An Investigation of Hospital Market Entropy In Virginia

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November 2014

Project Overview

For my capstone project I am interested in analyzing hospital patient choice patterns. Placing new hospitals or hospital services is a lengthy and costly endeavor, making accuracy important for predicting future patient behavior. Understanding how hospital patients chose hospitals is key to accurate planning. Because of the complex nature of hospital services, patients can have very different needs. For example, a young woman who is looking for a location to have a baby is a very different event than an older man who is having chest pain.

Selecting a provider is based on many factors: reputation, quality service, cost of care and travel time, etc., I would like to focus on the geographic component as a determiner of choice of practitioner. It is expected that many people choose a facility based on convenience, which can often translate into the closest hospital. The amount of time to prepare for the hospital visit, as well as the character of the event itself can have an impact on choice of hospital.

Healthcare is incredibly complex. Patients are rarely the primary payers for healthcare services, physicians have great power in 'steering' patients, choice of provider can be limited by in-network status, EMS squads may have an impact on choice in emergency situations, as well as personal preferences of the patients for specific doctors or facilities. This study does not purport to address this level of complexity.

Planning for healthcare resources is a complex process, including:

- Demographics, population growth, changes in medical utilization, market dynamics, spatial determinants
- Understanding what happened when a new entrant entered the market can help future planning efforts for expansion of services lines as well as de novo construction
- This project provides a methodology for investigating the current state of services before and after new hospitals or services open

This project provides a methodology for investigating the state of services before and after new hospitals or services open to help determine which services and patients are most impacted by the instruction of a new provider.

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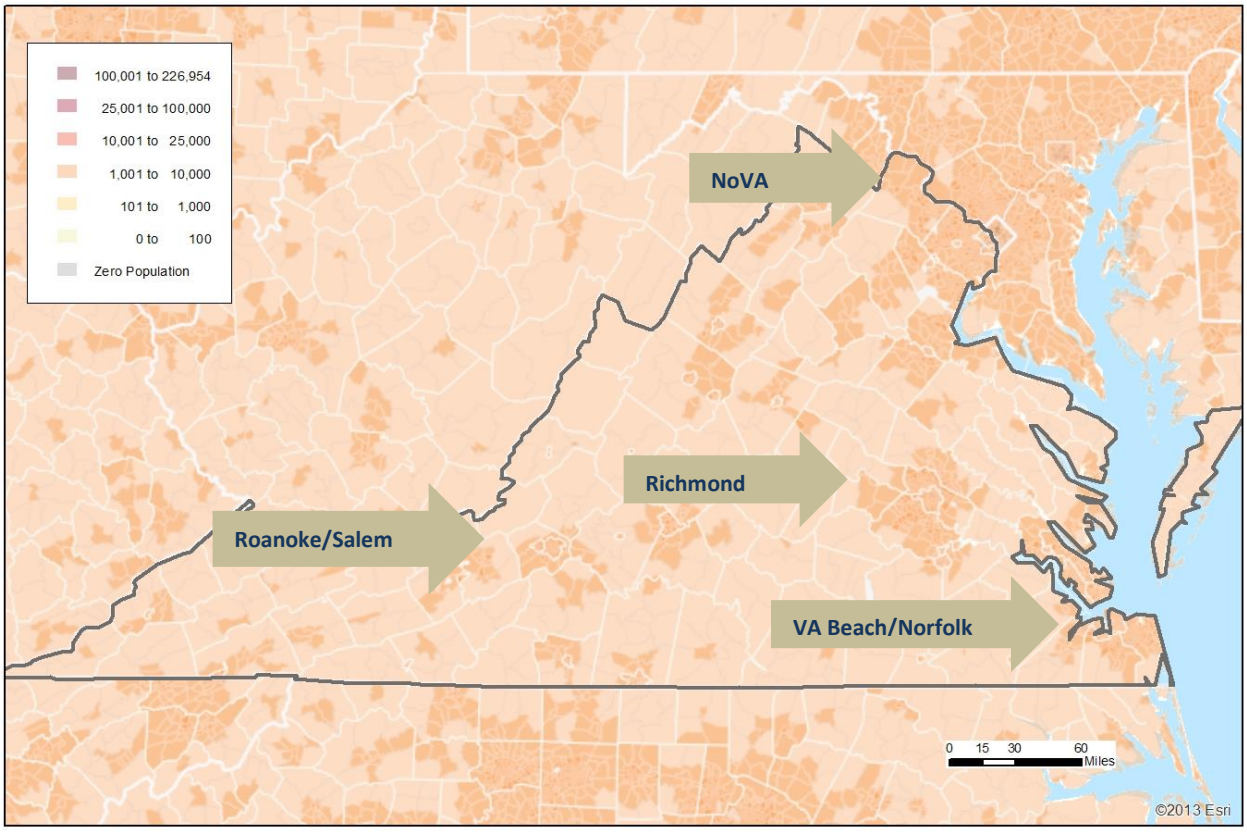
Background

Demographics in Virginia help inform health planning. Understanding elements such as age break out, use rates for health services, obstacles to access (both geographic and economic), and growth rates lead to better planning for future health needs of the state population.

Virginia has seen its strongest growth around areas of densest population, such as Richmond and northern Virginia. Not surprisingly this is also where new hospitals have been opened to address the needs of patients in those areas.



Reviewing the research, several areas of studies inform this project. Healthcare data is complex and ever growing. Currently however, inpatient data is the most robust, including information on the provider, the services provided and residential ZIP code of the patient. These data imply simplicity where the actual complex behavior of patients can be cloaked.

Healthcare continues to evolve as multiple pressures come to bear: payment policies, economic pressures, technology advances and shifting services from inpatient to the outpatient setting. These changes have long been noted and continue to challenge planners to adjust to better predict future needs of patients. (McLafferty, 2003)

As we are currently adjusting to the impacts of the Affordable Care Act, more pressure on the payment aspect of healthcare are coming into play. "Fiscal and administrative pressures are transforming health care delivery in the United States (p233)." (Cromley & McLafferty, 2012) In making a healthcare choice an individual must weigh the advantages and disadvantages of multiple factors, including proximity. Distance decay, the "tendency for interaction with service facilities to decrease with increasing distance" is certainly a factor in these choices (p235). This analysis is to try to understand how the tradeoff of geographical and non-geographical factors impact decision making in health service use. "(p243)

Part of the challenge to understand the factors in decision making is the limitation of available data. By only providing a ZIP code to identify the patient's residence much of the actual behavior of patients is lost, especially in rural areas where the size of ZIP codes can be larger than in urban areas. For example, in an emergency situation did the patient get care at a hospital that isn't the closest one to the patient's residence because of provider preference or because that person was at work or out shopping? Assigning patients to a ZIP code oversimplifies patient behavior. This is a known problem when using a residential area (ZIP code or census tract) as proxy for location, since many health events don't happen at home using a home addresses is problematic. It is a limitation of current data sources that we are not capturing the complexity around travel patterns (Matthews S. A., Spatial Polygamy and the Heterogeneity of Place, 2011). It is a simplifying assumption that the residential ZIP code is a close enough proxy for patient proximate location.

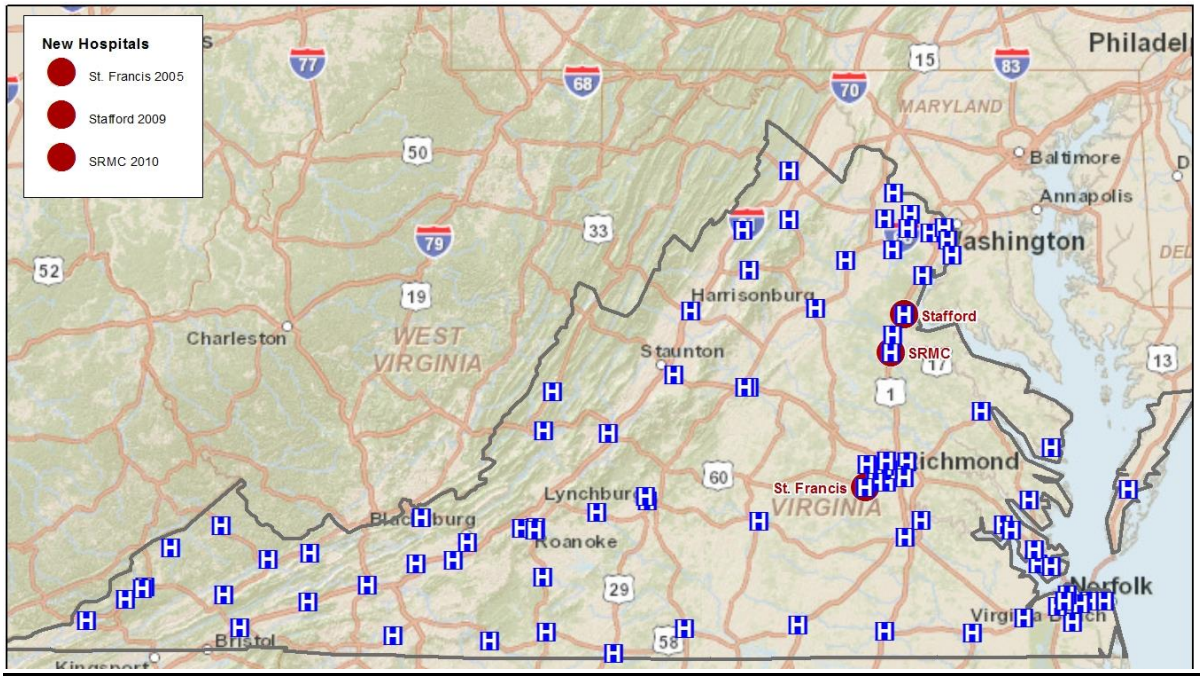
One study looked at patient patterns and determinants of inpatient choice in rural California. During the time of the study about 20% of US population live in rural areas (Kapur, 2009) this study used California discharge data for 2000, including source of admission (excluded admits from nursing homes and correctional facilities) for patients at least 5 years old. Distances were calculated from a patient's hospital to the centroid of the patient's ZIP of residence, a necessary simplification due to the limitations of the data to protect patient identity. Findings showed that two-thirds of rural patients were discharged from urban hospitals with emergency patients more likely to use rural hospitals, as were older patients. Public or no insurance patients were more likely to use a rural hospital. Sicker patients were more likely to travel to urban hospitals. Even accounting for other preferences, however, patients bypass rural hospitals in favor of urban ones.

Goals and Objectives

The proposal is to examine various hospital services, payer classes and admission type to see if patient behavior varies by comparing entropy scores before and after the opening of new hospitals.

The goal of this analysis is to see if the addition of a new hospital changes the level of choice for counties in Virginia. In 2013, more than 760,000 patients received inpatient services at Virginia hospitals. Looking at the overall experience for all patients will give a high level perspective, while segmenting different populations will show if more focused patient groups are impacted differently by the introduction of a new provider. The patient segments are cardiology verses orthopedics, patients that are admitted through the emergency room and Medicare and Medicaid patients.

Below is a map of Virginia with the acute care hospitals, the new hospitals that we opened between 2003 and 2013 are designated with a red circle. The hospitals are on the edges of major metropolitan areas. St. Francis is in Chesterfield County, in the southwest part of the greater Richmond area. Both Stafford and Spotsylvania are on the southern border of northern Virginia.



Methodology

In order to show how the introduction of two new hospitals impacted healthcare choice for area residents, this analysis assesses the area dynamics by measuring entropy in given years: before the hospitals opened in 2003, recently after the hospitals opened in 2011, and finally, after the hospitals were more established in 2013.

- 2003: Before the hospitals opened
- 2011: Status after all three hospitals opened
- 2013: Current status

To better understand more specifics about patient behavior additional service breakouts were measured to see if the patterns varied across patient sub-groups.

Total Discharges: The preliminary analysis used total volumes which includes all inpatient volumes excluding normal newborns. Normal newborns are excluded because they are in effect double counting the obstetrics volumes, this is due to payment convention; there is one payment for both the mother and baby. NICU volumes are included since those babies in effect are getting additional care and become patients themselves in the hospital.

Looking at the volumes for 2013 in Virginia some trends emerge. Older people make up the majority of volumes, and general medicine and cardiovascular volumes are the largest service lines for older patients (65+). Obstetrics is one of the 3 largest service lines, with the majority of volumes in the young adult (18-29 Years) and adult categories (30-64 Years).

Virginia patient level data, total excluding normal newborns 2013

Svc Rollup	MS DRG Cho	1 Infant	2 Child	3 Teen	4 Young Adult	5 Adult	6 Mature Adult	Grand Total
⊞ Medicine		1,596	4,309	1,611	8,655	56,278	61,140	133,589
⊟ Womens	Obstetrics	1	3	1,309	53,259	45,554		100,126
	Neonate	13,694			1	6		13,701
	Gynecology	17	47	58	633	6,081	1,417	8,253
Womens Total		13,712			53,893	51,641		122,080
⊞ CV		308	320	203	1,067	38,389	61,863	102,150
⊞ Pulmonary		2,034	4,071	469	2,103	25,379	37,594	71,650
⊞ Neuro		425	1,406	733	2,541	27,514	28,548	61,167
⊞ Ortho		85	673	407	1,572	22,178	31,089	56,004
⊞ Gen Surg		538	1,291	942	4,235	29,381	19,147	55,534
⊞ Behavioral		14	1,528	5,425	12,895	31,166	4,233	55,261
⊞ Gastro		433	1,135	489	2,541	20,647	22,860	48,105
⊞ Urology		329	504	237	1,075	8,308	13,544	23,997
⊞ Oncology		42	704	301	456	7,234	7,070	15,807
⊞ Diabetes			346	350	1,488	4,602	2,066	8,852
⊞ Rehab		25	61	58	250	3,235	5,191	8,820
⊞ Transplant		3	29	11	52	715	179	989
Grand Total		**19,544**	**16,427**	**12,603**	**92,823**	**326,667**	**295,941**	**764,005**

Orthopedics: This service line encompasses all age groups, spanning all ages. Below are the Major Diagnosis Categories (MDCs) for orthopedic patients. It is apparent looking at the table below where

the majority of volumes fall by MDC group. Mature adults dominate the diseases of the musculoskeletal system and endocrine. Injuries and toxic effect of drugs skew younger. And trauma patients are of all ages. Orthopedics covers all of these categories, and is thus one of the most representative services lines of various ages.

Virginia patient level data, Orthopedics 2013

	DISEASES & DISORDERS OF THE MUSCULOSKEL ETAL SYSTEM		ENDOCRINE, NUTRITIONAL & METABOLIC DISEASES & DISORDERS		INJURIES, POISONINGS & TOXIC EFFECTS OF DRUGS		MULTIPLE SIGNIFICANT TRAUMA		Total Cases	Total % of total
10YrGrp	Cases	% of total	Cases	% of total	Cases	% of total	Cases	% of total		
0 Yrs0-9	545	1.0%		0.0%	5	3.4%	4	1.0%	554	1.0%
1 Yrs10-19	785	1.4%		0.0%	6	4.1%	29	7.2%	820	1.5%
2 Yrs20-29	1,266	2.3%	8	1.0%	24	16.6%	65	16.2%	1,363	2.4%
3 Yrs30-39	1,563	2.9%	35	4.5%	27	18.6%	48	12.0%	1,673	3.0%
4 Yrs40-49	3,503	6.4%	129	16.5%	29	20.0%	35	8.7%	3,696	6.6%
5 Yrs50-59	9,797	17.9%	227	29.1%	30	20.7%	35	8.7%	10,089	18.0%
6 Yrs60-69	14,383	26.3%	208	26.7%	12	8.3%	27	6.7%	14,630	26.1%
7 Yrs70-79	12,435	22.7%	110	14.1%	7	4.8%	51	12.7%	12,603	22.5%
8 Yrs80-89	8,044	14.7%	54	6.9%	2	1.4%	65	16.2%	8,165	14.6%
9 Yrs90up	2,377	4.3%	9	1.2%	3	2.1%	42	10.5%	2,431	4.3%
Grand Total	**54,698**	**100.0%**	**780**	**100.0%**	**145**	**100.0%**	**401**	**100.0%**	**56,024**	**100.0%**

Emergency room admissions: This group of patients come in through the emergency room, and thus may have a more compressed time frame to decide, if the patient makes the decision at all, where to get services in contrast to patients that have a planned visit. Where ambulance services are in play, the ambulance squad may default to the closest hospital that provides the appropriate service, thereby minimizing travel time to be able to ready themselves for the next emergency.

Virginia patient level data, Total excluding normal newborn 2013

		Emerg/Urg		Other		Total Cases	Total % of total
Svc Rollup	MS DRG Cho	Cases	% of total	Cases	% of total		
⊞ Medicine		124,901	22.8%	8,730	4.0%	133,631	17.5%
⊟ Womens	Obstetrics	42,367	7.7%	57,854	26.8%	100,221	13.1%
	Neonate	1,288	0.2%	12,431	5.8%	13,719	1.8%
	Gynecology	2,059	0.4%	6,205	2.9%	8,264	1.1%
Womens Total		**45,714**	**8.3%**	**76,490**	**35.4%**	**122,204**	**16.0%**
⊞ CV		84,901	15.5%	17,281	8.0%	102,182	13.4%
⊞ Pulmonary		67,295	12.3%	4,379	2.0%	71,674	9.4%
⊞ Neuro		42,612	7.8%	18,572	8.6%	61,184	8.0%
⊞ Ortho		21,199	3.9%	34,825	16.1%	56,024	7.3%
⊞ Gen Surg		33,063	6.0%	22,495	10.4%	55,558	7.3%
⊞ Behavioral		40,931	7.5%	14,402	6.7%	55,333	7.2%
⊞ Gastro		45,647	8.3%	2,476	1.1%	48,123	6.3%
⊞ Urology		19,444	3.5%	4,559	2.1%	24,003	3.1%
⊞ Oncology		10,357	1.9%	5,454	2.5%	15,811	2.1%
⊞ Diabetes		8,596	1.6%	264	0.1%	8,860	1.2%
⊞ Rehab		3,342	0.6%	5,490	2.5%	8,832	1.2%
⊞ Transplant		564	0.1%	425	0.2%	989	0.1%
Grand Total		**548,566**	**100.0%**	**215,842**	**100.0%**	**764,408**	**100.0%**

Medicaid vs Medicare: breaking out specific payers allows us to see some dynamics that are skewed heavily toward older patients in the case of Medicare. Medicaid patients may be facing economic obstacles limiting their choice for provider.

Medicare patients are seeing the bulk of their services in general medicine, cardiology, and pulmonary services, with strong volumes in neurosciences, orthopedics and gastroenterology.

In contrast, Medicaid patient patients were predominantly obstetric or NICU patients, followed by psychiatric patients.

Virginia patient level data, Total excluding normal newborn 2013

		Medicare		Medicaid		Total Cases	Total % of total
Svc Rollup	MS DRG C	Cases	% of total	Cases	% of total		
Medicine		71,295	13.1%	14,679	10.6%	133,631	17.5%
Womens	Obstetrics	865	24.7%	33,283	23.5%	100,221	13.1%
	Neonate	42	2.8%	5,787	4.5%	13,719	1.8%
	Gynecology	1,708	1.9%	755	2.7%	8,264	1.1%
Womens Total		**2,615**	**29.4%**	**39,825**	**30.7%**	**122,204**	**16.0%**
CV		66,579	9.1%	5,377	7.9%	102,182	13.4%
Pulmonary		42,086	5.9%	9,058	5.9%	71,674	9.4%
Neuro		31,715	7.5%	4,660	4.2%	61,184	8.0%
Ortho		32,052	7.2%	2,489	5.0%	56,024	7.3%
Gen Surg		22,135	8.9%	5,058	5.9%	55,558	7.3%
Behavioral		13,144	7.0%	11,919	17.8%	55,333	7.2%
Gastro		25,861	5.4%	4,305	4.5%	48,123	6.3%
Urology		14,828	2.2%	1,979	1.5%	24,003	3.1%
Oncology		6,985	2.3%	1,787	1.0%	15,811	2.1%
Diabetes		3,201	1.0%	1,378	2.0%	8,860	1.2%
Rehab		5,291	0.9%	783	3.0%	8,832	1.2%
Transplant		429	0.2%	73	0.0%	989	0.1%
Grand Total		**338,216**	**100.0%**	**103,370**	**100.0%**	**764,408**	**100.0%**

Analysis was performed at the ZIP code as well as the county levels. For the main focus of this paper the county level will be discussed, but the ZIP code analysis on a smaller area of Virginia is available in the appendix.

Data limitations. The data that are available for research are limited by several factors, both for patient privacy as well as the costs of data collection. Protections for patient privacy include blinding the patient identifier as well as any information that might allow for a patient to be identified. Because of these concerns the address of the patient is not provided, but the ZIP code is. This allows for some special analysis at the ZIP code level. Obviously this aggregation limits the accuracy of analysis.

Additionally, the ZIP code provided is ZIP code used for billing; in most cases this is not an issue since most patient get their mail at their residence. This is inaccurate for patients that get their mail at a

Post Office, PO Box address can be misleading if the patient doesn't reside in the same ZIP code as the Post Office. This is not expected to have a significant impact on the analysis.

Finally, the data available at the state level includes patients that have been admitted to a hospital. Though inpatient data represents the most acute services, there are key services that are underrepresented. For example, oncology volumes are overwhelmingly outpatient (~95% of visits), with the multiple visits for radiation therapy being outpatient. This limitation is due to data collection systems, outpatient visits are much more numerous than inpatient, and state requirements, which currently do not require outpatient reporting.

Entropy Score

The calculation for the Entropy Score is symbolized by E: $$E = \sum_{r=1}^{n} p_r \ln\left(\frac{1}{p_r}\right)$$

The index shows where *pr* refers to group *r's* proportion of the population in a geographic unit and *n* signifies the number of groups under consideration.

In this calculation, equal groups will produce a higher E score implying there is choice for providers in the area, in contrast, where there is only one hospital provider the E score will be zero.

Entropy Score Trend

This analysis will indicate areas have seen improvement or deterioration in choice for patients between two points in time, before the hospitals opened in 2008 to the most recent year 2013.

Analysis steps

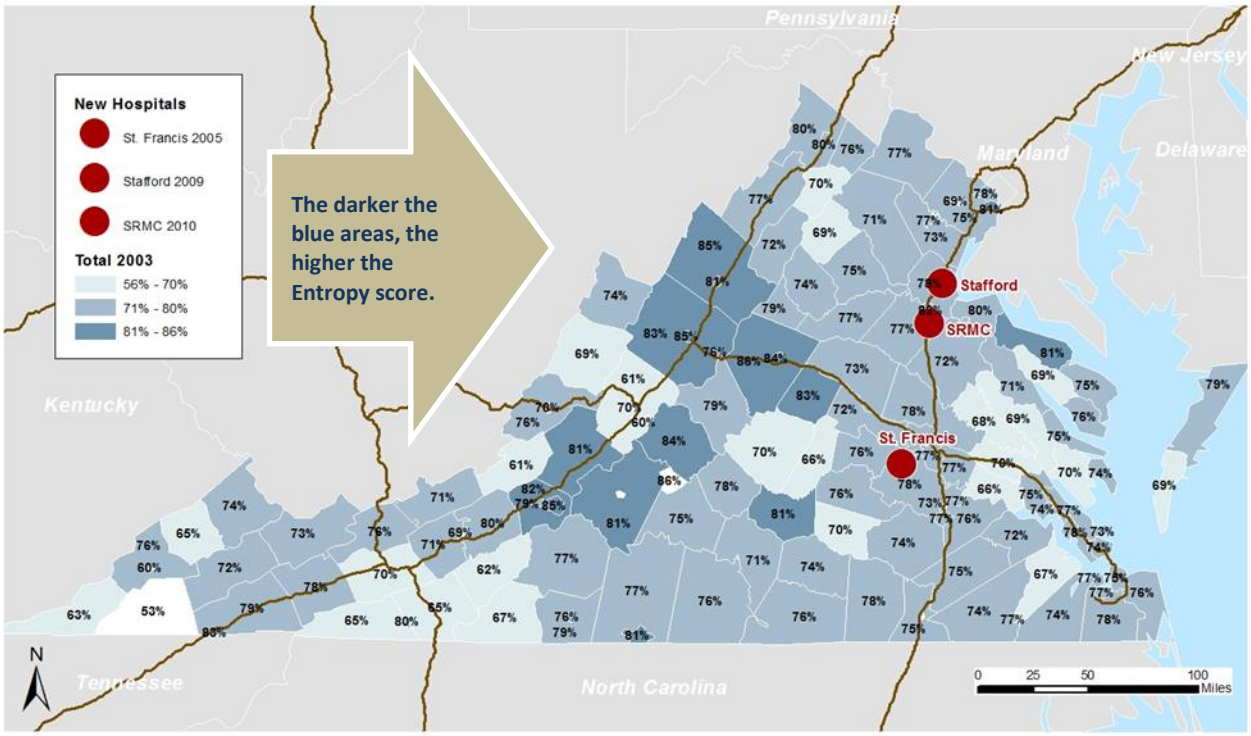
Cases were pulled for the total as well as the breakouts described above. The natural logarithm was calculated and divided by count of participants in that geographical area, providing the possible values on a scale from zero to 1.

Next a weights matrix was created using GeoDa, which assigned the spatial relationship of each geographical area to each boarding polygon using the queen contiguity. Creating a spatial weights matrix is needed to find clustering of areas with similar entropy scores. Without this step the geographic relationship would be unclear, not knowing which ZIP codes or counties touch.

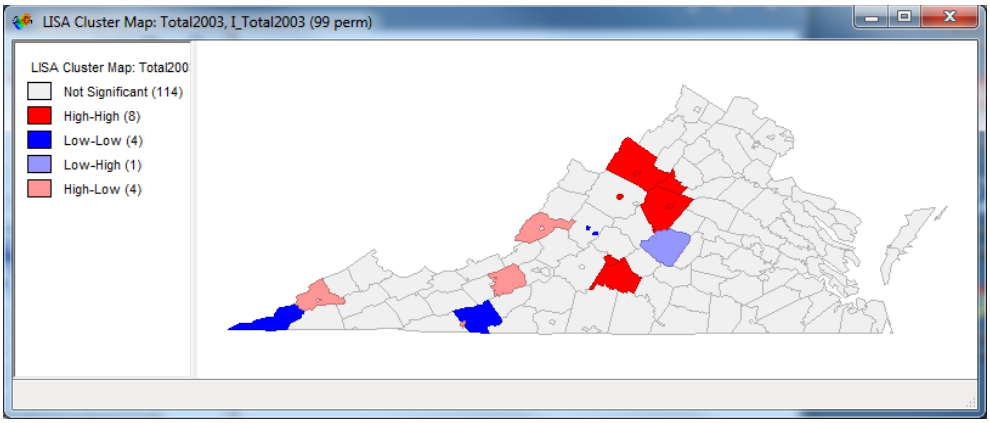
Lastly, analysis was performed to determine if the clustering found using the weights matrix was statistically significant using the Local Indicators of Spatial Association (LISA). LISA Cluster map shows areas that have significant high/high vs low/low relationships.

Total Entropy: 2003

In this step of the analysis, the entropy scores for the earliest year are shown, before any of the three hospitals opened. The greatest entropy scores in 2003 were at the crossroads of I-81 and I-64, indicating greater patient choice. The areas in which St. Francis, Stafford and Spotsylvania will eventually be located, fall the in the middle range for entropy.

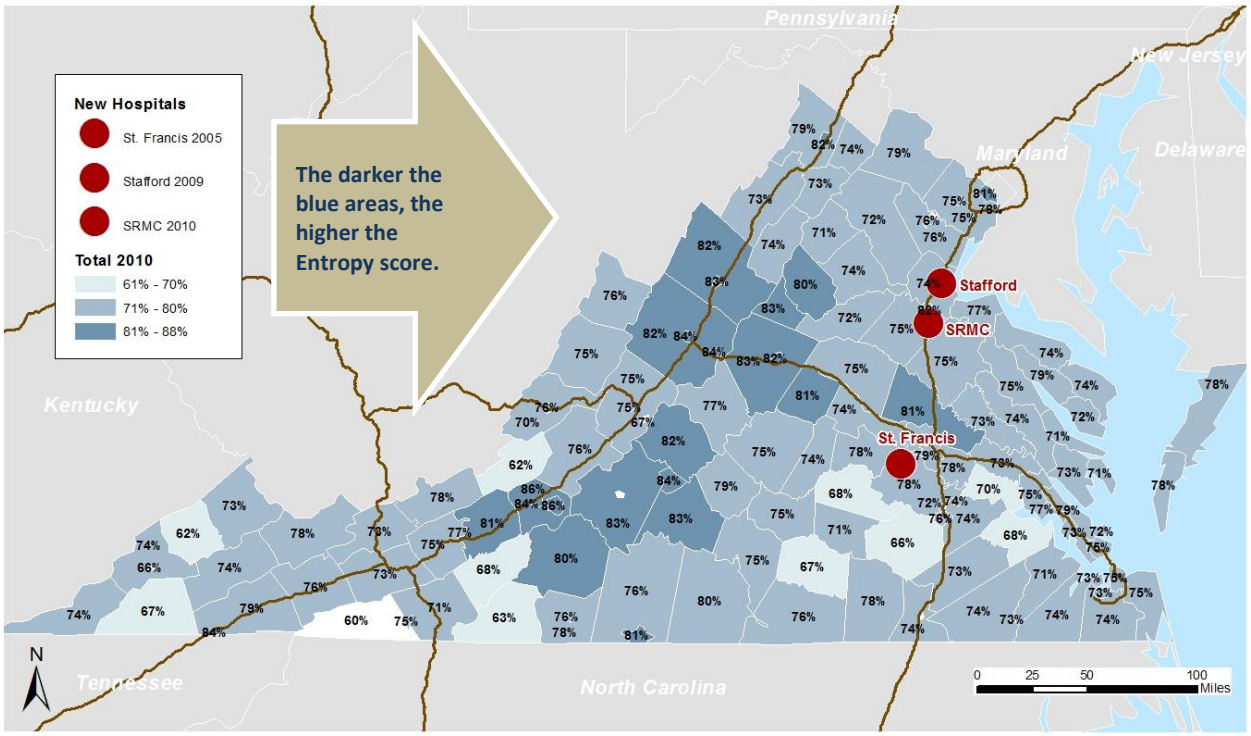


In 2003 the residents of counties near the crossroads of I-81 and I-64, are enjoying hospital choice, and it is statistically significant.

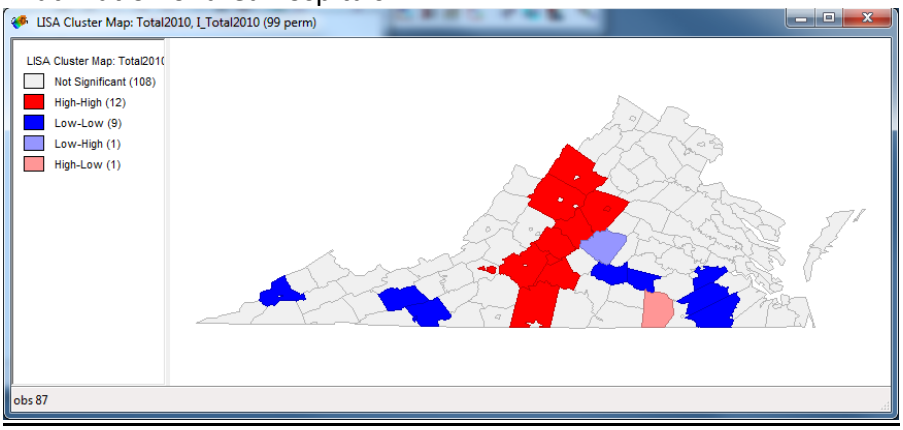


Total Entropy: 2010

In this step of the analysis, data is shown for 2010, St. Francis had been open for several years, and the Fredericksburg hospitals were both new. At this time the greatest entropy scores remained at the crossroads of I-81 and I-64, indicating greater patient choice. The county above St. Francis in the map below moved into a higher choice category (Hanover County).

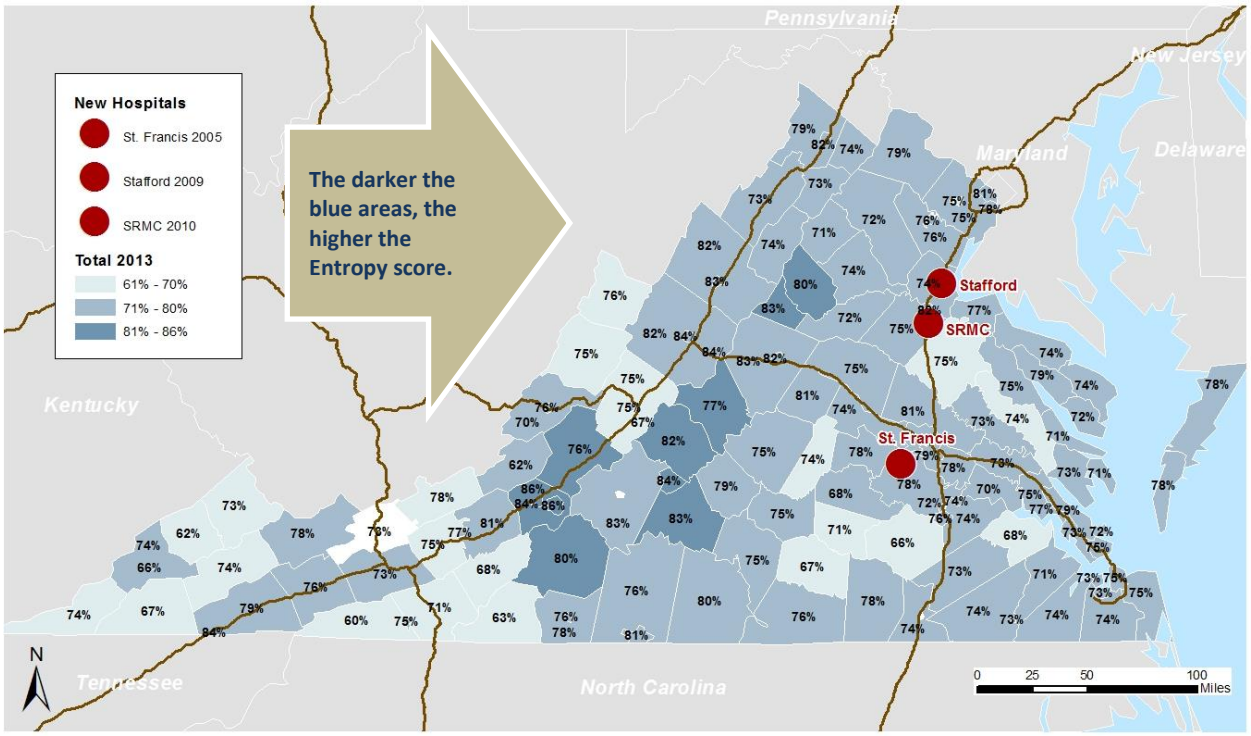


In 2010 the residents in counties near the crossroads of I-81 and I-64 and extending down the to the NC border, have high hospital choice scores and are statistically significant. This is showing a change in utilization of area hospitals.

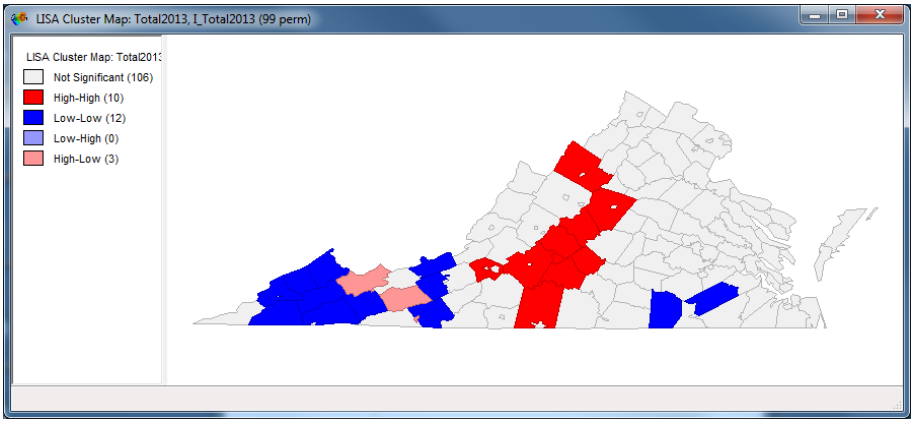


Total Entropy: 2013

In this step of the analysis, entropy scores are shown for 2013, allowing for all three hospitals to establish practice patterns. The entropy scores lessened around the crossroads of I-81 and I-64, indicating a deterioration of patient choice. The greatest entropy scores still show up around I-81. In 2010, Rockingham Memorial Hospital relocated to a new campus in the same area. Though the move was in the area, and no services were added, the opening of a new facility can have a 'halo' effect. This effect brings in patients that prefer a newer facility, with newer technology.



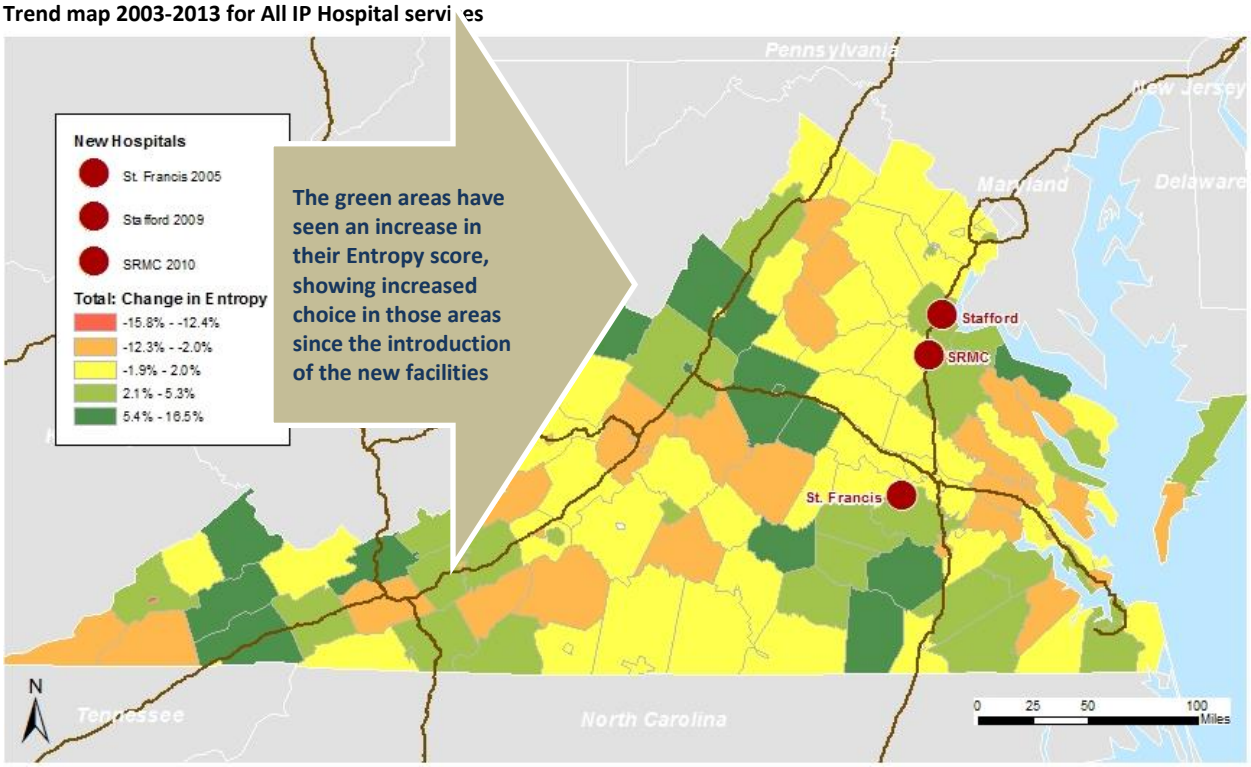
In 2013 the crossroads of I-81 and I-64, extending down the to the NC border, and now extending to the west into the Roanoke area, have high hospital choice scores and are statistically significant.



Trend Map 2003-2013

This step in the analysis shows the trends across the years included in the analysis. This map shows the parts of Virginia that saw an increase or decrease in hospital choice at the county level. The green areas show an increase in entropy, the darker the green the greater the increase. In contrast, the orange areas show a decrease in entropy, the darker the orange the greater the decrease. The yellow category designates areas that have not changed materially in the timeframe.

Trend map 2003-2013 for All IP Hospital services



Findings

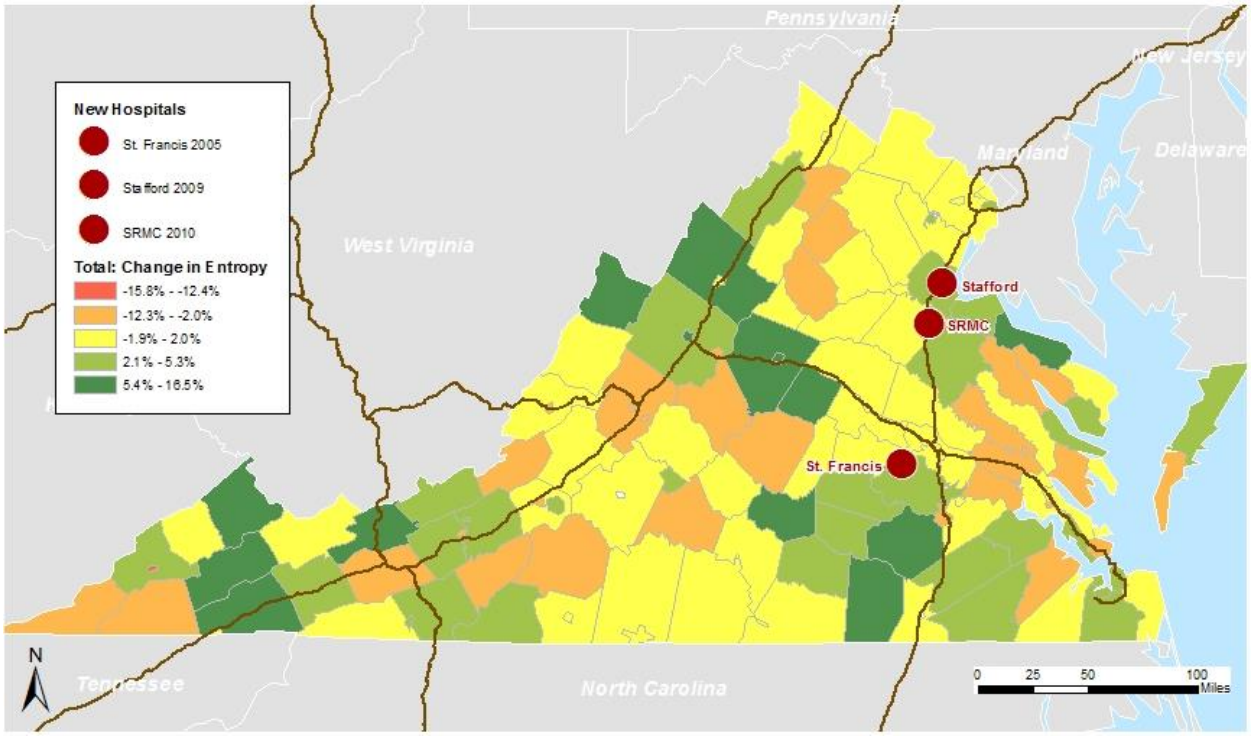
The patient subgroups showed a different pattern than the aggregated patient totals. As expected, different populations made decisions based on specific criteria that varied across services line, admit type and payer groups.

As expected, Total IP hospital volumes showed an increase in patient choose in counties proximate to the new hospitals. Between 2003 and 2013 the entropy scores increased for neighboring areas to both St. Francis and the Fredericksburg hospitals, Stafford and Spotsylvania.

St Francis is on the southern edge of Richmond and has introduced competition into counties to the south and west, areas that are more rural and traditionally have had fewer hospital resources. This increase in entropy is in aggregate for all hospital services.

Entropy scores rose in the counties around Stafford and SRMC as they ramped up their hospital services. Though these services are not as established as St. Francis, the counties around these hospitals are showing increased entropy for all inpatient hospital services.

Trend map 2003-2013 for All IP Hospital services

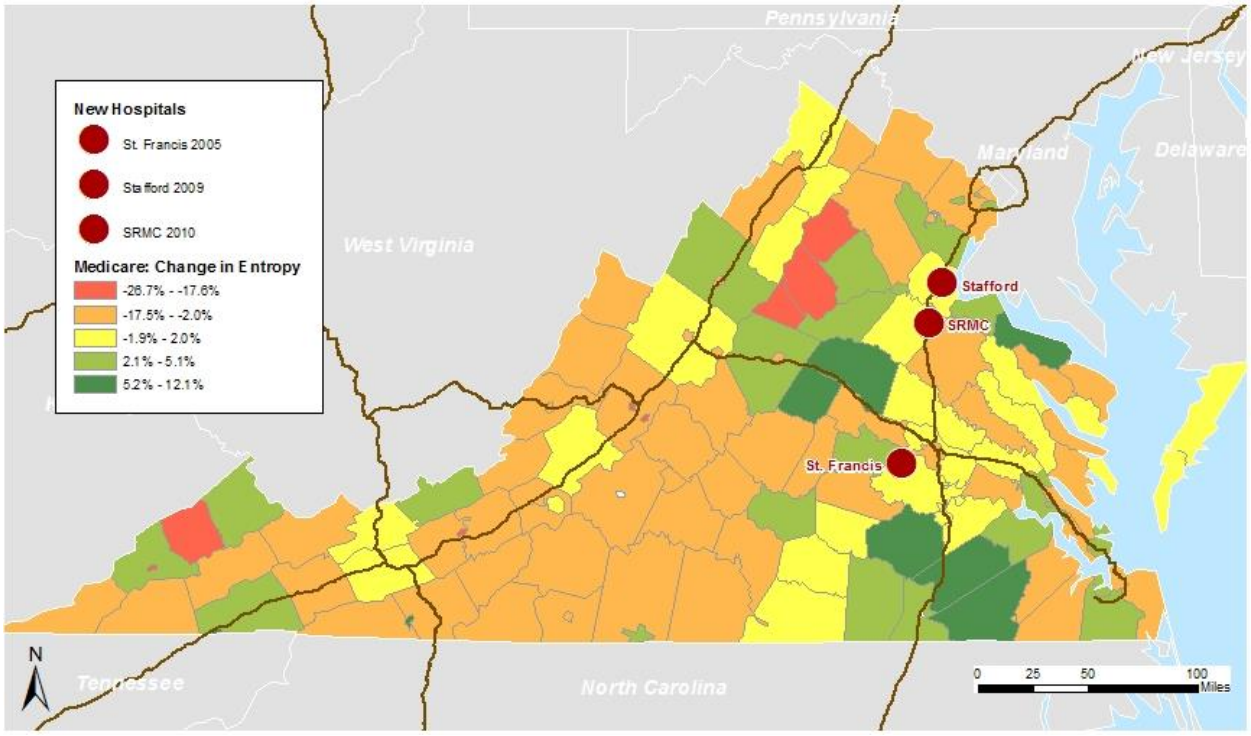


Medicare Patients

Medicare patients that live near Spotsylvania and in southern counties along the North Carolina border appear to enjoy more choice. Areas in the southwest appear to be consolidating Medicare patient patterns.

Older patients make up a greater percentage of volumes that are elective rather than emergent. Elective patients have more time to choose their hospital than those that are in an emergent situation. Indeed, emergency patients may not be making any of the decisions at the time due to incapacitation. Having time to weigh different elements of comparison for hospitals in the area or in the region results in a patient's choosing providers for reasons beyond geographic proximity. There are many factors that go into these decisions such as physician steering, quality measures available online and the total out-of-pocket expense between hospital providers.

Trend map 2003-2013 for Medicare patients

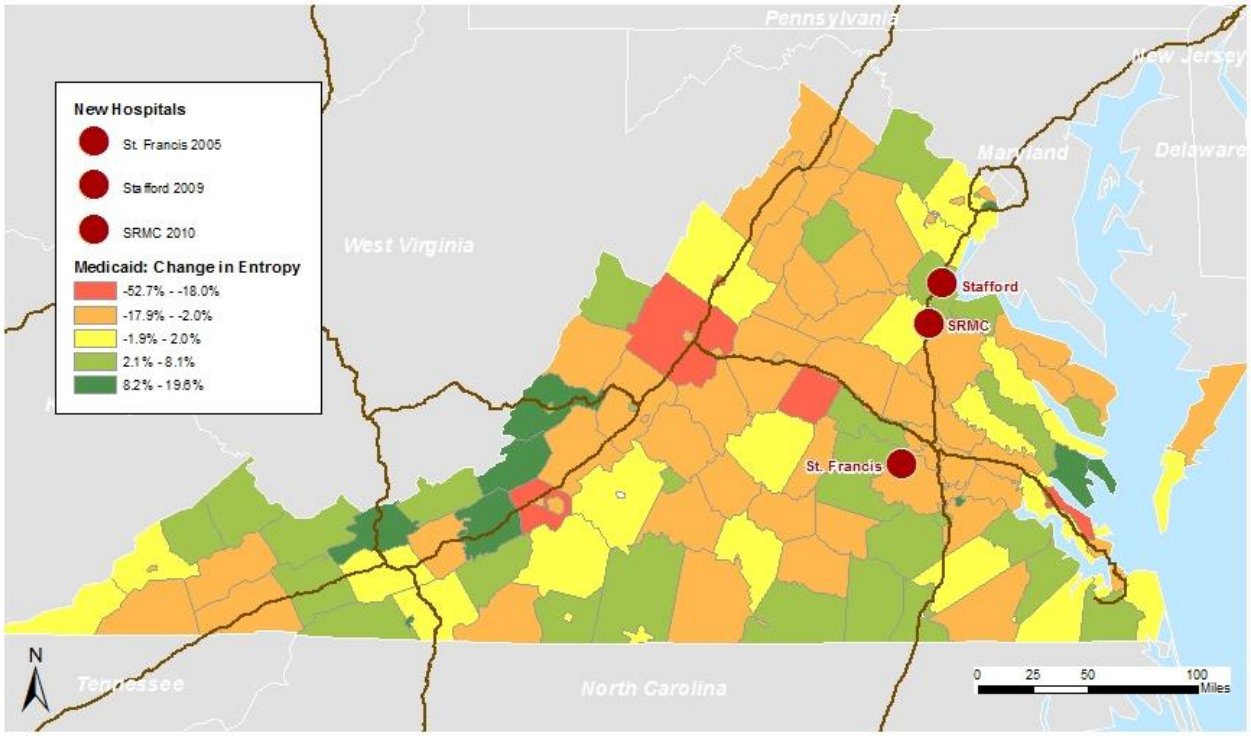


Medicaid Patients

Medicaid patients show a similar pattern around the new hospitals as Medicare patients. Consolidation of services to fewer providers is running along the I-64 corridor, an area sandwiched between the areas of greater competition.

Sadly, Medicaid patients in the greater Richmond area saw a decline in hospital choice in this timeframe. St. Francis opened in 2005, having plenty of time to ramp up and develop a robust patient base. Though this analysis implies that St. Francis is part of the environment that lead to greater choice to the west and south of Richmond, the greater part of Richmond saw consolidation during this timeframe.

Trend map 2003-2013 for Medicaid patients

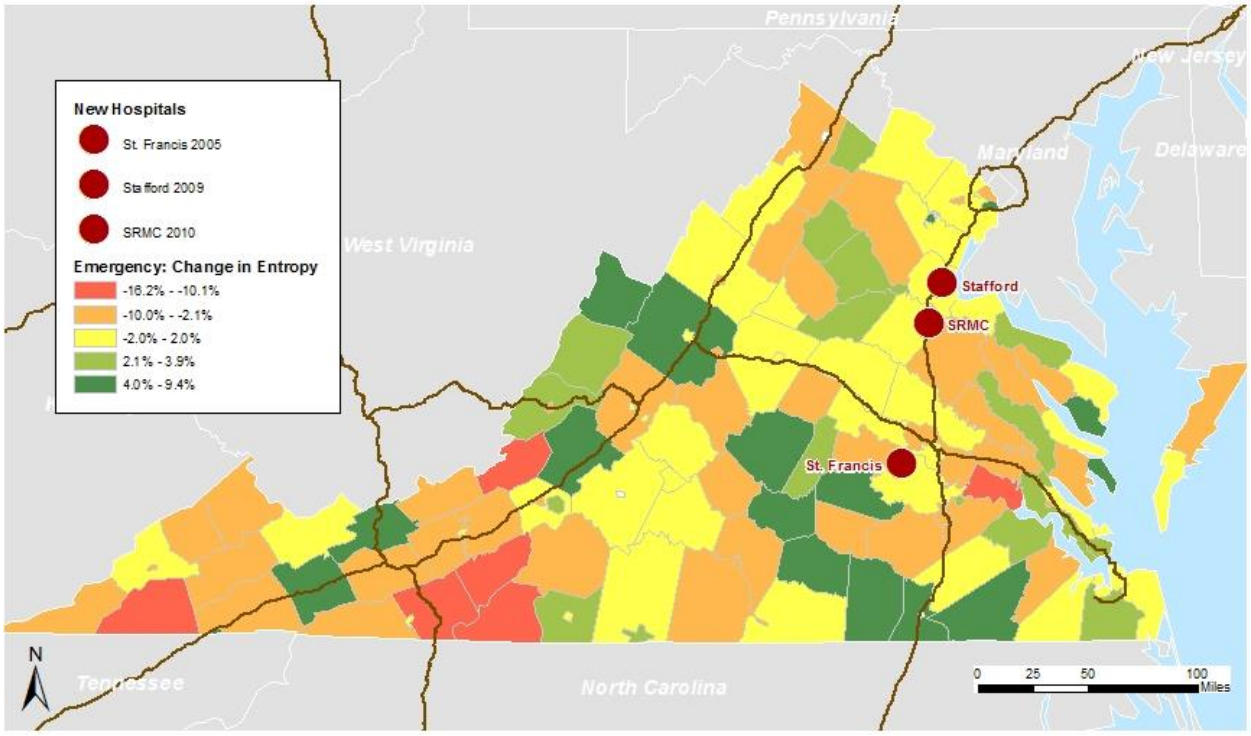


Emergency Room Patients

Admissions through the Emergency Room were a surprising finding. Counties to the periphery of the markets saw the benefits. Southwest of St. Francis saw a significant increase in choice, while Stafford, Fauquier and Culpeper saw benefits from Stafford and Spotsylvania hospitals. St Francis was built in a growing suburb of Richmond, where many children are, perhaps lending the need for a local option for emergent situations.

This dynamic may be in part due to the behaviors of EMS squads. Due to the large areas that rural EMS squads must cover, being able to bring a patient to a more proximate location, on the periphery of a metropolitan area, greatly increases their ability to get back to their coverage area. This increases the time that squads are available for local emergencies, because the travel time is minimized.

Trend map 2003-2013 for Emergency services

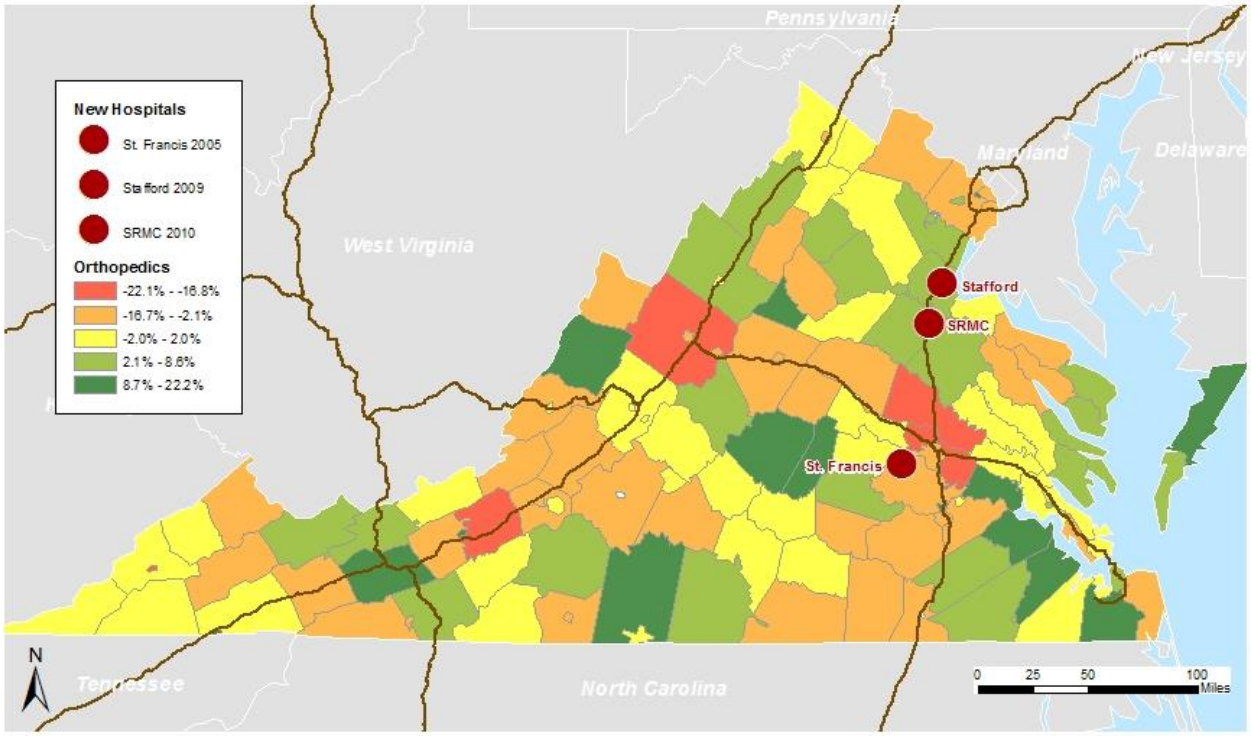


Orthopedic Patients

Orthopedic patients are enjoying greater choice around Stafford and Spotsylvania, but St. Francis does not appear to be having the same impact on this service line.

This may in part be due to the nature of orthopedics. Orthopedics services are needed by all age groups due to trauma. Car accidents can result in broken bones, which impacts people of all ages. This part of the service line is often emergent and is expected to have patients that are nearby as primary volumes. In contrast, older patients needing joint replacement surgery very often have time to choose their provider and may be willing to travel based on other preferences.

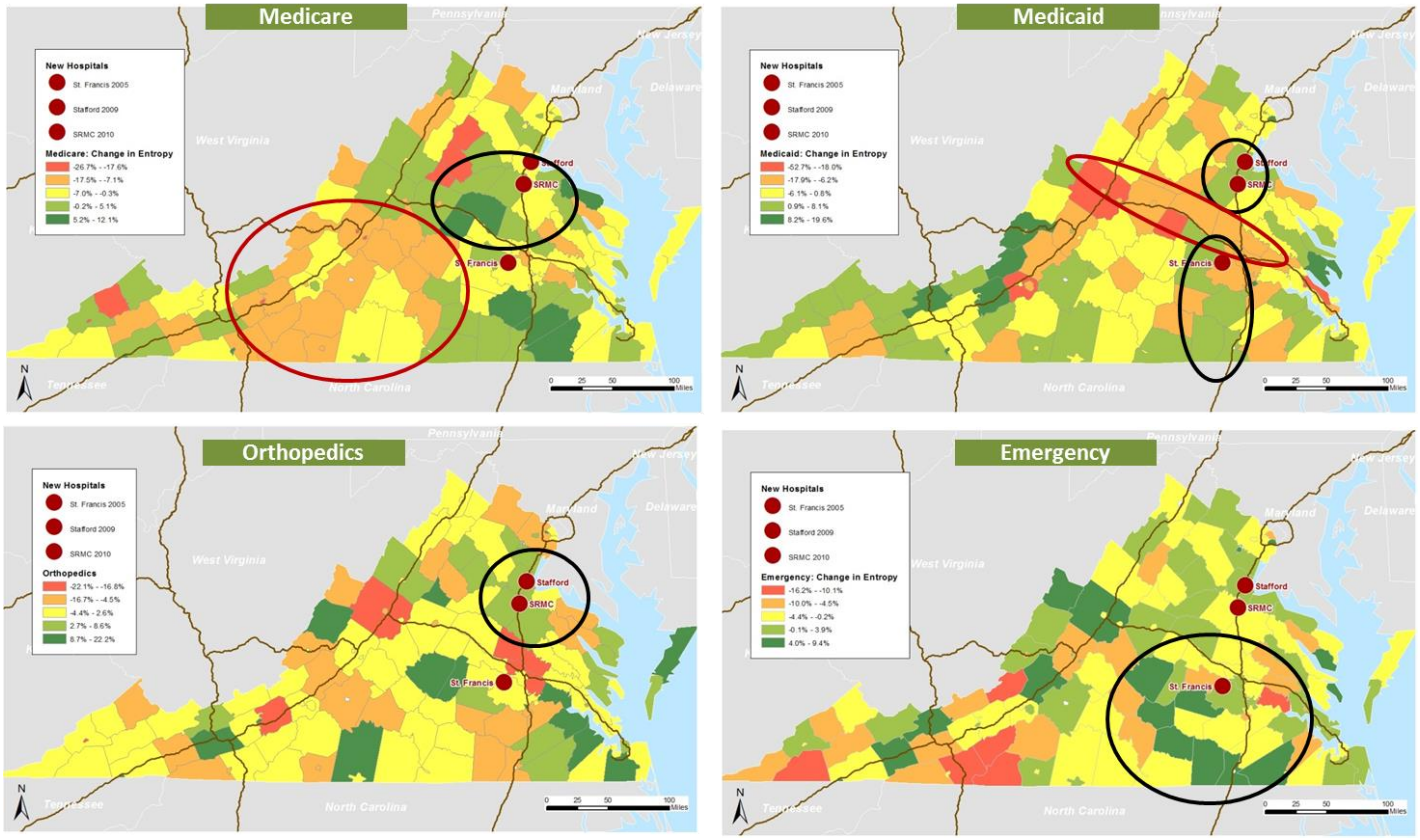
Trend map 2003-2013 for Orthopedic services



Comparison of Patient Groups

Comparison of the patient segments shows unexpected trends. There is little uniformity across the different patient groups, which isn't expected due to the varied needs of patient groups. Though some areas show increased patient choice, the areas differ across the various segments. This variability could indeed by the different choice of different patient populations or could be the limitation of this methodology. In order to tease out which it might be, further analysis is warranted.

Trend maps 2003-2013 for Medicare, Medicaid, Orthopedic and Emergency services



Next Steps

This analysis is not conclusive, though it is a start to understanding patient patterns for hospital choice in Virginia. Part of the variability of the findings could be due to the very different choices made by different patient segments. Further refinement of the methodology is in order. That refinement could take several paths, including a more specific service line group, smaller geographic units, further demographic specification, additional payer classes, or different timeframes.

Service Lines

Additional subgroups could be defined to further parse service lines, such as surgical versus medical patients. This analysis could also be more exhaustive of the standard service line groupings to include service lines such as neurology, pulmonology, gynecology and psychiatry. Expanding the services lines would give a more comprehensive picture of a greater proportion of hospital patients and services.

ZIP Code

To further refine this analysis a smaller geography, such as ZIP code could be used to show greater detail around the hospitals in question. The current patient level data would allow for this analysis, it would be the smallest unit of geography possible given the data limitations.

Demographic groups

Different age groups tend to require different hospital services. Looking explicitly at age groups would tease out some of the preferences for various demographic groups. For example, children are overwhelmingly seen in the emergency room, but when they are admitted it is often for orthopedics (broken bones) or pulmonology (asthma). Adolescents are primarily admitted for psychiatric services, followed by obstetrics. Young adult women are obviously mainly obstetrics patients, and have long been suspected of being the health care decision maker in their families for both their children as well as their partners to some extent. Mature patients tend to comprise the majority of

cardiology and cardiovascular (heart attacks), neurology and neurosurgery (stroke), as well as orthopedics (joint replacement).

Orthopedics in children tend to be emergency based (ie. Breaking an arm in a sporting event), versus an elective join replacement surgery for an older adult.

Payer Classes

Access to care is in part an issue of payment. Being close to medical resources may be of little help if one cannot afford the coverage, or perhaps not even have coverage. This continues to be a concern for many Americans as Obama care going into practice. The hope that Obama care will bring relief to our citizenry will play out over the next few years. Looking at payer classes would show the impact of these changes. Hospitals collect information on private payers, Medicare and Medicaid, but also on charity patients (defined differently across hospital systems, but indicates patients lacking financial resources) and self-pay patients (who may be above the poverty level, but may still find full hospital charges untenable).

Time Frames

Moving forward as new data are released further analysis would be helpful. There are several hospitals that will appear in the data in the next two years: Sentara Doctor's hospital in Williamsburg (40 beds), Novant Haymarket (60 beds), and StoneSprings Medical Center (124 beds). These hospitals have opened or will open in the next year and will provide an opportunity to see if hospital choice continues to grow in these areas as well as the impact of Obama care.

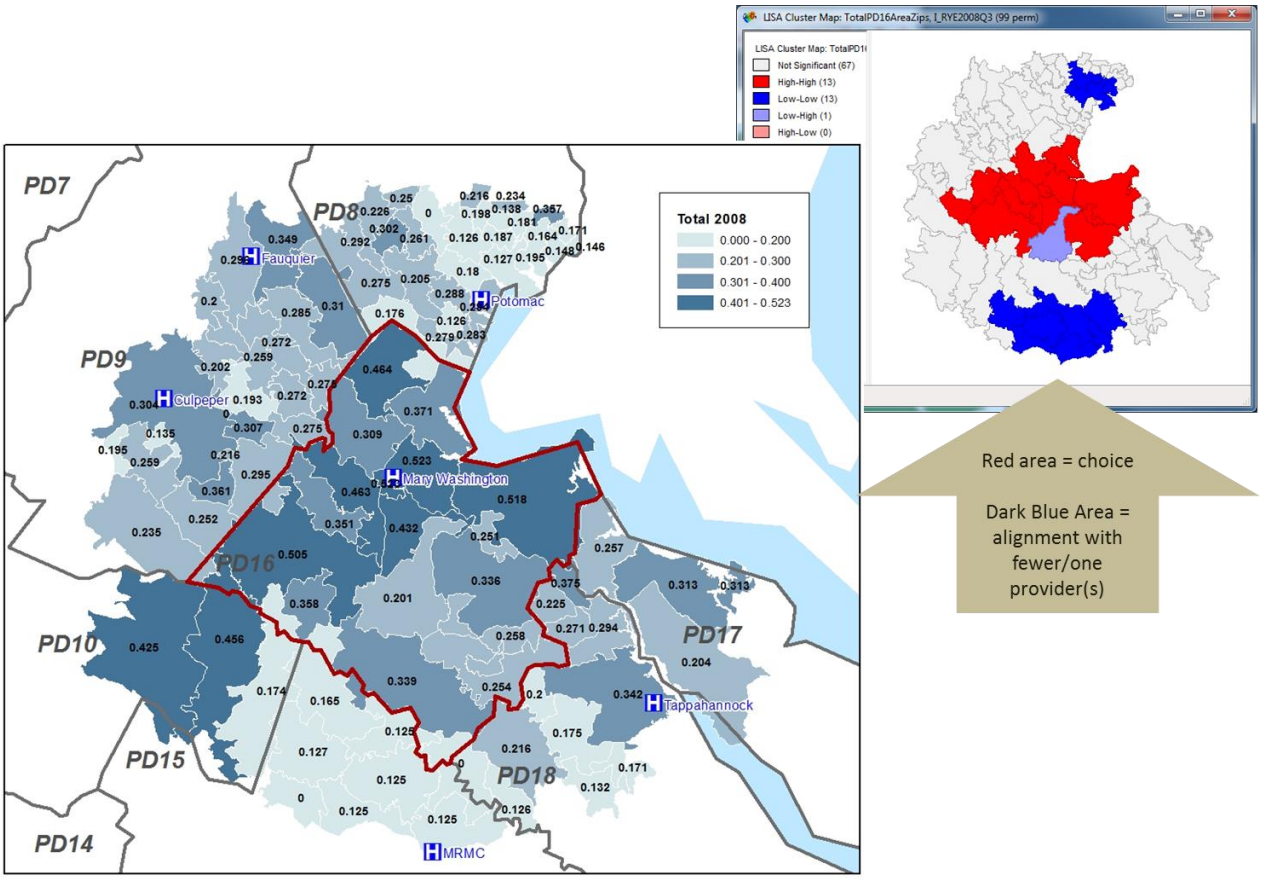
Appendix: ZIP code level analysis

The main map shows the Entropy scores for each ZIP code in the area. Given the pool of providers the areas with highest choice of provider are centered in the middle of the study area. PD16 is outlined in red on the map to give some context.

The map in the upper right corner is a cluster map produced by GeoDa, a spatial analysis software package. A weights matrix was created which assigns a spatial relationship to each polygon to be able to run a LISA analysis (Local Indicators of Spatial Association). In this map above you can see a large red area in the center of the map showing that ZIP codes in this area have a high E score and are bordered by other high E scores, "High-High". This is a cluster of ZIPs that have choice.

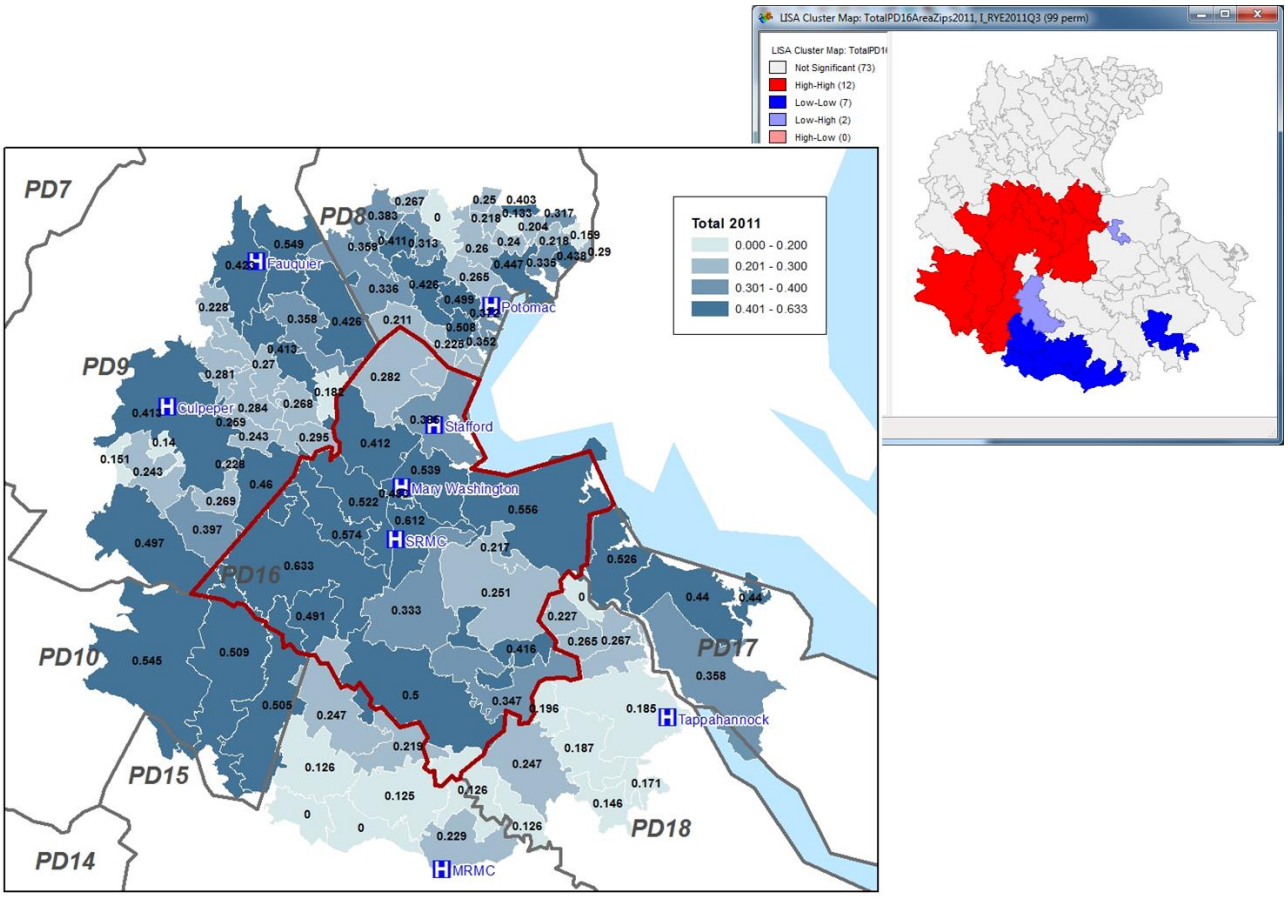
In the bottom of the map you see a dark blue area, this is an area of ZIPs that have low E scores and have neighbors with low scores. This is an area that is mainly getting services at one hospital.

Total Cases Entropy: 2008 (PD16 providers only – 8 area hospitals)



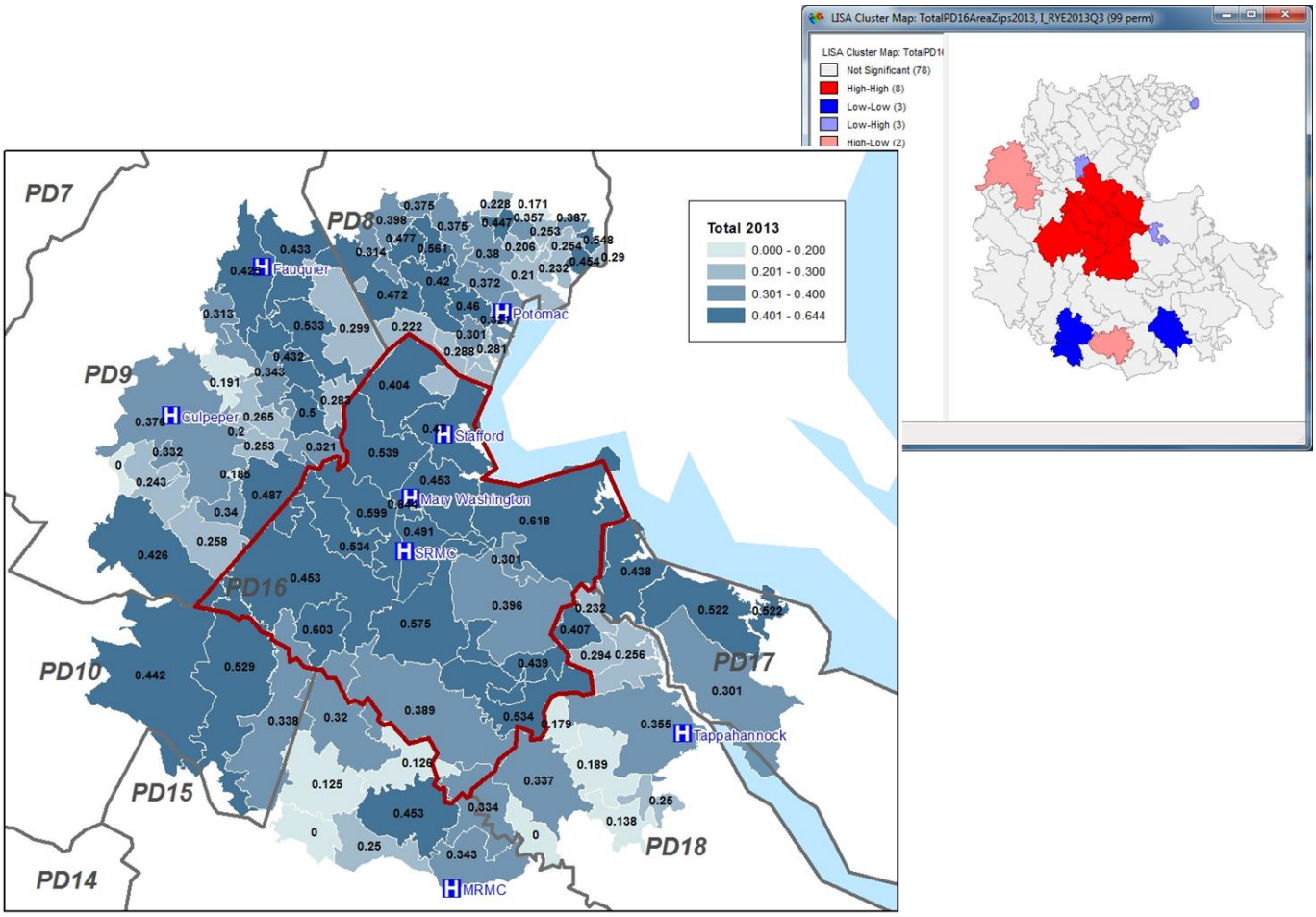
There is stronger hospital choice in PD16 and the southern part of the study area, with the significant High-High area extending down.

Total Cases Entropy: 2011 (PD16 providers only – 8 area hospitals)



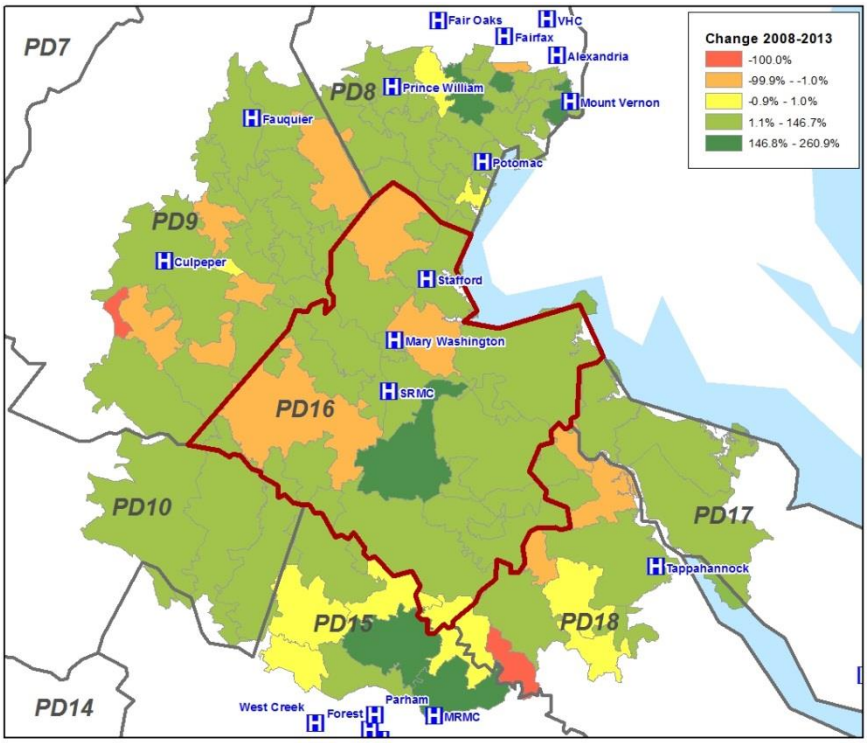
Hospital choice is getting stronger in PD16, and in particular, the southern part of the study area. The elimination of most of the light blue areas indicates an increase in competition, since the lighter areas had been served by fewer hospitals.

Total Cases Entropy: 2013 (PD16 providers only – 8 area hospitals)

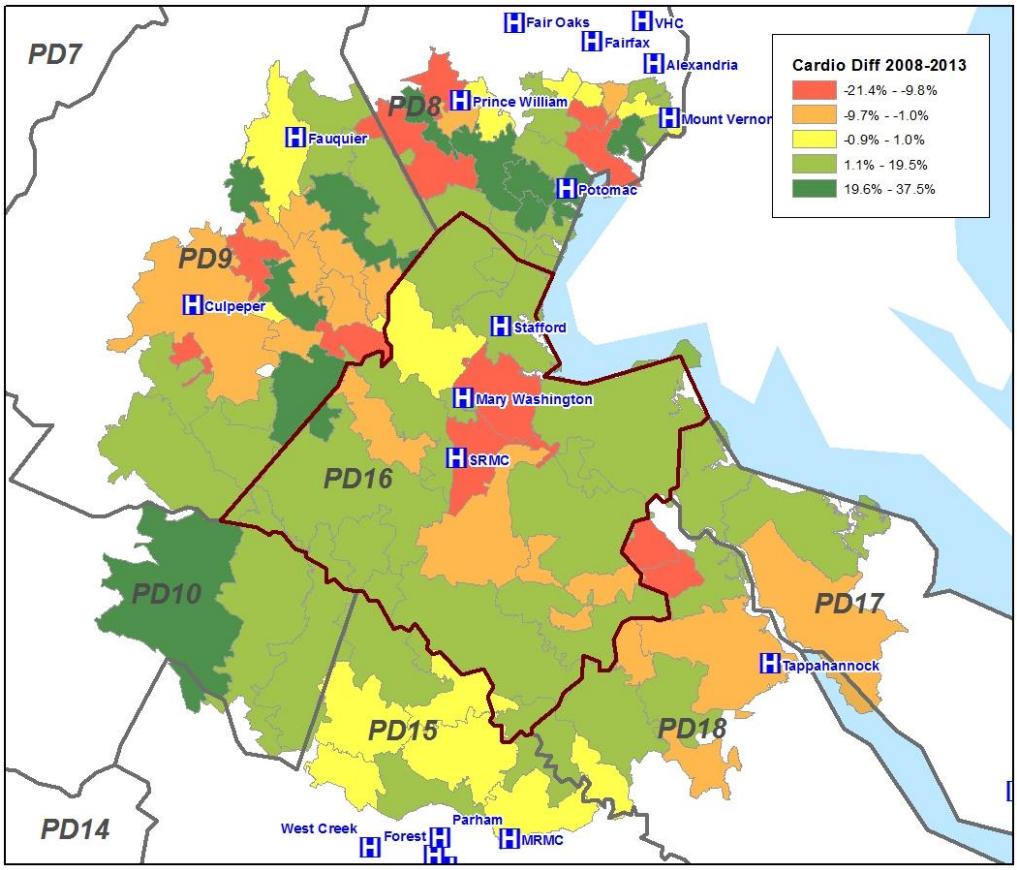


This is the trend map, showing the change in Entropy score from 2008 to 2013. As expected, most of the study area has seen an improvement in hospital choice during this timeframe.

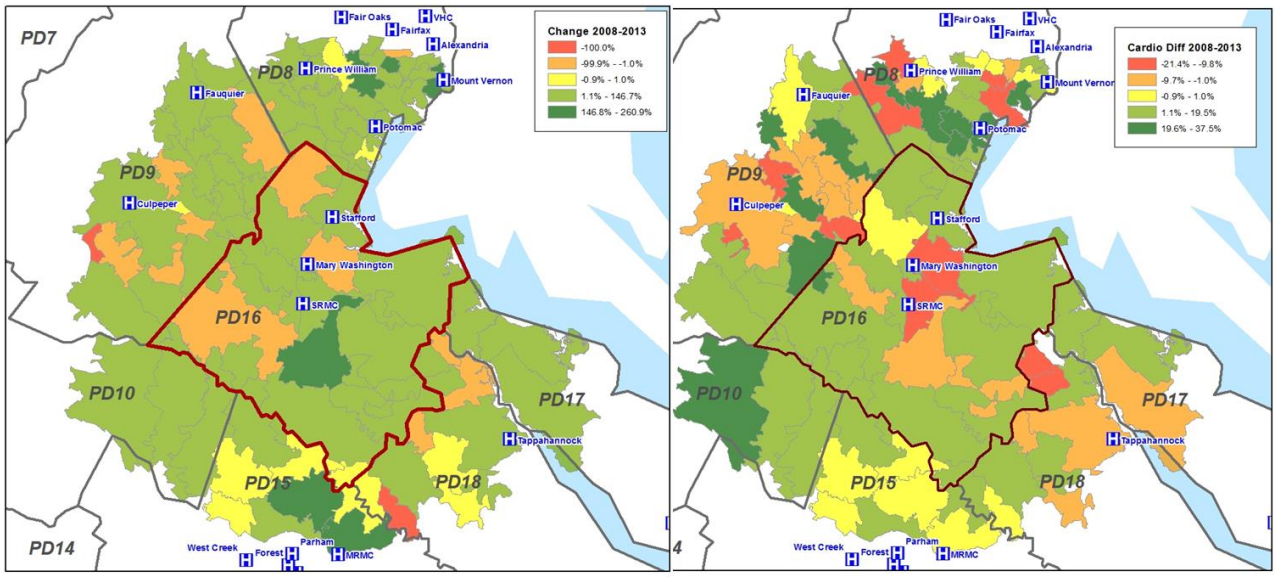
Total Cases Entropy Trend: 2008-2013



Cardiology Cases Entropy Trend: 2008-2013


PD7
PD8
PD9
PD10
PD14
PD15
PD16
PD17
PD18
Fair Oaks
VHC
Fairfax
Alexandria
Prince William
Mount Vernon
Fauquier
Potomac
Culpeper
Stafford
Mary Washington
SRMC
Tappahannock
West Creek
Forest
Parham
MRMC
Cardio Diff 2008-2013
-21.4% - -9.8%
-9.7% - -1.0%
-0.9% - 1.0%
1.1% - 19.5%
19.6% - 37.5%

Comparison


Change 2008-2013
-100.0%
-99.9% - -1.0%
-0.9% - 1.0%
1.1% - 146.7%
146.8% - 260.9%
Cardio Diff 2008-2013
-21.4% - -9.8%
-9.7% - -1.0%
-0.9% - 1.0%
1.1% - 19.5%
19.6% - 37.5%

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