FROM HOMETOWN TO PRACTICE: MAPPING AND ANALYZING THE MEDICAL STUDENT PIPELINE AT THE INDIANA UNIVERSITY SCHOOL OF MEDICINE

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FROM HOMETOWN TO MEDICAL PRACTICE: MAPPING THE MEDICAL STUDENT PIPELINE AT THE INDIANA UNIVERSITY SCHOOL OF MEDICINE

Indiana University School of Medicine (IUSM) teaches approximately 350 medical students each year. These students come from varied backgrounds and eventually end up practicing in a vast array of clinical specialties and settings. It is extremely important to monitor specialties and practice locations to understand exactly how IUSM is fulfilling physician workforce needs. This knowledge can help policymakers and school administrators shape programs and policies to better fulfill physician workforce needs. Geographic information technologies provide a framework to organize, analyze and visualize medical student data. Maps are a convenient and easily understandable method of conveying information with a location-based component. This project represents a step towards creating a coherent student database visualized with maps.

Using data about the graduating classes from 2011-2018, a database was created that linked together geographic information of students from the various segments of their medical education such as residency, fellowship, and practice location. ArcGIS 10.5 was used to produce maps visualizing segments of this database. These maps also served to answer questions about the medical student graduates at IUSM, such as how many came from an in-state location and how many practice in-state. SPSS 25 was also used to compare results of various segments of the medical education pipeline.

The database proves to be an incredibly necessary tool for keeping track of all IUSM graduates. Coherent, clean, and complete data is necessary for researchers at all levels as well as administrators. Keeping data up to date and centralized is essential and

this project provides an easily updateable and useable format. The maps created from this database are also useful in showing trends across the graduates of IUSM, such as the Indiana counties that the graduates are most likely to practice in or the likelihood of practicing in specific shortage areas.

Jeffrey Wilson, PhD Chair

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List of Abbreviations

GIS	–	Geographic Information Systems (or Science)
IUSM	–	Indiana University School of Medicine
RIME	–	Research in Medical Education
IUPUI	–	Indiana University-Purdue University Indianapolis
MCAT	–	Medical College Admissions Test
NRMP	–	National Residency Match Program
MSE	–	Medical Student Education
FORHP	–	Federal Office of Rural Health Policy
HRSA	–	Health Resources and Services Administration
HPSA	–	Healthcare Professional Shortage Area
MUA	–	Medically Underserved Area
RMC	–	Regional Medical Campus
MC	–	Main Campus
IMU	–	Index of Medical Underservice
PC	–	Primary Care
NPC	–	Non-Primary Care

Introduction

Educational research is a field of study that is primarily concerned with the collection and analysis of all types of data involving students, their education, and their career outcomes. It is a discipline deeply entrenched in numbers and statistics with the goal of better understanding and improving educational methods and outcomes. Often, much of the data analyzed for this purpose has a location-based element, such as hometowns of students, past educational facilities, and career choices and locations. This type of data is useful not only for school administrators, but also for policymakers to help inform new programs, policies, and institutions. Post-education career data can highlight the strengths of a program as well as areas that could be improved upon in the future. This is especially true regarding medical education research and data concerning the eventual practice specialties and locations of doctors. Knowing the locations and specific communities that medical graduates cater to is imperative to showing how an institution is fulfilling physician workforce needs as well as meeting its own mission goals.

Raw numbers, percentages, and tables have often been the preferred way to display and share data on medical education. These methods are very useful and necessary, but can be hard to understand and interpret, especially for those not closely involved in the research or well-versed in the study. Maps provide an optimal tool to display educational data with a spatial component in a visually informative way. These visual interpretations of data can help to disseminate and simplify data to a wider audience.

A search of available literature in medical education research shows that there are few published studies which utilize maps and Geographic Information System (GIS)

techniques in analysis of medical student data. More often, raw data and statistical analyses are used for this research without visual complements in the form of maps. In the winter of 2016, the Indiana University School of Medicine (IUSM) Research in Medical Education (RIME) unit began a partnership with the Department of Geography in the Indiana University School of Liberal Arts at Indiana University–Purdue University Indianapolis (IUPUI) to examine the potential use of geospatial techniques to track students from hometown to eventual practice location, and to develop a series of informative and visually appealing maps to illustrate details of spatial data. This project has been referred to as the Pipeline Project, as it follows the metaphorical pipeline from hometown, to medical school, to graduate medical education, to practice for each IUSM student from the cohort who graduated in 2011 to the cohort who graduated in 2018.

The Medical Education Pipeline

For the purpose of this study, it is imperative to understand the educational steps that all medical students in the United States progress through before they can practice medicine as a full-fledged doctor of medicine. These steps make up the location-based data segments of the pipeline study.

Undergraduate college is the first step in the journey to becoming a full-fledged practicing doctor. Students hoping to enter medical school often pursue a degree in pre-medicine or other biological sciences but there is no set requirement. After this, they

complete the Medical College Admission Test (MCAT) and apply to a medical school. Generally, medical school takes four years for students to complete.

Following completion of medical school, any graduate desiring to practice medicine professionally in the United States must complete a residency that provides hands-on education in a specialized field. These residency specialties can be divided into two categories: primary care and non-primary care. Primary care specialties focus on a more comprehensive approach to healthcare while non-primary care specialties focus on more detailed and specific aspects of health. For the purpose of this study, family medicine, internal medicine, pediatrics, and internal medicine-pediatrics (a combined specialty) are considered primary care specialties. All other specialties, including neurology and anesthesiology among others, are considered non-primary care. Residencies range from three years (e.g. family medicine) to seven years (e.g. neurosurgery). To begin a residency, the graduate must apply for the Match to assign specialty and location for the residency. The Match is the shorthand name for the National Resident Matching Program (NRMP), a United States-based organization that matches all US medical students with residencies around the country based on student input and a complex algorithm.

After completion of the three- to seven-year residency, physicians can go straight into practicing medicine or go into a fellowship for additional training. If they decide to enter a fellowship there are numerous specialty options, such as cardiology or pediatric neurology. Each individual fellowship program has its own duration for training, varying between one to three years. After completion of the fellowship, they can then practice

medicine in that specific subspecialty. Because of these choices, there are many routes that medical students can take through their graduate medical education.

About IUSM and RIME

IUSM is the largest medical school in the United States and enrolls over 1,400 students, with approximately 350 students per annual cohort. These students are spread across nine campuses throughout Indiana. The main campus is in Indianapolis, while the eight regional campuses are in Fort Wayne, Evansville, Gary, Terre Haute, Bloomington, South Bend, Lafayette, and Muncie. Terre Haute is unique among these regional campuses because it contains a specified rural track program with the goal of creating more rural-based physicians.

IUSM maintains a significant amount of information on their past and current medical students. However, much of this information is housed within different units. The Office of Medical Student Education (MSE) maintains information on student hometown, high school, and college, as well as information concerning regional campus assignment. In addition, the Office of MSE maintains Match information about IUSM graduates that shows where they went for their residency training. This national program provides location-based data on the residencies of IUSM students as well as the specific medical specialty.

Data received from the Office of MSE provided a substantial start to the pipeline and a wealth of locational information. However, no information was being collected on where medical students go after completing their residency. Some students opt for further specialized training in a fellowship at a teaching location while others move straight into

their career and practice location. The lack of fellowship or practice data was a large information gap that had to be filled to complete this project.

The RIME unit is part of the Indiana University School of Medicine Dean's Office of Educational Affairs and specializes in research and analysis of medical students and residents at IUSM. The team at RIME set out to fill in this missing data and bring it all to one central location where it could be updated on a regular basis. The goal for the team was to create a pipeline to track all IUSM graduates from 2011 to 2018, starting from hometown through the stages of their medical education training to their eventual practice location (if applicable).

From start to finish, the creation of the initial pipeline database took approximately four months. The entire team worked to fill in the database and bring it to fruition; I took the lead on this project and helped ensure the results were coherent and in a format that facilitated mapping and analysis using GIS technologies.

Research Goals

The first goal of the pipeline project was to create a clean, coherent database of our medical students that could be analyzed, tabulated, and mapped for a variety of current and future questions and purposes. The database was created such that it was easy to read, update, and utilize. Many aspects of its design were critically considered for relevance and usefulness, such as what information to include in the dataset versus what data were unnecessary.

After the initial creation of the database, the next steps were to count and quantify the raw data so it could be used for both analysis and mapping. This process focused on

simplifying the information further and focusing on key aspects of the pipeline. For example, hometown, residency, and practice locational information were deemed to be the most important aspects of the pipeline so these facets were focused on and analyzed in more ways than less important stages such as high school and college. This produced clean data that could be analyzed as well as tables and counts used for later mapping.

The second research goal was to create data visualizations in the form of maps. These maps helped to illustrate the many facets of the database in an easily understandable format. Shaded choropleth maps were created that illustrate the distribution of IUSM graduates across Indiana counties as well as U.S. states from 2011 to 2018. Diagram maps displaying data in pie chart format were created to highlight some of the differences between the main campus and the eight regional IUSM campuses in areas such as those students matching into a primary care versus non-primary care specialties, or those having a hometown location within Indiana versus outside the state.

During the map creation process, both design and functionality were critically considered. These maps were intended to be used by the school leadership, so it was imperative that they be well-designed, easy to interpret, and in formats that could be used in a variety of contexts (e.g., hardcopy reports, digital presentations, and web-based display) by IUSM faculty and staff with a broad range of backgrounds and technical expertise. In order to facilitate usability to a diverse audience, the RIME team had many meetings with faculty members, administrators, and staff to gain input and insight on the best designs for different purposes. Many different versions of the maps were created as a result of these conversations and suggestions were taken into consideration before settling on the final design choices.

Specific questions that maps were designed to inform included state-based retention, such as how many IUSM graduates choose to practice in Indiana, and how many IUSM graduates practiced in communities with less access to healthcare professionals or fewer resources. These details can help the IUSM leadership to strategically align the school's mission with the physician workforce demands, especially those in areas of need.

The resulting maps help to illustrate information in a way raw numbers and tables simply cannot. They allow viewers to easily understand different aspects of the pipeline in an intuitive way. It is our hope that the pipeline maps will assist the school in many new and different capacities.

Available Literature

A literature review was conducted with keyword searches on Google Scholar, WorldCat, IUCat, JSTOR, and PubMed. Keywords included “GIS”, “medical students”, “pipeline”, “database”, “footprinting”, “tracking”, “location”, “residency”, “medical school”, “geography”, and “demographics”. The search was limited to English language articles but did not specify a publication year. When determining the relevance of an article, first the title was analyzed and completely irrelevant titles were not considered for review. For any article with a relevant title, the abstract was then reviewed and if it met our search goals, the article was read in its entirety and then entered into an EndNote 7 library. Articles were considered useful to this research if they either 1) described a way in which a medical institution utilized GIS technologies and mapping to track their students and graduates or 2) provided additional statistics and insights into the medical student body and their location-based demographics.

Using these search and selection methods, it eventually became obvious that there was not a great depth of literature surrounding this research topic. By the end of the search, three articles were identified for their relevance on GIS methods at medical schools and four articles for their information on medical student location-based demographics. All selected articles originated from either the United States or Canada and were published from 2007 to 2012.

A publication found to have similar aims as the IUSM pipeline project, but on a smaller scale, focused on the family medicine residency program at the University of Hawai’i. This study, conducted by Hixon et al. (2012), tracked the practice locations of 86 University of Hawai’i family medicine residents from 1993 to 2010 in order to see

how many of their residents remained in Hawai'i and practiced in Healthcare Professional Shortage Areas (HPSAs). The study found that 73% of graduates remained within the state and over 36% practiced in HPSAs. This study was on a much smaller scale than the IUSM school-wide study, but it produced maps that helped to visualize what the researchers termed as the "residency footprint" or the area of influence of the Hawai'i family medicine residency program. The researchers concluded that the maps and GIS are a useful visual aid to help create strategies for retaining the University of Hawai'i graduates to practice within the state, as well as within their HPSAs.

Some additional work has been done on the idea of "footprinting" as a way to assess the breadth of residency and fellowship programs. The concept of footprinting looks at the geographic distribution of practitioners to determine the program's main area of effect. Some footprinting studies also focus on other geographic designations such as rural and HPSA areas. A specific study conducted by Reese et al. (2008) used the concept of residency footprinting to determine the breadth and effect of 37 family medicine programs that have recently closed. In this study, the authors used GIS tools to map the practice locations of the graduates of these programs to see areas that may begin to lose practitioners now that the programs have closed. Additionally, they determined the rural and HPSA status of these locations in an effort to see the potential effect in these areas. The researchers found a significant impact from closing the residency and fellowship programs. For example, there was a loss in rural physicians that may not have been as easily noticed and visualized without utilizing GIS. This study concludes that GIS and maps are powerful tools for presenting data in a way that can help policymakers and stakeholders understand the impact of policies and decisions.

A similar study was conducted by Schwartz (2007) of Pennsylvania State University that focused on the Pennsylvania dental education pipeline. Dental education follows a similar format as medical education, making this pipeline study relevant. Schwartz was primarily interested in analyzing the dental pipeline in regards to Pennsylvania practice location, rural practice, and low service area practice. He wanted to determine how well the Pennsylvania dental schools fulfilled their obligation to adequately staff Pennsylvania and its underserved areas with dentists. He used data obtained from the 2006 American Dental Association's master files which included current practice address. These practice addresses were then geocoded to determine coordinates as well as rural/urban designation of the address. Buffers were also created in order to determine low-service areas within the state. In the end, the study concluded that the Pennsylvania dental schools were not adequately fulfilling their obligation of fully staffing the state with dentists. Schwartz's study showed the importance and usefulness of the pipeline method to understand and analyze geographic-based practitioner trends.

Other research in the field of medical education has examined factors affecting the choice of practice location, including physician choice to practice in rural areas. One such article, published by IUSM scholars, analyzes the relationship between the eight IUSM regional campuses and students' eventual practice locations. Using multivariate regression, the researchers examined how studying at one of the regional campuses as opposed to the main campus in Indianapolis affected graduates' choice of practice locations. They concluded that those students who studied at IUSM's regional campuses were more likely to practice medicine in rural communities as opposed to the Indianapolis metropolitan area. While this research used older data (1988-1997), it

informed the current study by providing an earlier case study to compare with more recent IUSM graduate data. (Brokaw et al., 2009).

Several previous studies have examined whether medical students' hometowns or other previous residential locations were associated with practice locations. Pretorius et al. (2010) researched this possible connection by comparing places of residence listed on a physician's medical school application and their midcareer practice location. The study defined midcareer as 17-19 years after medical school graduation. The records of 433 medical students from the University at Buffalo were used as the basis of this study. The residence addresses used as a point of comparison were: birth place, residence during high school, residence during college, and residence during medical school. The study concluded that midcareer practice locations are associated with prior residences, as seen by 84% of the students in the study having a connection between at least one prior residence and their midcareer practice location.

Another study conducted by Wade et al. (2007) analyzed the connection between physician hometowns and practice location, specifically focused on the effect of a nonmetro hometown on similarly nonmetro practice location. Using the IUSM classes of 1988-1997 as the basis of this study, the researchers mapped the practice locations and ran logistic regressions to determine the influence that hometown locations have on eventual practice locations. The results of this study showed that students from nonmetro or rural areas were 4.7 times more likely to end up practicing in a nonmetro location, as opposed to students from metro areas. The conclusion of this study corroborates other studies, supporting the conclusion that hometown locations have a strong influence on physicians' practice locations.

Another study examined the factors that contribute to specialty choice of medical students. Gill et al. (2012) conducted a survey at the University of Alberta in Edmonton with the objective of determining what factors influence the choice of going into family medicine versus other possible specialty choices. The primary results of this survey and subsequent statistical analysis showed that medical students who chose to practice in family medicine were more likely to be older, female, and had lived in rural areas in the past. The significance of Gill's study to RIME's research is rooted in the connection between rural residences and choice of family medicine specialty. Of the students who chose to practice family medicine, 47% reported having lived in rural areas, as opposed to 24% of students who chose to practice in other specialties. This shows that rural residence had a strong influence on family medicine specialty choice in this study.

Data and Methods

The first step in creating a complete and coherent pipeline database for IUSM graduates was to acquire the data that already existed within the IU School of Medicine. The RIME team received two sets of data from the Office of MSE. One dataset provided the name, student ID, and campus assignment for each matriculate in the cohort. The campus assignment data included both the first- and the fourth-year campus locations. Previously, it was common for IUSM students to attend a regional campus for the first two years and then return to the Indianapolis campus for the third and fourth years of their training. These regional campuses used to only focus on the basic science training of medical students and were not equipped to train students through the more rigorous second-half of their training. However, during the 2011-2018 study period, hospitals affiliated with the regional campuses increased capacity to fully train medical students from first year through fourth year. The result was a transition to many more students remaining at the same campus for all four years.

The second set of pre-admission data received from the Office of MSE included information about each students' hometown, high school, and undergraduate college. In addition, the Office of MSE provided the official Match data showing the residency location and specialty of every IUSM student who graduated and successfully completed the Residency Match process.

The campus assignment data received from the Office of MSE served as the basis for our pipeline because it captured information on all students who matriculated. Student names served as the common identifier for all datasets. To reduce margin of error, all data were first cleaned and checked for spelling inconsistencies thereby ensuring all

names were identical in all data sources. Additionally, duplicated names and possible name changes were highlighted for further review and verification. Using these completed names, the first- and fourth-year student data, campus assignment data, and Match data were merged together into a single database for each graduating year using Excel 2013 and SAS 9.4. After running a SAS script, most student records were successfully merged. Student records that could not be merged included the duplicates and name changes. These records were then merged by hand and verified using other identifiers such as middle name or student ID.

Other unmatched records existed due to students not matching into a residency program during their graduation year. These records were maintained but not officially counted until they successfully matched into a program. The year that they matched and began their residency is considered their graduation year for the purposes of this study. Once these outliers and exceptions were accounted for, the foundation of the dataset was considered complete and provided the count (n) for each year of our study period, as seen in Table 1.

Table 1: Number of IUSM Graduates per Year

Year	# of Graduates
2011	293
2012	289
2013	300
2014	292
2015	302
2016	309
2017	307
2018	294
Total	2,386

The second set of data including pre-admission information was then linked using student names as the key identifier. The same manual review process as detailed above was used to minimize error. Merging the pre-admissions data produced a dataset that identified geographic locations of students from hometown through residency. At this point of the project, we had to find and add information regarding fellowship and/or practice locations of the students in the pipeline who were out of the residency phase of their education. To find these locations, we conducted Google searches. This was done through a methodical search of each name followed by key word strings such as “md,” “Indiana University,” “fellowship,” or their particular specialty, e.g. “family medicine.” To be as accurate as possible, we extensively verified these locations. Practice and fellowship locations were only recorded if they were included on an official website such as a university or hospital website. This process of double-checking provided a reasonable level of certainty concerning our data. The updated information on practice and/or fellowship was then added into its respective segment of the pipeline. After entering this data, all of the major segments of the database were complete.

Table 2 shows the completion percentage of the important data segments of the pipeline project. High school data was not included due to lack of relevance and use in the project. Additionally, it was very incomplete when compared to hometown data; only 56.3% percent of records had high school location information, while 93.3% included hometown. Residency data was not included in Table 2 because all IUSM graduates analyzed in this study had reported residency locations which produces a 100% completion rate for every year. Graduating years 2016-2018 do not have fellowship or

practice data due to the graduates from those years still being in the residency stage of their educational pipeline.

Table 2: Completeness of Data.

Year	Hometown		College		Fellowship		Practice	
	#	%	#	%	#	%	#	%
2011	251	85.7	251	85.7	91	31.1	273	93.2
2012	271	93.8	273	94.5	95	32.9	231	79.9
2013	281	93.7	276	92.0	86	28.7	183	61.0
2014	250	85.6	238	81.5	52	17.8	115	39.4
2015	289	95.7	270	89.4	20	6.6	60	19.9
2016	298	96.4	301	97.4	-	-	-	-
2017	303	98.7	303	98.7	-	-	-	-
2018	284	96.6	281	95.6	-	-	-	-
Totals	2,227	93.3	2,193	91.9	344	23.4	862	58.7

*Practice data is more complete in earlier years due to more graduates having completed all graduate medical education.

As seen in Table 2, hometown and college data is fairly complete for each year of the study period. Fellowship data is much less complete, partially because not all students complete this stage of education and partially because there is little data on the internet about individual physicians in fellowships. Practice data is more complete in earlier years due to more graduates having completed all graduate medical education (residency and fellowship) and moving into their career paths.

At this point we began to add ancillary data based on the given locations of students throughout the pipeline. Hometown locations were coded as either rural or urban based on ZIP code and the rural/urban classification used by the Federal Office of Rural Health Policy (FORHP). As stated on their webpage, rural ZIPs were identified as any ZIP code where more than 50% of its population resides in either a non-metro county

and/or a rural census tract (http://hrsa.gov). The same method was used to determine whether or not practice locations were in rural ZIP codes.

Practice locations were also coded as either being within a Healthcare Professional Shortage Area (HPSA) or a Medically Underserved Area (MUA), or neither. These two types of disadvantaged areas are designated by the Health Resources and Services Administration (HRSA) which is a part of the US Department of Health and Human Services. HRSA defines HPSAs as: "a specific geographic area with few service providers, a specific community such as low income that lacks sufficient providers in a defined geographic area, or a specific facility with a shortage of providers such as a correctional facility or a state mental hospital (http://bhw.hrsa.gov)." MUAs, meanwhile, are based on the Index of Medical Underservice (IMU) which is calculated from: "the population to provider ratio, the percent of population below the federal poverty level, the percent of the population over age 65, and the infant mortality rate." Areas that score 62 or less on this index qualify as MUAs. The designations for specific practice locations were determined by entering the exact addresses into the HRSA Data Warehouse Shortage Finder tool on their website (http://bhw.hrsa.gov).

Once this additional data were added, the pipeline was deemed complete and accurate to the best of our abilities and available resources. Now, it is easily updateable for subsequent years as a new cohort of students completes medical school and enters residency, as well as for residents from prior years who are entering a fellowship or practice. Maintaining the database will be an ongoing project, but the work conducted during this study has laid a solid foundation and reflects the most up-to-date and accurate data as of the spring of 2019.

Upon completion of the full pipeline database, the data were summarized by geographic variables for mapping and interpretation. This data was entered into SPSS 25 and descriptive analysis using crosstabs was used to produce year-by-year counts as well as counts by first year campus assignment. This method also helped to produce counts of students by state and county at each stage of the pipeline. These counts were entered into Excel 2013 to facilitate mapping and tabular display. Chi-square tests were also conducted to determine statistical significance of some of these comparisons. *P-values* less than 0.05 were considered statistically significant.

Counts for geographic variables were joined to state and country shapefiles using ArcGIS 10.5. These counts were used to create different maps to help visualize the pipeline data. Shaded choropleth maps illustrate the distribution and density of graduates from hometown through practice, while more specialized maps help depict topics such as graduates practicing in rural areas and graduates entering specific specialties. All choropleth maps use a modified version of the Jenks natural breaks classification method with 0 as a stand-alone class.

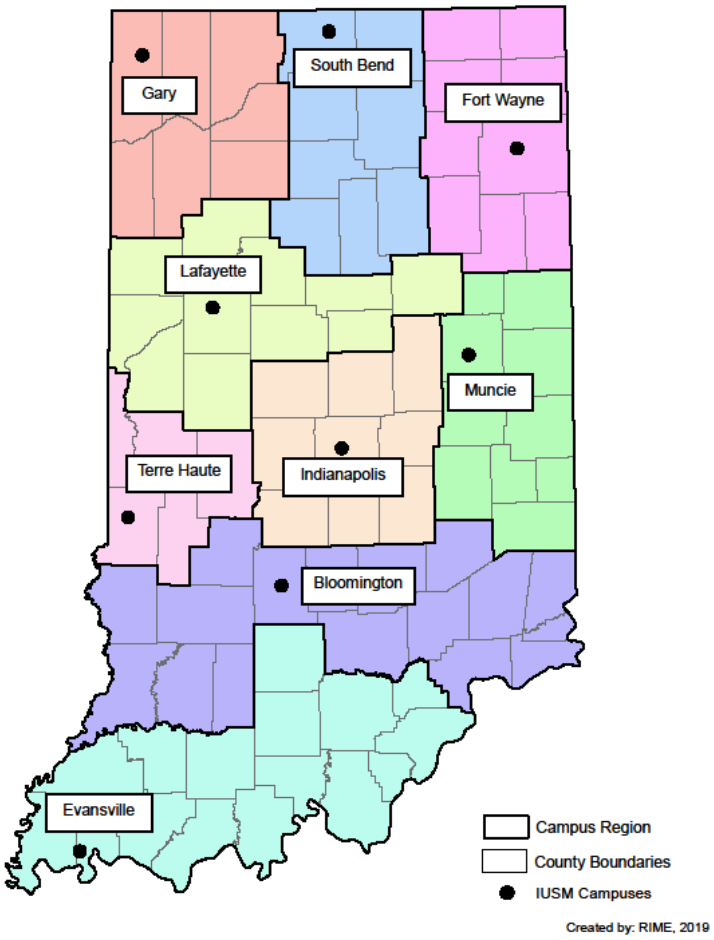
Results

This chapter shows the results in both table and map format of the pipeline study and analysis. The chapter is sub-divided into the specific segments of the pipeline (hometown, college, residency, fellowship, and practice) as well as a section for overall results. High school data has been excluded from reporting due to relative incompleteness and lack of value for overall research. For ease of interpretation, all percentages have been rounded to the nearest decimal.

Overall Results

In this study, we decided to report graduates by two different main categorizations. The first method was by medical school completion year, i.e., considered to be the year the student officially succeeded with NRMP placement. The second method of categorizing students that we have found helpful and meaningful was by first-year campus assignment. This method divides the cohort between the Indianapolis campus and the eight regional medical campuses located around the state of Indiana. As stated, these campuses are located in Bloomington, Evansville, Fort Wayne, Gary, Lafayette, Muncie, South Bend, and Terre Haute. Collectively they are known as Regional Medical Campuses (RMCs), while Indianapolis is known as the Main Campus (MC). The spread of these campuses across the state makes for convenient, easy, and attractive mapping as well as interesting geographic results. Therefore, first-year campus assignment was our targeted way of analyzing and displaying data beyond basic year-based interpretations.

Map 1: IUSM Campuses and Regions



Map 1 helps to visualize the nine IUSM campuses across the state. Each campus is labeled. The colored, outlined region surrounding each individual campus makes up its campus region. This is the set of counties considered to be a part of that individual campus's region and within its influence according to IUSM administration. This designation is primarily important for hometown location analysis.

Table 3: First-Year Campus Assignments by Graduation Year

Campus	2011	2012	2013	2014	2015	2016	2017	2018	Totals
Bloomington	26	24	32	32	28	36	31	28	237
Evansville	12	17	17	16	13	19	15	18	127
Fort Wayne	14	15	19	18	23	27	22	24	162
Gary	19	16	25	25	25	22	22	24	178
Indianapolis	147	133	128	121	126	133	128	121	1037
Lafayette	14	16	16	11	18	13	16	19	123
Muncie	20	23	20	27	24	20	23	19	176
South Bend	15	22	20	20	22	20	27	21	167
Terre Haute	23	23	23	22	23	19	23	20	176

As seen in Table 3, the distribution across these nine campuses has remained fairly even throughout the entire study period. There is no significant difference year-by-year in this assignment. Each IUSM campus is tied to a specific Indiana county based on where it is located. These counties served as geographic reference throughout this study.

Table 4: County Locations of IUSM Campuses and Their Regions

Campus	County	Counties Within Region
Bloomington	Monroe	Bartholomew, Brown, Daviess, Dearborn, Decatur, Greene, Jackson, Jefferson, Jennings, Knox, Martin, Ohio, Owen, Ripley, Sullivan, Switzerland
Evansville	Vanderburgh	Clark, Crawford, Dubois, Floyd, Gibson, Harrison, Lawrence, Orange, Perry, Pike, Posey, Scott, Spencer, Warrick, Washington
Fort Wayne	Allen	Adams, De Kalb, Huntington, La Grange, Noble, Steuben, Wells, Whitley
Gary	Lake	Jasper, La Porte, Newton, Porter, Pulaski, Starke
Indianapolis	Marion	Boone, Hamilton, Hancock, Hendricks, Johnson, Madison, Morgan, Shelby
Lafayette	Tippecanoe	Benton, Carroll, Clinton, Fountain, Grant, Howard, Montgomery, Tipton, Warren, White
Muncie	Delaware	Blackford, Fayette, Franklin, Henry, Jay, Randolph, Rush, Union, Wayne
South Bend	St. Joseph	Cass, Elkhart, Fulton, Kosciusko, Marshall, Miami, Wabash
Terre Haute	Vigo	Clay, Parke, Putnam, Vermillion

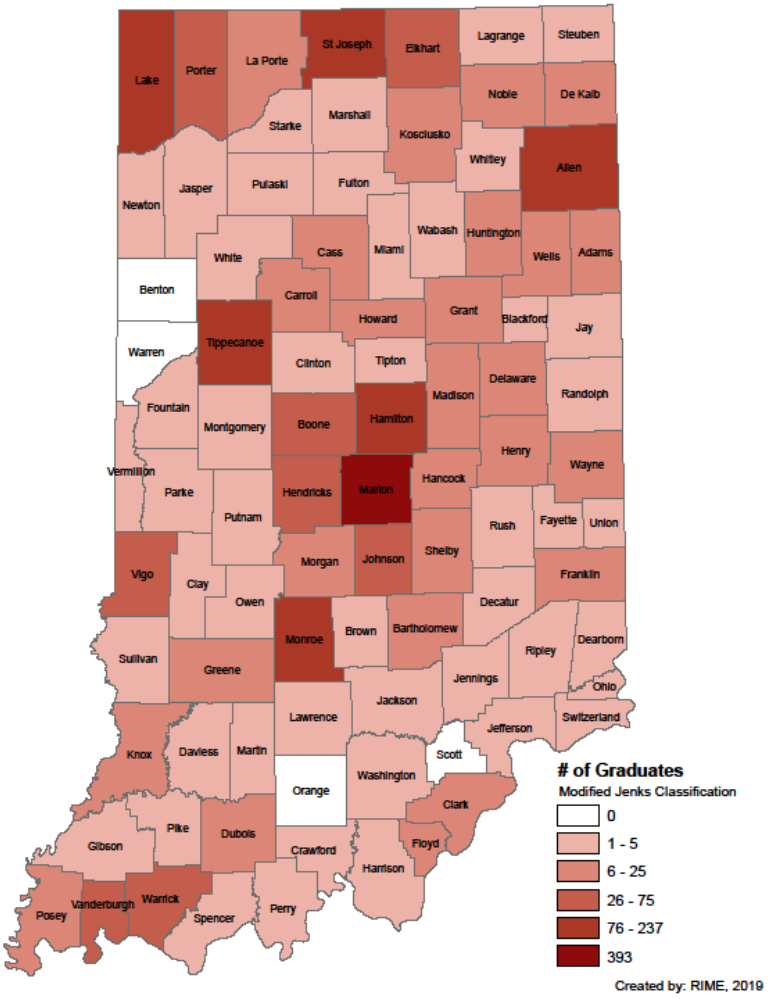
Table 4 shows where each of Indiana's 92 counties fall in terms of IUSM campus regions. These regions generally include the counties immediately surrounding the county in which a certain IUSM campus is located.

Hometown

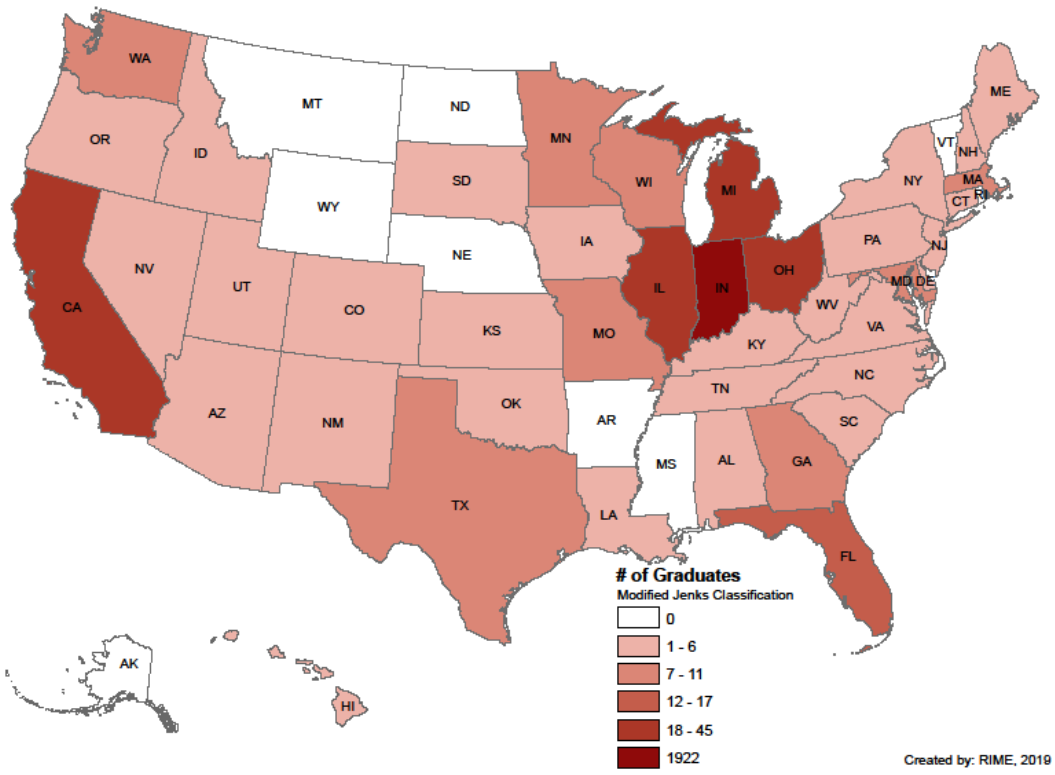
The hometown segment of the pipeline was concerned with the self-reported hometowns of IUSM graduates from 2011 to 2018. In this study we were concerned with the locations of these hometowns, their relation to first-year campus assignments, and how many students came from rural backgrounds.

Distributions

Map 2: IUSM Graduates' Hometown Locations in Indiana, 2011-2018



Map 3: IUSM Graduates' Hometown Locations in the US, 2011-2018



Maps 2 and 3 display the distribution of reported hometown locations across Indiana and the United States. Unsurprisingly, Marion County (n=393) and Indiana (n=1922) had the highest concentration of hometowns on each respective map. Only four Indiana counties had no reported hometowns during the study period: Orange, Scott, Benton, and Warren. Meanwhile, nine US states had no reported hometowns for the 2011-2018 cohort: Montana, North Dakota, Wyoming, Nebraska, Alaska, Arkansas, Mississippi, Vermont, and Rhode Island.

In-State vs. Out-of-State

Map 4: In-State vs. Out-of-State Distribution of Hometown Locations, 2011-2018

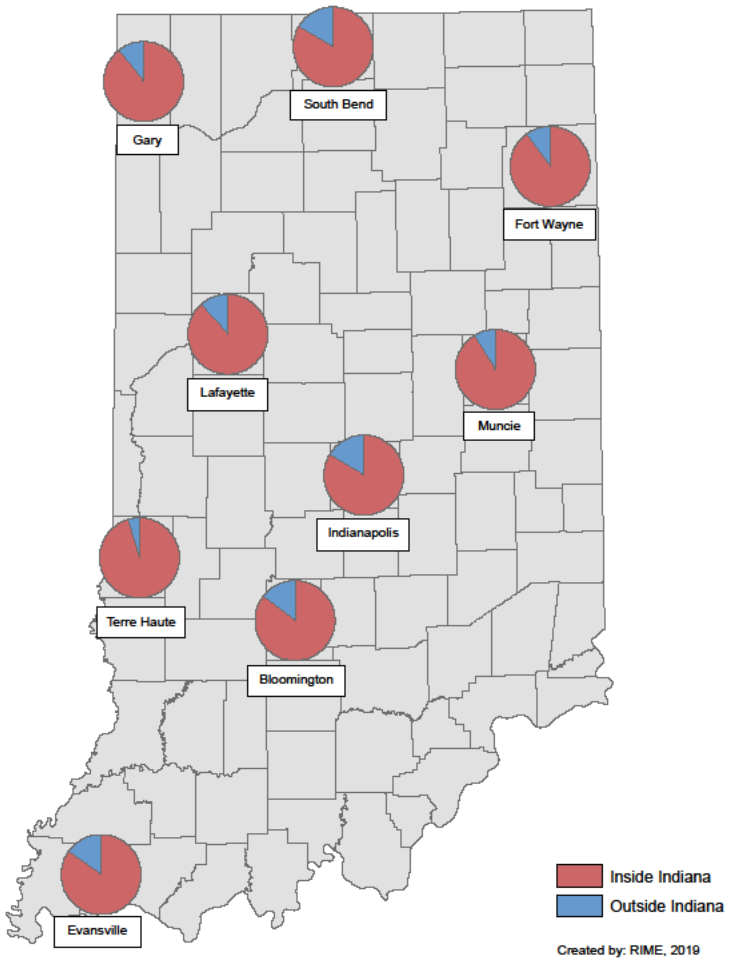


Table 5: In-State vs. Out-of-State Distribution of Hometown Locations, 2011-2018

	In-State		Out-of-State	
Campus	#	%	#	%
Bloomington	191	85.3	33	14.7
Evansville	105	84.7	19	15.3
Fort Wayne	142	89.9	16	10.1
Gary	149	89.2	18	10.8
Indianapolis	789	83.5	156	16.5
Lafayette	105	88.2	14	11.8
Muncie	151	91.0	15	9.0
South Bend	130	83.3	26	16.7
Terre Haute	160	95.2	8	4.8

Map 4 and Table 5 display the number and percentage of IUSM graduates with hometowns within Indiana and outside of the state by first-year campus assignment. The majority of graduates reported a hometown within the state of Indiana. Graduates who attended the Terre Haute campus had the highest percentage of in-state hometowns (95.2%) while those who attended the South Bend campus had the lowest percentage (83.3%).

Hometown Regions

Map 5: Hometown Locations by Campus Regions, 2011-2018

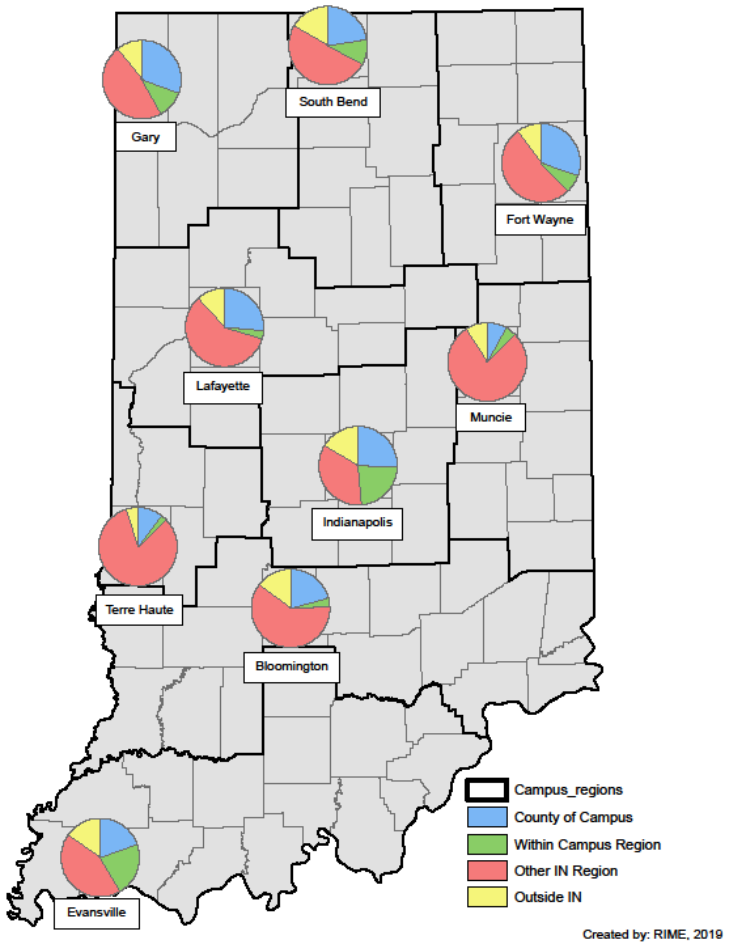


Table 6: Hometown Locations by Campus Regions, 2011-2018

	County of Campus		Within Campus Region		Other IN Region		Outside IN	
Campus	#	%	#	%	#	%	#	%
Bloomington	46	20.7	8	3.6	135	60.8	33	14.9
Evansville	24	19.5	27	22.0	53	43.1	19	15.4
Fort Wayne	47	30.1	12	7.7	81	51.9	16	10.3
Gary	51	30.5	19	11.4	79	47.3	18	10.8
Indianapolis	240	25.5	217	23.1	328	34.9	156	16.6
Lafayette	31	26.3	4	3.4	69	58.5	14	11.9
Muncie	13	8.0	7	4.3	128	78.5	15	9.2
South Bend	35	22.6	16	10.3	78	50.3	26	16.8
Terre Haute	17	10.2	4	2.4	137	82.5	8	4.8

Map 5 and Table 6 display the hometown locations of IUSM graduates with regard to the county the campus is in and the surrounding region (refer to Map 4 for more detail). There were some stark differences in the breakdown of this data based on the first-year campus assignment of the students. The campus in Gary had the largest percentage of students coming from Lake County, the same county as the campus (30.5%), while Muncie had the smallest percentages coming from Delaware County, its county of campus (8.0%). Indianapolis had the largest percentage coming from the other counties within its campus region (23.1%) and Terre Haute had the smallest percentage from its campus region (2.4%). It was clear from this data that certain campuses tended to attract more students from the area immediately surrounding the campus.

Rural vs. Urban Hometowns

Map 6: Hometowns in Rural vs Urban ZIPs, 2011-2018

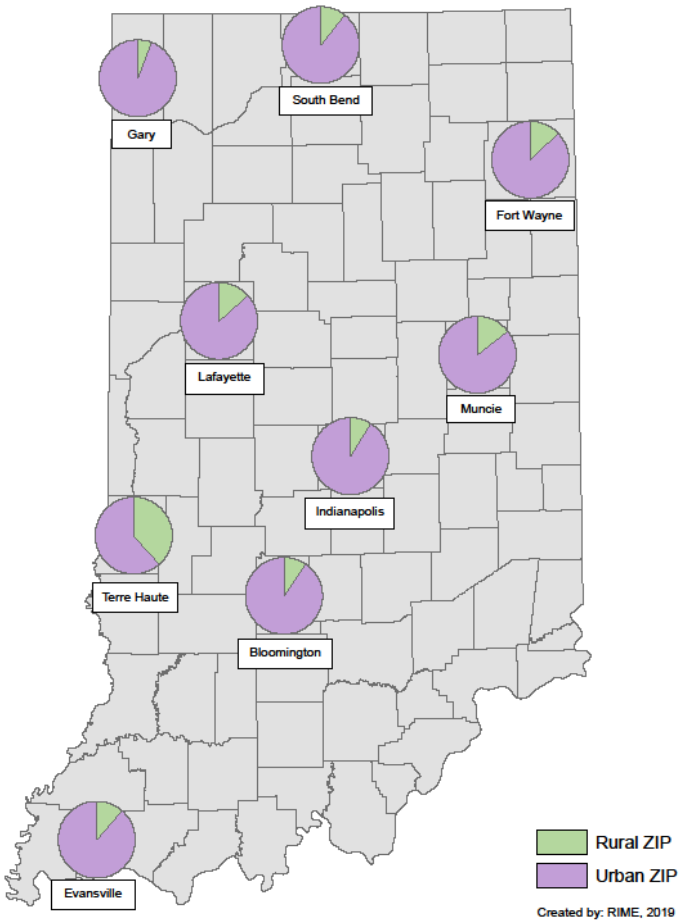


Table 7: Hometown Locations with Rural vs. Urban ZIPS, 2011-2018

	Rural ZIP		Urban ZIP	
Campus	#	%	#	%
Bloomington	18	9.4	173	90.6
Evansville	12	11.3	94	88.7
Fort Wayne	18	12.7	124	87.3
Gary	8	5.7	133	94.3
Indianapolis	67	8.7	704	91.3
Lafayette	13	13.3	85	86.7
Muncie	20	14.3	120	85.7
South Bend	14	10.4	120	89.6
Terre Haute	54	38.3	87	61.7

Map 6 and Table 7 depict the distribution of IUSM graduates' hometowns that fall within rural or urban ZIP codes, as defined by FORHP designation of rural and urban locations. Terre Haute had a significantly higher percentage of students coming from rural backgrounds (38.3%), likely due to its unique Rural Track program. The campus in Gary, meanwhile, had the fewest students with rural hometowns (5.7%). This ties in with the findings in Map 5 that showed a significant number of students at the Gary campus coming from Lake County which is an urban county.

Significant Findings

The hometown section of the pipeline project produced a few significant results and findings about the 2011-2018 IUSM graduating cohort. Firstly, the choropleth maps showed the unsurprising results that the majority of IUSM students had a hometown in Marion County and Indiana as opposed to other counties and states. These two maps also showed the counties and states in which no students had hometowns during the study period. This knowledge could be used by school officials to target recruitment efforts.

The diagram maps that showed the differences between the various IUSM campuses also provided significant information concerning the 2011-2018 graduating cohort. The Terre Haute campus stood out in many of these instances, displaying more graduates with rural hometowns and from Indiana than all other campuses. The Gary campus also stood out as significant due to the likelihood of its students to have come from Lake County itself and the fact that they had the fewest instances of rural hometowns across the nine campuses.

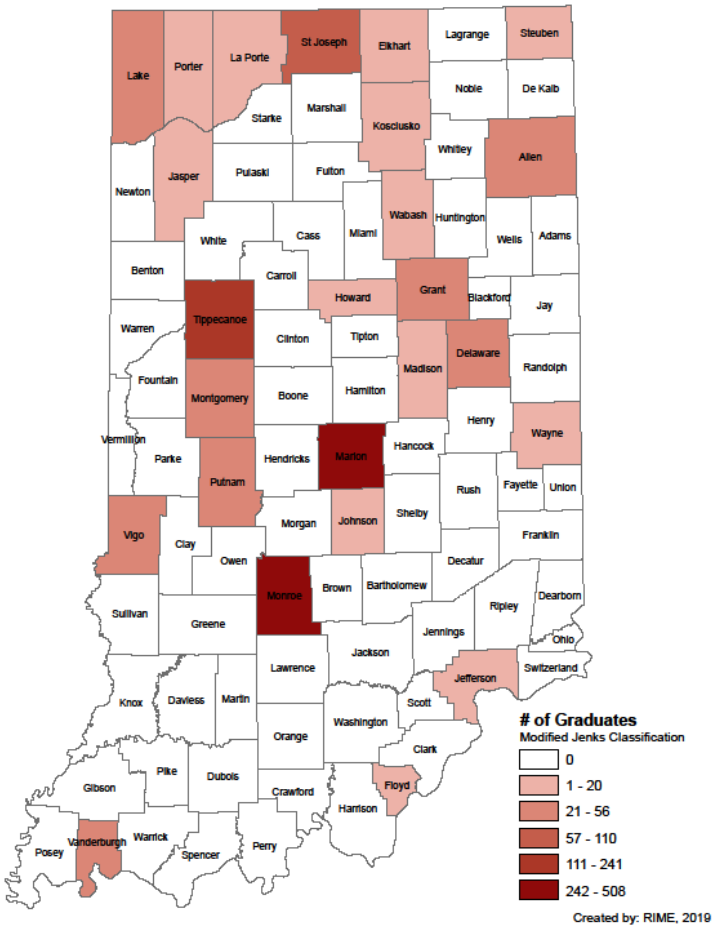
Despite these findings, it is notable that the Indianapolis campus, or the Main Campus, was not generally an outlier as compared to the Regional Medical Campuses. Much of the distribution of the Indianapolis campus was similar to other RMCs, showing there was little significant variance between the MC and RMC hometown data.

College

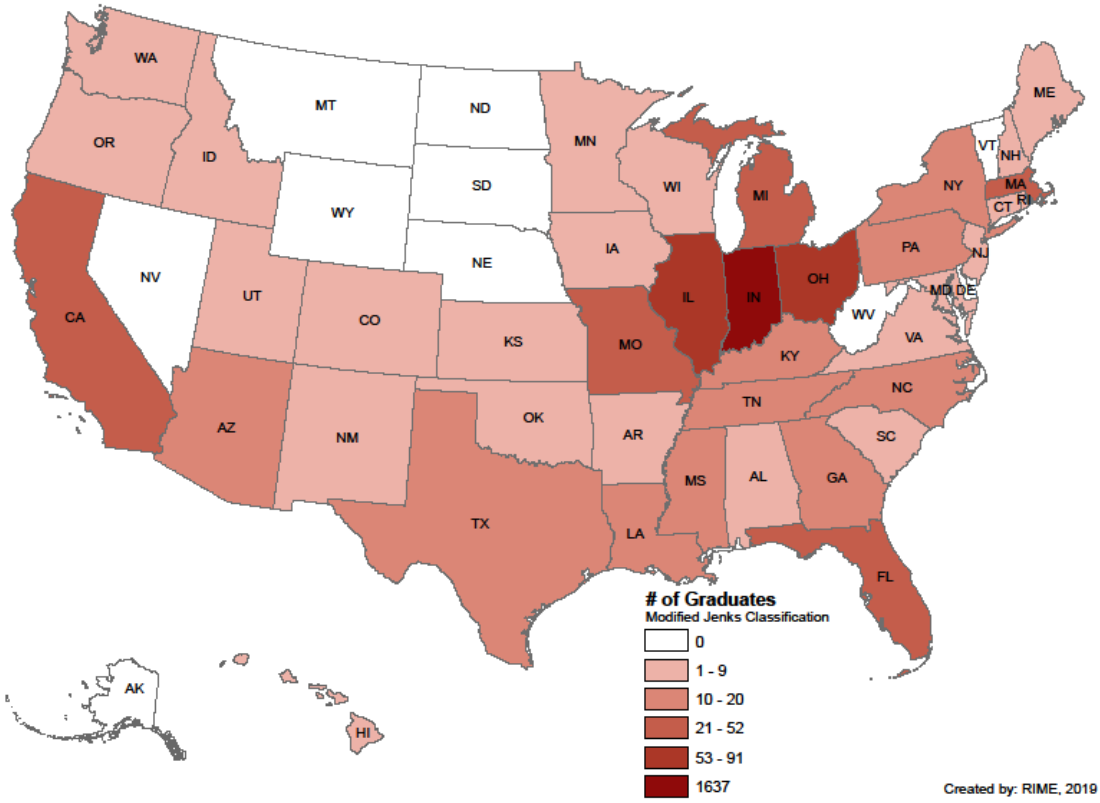
The next segment of the pipeline examined included the undergraduate college locations of the 2011-2018 IUSM graduating cohort. The information and distribution of the undergraduate college locations provided some interesting insights into the prior education locations of the medical student body.

Distributions

Map 7: IUSM Graduates' Undergraduate College Locations in Indiana, 2011-2018



Map 8: IUSM Graduates' Undergraduate College Locations in the US, 2011-2018



Maps 7 and 8 display the distribution of reported undergraduate college locations across Indiana and the United States. In a national context, Indiana had the highest concentration of reported college locations with 1637 instances. Many of the western states had few or no reported college locations of IUSM graduates. In Indiana, Monroe County had the highest concentration of undergraduate college reports with 508 IUSM graduates having attended college in the county, primarily at Indiana University Bloomington. Marion County (n=385) and Tippecanoe County (n=241) also included large portions of the Indiana college locations mostly representing Indiana University-Purdue University Indianapolis and Purdue University respectively.

In-State vs. Out-of-State

Map 9: In-State vs Out-of-State Distribution of College Locations, 2011-2018

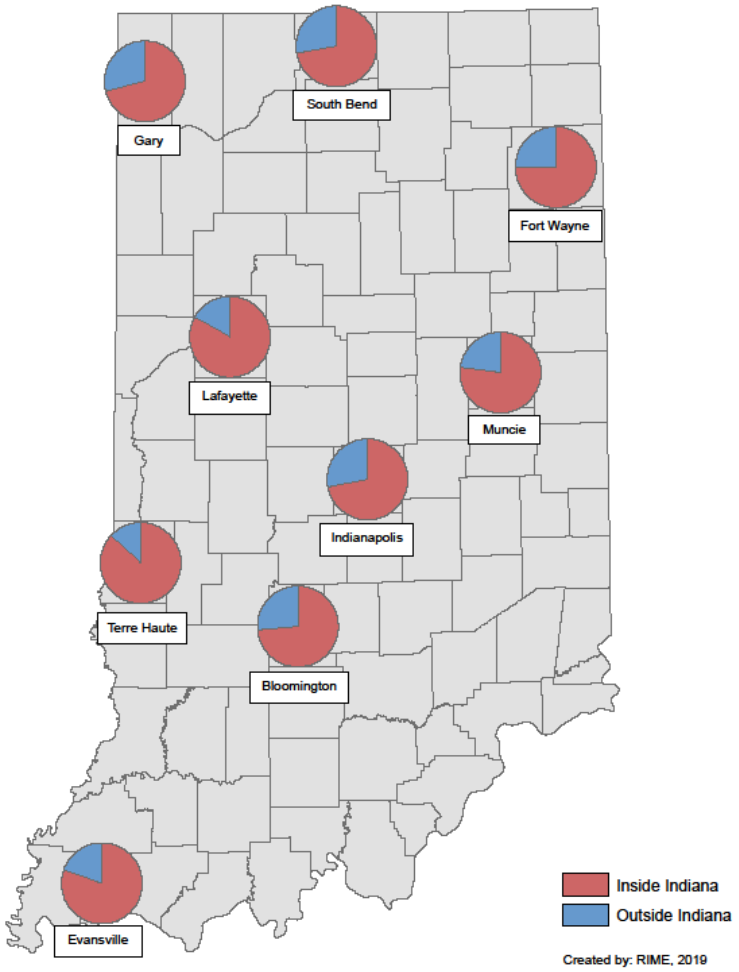


Table 8: In-State vs. Out-of-State Distribution of College Locations, 2011-2018

	In-State		Out-of-State	
Campus	#	%	#	%
Bloomington	162	73.6	58	26.4
Evansville	98	80.3	24	19.7
Fort Wayne	116	74.8	39	25.2
Gary	115	71.0	47	29.0
Indianapolis	668	71.9	261	28.1
Lafayette	98	83.1	20	16.9
Muncie	124	77.0	37	23.0
South Bend	112	72.3	43	27.7
Terre Haute	143	86.7	22	13.3

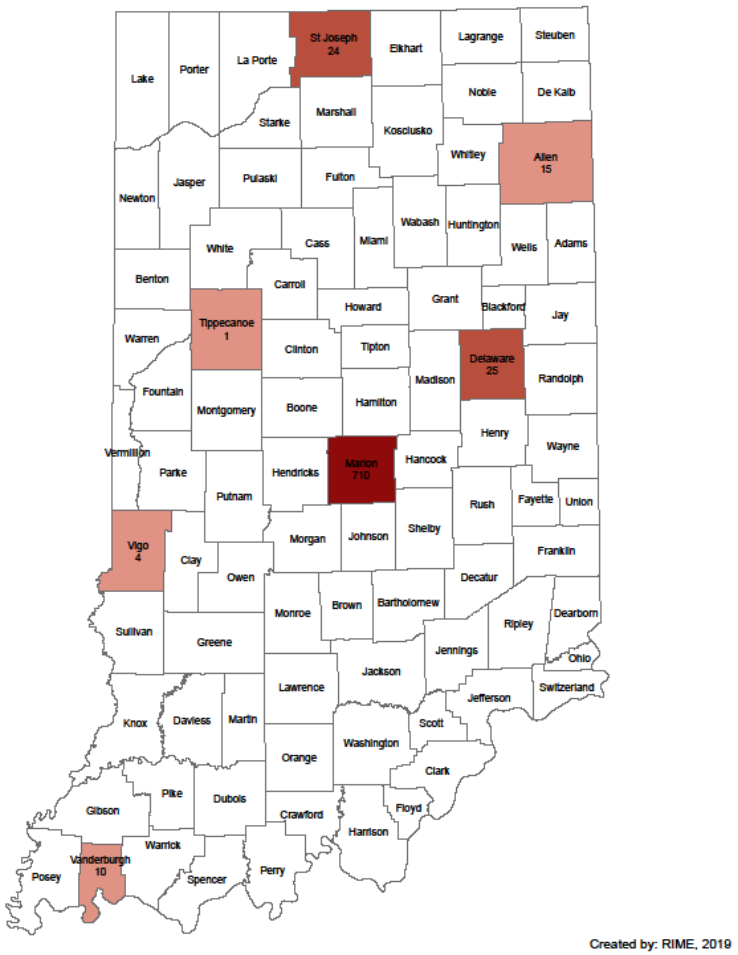
Map 9 and Table 8 show similar results as Map 4 and Table 3 displaying hometown locations. As with hometowns, the Terre Haute campus had the highest concentration of medical graduates with college locations in Indiana (86.7%). The Gary campus had the fewest graduates with Indiana college locations during the study period (71.0%).

Residency

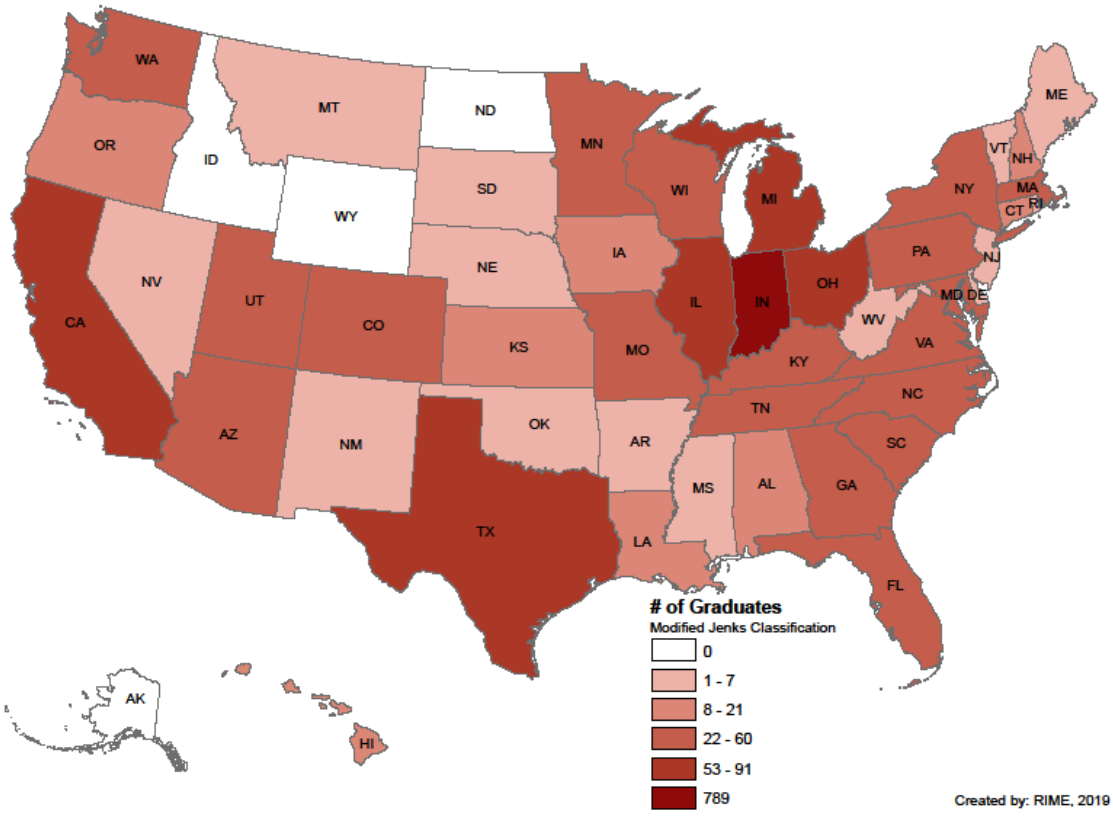
The residency section of the pipeline was concerned with the specialty as well as the specific resident locations of those graduating and completing the Match from 2011-2018. We looked at the spread of those locations across the state and county, their relation to first-year campus assignment, and the connections to match specialty choices.

Distributions

Map 10: IUSM Graduates' Residency Locations in Indiana, 2011-2018



Map 11: IUSM Graduates' Residency Locations in the US, 2011-2018



Maps 10 and 11 display the distribution of matched residency locations across Indiana and the United States. In Indiana, only a few counties offered residency programs for medical graduates during the study period. The majority of Indiana programs and opportunities were located within Marion County so there was little spread of graduates across the state. Of the 789 graduates who went to a residency program in Indiana, 710 of them were located in Marion County.

In a national context, the 2011-2018 graduates were spread out across the majority of the states. Only Alaska, Idaho, North Dakota, and Wyoming lacked any IUSM graduates completing residencies within them. Certain states stood out with more IUSM graduates going to residencies within them, such as other Midwest states like

Illinois and Ohio as well as large states with many different programs and residency positions, like California and Texas.

In-State vs. Out-of-State

Map 12: In-State vs. Out-of-State Distribution of Residency Locations, 2011-2018

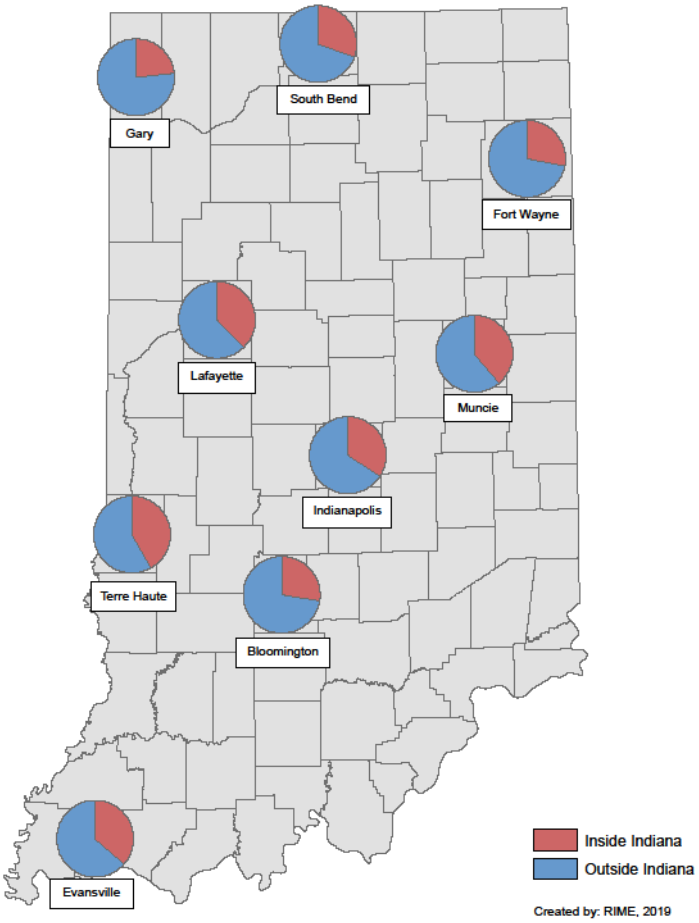


Table 9: In-State vs. Out-of-State Distribution of Residency Locations, 2011-2018

	In-State		Out-of-State	
Campus	#	%	#	%
Bloomington	65	27.4	172	72.6
Evansville	46	36.2	81	63.8
Fort Wayne	45	28.0	116	72.0
Gary	41	23.3	135	76.7
Indianapolis	352	34.0	682	66.0
Lafayette	46	37.4	77	62.6
Muncie	68	38.9	107	61.1
South Bend	51	30.5	116	69.5
Terre Haute	73	41.7	102	58.3

Map 12 and Table 9 show the differences between in-state and out-of-state residency locations of IUSM graduates. Unlike the previous segments of the pipeline, the majority of students at every campus location went outside of the state for residency training. This was most likely due to the limited number of programs within Indiana, especially for certain specialty training. Students from the Gary campus had the highest likelihood of going out-of-state for their residency (76.7%) while Terre Haute graduates were the most likely to remain in Indiana (41.7%). These results mirrored previous findings for the two campuses, with Gary generally representing a higher concentration of out-of-state instances and Terre Haute representing a higher concentration of in-state instances.

Residency Specialties

Map 13: Primary Care vs. Non-Primary Care Specialties of IUSM Graduates, 2011-2018

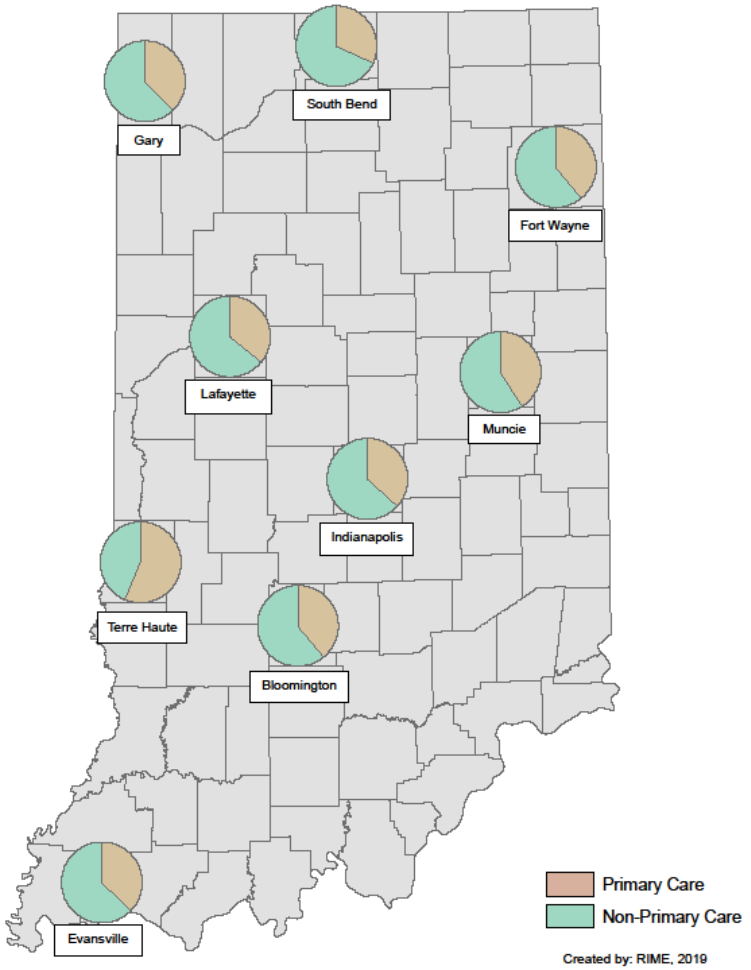


Table 10: Distribution of Primary Care vs. Non-Primary Care Residencies, 2011-2018

	Primary Care		Non-Primary Care	
Campus	#	%	#	%
Bloomington	92	38.8	145	61.2
Evansville	47	37.0	80	63.0
Fort Wayne	63	38.9	99	61.1
Gary	67	37.6	111	62.4
Indianapolis	379	36.5	658	63.5
Lafayette	44	35.8	79	64.2
Muncie	72	40.9	104	59.1
South Bend	53	31.7	114	68.3
Terre Haute	99	56.3	77	43.8

Map 13 and Table 10 show the campus-based differences between primary care (PC) and non-primary care (NPC) residency specialties. As noted previously, family medicine, pediatrics, internal medicine, and internal medicine-pediatrics are considered primary-care specialties, while all others fall under non-primary care for purposes of this study. Graduates from Terre Haute were much more likely than those from any other campus to practice in primary care (56.3%). This may be partially due to the Terre Haute Rural Track program that emphasizes the importance of primary care physicians in rural areas. South Bend, meanwhile, had the lowest concentration of primary care specialists (31.7%).

Table 11: IUSM Graduates in Residency Specialties, 2011-2018

Specialty	Count	PC or NPC
Anesthesiology	**282**	**NPC**
Child Neurology	11	NPC
Dermatology	40	NPC
Emergency Medicine	**192**	**NPC**
Family Medicine	**264**	**PC**
General Surgery	**169**	**NPC**
Internal Medicine	**364**	**PC**
Interventional Radiology	2	NPC
Medicine-Pediatrics	72	PC
Neurodevelopmental Disabilities	6	NPC
Neurological Surgery	31	NPC
Neurology	110	NPC
Obstetrics-Gynecology	99	NPC
Ophthalmology	42	NPC
Orthopedic Surgery	95	NPC
Otolaryngology	49	NPC
Pathology	46	NPC
Pediatrics	**216**	**PC**
Pediatrics/Psychiatry/Child Psychiatry	12	NPC
Pediatrics-Emergency Medicine	7	NPC
Physical Medicine and Rehabilitation	28	NPC
Plastic Surgery	20	NPC
Psychiatry	50	NPC
Radiation Oncology	13	NPC
Radiology Diagnostic	123	NPC
Thoracic Surgery	6	NPC
Urology	35	NPC
Vascular Surgery	2	NPC

Map 14: Top Specialties of IUSM Graduates, 2011-2018

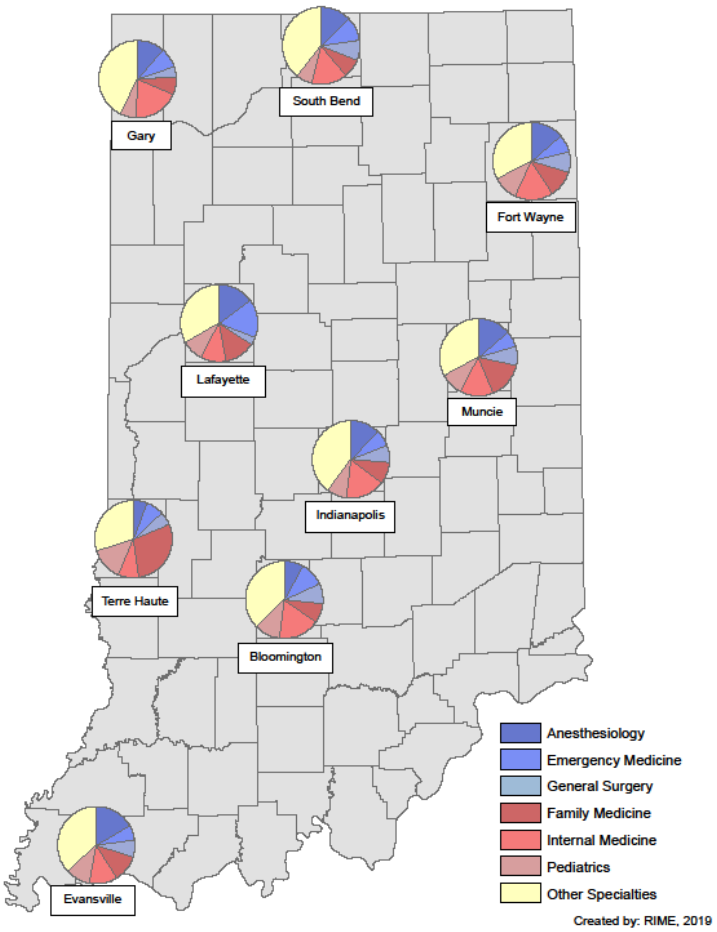


Table 11 shows the complete aggregated breakdown of how many IUSM graduates went into each specialty during the study period. Internal medicine was the most popular with 364 graduates entering this specialty. The following five most numerous were: anesthesiology (n=282), family medicine (n=264), pediatrics (n=216), emergency medicine (n=192), and general surgery (n=169). Map 14 shows a more detailed distribution of the top six specialties of IUSM graduates by their first-year campus assignment. In blue anesthesiology, emergency medicine, and general surgery represent the three most numerous non-primary care specialties. In pink family medicine,

internal medicine, and pediatrics represent the three most numerous primary care specialties. Notable on the graph for Terre Haute is the percentage of family medicine specialists. It is clear from this visualization that the Terre Haute campus had far more family medicine graduates than any other campus.

Comparisons to Hometowns and Practice Locations

Table 12: Primary Care vs. Non-Primary Care, Comparisons of Hometown and Practice Locations

% of Graduates	Rural Hometown	Rural Practice	In-state Hometown	In-state Practice	MUA or HPSA
Primary Care	13.9	10.7	87.6	57.8	53.0
Non-Primary Care	10.9	8.7	85.5	45.8	52.8
Chi-square p-value	*.144*	*.356*	*.173*	*.000*	*.944*

Table 12 summarizes differences between primary care and non-primary care specialists in terms of hometown and practice locations. This study was interested in how a few key factors might influence other choices and decisions along the medical education pipeline. Here, we were interested in how rural locations, in-state locations, and shortage areas were associated with the choice of specialty.

Primary care specialists were slightly more likely than non-primary care specialists to come from rural backgrounds, with 13.9% and 10.9% respectively coming from rural ZIP codes. Primary care specialists were also slightly more likely to end up practicing in a rural ZIP at 10.7% as compared to 8.7% of non-primary care specialists. Residents in primary care specialties were also slightly more likely to have hometowns in Indiana with 87.6% reporting in-state hometowns versus 85.5% of those in non-primary care reporting in-state hometowns. In-state practice locations represented the largest difference between primary care and non-primary care residents of all the factors we

looked at. 57.8% of primary care residents ended up practicing in state while only 45.8% of non-primary care residents did. This represented a 12% difference and a chi-square test of association produced a *p-value* of 0.000 showing that there was a statistically significant difference between these groups. The last facet that we compared to specialty choice was whether or not the graduates ended up practicing in a shortage area, either an MUA or a HPSA. There was a negligible difference between the two subsets. 53.0% of primary care specialists practiced in a shortage area compared to 52.8% of non-primary care specialists.

Significant Findings

The findings from the residency stage of the pipeline study did not reveal anything significant about IUSM graduates except for a few differences with the Terre Haute campus due to its focus on rural medicine. The spread of students across the state and country were mostly as expected with the knowledge of where residency programs tend to exist in the United States and Indiana specifically. The differences between graduates of each first-year campus were mostly similar as already seen in the hometown and college sections with Terre Haute having more in-state residents (41.7%) and Gary having the least in-state residents (23.3%).

Specialty choices of graduates were also examined in the residency stage of the pipeline. The main outlier between campuses and specialty choice was Terre Haute with a majority of graduates entering primary care residencies (56.3%), especially family medicine. These results were most interesting in what they didn't show rather than in what they did. The specialty differences showed very little deviation between campuses

with the exception of Terre Haute. It has often been the stereotype that RMCs produced more primary care specialists while the MC, Indianapolis in our case, produced more non-primary care specialists. We did not find this to be true in the case of this study period as both Lafayette and South Bend produced a higher percentage of non-primary care specialists than Indianapolis.

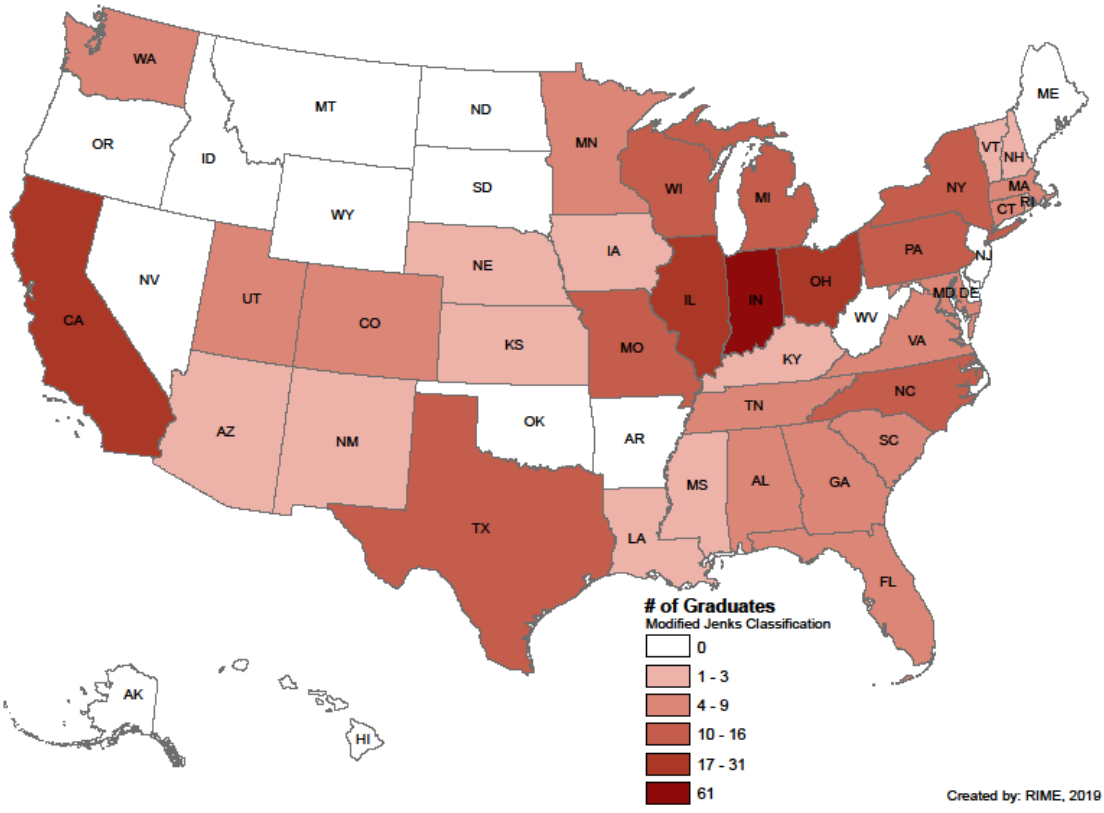
Comparisons to other segments of the pipeline proved to be slightly different. Graduates who pursued primary care specialties were somewhat more likely to have come from rural hometowns and in-state hometowns, and more likely to practice at in-state locations and at rural locations. It is interesting to note the differences between our findings and those of Gill et al. (2012) in Edmonton, Alberta. In their study, the researchers found that physicians practicing family medicine were much more likely to have come from a rural area, with 47% from rural areas as opposed to 24% for all other specialties. While we did not look at family medicine specifically, we did look at primary care as a whole versus non-primary care. The difference between these two groups in our study was much less pronounced, with only a 3% difference as opposed to the 23% difference reported by Gil et al. (2012). While the comparison is not identical, the differences indicate that IUSM overall had a more even distribution of rural hometowns when compared to specialty selection.

Fellowship

The next section of the pipeline contained information on graduates' fellowship specialties and locations. This segment was relatively incomplete due to a lack of available data about fellowships for IUSM graduates, as well as the fact that not all graduates have to complete a fellowship as a part of their medical education. Information on fellowship data was searched for all graduates from 2011-2015 who completed their residency as of the spring of 2019. The findings of those searches are displayed here.

Distributions

Map 15: IUSM Graduates' Fellowship Locations in the US, 2011-2015



Map 15 displays the distribution of fellowship locations across the United States. This portion of the study had far fewer instances across the study period, as reflected in the map, with many states having only a handful of locations or none at all. An Indiana distribution map was not included for the fellowship portion of the pipeline due to all instances (n=61) occurring within Marion County.

In-State vs. Out-of-State

Map 16: In-State vs. Out-of-State Distribution of Fellowship Locations, 2011-2015

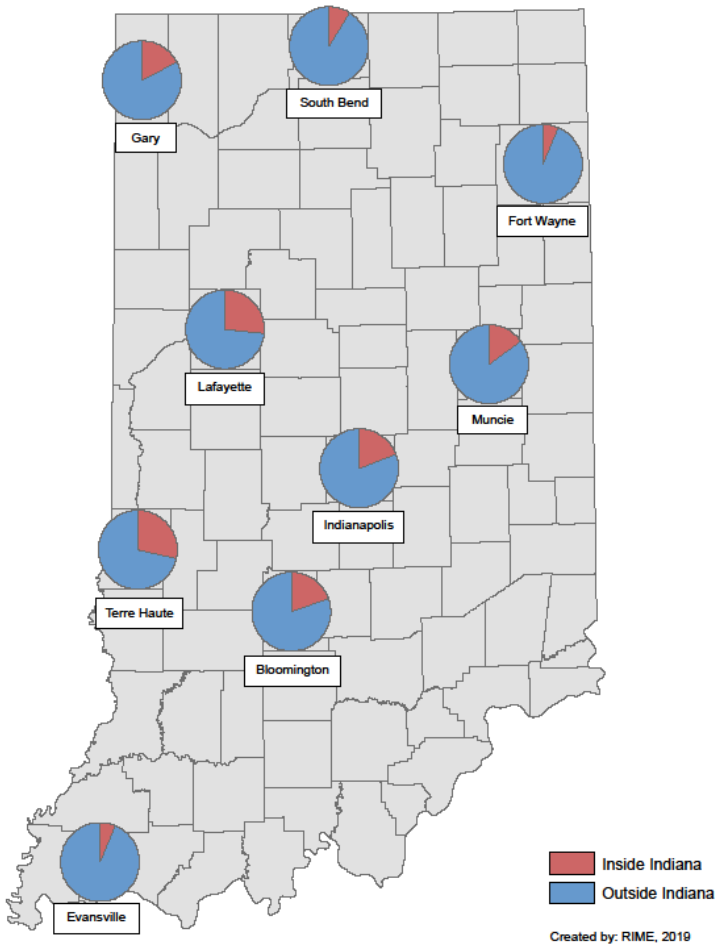


Table 13: In-State vs. Out-of-State Distribution of Fellowship Locations, 2011-2015

	In-State		Out-of-State	
Campus	#	%	#	%
Bloomington	8	19.5	33	80.5
Evansville	1	6.3	15	93.8
Fort Wayne	1	6.3	15	93.8
Gary	5	17.2	24	82.8
Indianapolis	31	19.1	131	80.9
Lafayette	4	26.7	11	73.3
Muncie	3	15.0	17	85.0
South Bend	2	8.7	21	91.3
Terre Haute	6	28.6	15	71.4

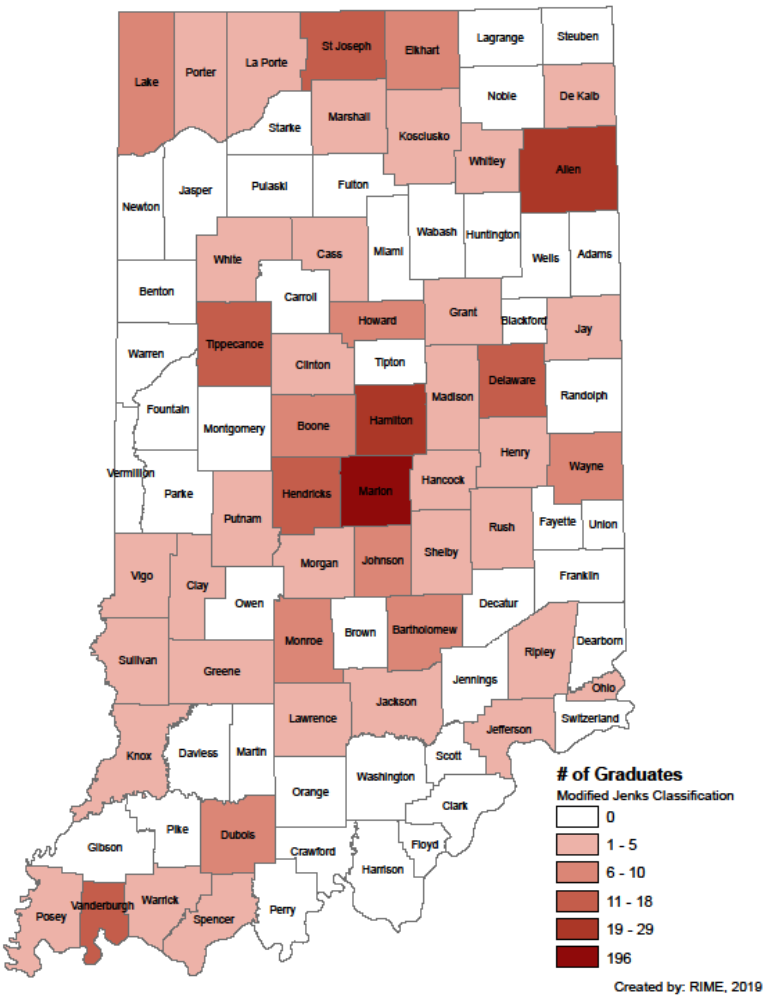
Map 16 and Table 13 show the differences in fellowship locations between graduates of each first-year campus. Due to the smaller numbers in this section overall, these visualizations were perhaps not as useful as those on more complete sections such as hometown or practice. Overall, only a few graduates had fellowships in Indiana, which created some very small percentages (6.3%) at both Evansville and Fort Wayne campuses. These two campuses represented the smallest percentage of in-state fellowships while Terre Haute again had the most at 28.6%. The small number of fellowship locations in Indiana as well as the difficulties involved with finding fellowship locations overall, most likely contributed to these results.

Practice

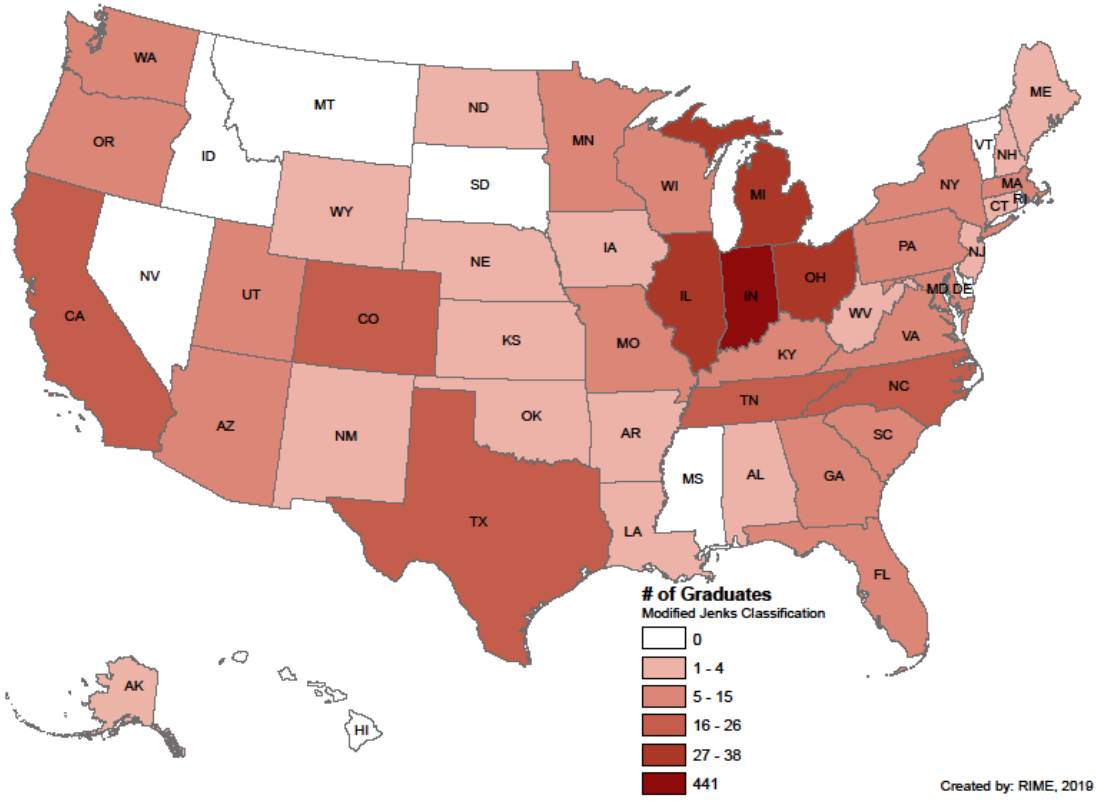
The practice location segment of the pipeline represents one of the important outcomes of the project. This information showed the physician staffing statistics of IUSM graduates in terms of the communities and locations that they serve. All graduates from 2011-2015 who completed the residency and fellowship portions of their education as of the spring of 2019 were searched to find their practice locations. These locations were mapped across the state and country and compared to first-year campus assignments as well as hometown locations. Additionally, these locations were analyzed for HPSA, MUA, and rural designations to see how IUSM graduates serve these unique areas.

Distributions

Map 17: IUSM Graduates' Practice Locations in Indiana, 2011-2015



Map 18: IUSM Graduates' Practice Locations in the US, 2011-2015



Maps 17 and 18 display the distribution of practice locations across the state of Indiana and the United States. These maps show that Indiana (n=441) and Marion County (n=196) represented by far the largest concentration of IUSM graduates. This showed that the majority of students return to the state to practice, demonstrating significant physician retention.

Across Indiana it is interesting to note that some of the highest concentrations of IUSM practitioners were in the counties that contain IUSM campuses, which also happen to be counties with the largest cities. More graduates seemed to go to these areas to practice as opposed to more rural counties, especially in the west and south of the state. At the national level, most states had at least one graduate of IUSM from 2011-2018

practicing within them. The exceptions are Delaware, Hawaii, Idaho, Mississippi, Montana, Nevada, South Dakota, and Vermont. Higher concentrations existed in the surrounding states of Illinois, Ohio, and Michigan.

In-State vs. Out-of-State

Map 19: In-State vs. Out-of-State Distribution of Practice Locations, 2011-2015

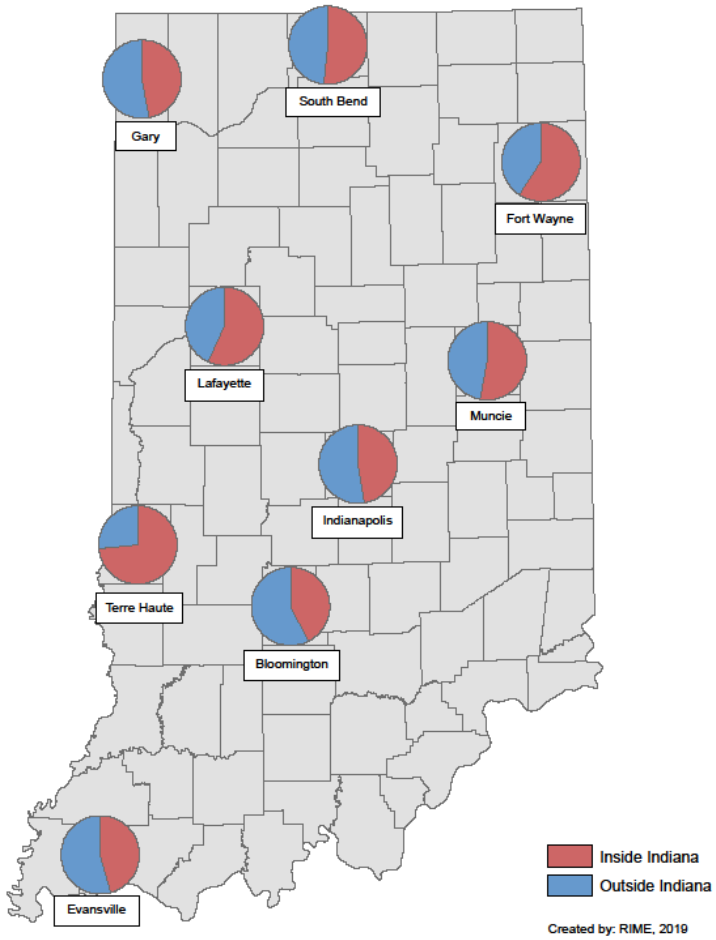


Table 14: In-State vs. Out-of-State Distribution of Practice Locations, 2011-2015

	In-State		Out-of-State	
Campus	#	%	#	%
Bloomington	33	42.3	45	57.7
Evansville	21	45.7	25	54.3
Fort Wayne	26	59.1	18	40.9
Gary	24	47.1	27	52.9
Indianapolis	185	47.4	205	52.6
Lafayette	25	56.8	19	43.2
Muncie	37	52.9	33	47.1
South Bend	30	51.7	28	48.3
Terre Haute	58	73.4	21	26.6

Map 19 and Table 14 show the differences in practice locations between graduates of each first-year campus. As with almost every other section, Terre Haute had the highest percentage of in-state locations at 73.4%. Bloomington, meanwhile, had the smallest percentage of in-state practice locations at 42.3%. It is interesting to compare these percentages to the corresponding hometown percentages. Terre Haute graduates had in-state hometowns 95.2% of the time. This comparison shows that the Terre Haute program retained a good proportion of their students within the state. Meanwhile, Bloomington graduates had in-state hometowns 85.3% of the time. This difference is interesting to see, because even though an overwhelming majority of Bloomington graduates were from Indiana less than half decided to practice within the state. Of note, Indianapolis graduates fell in the middle of the nine campuses with 47.4% practicing in-state, showing no significant difference between the MC and RMC outcomes in terms of state retention.

Rural vs. Urban Practice

Map 20: Practice Locations in Rural vs. Urban ZIPS, 2011-2015

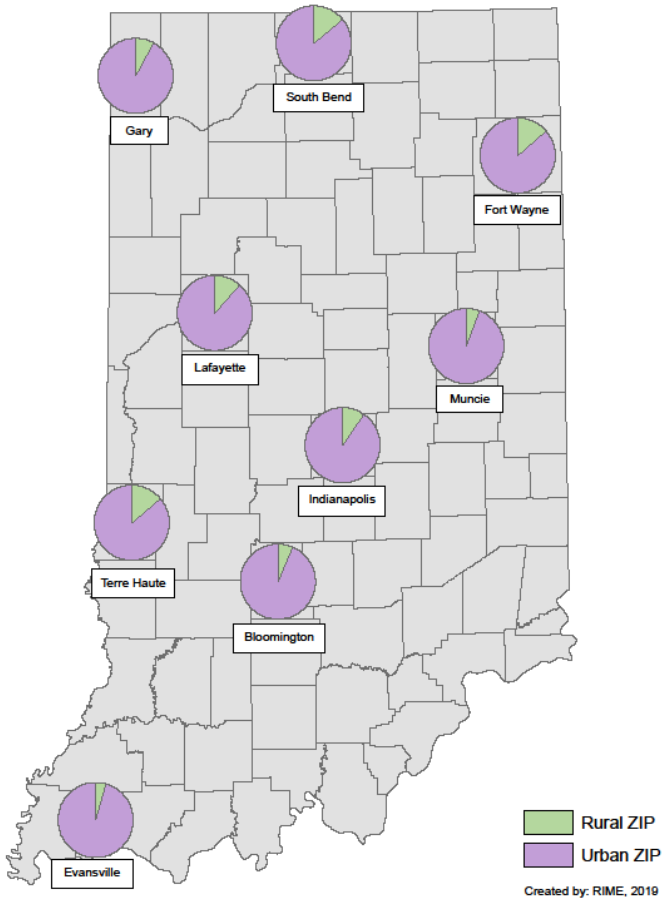


Table 15: Practice Locations with Rural vs. Urban ZIPS, 2011-2015

	Rural ZIPs		Urban ZIPs	
Campus	#	%	#	%
Bloomington	5	6.4	73	93.6
Evansville	2	4.3	44	95.7
Fort Wayne	6	13.6	38	86.4
Gary	4	7.8	47	92.2
Indianapolis	37	9.5	353	90.5
Lafayette	5	11.4	39	88.6
Muncie	4	5.7	66	94.3
South Bend	8	13.8	50	86.2
Terre Haute	11	13.9	68	86.1

Map 20 and Table 15 depict the distribution of IUSM graduates' practices that fall within rural or urban ZIP codes as defined by FORHP designations. Overall, there were not many graduates practicing in rural ZIPs (n=82), with the overwhelming majority in urban areas. Interestingly, while Terre Haute still had the highest percentage of rural practitioners (13.9%), this was not significantly higher than either South Bend (13.8%) or Fort Wayne (13.6%). This shows that despite the high concentration of rural hometowns, rural residencies, and the Rural Track program itself, the vast majority of Terre Haute graduates found their eventual careers in urban-coded ZIPs. Graduates of the Evansville campus had the fewest rural practice locations with only two practitioners in rural ZIPS, or 4.3%. Once again, the Indianapolis campus sat in the center numerically with 9.5%, showing there was no significant difference between RMC and MC practice locations in terms of the rural and urban divide.

Shortage Areas

Map 21: Practice Locations in Either MUA or HPSA, 2011-2015

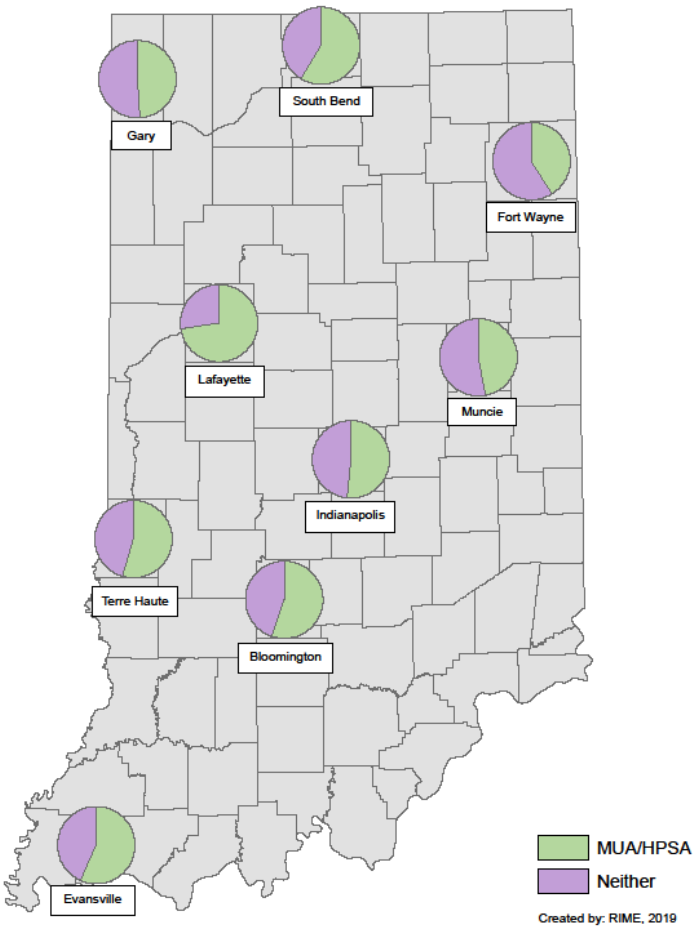


Table 16: Practice Locations in Either HPSAs or MUAs, 2011-2015

	Inside MUA		Inside HPSA		Within MUA and/or HPSA		Outside MUA and HPSA	
Campus	#	%	#	%	#	%	#	%
Bloomington	34	43.6	27	34.6	43	55.1	35	44.9
Evansville	16	34.8	20	43.5	26	56.5	20	43.5
Fort Wayne	13	29.5	12	27.3	18	40.9	26	59.1
Gary	19	37.3	19	37.3	25	49.0	26	51.0
Indianapolis	145	37.2	146	27.3	201	51.5	189	48.5
Lafayette	30	68.2	17	38.6	32	72.7	12	27.3
Muncie	28	40.0	23	32.9	33	47.1	37	52.9
South Bend	25	43.1	20	34.5	34	58.6	24	41.4
Terre Haute	30	38.0	31	39.2	43	54.4	36	45.6

Map 21 and Table 16 show the distribution of practitioners in the two types of shortage areas analyzed in this study, MUAs and HPSAs, divided by first-year campus assignment. Map 21 shows in green the percentage of graduates that were practicing in either a HPSA, an MUA, or both. Many locations fall under both shortage areas, so there is a great deal of overlap between the two designations. Table 16 breaks this data down further, showing not only the combined shortage areas statistics, but also HPSA and MUA alone.

Graduates who were assigned to the Lafayette campus had by far the highest concentration of MUA locations (68.2%) and shortage area locations overall (72.7%). Evansville had the highest concentration of HPSA locations (43.5%). Fort Wayne had the lowest number of practitioners in all three sections, with 29.5% in HPSAs, 27.3% in MUAs, and only 40.9% in either type of shortage area.

Overall Statistics

Table 17: Overall Statistics of Practice Locations, 2011-2015

Practice Location	In-State	Rural	HPSA	MUA	HPSA and/or MUA
% of Total	51.2	9.5	36.7	39.6	52.9

Table 17 shows the percentages of the total number of IUSM graduates who practice in specific practice locations. These totals show that at least half of IUSM graduates remained within the state (51.2%) and at least half practiced in shortage areas (52.9%). However, only a very small percentage practiced in rural areas (9.5%).

Comparisons with Hometown Locations

Table 18: Practice Location Comparisons to Hometown Locations, 2011-2015

% of Students	Rural Practice	Practice In-state	MUA or HPSA
Rural Hometown	25.0	68.3	55.0
Urban Hometown	9.4	51.5	49.0
Chi-squared p-value	*.000*	*.013*	*.107*
In-State Hometown	10.3	55.5	53.2
Out-of-State Hometown	3.2	25.8	49.5
Chi-squared p-value	*.091*	*.000*	*.758*

Table 18 compares some of the facets of practice locations (rural, in-state, and shortage areas) to hometowns in rural or urban areas as well as in-state versus out-of-state hometown locations. This comparison shows that 25% of those students who had a rural hometown eventually go on to practicing in a rural area as opposed to only 9.4% of students from an urban area. The chi-square test for this comparison was statistically significant. Similarly, 10.3% of those with an in-state hometown chose to practice in a rural location while only 3.2% of those from out-of-state opted to practice in a rural ZIP. Those with rural hometowns were also more likely to practice in-state eventually (68.3%) as opposed to those with urban hometowns (51.5%). Unsurprisingly, students with Indiana hometowns were much more likely to practice in Indiana (55.5%) as compared to students with out-of-state hometowns (25.8%). The statistically significant *p-value* of 0.000 clearly shows that having an Indiana hometown is a fairly strong predictor of practicing within the state. The disparity between the groups was less significant when it came to practicing in shortage areas. 55% of students from rural areas ended up practicing in a shortage area while 49% of students from urban areas ended up in these

designated areas. Students with in-state hometowns ended up practicing in shortage areas 53.2% of the time compared to out-of-state hometowns at 49.5%.

Significant Findings

Examining data from the practice section of the pipeline provided significant findings, especially when compared to the hometown data results. The practice section was probably the most important for understanding how IUSM is fulfilling physician workforce needs. Data compiled during this research suggest that there were some key differences between the nine IUSM campuses, though few between the RMCs as a whole and the main Indianapolis campus. The Terre Haute campus had a higher concentration of graduates practicing within the state, though interestingly they were not a stand-out in terms of rural practitioners. In all, the entire IUSM cohort in practice had very few graduates practicing in rural areas. As far as shortage areas, those who attended the Lafayette campus had a higher chance of practicing in MUAs or HPSAs.

Our results on IUSM practice data can be compared to similar research findings. Hixon et al. (2012) found in their study concerning the family medicine residents of Hawai'i that that the vast majority remained within the state (73%) and 36% practiced in HPSAs. Our study showed far fewer in-state practitioners, though this was perhaps due to the remoteness of Hawai'i as compared to Indiana. Our study did show an almost identical percentage of HPSA practitioners at 36.7%. Brokaw et al. (2009) found in their study concerning an older cohort of IUSM graduates that those who studied at RMCs were much more likely to practice in rural locations. Interestingly, this did not appear to be the case for our study period. When averaged together, the percentage of all RMC

students practicing in rural areas was 9.6%. This was virtually identical to the Indianapolis percentage of 9.5%. Therefore, we saw no significant difference in campus assignment and rural status of practice location.

The study by Wade et al. (2007) found that doctors with a rural hometown were 4.7 times more likely to practice in a rural area as compared to those with an urban hometown. Our study had similar results, with our graduates from rural hometowns also being significantly more likely to practice in a rural areas. This suggests a connection between rural hometowns and eventual rural practice. The final study that provided similar research goals as our pipeline project was that by Pretorius et al. (2010) which looked at connections between former residence locations and midcareer practice location, defined as 17-19 years post-graduation. The current study focused on initial practice locations after graduation rather than midcareer and thus was not directly comparable. Additionally, our statistics looked only at the connection between hometown and practice, but we found that 55% of our graduates with an in-state hometown had Indiana practice locations. This shows that a majority of students from Indiana remained in the state to practice, as compared to 25.8% of those from out-of-state who practiced in Indiana. Pretorius et al. (2012) found that 84% of the students in their study had a connection between their practice location and a previous location of residence. Again, this is clearly not immediately comparable but we also found a similar connection between prior locations and in-state practice.

Overall, the information on practice locations of IUSM graduates was very useful in seeing where graduates go and in what type of locations they practice. This information can be invaluable to leadership, researchers, and administrators, and the

visualizations through maps can communicate this information in an appealing and simple format.

Limitations

While this study is extremely valuable and was conducted with the highest possible attention to detail and adherence to data integrity, there are many notable limitations. The main and most affecting limitation was that data were collected from Google searches that, despite best efforts, may not have been completely accurate. This searched information relied on hospitals, universities, and other facilities to have updated and accurate information available on their websites, which was not always the case. Additionally, data came from many sources which resulted in the inevitable missing or inaccurate data elements due to errors in data entry, data keeping, and data management through various sources. Name changes also made data verification difficult without further identifying factors, therefore it is likely that some graduates could not be located due to those differences. Lastly, it was difficult to verify the practice location of graduates with common names (e.g. John Smith). We did everything we could to minimize these errors and work around our limitations, but they cannot be ignored.

Future Research

This pipeline project represents only the beginning of what can be done with this research. With the database framework completed, there are many other analyses and visualizations that can be conducted on the various aspects of the educational pipeline. Additionally, there is more information that could eventually be added to the pipeline. Using names and student IDs, demographic information could perhaps be added to give more depth to the data and to provide more tools for analysis.

The pipeline database will be continually updated as more information becomes available, especially after each subsequent Match program finishes in March of each year. This will add more students and more locations that can be analyzed and mapped. Eventually, we hope that this data will provide the baseline for more publications and presentations.

Conclusions

The medical education pipeline project has been very successful as both a data management and a GIS visualization project. This project has made apparent the necessity for clean, concise, and consistent data on IUSM students and graduates. There is a definite need for this information to be held in a centralized location so it can be easily maintained and accessed by researchers throughout IUSM. Through many hours of work, we were able to compile a database that provides a baseline for future analyses and publications and informs the needs of the IUSM administration and, more broadly, health workforce research.

The maps produced as part of this project help to display various elements of the pipeline in unique and malleable ways. They illustrate raw data in a manner that make it simple for faculty, students, and researchers to quickly understand spatial patterns.

This thesis and project represents only the very beginning of what can be done with this type of research. There is a potential for collaboration between medical schools in the future to build broader datasets with more far-reaching data. Perhaps this is the first step in creating a national system for tracking medical graduates that could help shape and improve physician training and health care access on a larger scale. Physician workforce needs are incredibly important to consider on a national level and it is our hope that this pipeline project might make it a little easier to fulfill those needs or at least attempt to understand them.

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Curriculum Vitae

Laurie Michelle Fancher

Education

- M.S. in Geographic Information Science from Indiana University, earned at Indiana University-Purdue University Indianapolis, October 2019
- B.A. in History from Indiana University, earned at Indiana University-Purdue University Indianapolis, May 2015
- B.A. in Anthropology from Indiana University, earned at Indiana University-Purdue University Indianapolis, May 2015
- Undergraduate Certificate in Museum Studies from Indiana University, earned at Indiana University-Purdue University Indianapolis, May 2015

Professional Experience

- Graduate Research Assistantship in Medical Education at Indiana University School of Medicine, November 2016-Present
- Undergraduate Internship in Cultural Research at the Indiana State Museum, January 2015-May 2015

Honors and Awards

- Graduated with Honors, IUPUI, May 2015
- Chancellor's Scholarship, 2011-2015
- Dean's List, 2011-2015
- Awarded Top Undergraduate Anthropology Student, May 2015

Conference Presentations

Local:

1. Kochhar K, Fancher L. "Presentation of School-wide Data using Maps" For the IUSM Deans Office of Education Committee, Indianapolis, August 1, 2016

2. Kochhar K, Fancher L. "Medical Student Data Pipeline using GIS: Hometown To Practice, 2011-2017" For the IUSM Deans Office of Education Committee, Indianapolis, October 2, 2017

3. Kochhar K, Ho M, Fancher L, Lozefski K, Joshi A, Brewer C. "Results of the 2017 Indiana Family Medicine Residencies Exit Survey" For the Indiana Medical Education Board, December 6, 2017

4. Kochhar K, Fancher L. "IUSM Medical Student Pipeline Data" For the Curriculum Council Steering Committee, August 3, 2018

5. Kochhar K, Ho M, Joshi A, Fancher L. "Results of the Impact of Indiana Medical Education Board Grant, 2018" at the Winter IMEB Board Meeting, December 5, 2018

Regional:

1. Kochhar K, Fancher LM, Brokaw JJ, Wilson J, Nalin PM. "Using GIS to Track Medical Trainees from Hometown through Practice, 2011-2017" Association of American Medical Colleges, Central Group on Educational Affairs Conference, Rochester MN, March 21-23, 2018

2. Kochhar K, Fancher LM, Brokaw JJ, Wilson JS, Nalin PM. "Tracking Medical Students and Graduates from Hometown through Practice using Geographic Information Systems" For the Indiana Geographic Information Council, Annual Indiana GIS Conference, Fort Wayne IN, May 9-11, 2018

National:
1. Kochhar K, Fancher LM, Brokaw JJ, Wilson JS, Nalin PM. "Medical Student Pipeline, From Hometown to Practice, Using Geographic Information Systems" Association of American Medical Colleges, Group on Regional Medical Campuses Conference, Washington DC, April 4-6, 2018

2. Kochhar K, Fancher LM, Brokaw JJ, Wilson JS, Nalin PM. "Tracking Medical Students and Graduates from Hometown through Practice Using Geographic Information Systems" Association of American Medical Colleges, Health Workforce Research Conference, Tysons VA, May 9-11, 2018

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1. Kochhar K, Fancher LM, Brokaw JJ, Wilson JS, Nalin PM. "Tracking medical students and graduates from hometown to practice using Geographic Information Systems, 2011-2017" *J Reg. Med. Campuses*, 1:3, 2018. Available from https://doi.org/10.24926/jrmc.v1i3.1136

2. Kochhar K, Fancher LM, Brokaw JJ, Nalin, PM. "Does Attending a Regional Medical Campus Influence the Training Outcomes of Family Medicine Residents?" *J Reg. Med. Campuses*, Vol 2, Issue 2, 2019. Available from https://doi.org/10.24926/jrmc.v2i1.1997

Technical Reports
1. Kochhar K, Fancher L, Nalin P. "Maps Showing Medical Student Pipeline-Hometown to Practice" For the IU School of Medicine, Dean's Office of Education Meeting, October 2017

2. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report" For the Indiana Medical Education Board, October 2017

3. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report, Community Health Network Family Medicine Residency -- Indianapolis" For the Indiana Medical Education Board, October 2017

4. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. . "2017 Indiana Family Medicine Residencies Exit Survey Report, Deaconess Family Medicine Residency - Evansville" For the Indiana Medical Education Board, October 2017

5. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report, Franciscan Health Family Medicine Residency -- Indianapolis" For the Indiana Medical Education Board, October 2017

6. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report, Fort Wayne Medical Education Program Family Medicine Residency – Fort Wayne" For the Indiana Medical Education Board, October 2017

7. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report, Indiana University Health Ball Memorial Hospital Family Medicine Residency - Muncie" For the Indiana Medical Education Board, October 2017

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10. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report, St. Joseph Regional Medical Center Family Medicine Residency – South Bend" For the Indiana Medical Education Board, October 2017

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13. Kochhar K, Ho, M, Fancher L, Lozefski K, Brewer C, Joshi A. "2017 Indiana Family Medicine Residencies Exit Survey Report, Community Westview Hospital Osteopathic Family Medicine Residency - Indianapolis" For the Indiana Medical Education Board, October 2017

14. Kochhar K, Ho M, Joshi A, Fancher L. "2018 Indiana Family Medicine Residencies Exit Survey Report" For the Indiana Medical Education Board, November 2018

15. Kochhar K, Ho M, Joshi A, Fancher L. “2018 Indiana Family Medicine Residencies Exit Survey Report, Community Health Network Family Medicine Residency” For the Indiana Medical Education Board, November 2018

16. Kochhar K, Ho M, Joshi A, Fancher L. “2018 Indiana Family Medicine Residencies Exit Survey Report, Community South Osteopathic Family Medicine Residency” For the Indiana Medical Education Board, November 2018

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