Hospital Monopoly Practices in the U.S.

Healthcare Data Analytics and Data Mining

Group 1

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Introduction

As noted by a number of media[1], hospitals across the U.S. are in the trend of merger and acquisition. This is sad news for many communities, especially those impoverished ones. Local community hospitals, after being acquired by a big healthcare brand name, are forced to shut down owing to a short of revenue. These hospitals in underprivileged areas have for a long time operated in deficit budget status, since patient admissions are usually sponsored by government-backed insurance packaged, i.e. Medicare or Medicaid, or they don't have healthcare insurance at all and are highly probable to default payment for healthcare services. A shortage of revenue will in turn hurt these hospitals' ability to advance research and provide good quality healthcare services. In the end, they are forced to shut down and their closure means the local communities lose access to healthcare at all. On the other hand, large complex hospitals, owing to their ability to provide complicated medical services and attract affluent commercial insurance beneficiaries, generate sustainable cash flow. They are flexing muscles in the acquisition process by driving smaller hospitals out of business and consolidating their monopoly power in the healthcare market. In turn, they advance medical research and attract a larger number of wealthy patients. To put the trend in a more general social economic background, the U.S. has seen a shrinkage in middle-class size and a polarized income level in the past 40 years. The merger and acquisition trend in the healthcare industry may as well reflect the general social movement in the U.S.

In this case, we will be exploring the Inpatient Data publicized by Vermont State and investigate how big and rich players exercise monopolistic power in the market. In particular, we want to test whether in more complex procedures among the Major Diagnostic Categories MDCs the larger hospitals attract more of the well-paid Commercial insurance patients and fewer government paid Medicare beneficiaries.

To do that, we will construct four Origin-Destination matrices to model the referral patterns among hospitals, including the big and the small ones, in Vermont. Elements on the diagonal line of any one matrix show the number or percentage of the care that is rendered with no referral involved.

In the first matrix, we will be investigating the local treatment and referral percentage of hospitals in circulatory system treatment (MDC code: 5) for commercial insurance beneficiaries, which is believed to be a high-end care.

In the second, we will be looking at the local treatment and referral percentage of hospitals in musculoskeletal care (MDC code: 8), which does not require highly specialized staff and super fancy technology. Since treatment for illness in this category does not generate large cash flow, we expect to see lower referral rate from community hospitals to University of Vermont Health Center, however, we expect to see that University of Vermont Health Center will have a large market share for musculoskeletal treatment in the first place, owing to its monopolistic status in the region.

In the third and fourth matrix, we will be looking at the market of the same care for government-sponsored insurance beneficiaries. If the claim reported by CNBC holds true, we shall see that the 'magnet' hospital, University of Vermont Health Center, located in the Burlington area will admit a large number of commercial insurance beneficiaries in this MDC category by referrals from other hospitals; whereas, it will absorb fewer patients with government-sponsored insurance.

[1] CNBC Report: Why U.S. Hospitals Are Closing? https://www.youtube.com/watch?v=18kxPz4Z_g8

Monopolistic Status of the Major Referral Regions

Before we dive into the O-D matrices, we will first calculate the HHI Index for the five regions in Vermont based on records and charges respectively to examine the market share of each region's hospitals. The results we calculated are shown below:

Table 1 HHI index based on records

RR	HHI
RR1	6584.52
RR5	5811.77
RR2	5809.22
RR3	5022.87
RR4	2606.19

Table 2 HHI based on charges

RR	HHI
RR1	8058.97
RR5	6817.21
RR2	5941.76
RR3	5025.60
RR4	2567.37

The results came as no surprise, since RR1 represents the Burlington area where University of Vermont Health Center is located. As a result, we see a significantly higher HHI value for healthcare providers in RR1 either based on patient records or charges.

We also calculated the market share of each hospital based on records and charges respectively in Vermont to examine the monopolistic pattern on the hospital level. The results are shown below:

Table 3 Market share of each hospital based on records

RR	hum2	market share
RR1	5	0.80
RR1	1	0.13
RR1	9	0.07
RR2	6	0.70
RR2	4	0.30
RR3	2	0.53
RR3	3	0.47
RR4	10	0.29
RR4	12	0.29
RR4	15	0.28
RR4	11	0.12
RR4	14	0.02
RR5	8	0.70
RR5	16	0.30

Table 4 Market share of each hospital based on charges

RR	hnum2	Market share
RR1	5	0.89
RR1	1	0.06
RR1	9	0.05
RR2	6	0.72
RR2	4	0.28
RR3	3	0.54
RR3	2	0.46
RR4	10	0.32
RR4	12	0.26
RR4	15	0.24
RR4	11	0.16
RR4	14	0.01
RR5	8	0.80
RR5	16	0.20

As highlighted in the two tables above, hospital 5, 6 and 8, which are University of Vermont Medical Center, Central Vermont Hospital and Rutland Regional Medical Center, have market share values of more than 0.70, compared to the values of lower than 0.40 for the rest. The contrast of market share values show disparity between the two cohorts, i.e. the monopolistic pattern. Moreover, it should be noted that on either record or charge basis, University of Vermont Medical Center ranks the top in terms of market share.

As for the reason why the University of Vermont Medical Center dominates the healthcare market in Vermont, we believe that the ability to provide comprehensive and lucrative medical services, especially in fields of heart, brain, and tiny blood vessels is a vital factor. Patients who can afford the services while finding no other comparable good-quality healthcare services in the state will then transfer to the 'magnet' hospital and bring a huge amount of revenue. In turn, the hospital will be able to advance its research and provide better training for its medical students, and thus obtain more superiority over hospitals in the state.

Two Factors Leading to Monopoly

According to CNBC, larger hospitals with more capital assets and better access to technology and staff thrive and gradually to become monopolies. They have formed a healthy revenue pattern by providing high-ended care, jacking up healthcare service prices, and attracting well paid patients. Therefore, in this report, we want to investigate whether in more complicated procedures among the MDCs, the larger hospitals attract more well-paid commercial insurance patients and fewer government-paid Medicare beneficiaries. Our basic hypotheses are that the types of patients (commercial insurance payers and government-supported insurance payers) and the complexity of MDC procedures are the two main influencers of monopoly.

（1）Financial Status of Patients

To demonstrate the financial status and payment ability of patients, we choose two groups: well-paid commercial and government paid Medicare patients. We use the *PPAY* to separate the payers where Medicare is coded by 1 and Commercial are coded 6 and 7.

（2）Complexity of Major Diagnostic Categories

Further, we investigate to inpatient services portfolio under Commercial and Medicare insurances into find proper high-end and low-end MDCs with a good volume, which is fundamental for solid statistically speaking.

From the pie chart of Medicare, we observe that the top-5 MDCs are Musculoskeletal, Heart & Circulatory, Respiratory, Digestive, and Infection.

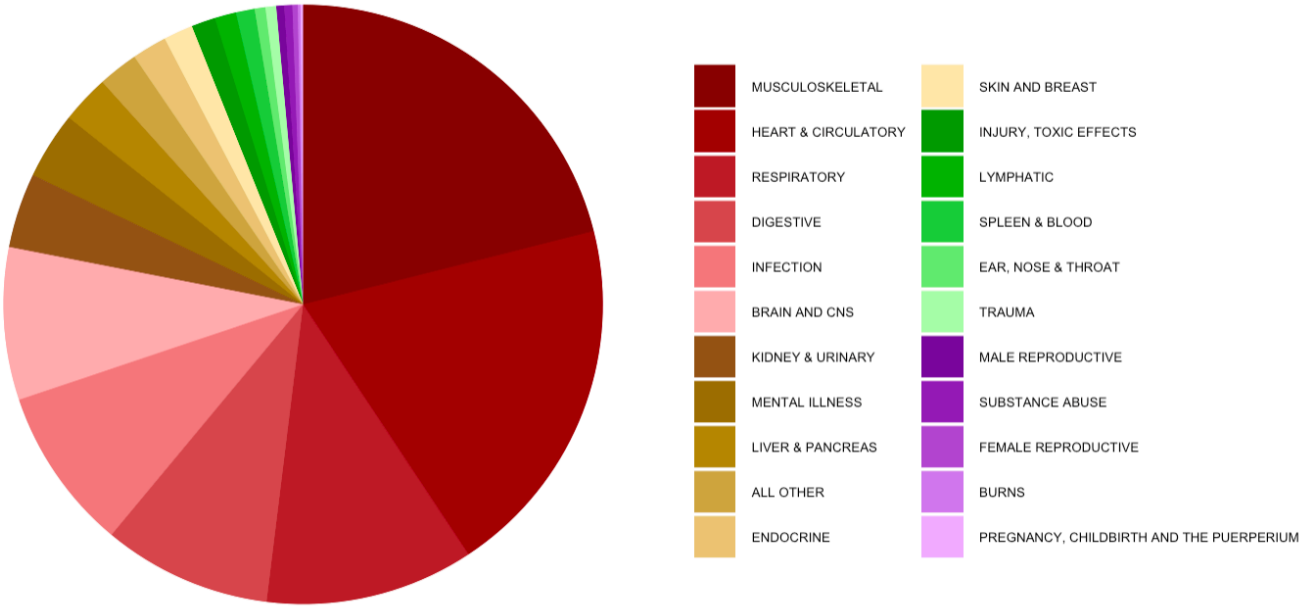

Figure 1 Inpatient services of Medicare

According to the pie chart, commercial payers mainly pay for Musculoskeletal, Heart & Circulatory, Brain and CNS, Pregnancy, Childbirth and the Puerperium and Digestive.

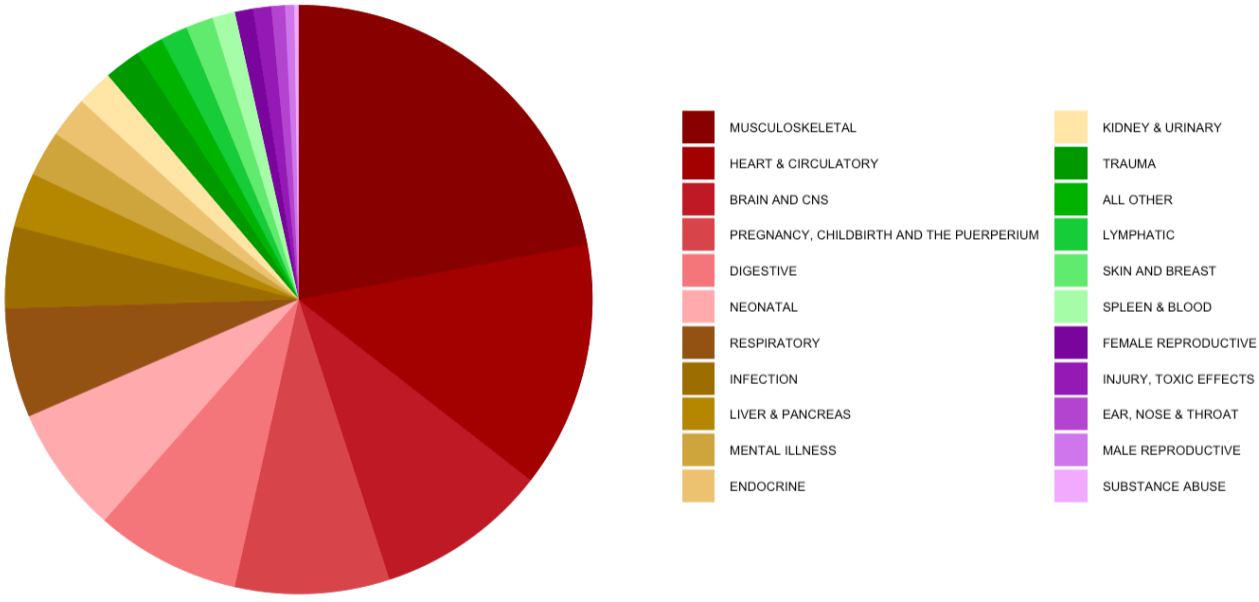

Figure 2 Inpatient services of Commercial Payers

Since Musculoskeletal (MDC code: 5) and Heart & Circulatory (MDC code: 8) are the most common MDCs of Commercial and Medicare insurances, and Musculoskeletal is a typical representative for low-end diseases while Heart & Circulatory is a typical representative for high-end diseases, we decide to analyze these two MDCs to show the influence of disease complexity towards hospital monopoly.

Monopolistic Pattern with Origin-Destination Matrix

By showing the monopolistic status of the major referral regions in terms of market share, two groups of patients with different financial ability, and two common MDCs represent for high-end and low-end MDCs, we would like to further investigate how financial status of patients and complexity of diseases lead to monopoly by constructing 8 pairs of O-D matrices of patient referrals.

In this part, we also constructed origin-destination matrix with percentages for further analysis of hospital monopoly. Therefore, the origin-destination matrix here is a matrix which is each cell represent the proportion of trips from origin (row) to the destination (column). We first create referral patterns with admission counts, and then we further create referral patterns with market share according to referral patterns with admission counts.

（1）Referral Patterns with Admission Counts

First of all, the O-D matrices of admission counts shows the patients movements between referral regions under a certain kind of MDC.

From Table 5, we can find that for most of the referral regions, the admission counts heavily concentrated in the diagonal elements with every few leakages to other areas, except RR2-Barre. Most of the well-paid patients with high-end MDC choose to travel other region such as Burlington instead of taking localized care (Table 5-1). This leakage problem can be alleviated when the MDC becomes less sever (Table 5-2) or government power and regulations is provided (Table 5-3).

We should notice that when the MDC is low-end and political regulation is provided (Table 5-4), most of the patients choose to take localized care with no necessary need for traveling out of the region – the diagonal elements is highly concentrated.

Table 5 O-D Matrix with admission counts

table 5-1 Commercial * Circulatory system

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St Jns	RR4--Randolph	RR5--Rutland	Total Admissions
RR1--Burlington	518	3	0	0	1	522
RR2-- Barre	130	88	0	1	0	219
RR3-- Newport/St. J	8	2	41	0	0	51
RR4--Randolph	10	3	0	48	3	64
RR5-- Rutland	61	0	0	4	96	161
SubTotal	728	96	41	53	100	1018

table 5-2 Commercial * Musculoskeletal System

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St_Jns	RR4--Randolph	RR5--Rutland	Total Admissions
RR1--Burlington	674	81	0	1	21	777
RR2-- Barre	61	169	4	19	1	254
RR3--Newport/St. J	9	9	52	2	1	73
RR4--Randolph	3	4	2	123	25	157
RR5--Rutland	15	2	0	12	241	270
SubTotal:	762	267	58	157	289	1533

table 5-3 Government * Circulatory system

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St Jns	RR4--Randolph	RR5--Rutland	Total Admissions
RR1--Burlington	1417	5	0	1	5	1428
RR2-- Barre	287	557	6	20	0	870
RR3--Newport/St. J	34	10	301	1	1	347
RR4--Randolph	26	8	1	387	13	435
RR5--Rutland	98	0	1	5	647	751
SubTotal:	1862	580	309	414	666	3831

table 5-4 Government * Musculoskeletal System

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St Jns	RR4--Randolph	RR5--Rutland	Total Admissions
RR1--Burlington	1123	105	2	3	26	1259
RR2-- Barre	79	450	9	23	4	565
RR3--Newport/St. J	23	20	247	10	0	300
RR4--Randolph	10	10	3	420	52	495
RR5--Rutland	37	2	0	17	671	727
SubTotal:	1272	587	261	473	753	3346

（2）Referral Patterns with Market Share

We further calculate the market share of five referral regions under two MDCs. The results are shown in Table 6.

Influences of diseases' complexity

As manifested in the percentage matrix of Table 6-1, hospitals in the Burlington area (area code: RR1) takes 72% of the total market share for circulatory system treatment. Though not explicitly shown, it's not hard to guess that the University of Vermont Medical Center in the Burlington area takes a large slice of the 72% market share. Moreover, hospitals in this region are undoubtedly the top target destinations for patient referrals from other regions. It is safe to conclude that hospitals in this region, namely, the University of Vermont Medical Center, hold unchallenged superiority in the circulatory system care market for commercial insurance beneficiaries.

However, Musculoskeletal treatment is believed to be a "light" treatment compared to circulatory system care, while the former does not require super fancy technology nor highly specialized staff to perform complicated and over-priced operations. In another word, patients belonging to this category are more likely to recover in local small hospitals than patients who suffer from circulatory system issues. As a result, they will not seek advanced treatment in large hospitals such as University of Vermont Medical Center. Meanwhile, treatments in this category do not generate large cash flows and are less enticing to large and complex players who look for more profitable deals. Consequently, the Burlington area, where the University of Vermont Medical Center sits, does not have as large a market share (near 50%) as it has for the commercial insurance beneficiaries' circulatory system care market (Table 6-2). Though it still takes a half the market and ranks as the top one target for patient referrals from neighboring areas, it dispatches roughly 10% patients to other areas as well. Moreover, hospitals in other regions tend to keep patients in house, as all these regions have a rate of more than 65% (green areas) to keep patients in house.
Comparing Table 6-1 and Table 6-2, we find out that the percentage of commercial payers who go to RR1 for heart and circulatory system is more than 20% higher than those who go to RR1 for musculoskeletal system. Then we

conclude that well paid patients from private commercial insurers are more willing to go to RR1 for high-end and pricey care than routine and standard care.

Table 6 O-D Matrix with market share

table 6-1 Commercial * Circulatory system

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St_Jns	RR4--Randolph	RR5--Rutland
RR1--Burlington	99.23%	0.57%	0.00	0.00	0.19%
RR2-- Barre	59.36%	40.18%	0.00	0.46%	0.00
RR3--Newport/St. J	15.69%	3.92%	80.39%	0.00	0.00
RR4--Randolph	15.63%	4.69%	0.00	75%	4.69%
RR5--Rutland	37.89%	0.00	0.00	2.48%	59.63%
Market Share	71.51%	9.43%	4.03%	5.21%	9.83%

table 6-2 Commercial * Musculoskeletal System

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St_Jns	RR4--Randolph	RR5--Rutland
RR1--Burlington	86.74%	10.42%	0.00	0.13%	2.70%
RR2-- Barre	24.02%	66.54	1.57%	7.48%	0.39%
RR3--Newport/St. J	12.33%	12.33%	71.23%	2.74%	1.37%
RR4--Randolph	1.91%	2.55%	1.27%	78.34%	15.92%
RR5--Rutland	5.56%	0.74%	0.00	4.44%	89.26%
Market Share	49.71%	17.42%	3.78%	10.24%	18.85%

table 6-3 Government * Circulatory system

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St_Jns	RR4--Randolph	RR5--Rutland
RR1--Burlington	99.23%	0.35%	0.00	0.07%	0.35%
RR2-- Barre	32.99%	64.02%	0.69%	2.30%	0.00
RR3--Newport/St. J	9.80%	2.88%	86.74%	0.29%	0.29%
RR4--Randolph	5.98%	1.84%	0.23%	88.97%	2.99%
RR5--Rutland	13.05%	0.00	0.13%	0.67%	86.15%
Market Share	48.60%	15.14%	8.07%	10.81%	17.38%

table 6-4 Government * Musculoskeletal System

RRName	RR1--Burlington	RR2--Barre	RR3--Newport/St_Jns	RR4--Randolph	RR5--Rutland
RR1--Burlington	89.20%	8.34%	0.16%	0.24%	2.07%
RR2-- Barre	13.98%	79.65%	1.59%	4.07%	0.71%
RR3--Newport/St. J	7.67%	6.67%	82.33%	3.33%	0.00
RR4--Randolph	2.02%	2.02%	0.61%	84.85%	10.51%
RR5--Rutland	5.09%	0.28%	0.00	2.34%	92.30%
Market Share	38.02%	17.54%	7.80%	14.14%	22.50%

Influences of patients' financial abilities

Let's then look at the pattern of the same categories of healthcare for government-sponsored insurance beneficiaries.

According to Table 6-3, the referral pattern confirms the claim held by CNBC that large and complex players in the healthcare market are more likely to admit patients with commercial insurance coverage while this group of people can afford the fancy and expensive treatment provided by the large and complex hospitals. As shown in the matrix with market share, hospitals in each region are more probable to keep the patients within, all with a probability of more than 60% (green areas). Moreover, the market share taken by hospitals in RR1, namely the University of Vermont Medical Center, is lower than 50%, though the market share still establishes the 'magnet' hospital as the superior power in the market, compared to the market share of 72%, it is considerably lower.

Comes to the treatment of musculoskeletal issues for government-sponsored insurance beneficiaries who do not have a deep pocket, big and complex hospitals show less interest. Hospitals in the Burlington area take only 38% of market share while hospitals in all regions have a rate of keeping patients in house for more than 80% (green areas) according to Table 6-4. Though the "magnet" hospital still leads the market share, however, its edge is not as significant as in the case of the healthcare market for the wealthy with circulatory system issues.

Comparing Table 6-3 and Table 6-4, we find out that the percentage of payers in Medicare who go to RR1 for heart and circulatory system is 10% higher than those who go to RR1 for musculoskeletal system. We conclude that well patients who are supported by the government are more willing to go to RR1 for high-end and pricey care than routine and standard care.

Meanwhile, the percentage difference between heart and circulatory system and musculoskeletal system for commercial payers is 1 time that for government-supported payers, which reveals that commercial payers are more sensitive to the different types of care than Medicare payers. Commercial payers are more likely to go to RR1 than Medicare payers in general.

One thing needs to mention is that most percentages are concentrated on the diagonal line, expect for RR2. In particular, as for circulatory system, only 40% commercial payers in RR2 are treated locally. We form a hypothesis that maybe the medical treatment of circulatory system is not that developed and most commercial payers will choose hospitals in other RRs. There are only 64% of Medicare payers in RR2 who choose to go to local hospitals, the percentage is also not very high.

（3）Conclusion

Comparing the market shares of RR1 from all four tables in Table 6 (orange areas), we find that the market share of RR1 is the largest when it serves for commercial patients with high-end diseases (72%), followed by commercial patients with low-end diseases (50%). The market share of RR1 is the least when it serves for government-sponsored insurance patients with low-end diseases (38%), and market share of RR1 when it serves for government-sponsored insurance patients with high-end diseases comes to the third place (49%).

This phenomenon perfectly proves the hypothesis in the CNBC report that claims big hospitals compete in two dimensions, disease complexity and patient financial ability, simultaneously. Disease complexity and patient financial ability can be the two mean factors that lead to the monopoly status of a referral region and influence the movement of patients between referral regions.

Extended Research

Based on the above analysis, we have demonstrated the difference between market share. Then, we want to go further to see the major DRG where the monopolistic practices are more pronounced. In order to find a pair of high and low-end DRG, we run a program to generate the Herfindahl-Hirschman Index (HHI), which stands for the monopoly of hospitals in providing services for the specific DRG groups. We calculated the HHI score for governmental and commercial groups respectively. According to the difference in HHI score between these two groups, we get the lowest difference from DRG 470, which is classified in musculoskeletal MDC. When Patients who suffer from Major joint replacement or reattachment of lower extremity in the Medicare group (Table 1a), they were distributed in our 5 divided area, 433 patients from Burlington, 191 from Barre, 104 from Newport, 155 from Randolph, 302 from Rutland, and most of them received their treatment in their region, other than 81 of patients from Burlington, 13 of patients from Newport, 21 patients from Randolph, 66 patients from Rutland, 36 of patients from Barre were transferred.

Additionally, Although the number of patients with DRG 470 in the commercial group is 500 less than in the Medicare group, there is still a small number of patients traveling to other regions to receive treatment. Majority of patients suffering from Major joint replacement or reattachment of lower extremity were coming from Burlington, taking up to almost half of the total patients.

RR_origin	RR1	RR2	RR3	RR4	RR5	Total
RR1	352	61	0	0	20	433
RR2	11	155	4	17	4	191
RR3	5	8	91	0	0	104
RR4	4	5	2	102	42	155
RR5	15	0	0	6	281	302
Total	387	229	97	125	347	1185

Table 1a Government * low-end

RR_origin	RR1	RR2	RR3	RR4	RR5	Total
RR1	165	0	0	1	2	168
RR2	9	95	1	0	0	105
RR3	0	0	25	0	0	25
RR4	1	0	0	36	0	37
RR5	2	0	0	0	62	64
Total	177	95	26	37	64	399

Table 1b Government * high-end

RR_origin	RR1	RR2	RR3	RR4	RR5	Total
RR1	299	59	0	0	12	370
RR2	17	71	3	9	1	101
RR3	2	6	32	0	0	40
RR4	1	3	1	50	18	73
RR5	6	1	0	4	118	129
Total	325	140	36	63	149	713

Table 1c Commercial * low-end

RR_origin	RR1	RR2	RR3	RR4	RR5	Total
RR1	49	0	0	0	0	49
RR2	2	7	0	0	0	9
RR3	0	0	1	0	0	1
RR4	0	0	0	3	0	3
RR5	1	0	0	0	9	10
Total	52	7	1	3	9	72

Table 1d Commercial * high-end

Figure 3 O-D Matrix with admission counts

We get the high HHI value from DRG 189, which is a more complex disease: Pulmonary edema & respiratory failure, classified in respiratory MDC (Table 1b). Among the patients, 399 of them incurred government insurances, 72 patients with commercial insurances. For patients in the Medicare group, majority of them were from Burlington and Barre, and most patients from Burlington stayed in Burlington, Northwestern Medical Center, University of Vermont Medical Center, or Porter Medical Center, to receive treatment.

Moreover, there are 72 patients suffering from Pulmonary edema & respiratory failure in commercial groups. Majority of patients were from Burlington and received treatment in Burlington, other than one patient transferred to Randolph and 2 patients transferred to Rutland.

In Summary, although the patients suffering from DRG 470 did not always visit hospitals in their referral regions, they tend to have no preference in hospitals outside their regions. In other words, there is no 'magnet' RR on Major joint replacement or reattachment of lower extremity. On the opposite, patients in DRG 189 tend to stay in their area, however, RR1 has appealed to some out-region patients.

RR_origin	RR1	RR2	RR3	RR4	RR5
RR1	81.29%	14.09%	0%	0%	4.62%
RR2	5.76%	81.15%	2.09%	8.90%	2.09%
RR3	4.81%	7.69%	87.50%	0%	0%
RR4	2.58%	3.23%	1.29%	65.81%	27.10%
RR5	4.97%	0%	0%	1.99%	93.05%
Market share %	32.66%	19.32%	8.19%	10.55%	29.28%

Table 2a Government * low-end

RR_origin	RR1	RR2	RR3	RR4	RR5
RR1	98.21%	0%	0%	0.60%	1.19%
RR2	8.57%	90.48%	0.95%	0%	0%
RR3	0%	0%	100%	0%	0%
RR4	2.70%	0%	0%	97.30%	0%
RR5	3.12%	0%	0%	0%	96.88%
Market share %	44.36%	23.81%	6.52%	9.27%	16.04%

Table 2b Government * high-end

RR_origin	RR1	RR2	RR3	RR4	RR5
RR1	80.81%	15.95%	0%	0%	3.24%
RR2	16.83%	70.30%	2.97%	8.91%	0.99%
RR3	5%	15%	80%	0%	0%
RR4	1.37%	4.11%	1.37%	68.49%	24.66%
RR5	4.65%	0.78%	0%	3.10%	91.47%
Market share %	45.58%	19.64%	5.05%	8.84%	20.90%

Table 2c Commercial * low-end

RR_origin	RR1	RR2	RR3	RR4	RR5
RR1	100%	0%	0%	0%	0%
RR2	22.22%	77.78%	0%	0%	0%
RR3	0%	0%	100%	0%	0%
RR4	0%	0%	0%	100%	0%
RR5	10%	0%	0%	0%	90%
Market share %	72.22%	9.72%	1.39%	4.17%	12.50%

Table 2d Commercial * high-end

Figure 4 O-D Matrix with market share

After looking at the differences in numbers, we want to go further to see the distinctive difference in their market share (Table 2a-d). According to Table 2a, we can see that the market share is almost evenly distributed among 5 revised regions and there is no obvious high-degree monopolistic for Major joint replacement or reattachment of lower extremity. Looking at the diagonal element of the O-D matrix, the percentage of the care that was rendered locally is around 80% to 90%, except Randolph with lower proportion 65.81%. The diagonal number for patients suffering from Major joint replacement in commercial groups is distributed unevenly and slightly lower, mainly concentrated between 70% to 80%, except Rutland with higher rate 91.47%. In contrast, the O-D matrix remains heavily concentrated in the diagonal elements with very few leakages to other areas for Pulmonary edema & respiratory failure Medicare group. localized care reached approximately 97 to 100 % for our 5 revised regions, other than slightly lower in Barre with 90.48%. It's more pronounced for commercial groups, with 100% localized care weight in Burlington (RR1), Newport (RR3) and Randolph (RR4), 90% in Rutland (RR5) and slightly lower in Barre with 77.78%.

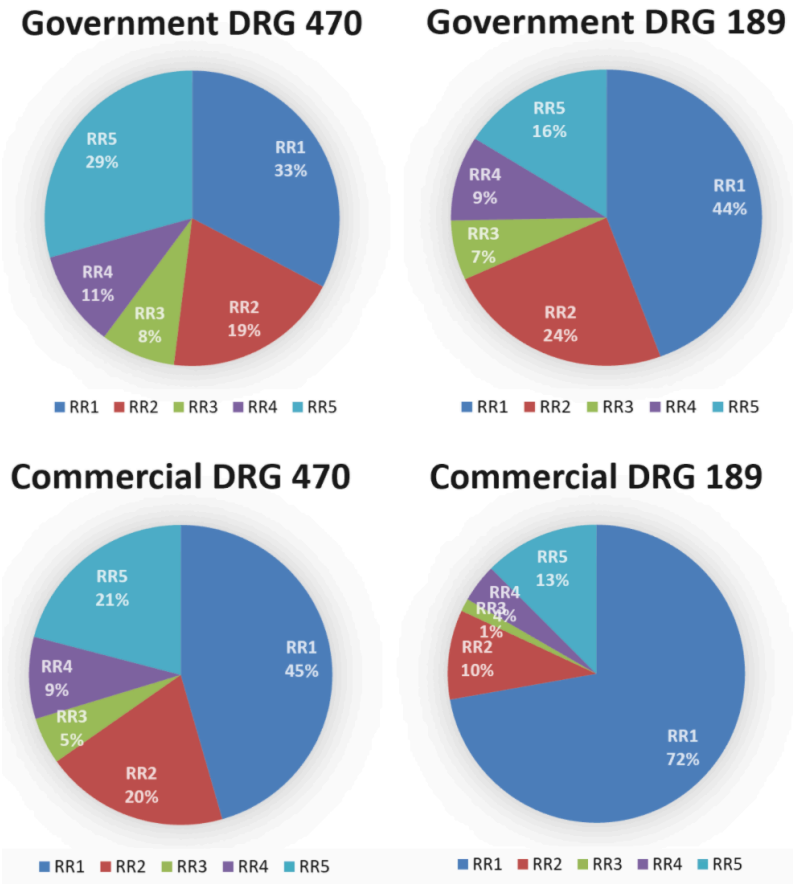

Figure 5 Market shares of 5 referral regions under two MDCs

University of Vermont Medical Center, largest hospital of state, was located in Burlington. It provides advanced care to approximately one million people in Vermont and northern New York. Its professional and capacity for patients attracts a lot of patients from other regions. According to the 4 O-D matrixes, Burlington accounted for the largest market share in 4 different situations. Joint replacement is a procedure of orthopedic surgery in which an arthritic or dysfunctional joint surface is replaced with an orthopedic prosthesis. Joint replacement surgery is becoming more common with knees and hips replaced most often. About 773,000 Americans had a hip or knee replaced in 2009. With low- degree of monopolistic competition, the market share is almost evenly distributed, Burlington still holds the largest market share with 32.66%, but closely followed by Rutland with 29.28%. Barre ranked third in market share, taking up 19%, as same as the combination of Randolph and Newport. When patients suffering from Pulmonary edema & respiratory failure were analyzed in the Medicare group, the market share for Burlington slightly increased to 44.36%. The portion of patients Barre received does not change much, with a 5% increase, still taken up almost one fourth. When it turns to Pulmonary edema & respiratory failure in commercial groups, the portion in other regions experienced a dramatic decrease, other than Burlington. Barre cut patients treatment in half, from 24% to 10%. The market share for Newport and Randolph decreased to less than half of the Medicare group. In contrast, Market share for Burlington doubled for commercial group. Through the comparison of market share between commercial and government groups, we can conclude that the private insurance payers are more willing to transfer to hospitals with better medical resources, and this is the reason why Burlington took up 72% in the market. What's more, compared with patients suffering joint replacement in commercial groups, which Burlington make up 45 % of the market, the treatment of Pulmonary edema & respiratory failure has apparent advantages of monopoly. Because of the strict requirement for Pulmonary edema & respiratory failure treatment, not all hospitals are eligible for serious situations, some patients prefer to transfer to hospitals with high quality medical resources. In conclusion, it's clear that private insurance payers and patients needing high-end care are more likely attracted by the high-quality medical resources.

Summary

We can generate four conclusions from the analysis above.

First of all, RR1 shows a monopoly status where University of Vermont Medical Center, Central Vermont Hospital and Rutland Regional Medical Center are the significant lion players with market share values of more than 0.70. Furthermore, disease complexity and patient financial ability can be the key factors that lead to the monopoly status. Results generated by exploring the Vermont inpatient dataset suggests that the claim made by CNBC and a few other medias is true: after some time of market consolidation, large players in the healthcare have an upper hand to provide more advanced and expensive to the upper-middle class who for the most part are covered by good-quality commercial insurance packages. The ability to make a profit on the patients will in turn keep these large players in dominance over small community hospitals. A large number of hospitals in the latter category have been driven to bankruptcy despite their importance in local communities.

Besides, it is also these two factors that stimulates the movement of patients between referral regions and the concentration in the diagonal elements.

Finally, this report also shows that some state governments have realized this problem, however, they have failed to provide an adequate solution. Their efforts have been too few and too late.[2] Maybe only a structural change on the federal level and a recognition of healthcare as basic human right rather than a business can prevent the healthcare system from further heading south, which will certainly be a bittering process.

[2] https://www.bizjournals.com/boston/news/2019/09/20/new-hampshire-ag-blocks-partners-acquisition-over.html
https://www.bostonglobe.com/business/2015/01/29/partners/s9TxpYCBakjPN6pDbBFHGL/story.html

Appendix

```{r loadlib, echo=T, results='hide', message=F, warning=F}
library(ggplot2)
library(tidyverse)
library(reshape2)
source("http://pcwww.liv.ac.uk/~william/R/crosstab.r")
```
```{r}
inpatient = read.csv("VTINP16_upd.TXT")
RR_map = read.csv('RR_mapping.csv')
hsa_map = read.csv('hsa_mapping.csv')
```
```{r}
# patient data in mdc==5,8; ppay== 1，6，7
dta = inpatient[inpatient$PPAY==1|inpatient$PPAY==6|inpatient$PPAY==7,]
dta = dta[dta$MDC==5|dta$MDC==8,]
# merge RR into dataset
dta = merge(dta,RR_map[c('hnum2','RRName')]) # RRName is destination
dta = merge(dta,hsa_map[c('HSA.Health.Service.Area','RR.Name')],by.x = 'hsa', by.y = 'HSA.Health.Service.Area') # RR.Name is origin
```
```{r}
#commercial * circulatory
dta1 = dta[dta$MDC==5,]
dta1 = dta1[dta1$PPAY==6|dta1$PPAY==7,]
crosstab(dta1, row.vars = "RR.Name", col.vars = "RRName", type = "f")
crosstab(dta1, row.vars = "RR.Name", col.vars = "RRName", type = "r")
```
```{r}
#commercial * musculoskeletal
dta2 = dta[dta$MDC==8,]
dta2 = dta2[dta2$PPAY==6|dta2$PPAY==7,]
crosstab(dta2, row.vars = "RR.Name", col.vars = "RRName", type = "f")
crosstab(dta2, row.vars = "RR.Name", col.vars = "RRName", type = "r")
```
```{r}
#government * circulatory
dta3 = dta[dta$MDC==5,]
dta3 = dta3[dta3$PPAY==1,]
crosstab(dta3, row.vars = "RR.Name", col.vars = "RRName", type = "f")
crosstab(dta3, row.vars = "RR.Name", col.vars = "RRName", type = "r")
```
```{r}
#government * musculoskeletal
dta4 = dta[dta$MDC==8,]
dta4 = dta4[dta4$PPAY==1,]
crosstab(dta4, row.vars = "RR.Name", col.vars = "RRName", type = "f")
crosstab(dta4, row.vars = "RR.Name", col.vars = "RRName", type = "r")
```
```{r}
# preprocessing
inpatient_RR <- merge(inpatient, RR_map[c('hnum2', 'RR')])
inpatient_RR <- merge(inpatient_RR, hsa_map[c('HSA.Health.Service.Area', 'RR.Collapsed.Referral.Region')], by.x = 'hsa', by.y = 'HSA.Health.Service.Area')
names(inpatient_RR)[names(inpatient_RR)=='RR'] = 'RR_destination'
names(inpatient_RR)[names(inpatient_RR)=='RR.Collapsed.Referral.Region'] = 'RR_origin'

inpatient_RR <- inpatient_RR %>% filter(RR_origin %in% paste('RR', 1:5, sep = ''))
```
MDC monopoly in 5 RRs: HHI based on admissions
```{r}
# circulatory
mdc_monopoly <- inpatient_RR %>% filter(RR_destination %in% c("RR1", "RR2", "RR3","RR4", "RR5")) %>% group_by(RR_destination) %>% count(hnum2)
A = aggregate(n~RR_destination,data = mdc_monopoly,FUN="sum")
mdc_monopoly = merge(mdc_monopoly, A, by = "RR_destination")
names(mdc_monopoly) = c("RR_destination","hum2","count","total")
mdc_monopoly_1 <- mdc_monopoly %>% mutate(market_share = count/total)
mdc_monopoly_2 <- mdc_monopoly_1 %>% arrange(RR_destination,desc(market_share))
mdc_monopoly_2 # market share for each hospital
write_xlsx(mdc_monopoly_2, "marketshare for each hospital records")
mdc_monopoly_3 <- mdc_monopoly_2 %>% mutate(market_share_square = (market_share*100)^2)
mdc_monopoly = aggregate(market_share_square~RR_destination,data = mdc_monopoly_3,FUN="sum") %>% arrange(desc(market_share_square))
mdc_monopoly # HHI index for each RR
write_xlsx(mdc_monopoly, "marketshare for each RR records")
```

MDC monopoly in 5 RRs: HHI based on charges

```{r}
mdc_monopoly_charge = inpatient_RR %>% filter(RR_destination %in% c("RR1", "RR2", "RR3","RR4", "RR5")) %>% group_by(RR_destination)
table_sum = aggregate(CHRGS~RR_destination, data = mdc_monopoly_charge,FUN = "sum")
table2 = aggregate(CHRGS~hnum2, data = mdc_monopoly_charge,FUN = "sum")
table_total = merge(table2, RR_map, by = "hnum2")
table_all = select(table_total, -c(RRName,HospitalName))

table_monopoly = merge(table_all,table_sum, by.x = "RR", by.y = "RR_destination")
table_monopoly2 <- table_monopoly %>% mutate(charges_percentage = CHRGS.x/CHRGS.y) %>% mutate(charges_percentage_square = (100*charges_percentage)^2)
table_marketshare_hospital = select(table_monopoly2, c(RR, hnum2, charges_percentage)) %>% arrange(RR,desc(charges_percentage))
table_marketshare_hospital # market share for each hospital
write_xlsx(table_marketshare_hospital, "marketshare for each hospital charges")

table_monopoly_final = aggregate(charges_percentage_square~RR, data = table_monopoly2, FUN = "sum") %>% arrange(desc(charges_percentage_square))
table_monopoly_final # HHI index for each RR
write_xlsx(table_monopoly_final, "HHI index for each RR charges")
```

```{r}
library(ggplot2)
library(tidyverse)
library(reshape2)

inpatient = read.csv("VTINP16_upd.TXT")
RR_map = read.csv('RR_mapping.csv')
hsa_map = read.csv('hsa_mapping.csv')
mdc_map = read.csv('MDC_mapping.csv')
```

```{r}
# preprocessing
inpatient_RR = merge(inpatient, RR_map[c('hnum2', 'RR')])
inpatient_RR = merge(inpatient_RR, hsa_map[c('HSA.Health.Service.Area', 'RR.Collapsed.Referral.Region')], by.x = 'hsa', by.y = 'HSA.Health.Service.Area')
names(inpatient_RR)[names(inpatient_RR)=='RR'] = 'RR_destination'
names(inpatient_RR)[names(inpatient_RR)=='RR.Collapsed.Referral.Region'] = 'RR_origin'

inpatient_RR = inpatient_RR %>% filter(RR_origin %in% paste('RR', 1:5, sep = ''))
```

```{r}
odmatrix_drg_count = function(inpatient_RR, drg, pay_type = NA) {
  if(is.na(pay_type)) {
    inpatient = inpatient_RR %>% filter(DRG == drg)
  } else if(pay_type %in% c('g', 'c')) {
    if(pay_type == 'g') inpatient = inpatient_RR %>% filter(DRG == drg) %>% filter(PPAY == 1)
    if(pay_type == 'c') inpatient = inpatient_RR %>% filter(DRG == drg) %>% filter(PPAY == 6 | PPAY == 7)
  } else {
    stop('Invalid pay_type.')
  }

  if(dim(inpatient)[1] == 0) return(NA)

  crosstab = dcast(inpatient, RR_origin ~ RR_destination, length)
  crosstab = crosstab[!is.na(crosstab$RR_origin),]

  return(crosstab)
}

odmatrix_share = function(tab) {
  if(is.na(tab)) return(NA)

  cols = paste('RR', 1:5, sep = '')
  for (row in cols) {
    if (!(row %in% tab$RR_origin)) tab[row, ] = c(row, rep(0, 5))
  }
  for (col in cols) {
    if (!(col %in% colnames(tab))) tab[, col] = 0
    tab[, col] = as.numeric(tab[, col])
  }

  tab = tab[order(tab$RR_origin), c('RR_origin', cols)]
  tab[6, cols] = apply(tab[, cols], 2, sum)
  tab$RR_origin = c(cols, 'Total')

  rownames(tab) <- NULL
```

```
    print(cbind(tab, Total = apply(tab[, cols], 1, sum)))

    tab$RR_origin = c(cols, 'Market share %')

    denom = apply(tab[, cols], 1, sum)
    denom[denom == 0] = 1
    tab[, cols] = tab[, cols] / denom

    for (col in cols) {
        tab[, col] = sapply(tab[, col], function(x) paste(100*round(x, 4), '%', sep = ''))
    }

    print('\n')
    print(tab)
}

odmatrix = function(inpatient_RR, drg, pay_type) {
    odmatrix_share(odmatrix_drg_count(inpatient_RR, drg, pay_type))
}

HHI = function(tab) {
    if(is.na(tab)) return(NA)

    cols = intersect(paste('RR', 1:5, sep = ''), colnames(tab))
    if(length(cols) == 1) return(NA)
    mkt_share = apply(tab[, cols], 2, sum) / sum(tab[, cols])
    hhi = sum(mkt_share^2)
    return(hhi)
}
```

```{r}
drg_map <- read.csv('DRG_mapping.csv')
drg_map$MDC_NO = sapply(drg_map$MDC_NO, function(x) {
    if(x %in% mdc_map$MDC) {
        return(mdc_map[mdc_map$MDC == x, 'MDC_CAT_NAME'])
    } else {
        return(x)
    }
})
colnames(drg_map) = c("MSDRG", "MDC", "MSDRG_DESC")
drg = inpatient_RR %>% group_by(DRG) %>% tally()
drg_map = merge(drg, drg_map, by.x = 'DRG', by.y = 'MSDRG')
```

```{r message = FALSE}
drg_map$HHI_g = sapply(drg_map$DRG, function(x) HHI(odmatrix_drg_count(inpatient_RR, x, 'g')))
drg_map$HHI_c = sapply(drg_map$DRG, function(x) HHI(odmatrix_drg_count(inpatient_RR, x, 'c')))
rownames(drg_map) <- NULL
drg_map$HHI_d = drg_map$HHI_c - drg_map$HHI_g
```

```{r}
HHI_rank = drg_map[!is.na(drg_map$HHI_d), c('DRG', 'MDC', 'MSDRG_DESC', 'HHI_d', 'n')]
HHI_rank = HHI_rank[order(HHI_rank$HHI_d), ]
rownames(HHI_rank) = NULL
HHI_rank = HHI_rank[HHI_rank$n > 500, ]
HHI_rank = HHI_rank[HHI_rank$HHI_d > 0, ]
HHI_rank
```

```{r}
# DRG:             470
# DRG_DESC:     Major joint replacement or reattachment of lower extremity w/o MCC
# MDC:             MUSCULOSKELETAL
# PAY:             GOVERNMENT
# PATIENTS:     2151
odmatrix(inpatient_RR, 470, 'g')
```

```{r}
# DRG:             189
# DRG_DESC:     Pulmonary edema & respiratory failure
# MDC:             RESPIRATORY
# PAY:             GOVERNMENT
# PATIENTS:     594
odmatrix(inpatient_RR, 189, 'g')
```

```{r}
# DRG:              470
# DRG_DESC:      Major joint replacement or reattachment of lower extremity w/o MCC
# MDC:              MUSCULOSKELETAL
# PAY:              COMMERCIAL
# PATIENTS:      2151
odmatrix(inpatient_RR, 470, 'c')
```

```{r}
# DRG:              189
# DRG_DESC:      Pulmonary edema & respiratory failure
# MDC:              RESPIRATORY
# PAY:              COMMERCIAL
# PATIENTS:      594
odmatrix(inpatient_RR, 189, 'c')
```