.6%	
Birth county below National median income	Yes	926	340	47.6%	0.255
	No		586	44.9%	

HPSA only					
Independent variables		Total	#	%	p-value
Foreign-born	Yes	589	79	26.1%	0.798
	No		510	25.2%	
Gender	Male	589	437	26.0%	0.274
	Female		152	23.6%	
Birth county below state median income	Yes	509	220	28.4%	0.010
	No		289	23.2%	
Birth county below National median income	Yes	509	193	27.0%	0.177
	No		316	24.2%	

Rural classification					
Independent variables		Total	#	%	p-value
Foreign-born	Yes	305	35	11.6%	0.442
	No		270	13.3%	
Gender	Male	305	238	14.1%	0.021
	Female		67	10.4%	
Birth county below state median income	Yes	270	131	16.9%	< 0.001
	No		139	11.2%	
Birth county below National median income	Yes	270	106	14.8%	0.169
	No		164	12.6%	

The foreign-born predictor variable only showed significance in predicting practice in combined MUA/HPSAs (p=0.028), indicating a higher likelihood of practice in these areas when the physician was foreign-born. Likewise, gender only showed significance with the rural classification response variable (p=0.021). In this case, males were more likely to practice in a rural county than females. The predictor variable indicating the physicians' county of birth fall below that state's median income level showed significance in all three response variables (p=0.011 for combined MUA/HPSA, 0.010 for HPSA only, and <0.001 for rural classification). The predictor variable indicating physician county of birth fall below National median income level was not significant in any of the three response variables. This outcome suggests a consistent statistical significance, regardless of geographic response variable, of economic surroundings in choice of future practice location, which holds at a more localized level (state), but does not apply in a larger scale.

Logistic Regression Results: Dataset 1

The binary multiple logistic regression model for Dataset 1 included predictor variables foreign-born, gender (male), age at graduation, graduation from medical school in the state of Indiana (the Indiana University School of Medicine being the only member), and graduation from a medical school in the Midwest. The model was run with each of these variables (as a group) against each of the response variables (physician location in MUA/HPSA, in HPSA only, or in an area classified as rural). A summary of the categorical variables for each regression model is listed in Appendix B. As in the chi square analyses, regression results varied depending upon the response variable. As shown in Table 5, the foreign-born predictor variable showed significance in just one response variable; HPSA only (p=0.044). This result indicates foreign-born practitioners in these instances were actually less likely to practice in an HPSA, meaning that US-born physicians were 1.39 times as likely to practice in an HPSA.

Table 5: Dataset 1 Logistic Regression model results

MUA and HPSA				
			Confidence interval (95%)	
Independent variables	p-value	Odds ratio	*Lower*	*Upper*
Foreign-born	0.836	1.03	*0.77*	*1.37*
Gender (m)	0.087	1.18	*0.98*	*1.42*
Age at graduation	0.041	0.97	*0.95*	*1.00*
Med school in Indiana	<0.001	0.67	*0.54*	*0.84*
Med school in Midwest	0.903	0.98	*0.76*	*1.28*

HPSA only				
			Confidence interval (95%)	
Independent variables	p-value	Odds ratio	*Lower*	*Upper*
Foreign-born	0.044	0.72	*0.52*	*0.99*
Gender (m)	0.254	1.13	*0.91*	*1.41*
Age at graduation	0.076	0.97	*0.94*	*1.00*
Med school in Indiana	0.057	0.78	*0.61*	*1.01*
Med school in Midwest	0.030	0.72	*0.54*	*0.97*

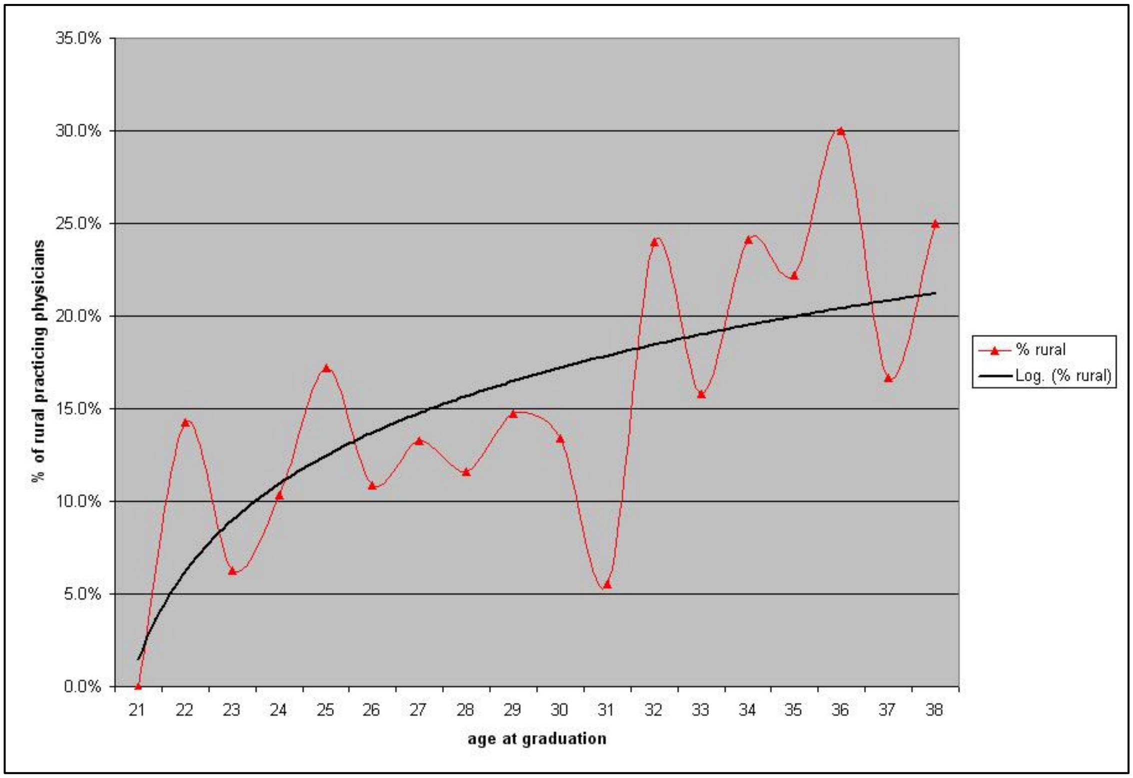
Rural classification				
			Confidence interval (95%)	
Independent variables	p-value	Odds ratio	*Lower*	*Upper*
Foreign-born	0.686	0.91	*0.59*	*1.42*
Gender (m)	0.016	1.43	*1.07*	*1.92*
Age at graduation	0.011	1.05	*1.01*	*1.08*
Med school in Indiana	0.011	1.58	*1.11*	*2.25*
Med school in Midwest	0.079	0.69	*0.46*	*1.04*

Gender showed significance only in the rural classification (p=0.016), with males being 1.43 times as likely to practice in rural areas as females. Age at graduation, the only continuous variable analyzed, showed significance in two of the three response variables, combined MUA/HPSA (p=0.041) and rural (p=0.011), however, they indicate a contrasting result. The odds ratio for the rural classification suggests an incremental increase (5%) in the likelihood that a physician will practice in a rural area for each year older they are at the time of graduation, assuming that the relationship is linear. In Dataset 1, there were 305 physicians practicing in an area classified as rural. These physicians were charted against age at graduation to visualize this result (Figure 6). However, the age at graduation variable in the combined MUA/HPSA response indicates a decreased likelihood of practicing in a MUA/HPSA with age.

Graduating from the IU School of Medicine was a significant predictor of practice in a MUA/HPSA (p=<0.001) and rural area (p=0.011); again, the odds ratios for these findings showed an opposite result. The rural classification result indicates a physician is nearly 1.6 times as likely to chose a rural practice location if they graduated from the IU School of Medicine (odds ratio = 1.58), while the combined MUA/HPSA result shows a physician graduating from an institution in a state *other than* Indiana is more likely to practice in such an area.

Because each of the response variables represent a different geographic area, these results should be considered independently; however, there were interesting parallels in the results for this analysis of all physicians practicing in Indiana. The predictor variables

Figure 6: Trend of rural physicians by age at graduation



showing significance for response variable HPSA only are exactly *opposite* of those in the rural classification. This result is significant, in that the HPSA designations in this study are based on ZIP Code reclassifications, while rural classifications are determined based on county. Neither geographic unit appears perfectly suited to represent these phenomena. The use of more precise geographic units, such as census tracts or block groups, may produce better results, but practice location data were not available at this level of geography from the AMA Masterfile.

Logistic Regression Results: Dataset 2

The binary logistic regression model for Dataset 2 included predictor variables gender (male), age at graduation, graduation from the IU School of Medicine, graduation from a medical school in the Midwest, birth state region (Northeast, South, West, and reference region Midwest), birth county of physician below State median income level, and birth county of physician below National median income level. The model was run with each of these variables (as a group) against each of the response variables (physician location in MUA and HPSA, in HPSA only, or in an area classified as rural). A summary of the categorical variables for each regression model is listed in Appendix B. Table 6 shows the results of each of the iterations of this model. Predictor variables gender, graduation from a medical school in the Midwest, and birth state region were not significant. Age at graduation showed significance for response variables MUA/HPSA and HPSA only ($p=0.031$ and $p=0.027$ respectively). The odds ratio suggests a slight decrease in likelihood of practice in these areas for each year older they are at the time of graduation.

Graduation from the IU School of Medicine had contrasting results. For response variable MUA/HPSA, the odds ratio (0.66) suggests physicians who graduated from the IU School of Medicine were less likely to practice in a combined MUA/HPSA area compared to graduates of out-of-state schools. However, the model for rural classification shows a physician is 1.56 times as likely to practice in a rural area after having graduated from the IU School of Medicine.

Table 6: Dataset 2 Logistic Regression model results

MUA and HPSA				
			Confidence interval (95%)	
Independent variables	p-value	Odds ratio	*Lower*	*Upper*
Gender (m)	0.204	1.14	*0.93*	*1.40*
Age at graduation	0.031	0.97	*0.94*	*1.00*
Med school in Indiana	<0.001	0.66	*0.52*	*0.83*
Med school in Midwest	0.961	1.01	*0.76*	*1.34*
Birth state Midwest	reference	reference	*reference*	*reference*
Birth state South	0.695	0.94	*0.70*	*1.27*
Birth state Northeast	0.513	1.12	*0.80*	*1.58*
Birth state West	0.170	0.70	*0.42*	*1.17*
Birth county below state median income	0.040	1.36	*1.01*	*1.82*
Birth county below National median income	0.676	0.94	*0.69*	*1.27*

HPSA only				
			Confidence interval (95%)	
Independent variables	p-value	Odds ratio	*Lower*	*Upper*
Gender (m)	0.279	1.14	*0.90*	*1.44*
Age at graduation	0.027	0.96	*0.93*	*1.00*
Med school in Indiana	0.094	0.80	*0.61*	*1.04*
Med school in Midwest	0.053	0.73	*0.54*	*1.00*
Birth state Midwest	reference	reference	*reference*	*reference*
Birth state South	0.287	1.20	*0.86*	*1.67*
Birth state Northeast	0.403	1.17	*0.81*	*1.71*
Birth state West	0.972	1.01	*0.57*	*1.79*
Birth county below state median income	0.010	1.53	*1.10*	*2.11*
Birth county below National median income	0.353	0.85	*0.61*	*1.19*

Rural classification				
			Confidence interval (95%)	
Independent variables	p-value	Odds ratio	*Lower*	*Upper*
Gender (m)	0.094	1.30	*0.96*	*1.78*
Age at graduation	0.051	1.04	*1.00*	*1.08*
Med school in Indiana	0.016	1.56	*1.09*	*2.25*
Med school in Midwest	0.427	0.83	*0.53*	*1.31*
Birth state Midwest	reference	reference	*reference*	*reference*
Birth state South	0.727	0.92	*0.57*	*1.48*
Birth state Northeast	0.646	1.12	*0.69*	*1.82*
Birth state West	0.118	1.66	*0.88*	*3.12*
Birth county below state median income	<0.001	2.26	*1.50*	*3.39*
Birth county below National median income	0.021	0.61	*0.40*	*0.93*

The dichotomy between physicians *increased* likelihood of practice in a rural area and *decreased* likelihood to practice in combined MUA/HPSA areas again reflects the variability across the geographically-based response variables. The predictor variable birth county below state median income level was consistently significant across each iteration; p=0.040, p=0.010 and p=<0.001 respectively for the response variables combined MUA/HPSA, HPSA only and rural. This consistency held in the odds ratios for each, ranging from 1.36 (MUA/HPSA) to 2.26 (rural classification). Like the result for this same variable in the chi square analysis, this outcome suggests a consistent statistical significance, regardless of geographic response variable, in economic surroundings in choice of future practice location.

Discussion

The significance of the independent variables examined in this study for predicting physician practice location varies depending on the geographic categories examined. Only one variable was consistent across response variables in its significance and direction (county of birth below State median income). Age at graduation was also notable for significance across the response variables, though the outcomes were divergent, depending on which response variable is examined. Similarly, findings for matriculation from the IU School of Medicine were divergent, though consistent across response variables. In both regression models, IU Medical School graduates were less likely to practice in combined MUA/HPSAs, but more likely to practice in rural areas. This study did not find gender, matriculation from a medical school in the Midwest, or birth county falling below the National median income to be consistent predictors of practice in an underserved area or rural area, though individual instances of significance did occur.

The pattern of positive significance of birth county below State median income is noteworthy, and warrants further study. When compared to other studies which have concluded that hometown or birthplace is a positive predictor [21, 30, 31], this result suggests that the *economic status* of the physician's hometown and/or birthplace is a characteristic predictive of future practice in underserved and rural areas. Also, the differences occurring between response variables (i.e., MUA/HPSA, HPSA only and rural classification) are notable. The geographic differences between these variables have an impact on results, reinforcing the role adjacency plays in any geographic study.

Inclusion of more detailed geographic location information in physician practice location databases, such as census tracts or block groups, could support further investigation at a finer geographic resolution. A strength of this study is the comparisons of several iterations of the same model against unique geographically-based response variables. While an unintended result, this analysis shows the inherent weakness of current data sources in analyzing the distribution of physician practice locations.

There are several limitations in this study. As discussed, the spatial location of physician practice locations was defined only to the ZIP Code level, which is not an ideal geographic boundary. Utilizing the AMA Masterfile as the single data source for physician practice locations dictated the use of ZIP Codes, and as such, limited expansion of independent variables and spatial specificity of analysis. It was desirable to follow the Indiana Physician Mapping project [47] in designating areas that met MUA criteria, but had not been designated as such, and examining those areas in conjunction with officially designated MUAs/HPSAs. Again, reliance on ZIP Codes made this problematic. Many areas the Indiana Mapping project identified as potential MUAs were smaller census tracts and minor civil divisions. When these areas were applied to the methodology of this study (counting an entire Zip Code as inclusive in the instance of any overlap) the areas included for study were inordinately large. Future studies focusing on finer geographic resolution may result in significant improvement in results.

Another limitation lies in utilizing the county in which the physician was born in determining if the physician hails from an area that was above or below the median income level. The county of origin is not necessarily the environment in which the person grew up. The physician could have been born in a hospital just across a county line, or the family could have moved to a different location. Additionally, significant variation in income levels can occur within a county, so the county-level average may not be indicative of the neighborhood in which the physician was raised. However, the attempt in this study to explore an economic background variable produced significant results. Future studies could pursue this further by collecting more precise background data from other sources or from physicians directly.

Finally, in paring physician records down to the final useable dataset (2,327), 1,096 records were lost because country of origin, birth city or state was unknown. This may represent some bias in the data.

With rapidly changing economic and public policy climates in the US, understanding the driving forces of physician practice location choices is crucial. Developing a better understanding of maldistribution has the potential to influence policies that increase access to those who need it most. It seems likely that even as economic forces temporarily slow urban growth, it will not halt altogether. As populations increasingly concentrate in expanding urban areas, the problem of poor access to medical care will only grow. As more potential medical students come from these increasingly urban areas, the likelihood they will have the hometown economic characteristics which predispose them to practice in underserved or rural areas may decrease. This tide could be turned if medical schools made incentives available to students with these characteristics. Altering admissions policy, and even more actively recruiting such students, may increase primary care physician practice in medically underserved and rural areas.

Appendix A: Crosstab Tables

Table 7: Physicians in an MUA/HPSA crosstab variable gender

			Gender		
			Female	Male	Total
MUA/HPSA	Not in an MUA/HPSA	Count	361	878	1239
		% within MUA/HPSA	29.1%	70.9%	100.0%
		% within gender	56.1%	52.1%	53.2%
		% of total	15.5%	37.7%	53.2%
	In an MUA/HPSA	Count	282	806	1088
		% within MUA/HPSA	25.9%	74.1%	100.0%
		% within gender	43.9%	47.9%	46.8%
		% of total	12.1%	34.6%	46.8%
Total		Count	643	1684	2327
		% within MUA/HPSA	27.6%	72.4%	100.0%
		% within gender	100.0%	100.0%	100.0%
		% of total	27.6%	72.4%	100.0%

Table 8: Physicians in an MUA/HPSA crosstab variable foreign-born

			Foreign-born		
			US-born	Foreign-born	Total
MUA/HPSA	Not in an MUA/HPSA	Count	1096	143	1239
		% within MUA/HPSA	88.5%	11.5%	100.0%
		% within foreign-born	54.2%	47.2%	53.2%
		% of total	47.1%	6.1%	53.2%
	In an MUA/HPSA	Count	928	160	1088
		% within MUA/HPSA	85.3%	14.7%	100.0%
		% within foreign-born	45.8%	52.8%	46.8%
		% of total	39.9%	6.9%	46.8%
Total		Count	2024	303	2327
		% within MUA/HPSA	87.0%	13.0%	100.0%
		% within foreign-born	100.0%	100.0%	100.0%
		% of total	87.0%	13.0%	100.0%

Table 9: Physicians in an MUA/HPSA crosstab variable birth county below state median income level

			Below state median income		
			Birth county below state median income	Birth county above state median income	Total
MUA/HPSA	Not in an MUA/HPSA	Count	391	703	1094
		% within MUA/HPSA	35.7%	64.3%	100.0%
		% within below state median income	50.5%	56.4%	54.2%
		% of total	19.4%	34.8%	54.2%
	In an MUA/HPSA	Count	383	543	926
		% within MUA/HPSA	41.4%	58.6%	100.0%
		% within below state median income	49.5%	43.6%	45.8%
		% of total	19.0%	26.9%	45.8%
Total		Count	774	1246	2020
		% within MUA/HPSA	38.3%	61.7%	100.0%
		% within below state median income	100.0%	100.0%	100.0%
		% of total	38.3%	61.7%	100.0%

Table 10: Physicians in an MUA/HPSA crosstab variable birth county below National median income level

			Below National median income		
			Birth county below National median income	Birth county above National median income	Total
MUA/HPSA	Not in an MUA/HPSA	Count	374	720	1094
		% within MUA/HPSA	34.2%	65.8%	100.0%
		% within below National median income	52.4%	55.1%	54.2%
		% of Total	18.5%	35.6%	54.2%
	In an MUA/HPSA	Count	340	586	926
		% within MUA/HPSA	36.7%	63.3%	100.0%
		% within below National median income	47.6%	44.9%	45.8%
		% of total	16.8%	29.0%	45.8%
Total		Count	714	1306	2020
		% within MUA/HPSA	35.3%	64.7%	100.0%
		% within below National median income	100.0%	100.0%	100.0%
		% of total	35.3%	64.7%	100.0%

Table 11: Physicians in an HPSA only crosstab variable foreign-born

			Foreign-born		
			US-born	Foreign-born	Total
HPSA only	Not in an HPSA	Count	1514	224	1738
		% within HPSA only	87.1%	12.9%	100.0%
		% within foreign-born	74.8%	73.9%	74.7%
		% of total	65.1%	9.6%	74.7%
	In an HPSA	Count	510	79	589
		% within HPSA only	86.6%	13.4%	100.0%
		% within foreign-born	25.2%	26.1%	25.3%
		% of total	21.9%	3.4%	25.3%
Total		Count	2024	303	2327
		% within HPSA only	87.0%	13.0%	100.0%
		% within foreign-born	100.0%	100.0%	100.0%
		% of total	87.0%	13.0%	100.0%

Table 12: Physicians in an HPSA only crosstab variable gender

			Gender		
			Male	Female	Total
HPSA only	Not in an HPSA	Count	1247	491	1738
		% within HPSA only	71.7%	28.3%	100.0%
		% within gender	74.0%	76.4%	74.7%
		% of total	53.6%	21.1%	74.7%
	In an HPSA	Count	437	152	589
		% within HPSA only	74.2%	25.8%	100.0%
		% within gender	26.0%	23.6%	25.3%
		% of total	18.8%	6.5%	25.3%
Total		Count	1684	643	2327
		% within HPSA only	72.4%	27.6%	100.0%
		% within gender	100.0%	100.0%	100.0%
		% of total	72.4%	27.6%	100.0%

Table 13: Physicians in an HPSA only crosstab variable birth county below state median income level

			Below state median income		
			Birth county below state median income	Birth county above state median income	Total
HPSA only	Not in an HPSA	Count	554	957	1511
		% within HPSA only	36.7%	63.3%	100.0%
		% within below state median income	71.6%	76.8%	74.8%
		% of total	27.4%	47.4%	74.8%
	In an HPSA	Count	220	289	509
		% within HPSA only	43.2%	56.8%	100.0%
		% within below state median income	28.4%	23.2%	25.2%
		% of total	10.9%	14.3%	25.2%
Total		Count	774	1246	2020
		% within HPSA only	38.3%	61.7%	100.0%
		% within below state median income	100.0%	100.0%	100.0%
		% of total	38.3%	61.7%	100.0%

Table 14: Physicians in an HPSA only crosstab variable birth county below National median income level

			Below National median income		
			Birth county below National median income	Birth county above National median income	Total
HPSA only	Not in an HPSA	Count	521	990	1511
		% within HPSA only	34.5%	65.5%	100.0%
		% within below National median income	73.0%	75.8%	74.8%
		% of total	25.8%	49.0%	74.8%
	In an HPSA	Count	193	316	509
		% within HPSA only	37.9%	62.1%	100.0%
		% within below National median income	27.0%	24.2%	25.2%
		% of total	9.6%	15.6%	25.2%
Total		Count	714	1306	2020
		% within HPSA only	35.3%	64.7%	100.0%
		% within below National median income	100.0%	100.0%	100.0%
		% of total	35.3%	64.7%	100.0%

Table 15: Physicians in a rural classification crosstab variable foreign-born

			Foreign-born		
			US-born	Foreign-born	Total
Rural classification	Not in a rural area	Count	1754	268	2022
		% within rural classification	86.7%	13.3%	100.0%
		% within foreign-born	86.7%	88.4%	86.9%
		% of total	75.4%	11.5%	86.9%
	In a rural area	Count	270	35	305
		% within rural classification	88.5%	11.5%	100.0%
		% within foreign-born	13.3%	11.6%	13.1%
		% of total	11.6%	1.5%	13.1%
Total		Count	2024	303	2327
		% within rural classification	87.0%	13.0%	100.0%
		% within foreign-born	100.0%	100.0%	100.0%
		% of total	87.0%	13.0%	100.0%

Table 16: Physicians in a rural classification crosstab variable gender

			Gender		
			Male	Female	Total
Rural classification	Not in a rural area	Count	1446	576	2022
		% within rural classification	71.5%	28.5%	100.0%
		% within gender	85.9%	89.6%	86.9%
		% of total	62.1%	24.8%	86.9%
	In a rural area	Count	238	67	305
		% within rural classification	78.0%	22.0%	100.0%
		% within gender	14.1%	10.4%	13.1%
		% of total	10.2%	2.9%	13.1%
Total		Count	1684	643	2327
		% within rural classification	72.4%	27.6%	100.0%
		% within gender	100.0%	100.0%	100.0%
		% of total	72.4%	27.6%	100.0%

Table 17: Physicians in a rural classification crosstab variable birth county below state median income level

			Below state median income		
			Birth county below state median income	Birth county above state median income	Total
Rural classification	Not in a rural area	Count	643	1107	1750
		% within rural classification	36.7%	63.3%	100.0%
		% within below state median income	83.1%	88.8%	86.6%
		% of total	31.8%	54.8%	86.6%
	In a rural	Count	131	139	270
		% within rural classification	48.5%	51.5%	100.0%
		% within below state median income	16.9%	11.2%	13.4%
		% of total	6.5%	6.9%	13.4%
Total		Count	774	1246	2020
		% within rural classification	38.3%	61.7%	100.0%
		% within below state median income	100.0%	100.0%	100.0%
		% of total	38.3%	61.7%	100.0%

Table 18: Physicians in a rural classification crosstab variable birth county below National median income level

			Below National median income		
			Birth county below National median income	Birth County above National median income	Total
Rural classification	Not in a rural area	Count	608	1142	1750
		% within rural classification	34.7%	65.3%	100.0%
		% within below National median income	85.2%	87.4%	86.6%
		% of total	30.1%	56.5%	86.6%
	In a rural area	Count	106	164	270
		% within rural classification	39.3%	60.7%	100.0%
		% within below National median income	14.8%	12.6%	13.4%
		% of total	5.2%	8.1%	13.4%
Total		Count	714	1306	2020
		% within rural classification	35.3%	64.7%	100.0%
		% within below National median income	100.0%	100.0%	100.0%
		% of total	35.3%	64.7%	100.0%

Appendix B: Regression Model Predictor Variable Coding

Table 19: Categorical variable coding summary - Dataset 1 - MUA and HPSA, HPSA only and rural classification

		Frequency	Parameter coding (1)
Med school Midwest	Med school not in Midwest	660	.000
	Med school in Midwest	1612	1.000
Gender	Female	634	.000
	Male	1638	1.000
Med school Indiana	Med school state all non-Indiana	1104	.000
	Med school state Indiana	1168	1.000
Foreign-born	US-born	1970	.000
	Foreign-born	302	1.000

Table 20: Categorical variable coding summary - Dataset 2 - MUA and HPSA, HPSA only and rural classification

		Frequency	Parameter coding		
			(1)	(2)	(3)
Birth state region	Midwest	1487	.000	.000	.000
	South	249	1.000	.000	.000
	Northeast	162	.000	1.000	.000
	West	68	.000	.000	1.000
Below National median income	Birth county below National median income	703	1.000		
	Birth county above National median income	1263	.000		
Med school Indiana	Med school state all non-Indiana	823	.000		
	Med school state Indiana	1143	1.000		
Med school Midwest	Med school not in Midwest	395	.000		
	Med school in Midwest	1571	1.000		
Below state median income	Birth county below state median income	754	1.000		
	Birth county above state median income	1212	.000		
Gender	Male	1419	1.000		
	Female	547	.000		

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