Group 1

Final Report: Insurance Claims - Part 2 Hospital Monopoly

HS 256F Healthcare Data Analytics and Data Mining

Chujun Chen

Leah Peretsky

Hongxiao Luo

Nicole Levesque

Jianying Zhu

03/17/2021

Introduction

The healthcare industry is not immune to the perils of monopolies, especially in the fragmented system that exists in the United States. According to a report by CNBC (2020), monopolistic practices are a key factor leading to the closure of rural hospitals. A recurring trend within health systems is the following: a big hospital buys the smaller local hospitals, the big hospital attracts high-paying patients with private insurance, and the hospital raises prices before the government can step in to impose restrictions on mergers and acquisitions. The result is a monopoly where patients seeking quality healthcare services end up paying high prices for higher end care that often includes specialized testing and procedures using new and expensive technology.

This report tests the hypothesis posed by CNBC by examining the patterns that patients take in accessing healthcare services. It will examine the relationship between patients with high-paying, private insurance and high-end or low-end care. Conversely, it will look into the relationship between patients with lower reimbursement rates through Medicare and Medicaid and whether they are more likely to obtain high-end or low-end care. The analysis will be based on a series of origin-destination matrices for high-end and low-end care, and for high-paying and low-paying patient populations. Data used for these analyses pertain to inpatient claims data for the state of Vermont in 2016.

A Monopolistic Hospital System

A monopoly occurs when a company or organization dominates a single sector of the market, and benefits from a lack of competition. By charging a variety of prices for the same good/service, contingent on a buyer's willingness to pay, monopolies are able to further increase their profits and remain in power. In the healthcare market, this concept is especially relevant with hospital systems. With a growing trend of monopolies emerging in the market, health care costs continue to rise, making care increasingly unaffordable for many American families. Also, while there is no considerable competitive hospital market remaining in the US, with an increasing number of hospitals buying out their competitors, the effect is naturally higher prices. Thus, hospital costs continue to be the most substantial component of health care expenditure. In fact, a study conducted by an esteemed economist at Yale University reveals, "if you stay in a hospital that faces no competition, your bill will be $1,900 higher on average than if you stay in a hospital facing four or more competitors" (Cooper et al., 2015). To put this into perspective, this burden is approximately 15% higher than hospitals facing competition; overall, the larger the hospital, the greater ability it has to raise prices (Harvard School of Public Health, 2015). Finally, it comes as no surprise that with the enactment of Obamacare, which granted millions of more Americans reliable health insurance coverage, hospitals naturally opted to charge those insurance plans higher rates (Novak, 2020).

Patient Referral Patterns

Of particular interest in this study is whether patients receive healthcare services close to home, or whether and where they travel if they choose to seek healthcare services in another region. Vermont is a small, rural state, so its population could feasibly travel to another region if they believe they can receive better healthcare services elsewhere. In order to investigate the geographical referral patterns for inpatient hospital care in the state of Vermont, the state will be divided into five Health Service Areas (HSAs). HSAs are defined by the Centers for Disease Control and Prevention, and are considered to be regions or counties where hospital care is relatively self-contained. Figure 1 below shows a map of Vermont by HSA and revised regions for this assignment.

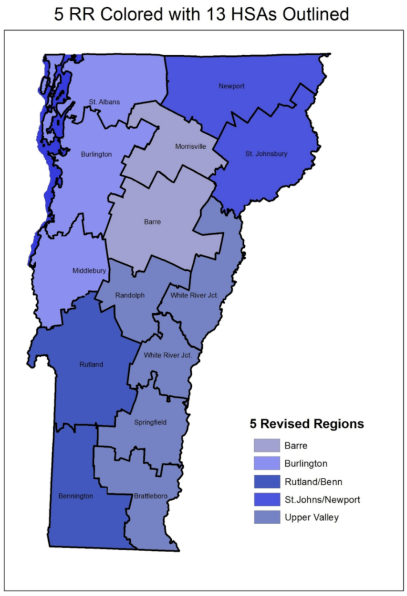


Figure 1: HSAs and Revised Regions in Vermont

A notable revised region in Vermont is represented in light purple in Figure 1 and includes the city of Burlington. The state's largest hospital, the University of Vermont Medical Center, is located within the city and the revised region of Burlington. This report will examine the power that this "magnet" hospital has on receiving patients throughout the state, and the analysis will consider the reasons for the hospital's prominence. State-wide, the University of Vermont Medical Center has 41% of the market share.

Figure 2 below presents the breakdown of market share for each hospital in the state of Vermont for all inpatient admissions in the year 2016. Recent estimates from the U.S. Census Bureau (2020) estimated Vermont's total population to be 623,989 in total, while 42,545 people live in Burlington alone. The second most populated city in Vermont is Essex, with only 21,467 people. As a state renowned for its vast farmland and sparsely populated inhabitants, it is likely that Vermonters are well accustomed to traveling long distances to meet their needs.

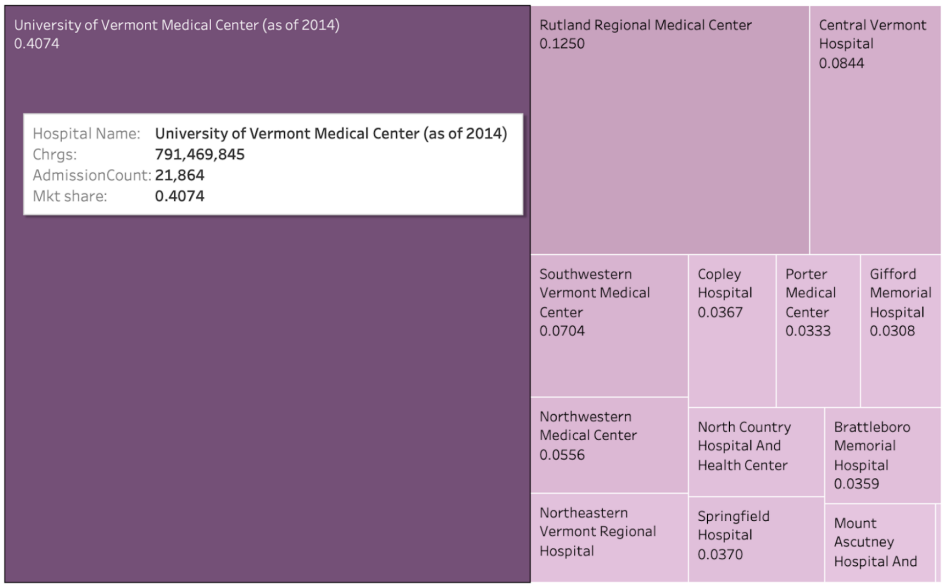


Figure 2: Market share of inpatient admissions per hospital in Vermont

Origin-Destination Matrix Analysis

An analysis of the patients by origin and destination allow for a comprehensive analysis of patient referral patterns. Using the previously defined healthcare regions within Vermont, a matrix assessment highlights where healthcare services are localized and where they patients are spilling into other regions in search of necessary medical care. This analysis will review inpatient admissions within Vermont hospitals in 2016, and will consider each patient's region of origin and destination.

Table 1 below presents a statewide overview of patient referral patterns for the five regions within Vermont. The regions listed on the y-axis represent the patient's origin, while the x-axis represents where the patient went to receive all types of inpatient hospital treatment. The percentages in the green cells describe the proportion of Vermonters who received healthcare services in the same region in which they live. Importantly, these values are the highest in each column, representing that overall, Vermonters are admitted to hospitals close to home. Also of note is the high proportion of patients who leave their home region for Burlington to receive care, as shown by the high percentages in the column for Burlington.

Table 1: Origin-Destination Matrix for all Inpatient Hospital Admissions in Vermont in 2016

RRName	Burlington	Barre	Newport/St. Jns	Randolph	Rutland	Total Admissions
Burlington	13621	265	14	24	124	**14048**
Barre	1635	4346	58	261	12	**6312**
Newport/St. Jns	208	97	2257	23	12	**2597**
Randolph	127	114	36	3649	222	**4148**
Rutland	647	11	2	142	6243	**7045**
Out of State	3503	116	78	740	1254	**5691**
Destination Hosp Subtotal:	**19741**	**4949**	**2445**	**4839**	**7867**	**39841**
Destination Hosp Subtotal:	**49.55%**	**12.42%**	**6.14%**	**12.15%**	**19.75%**	**100.00%**

To deepen this analysis and relate it to the CNBC report, by breaking down the original data, the origin-destination matrices can also examine referral patterns for patients depending on the type of care they receive and the type of insurance coverage they have. The hypothesis to test is that "magnet" hospitals such as the University of Vermont Medical Center tend to attract high-paying patients with high-end services, because they have the edge to perform more complex procedures among the Major Diagnostic Categories MDCs. For the purposes of the analysis, patients will be considered high-paying if they are covered by Blue Cross Blue Shield or a Commercial Healthcare Insurance, while patients will be considered low-paying if they are covered by Medicare. The type of inpatient medical care received will be represented by claims for Major Diagnostic Categories (MDCs) for Cardiac and Musculoskeletal care. Although procedures may vary within MDCs, Cardiac care will be considered high-end care, as it often utilizes advanced technologies and specialized staff. Alternatively, Musculoskeletal care will be considered low-end care because such procedures can commonly be carried out in hospitals with basic infrastructure and technology.

In this section, we attempt to examine the patient referral network pattern by care type and payer type in order to see if hospitals with large market power are able to attract more of the well paid

commercial insurance patients and fewer government paid Medicare beneficiaries. Tables 2-5 below present Origin-Destination matrices for all combinations of payers and care: High-end Care and High Payers; Low-end Care and High Payers; High-end Care and Low Payers; and Low-end Care and Low Payers. Similar to Table 1 above, the following tables present hospital admissions by revised region in Vermont. Differing from Table 1, these tables separate service visits by high-paying patients for high-end care, high-paying patients for low-end care, low-paying patients for high-end care, and low-paying patients for low-end care. The green cells highlight patients with the same origin and destination, while the white cells refer to patients with destinations that differ from their origins.

Table 2: O-D Matrix for Hospital Admissions in Vermont for High-end Care/ High Payer

	Burlington	Barre	Newport	Randolph	Rutland	Total Admissions
Burlington	518	3	0	0	1	**522**
Barre	130	88	0	1	0	**219**
Newport	8	2	41	0	0	**51**
Randolph	10	3	0	48	3	**64**
Rutland	61	0	0	4	96	**161**
Out of State	271	3	3	10	19	**306**
Destination Hosp Subtotal:	**999**	**99**	**44**	**63**	**119**	**1324**
Destination Hosp Subtotal:	**75.45%**	**7.48%**	**3.32%**	**4.76%**	**8.99%**	**100.00%**

Table 3: O-D Matrix for Hospital Admissions in Vermont for Low-end Care/ High Payer

	Burlington	Barre	Newport	Randolph	Rutland	Total Admissions
Burlington	674	81	0	1	21	**777**
Barre	61	169	4	19	1	**254**
Newport	9	9	52	2	1	**73**
Randolph	3	4	2	123	25	**157**
Rutland	15	2	0	12	241	**270**
Out of State	322	23	4	53	91	**493**
Destination Hosp Subtotal:	**1084**	**290**	**62**	**210**	**380**	**2026**
Destination Hosp Subtotal:	**53.50%**	**14.31%**	**3.06%**	**10.37%**	**18.76%**	**100.00%**

Table 4: O-D Matrix for Hospital Admissions in Vermont for High-end Care/ Low Payer

	Burlington	Barre	Newport	Randolph	Rutland	Total Admissions
Burlington	1417	5	0	1	5	**1428**
Barre	287	557	6	20	0	**870**
Newport	34	10	301	1	1	**347**
Randolph	26	8	1	387	13	**435**

Rutland	98	0	1	5	647	**751**
Out of State	295	12	6	36	113	**462**
Destination Hosp Subtotal:	**2157**	**592**	**315**	**450**	**779**	**4293**
Destination Hosp Subtotal:	**50.24%**	**13.79%**	**7.34%**	**10.48%**	**18.15%**	**100.00%**

Table 5: O-D Matrix for Hospital Admissions in Vermont for Low-end Care/Low Payer

	Burlington	**Barre**	**Newport**	**Randolph**	**Rutland**	**Total Admissions**
Burlington	1123	105	2	3	26	**1259**
Barre	79	450	9	23	4	**565**
Newport	23	20	247	10	0	**300**
Randolph	10	10	3	420	52	**495**
Rutland	37	2	0	17	671	**727**
Out of State						
Destination Hosp Subtotal:	**1272**	**587**	**261**	**473**	**753**	**3346**
Destination Hosp Subtotal:	**38.02%**	**17.54%**	**7.80%**	**14.14%**	**22.50%**	**100.00%**

Tables 2-5 give an overview of the referral patterns of patients receiving healthcare services in Vermont. The highlighted cell, for the Burlington hospital subtotal, is particularly insightful in analyzing the market power of the "magnet" hospital, the University of Vermont Medical Center. For all patients receiving high-end, cardiac care and covered by high-end, private insurance, 75.45% of all hospital admissions were in Burlington. For high-paying patients in need of low-end, musculoskeletal care, 53.5% were admitted in Burlington. For low-paying patients receiving high-end, cardiac care, 50.24% were admitted in Burlington. Finally, only 38% of low-paying patients receiving low-end care were admitted in Burlington.

Our findings support CNBC's hypothesis that large, "magnet" hospitals such as UVMC aim to increase their revenue by attracting privately insured patients and providing expensive and technologically complex healthcare services. This analysis indicates that high-paying patients in need of high-end care are the most likely to drive long distances and seek cross-border care at advanced hospitals. Even when in need of low-end care, high-paying patients were still shown to seek cross-border care at prestigious hospitals. Similarly, low-paying patients in need of high-end care were incentivized to travel long distances to receive highly specialized healthcare services in Burlington. For low-paying patients seeking low-end care, the market share is more evenly divided, as patients in this category are the least likely to seek prestigious cross-border care, perhaps because UVMC does not market their services to this population. Thus, an Origin-Destination matrix analysis of patients by insurance type and healthcare need type supports the hypothesis that larger, more advanced hospitals strive to strengthen their monopolistic power by attracting well-paying patients, and patients in need of specialized, costly services.

Burlington: Home of the "magnet" hospital

Based on the analysis above, the majority of the patients go to Burlington. Within Burlington, patients can choose between the University of Vermont Medical Center, Northwestern Medical Center, and Porter Medical Center. Table 6 below presents an overview of the Burlington inpatient admission

destination for patients from all five regions in Vermont. The green row highlights patients with both an origin and destination of Burlington, while the five following columns refer to patients from other Vermont regions and out-of-state patients. This table separates service visits by high-paying patients for high-end care, high-paying patients for low-end care, low-paying patients for high-end care, and low-paying patients for low-end care. 99% of patients from Burlington in need of high-end care, regardless of insurance type, remained in Burlington to access services. When in need of low-end care, however, only 87%-89% of Burlington natives remained in Burlington. These findings indicate that the "magnet" hospital University of Vermont Medical Center is likely attracting patients in need of high-end care to their facility. In addition, 59% of high-paying patients in need of high-end care from Barre left to receive care in Burlington, while 89% of high-paying out-of-state patients in need of high-end care went to Burlington as well. This could indicate that higher-paying patients in general are more likely to seek care at "magnet" facilities, but this will be examined in further detail in the following section.

Of the patients receiving care for high-end cardiac services, 99% of the individuals are from Burlington and received care locally, without any need to travel outside of the region. However, of the people who received care in Burlington but were not from the area, 59% were found to be from Barre, 16% from Newport, 16% from Randoph, 38% from Rutland, which equates to an out of state total of 89%. On the other hand, in assessing those receiving care for low-end musculoskeletal concerns, 87% of patients from Burlington also obtained care locally in Burlington, while the remaining traveled to Burlington from a farther destination to seek out essential health services. Among those who traveled to Burlington for medical care, 24% are from Barre, 12% come from Newport, only 2% travel from Randolph, and 6% arrive from Rutland.

Table 6: Market share by hospital admissions in Burlington

Share of Hospital Admissions by Care Type and Payer Type				
Type	**High Care -- High payer**	**Low Care -- High Payer**	**High Care -- Low Payer**	**Low Care -- Low Payer**
Origin	**Destination: Burlington**			
Burlington	99%	87%	99%	89%
Barre	59%	24%	33%	14%
Newport	16%	12%	10%	8%
Randolph	16%	2%	6%	2%
Rutland	38%	6%	13%	5%
Out of State	89%	65%	64%	0%

Given we find that a great percentage of people in other parts of Vermont would seek medical treatments in Burlington, in this section, we further examine the market power of hospitals in the Burlington area depending on different types of care and payer. The three hospitals located in the Burlington region are Northwestern Medical Center, Porter Medical Center, and the University of Vermont Medical Center (UVMC). In the matrices below, we observe that UVMC always captures the largest market share regardless of the care and payer group in 2016. Furthermore, from the low-end care & low-end payer group to the high-end care & high-end payer group, UVMC's market share grows from 77.17% to 91.69% by admission counts, indicating that CNBC's hypothesis might be correct, that the "magnet" hospital tends to attract more patients with commercial insurance coverage seeking more sophisticated care. In this light, it is reasonable to see UVMC gets around 97% of revenue in-high care admission, while the figure is roughly 80% for low-care admission.

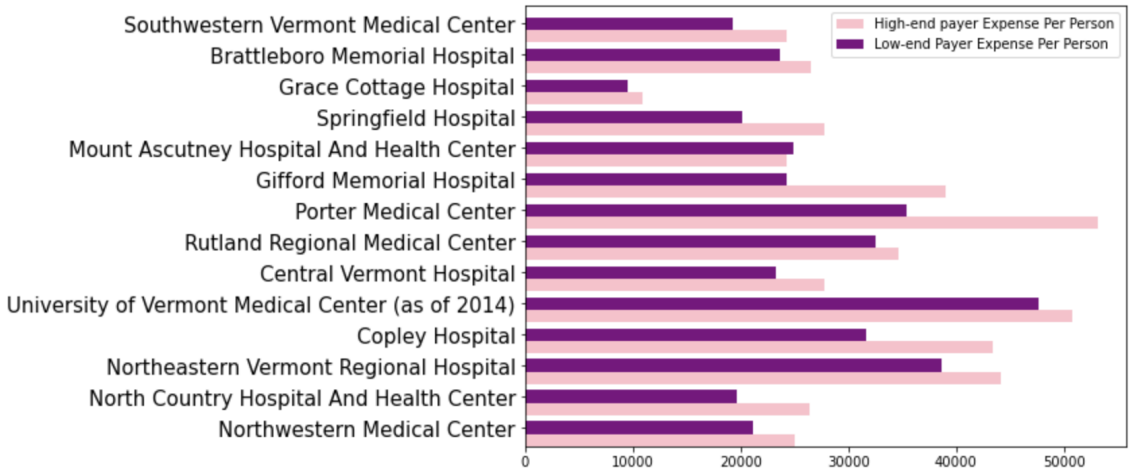
Table 7: Market share by Burlington hospital admissions

Share of Hospital Admissions only in Burlington by Care Type and Payer Type				
	High Care -- High payer	**Low Care -- High Payer**	**High Care -- Low Payer**	**Low Care -- Low Payer**
Northwestern Medical Center	6.91%	6.72%	15.04%	13.35%
Porter Medical Center	1.40%	5.01%	6.37%	9.48%
University of Vermont Medical Center	91.69%	88.27%	78.60%	77.17%

Cost of Care by Payer Type and Care Type

After finding that privately insured patients in need of high-end care are drawn toward Burlington, where the University of Vermont Medical Center is located, this report will shift gears to test the other part of the hypothesis posed by CNBC. To determine whether "magnet" hospitals focus on bringing in high-paying patients with private insurance, this report will consider patients' expenses based on their insurance type. Figure 3 below presents the average per capita expense for high-end and low-end payers at each Vermont hospital. High-end payers are considered those with private insurance, while Medicare beneficiaries are considered low-end payers in this analysis. All costs are averaged for these patients for both high-end and low-end care. Figure 3 shows that patients with private insurance, shown in pink, pay greater average expenses at almost every hospital. This could be due to lower reimbursement rates for services rendered to Medicare beneficiaries, but it could also indicate that patients with private insurance seek more costly services.

Figure 3: Average Per Capita Expenses for Inpatient Stays at Vermont Hospitals, by Insurance Type



Our analyses from previous sections have alluded to the finding that high-end patients with private insurance coverage may be attracted toward "magnet" hospitals with higher costs. The findings presented in Table 6, regarding inpatient hospital admissions in Burlington, concluded that 59% of high-paying patients in need of high-end care from Barre left to receive care in Burlington, while 89% of high-paying out-of-state patients in need of high-end care went to Burlington as well. This indicates that in some cases, a majority of patients from outside of Burlington went out of their way to receive care in the region where the "magnet" hospital is located. Table 8 elaborates on this by showing that within Burlington, the University of Vermont Medical Center has anywhere from 79.82% to 97.99% of the market share of charge, depending on the type of care and the type of payer.

Interestingly, Porter Medical Center appears to attract substantially more patients seeking low-end care than high-end care. As shown in the table below, only 0.52%-1.74% of patients receiving high care in Burlington go to Porter Medical Center, while the hospital attracts anywhere from 8.18%-11.25% of patients seeking low-end care, depending on the patients' insurance type. Northwestern Medical Center shows a similar trend, as it appears to attract more patients in need of low-end care. These findings support our earlier assertion that patients needing high-end care are drawn toward the "magnet" hospital of UVMC.

Table 8: Market share by Burlington hospital charges

Share of Hospital Charge by Care Type and Payer Type				
	High Care -- High payer	**Low Care -- High Payer**	**High Care -- Low Payer**	**Low Care -- Low Payer**
Northwestern Medical Center	1.49%	10.01%	1.66%	8.93%
Porter Medical Center	0.52%	8.18%	1.74%	11.25%
University of Vermont Medical Center	97.99%	81.81%	96.60%	79.82%

Bonus Activity: DRG Analysis

To expand on the analysis for high-end care and low-end care, this section will complete a deeper analysis by focusing on specific Diagnosis-Related Groups (DRGs) within the selected Major Diagnostic Categories (MDCs) of cardiovascular care (high-end) and musculoskeletal care (low-end). Within each MDG, the specific DRGs can vary substantially based on the type of procedure, the admission count, and the costs associated with them. The specific DRGs chosen for this analysis are representative of the major inpatient DRGs in Burlington, as a substantial portion of our report has focused on this region. The analysis of the DRGs separates the total inpatient admission in Vermont's five biggest hospitals in terms of market share. This analysis of DRGs additionally focuses on different care and payer combinations. This section aims to investigate our hypothesis further to see the leading DRGs within the monopolistic hospitals systems. Our analysis determines that the University of Vermont Medical Center provided the largest total number of admissions for the selected DRGs, followed by Rutland Regional Medical Center.

Table 9: Hospital Admissions for DRGs in Vermont for High Care/ High Payer

DRG	Northwestern Medical Center	Porter Medical Center	University of Vermont Medical Center	Rutland Regional Medical Center	Southwestern Vermont Medical Center	Total Admissions
247	0	0	181	0	0	**181**
310	3	2	54	14	8	**81**
291	15	0	29	2	8	**54**
309	6	1	30	9	3	**49**
287	0	0	48	0	0	**48**
246	0	0	44	0	0	**44**
308	7	1	17	5	8	**38**
220	0	0	33	0	0	**33**
282	7	1	15	8	1	**32**
292	5	3	19	4	1	**32**
Destination DRG Subtotal:	**43**	**8**	**470**	**42**	**29**	**592**

Table 9 displays inpatient admissions by DRG for the five biggest hospitals in Vermont for patients with high-paying insurance who are in need of high-end care. DRG 247, *Percutaneous Cardiovasc procedure with drug-eluting stent without major complications or comorbidities*, is classified within the Heart & Circulatory MDC. Table 9 shows that all 181 patients admitted for DRG 247 sought care at the University of Vermont Medical Center. This high-end procedure was concentrated entirely at Vermont's "magnet" hospital, supporting the hypothesis that larger hospitals focus on raising their revenue by providing expensive and highly specialized procedures.

Table 10: Hospital Admissions for DRGs in Vermont for Low Care/ High Payer

DRG	Northwestern Medical Center	Porter Medical Center	University of Vermont Medical Center	Rutland Regional Medical Center	Southwestern Vermont Medical Center	Total Admissions
470	64	57	246	151	18	**536**
460	38	0	86	5	6	**135**
494	2	3	21	22	14	**62**
462	1	3	23	22	0	**49**
552	6	0	31	6	3	**46**
481	8	0	23	7	6	**44**
473	3	0	34	3	3	**43**
560	0	0	40	1	0	**41**
561	0	0	38	0	0	**38**
482	6	0	18	6	4	**34**
Destination DRG Subtotal:	**128**	**63**	**560**	**223**	**54**	**1028**

Table 10 displays inpatient admissions by DRG for the five biggest hospitals in Vermont for patients with high-paying insurance who are in need of low-end care. DRG 470, *major joint replacement of reattachment of lower extremity without major complications or comorbidities*, is classified within the Musculoskeletal MDC. Table 10 shows that DRG 470 has the highest number of admissions for high-end payers covered by commercial insurance. The majority of high-paying patients in need of joint replacements (246) went to UVMC, followed by Rutland Regional Medical Center (151), Northwestern Medical Center (64), Porter Medical Center (57), and Southwestern Vermont Medical Center (18). This finding supports our hypothesis by highlighting UVMC's rapport for providing care to high-end payers.

Table 11: Hospital Admissions for DRGs in Vermont for High Care/ Low Payer

DRG	Northwestern Medical Center	Porter Medical Center	University of Vermont Medical Center	Rutland Regional Medical Center	Southwestern Vermont Medical Center	Total Admissions
291	45	20	136	76	61	**338**
292	12	25	125	48	45	**255**
247	0	0	199	0	0	**199**
309	10	10	81	64	27	**192**

310	3	12	61	52	19	**147**
280	21	6	74	20	18	**139**
246	0	0	108	0	0	**108**
308	6	2	41	35	23	**107**
281	16	1	55	23	6	**101**
312	6	10	37	34	13	**100**
Destination DRG Subtotal:	**119**	**86**	**917**	**352**	**212**	**1686**

Table 11 displays inpatient admissions by DRG for the five biggest hospitals in Vermont for patients with low-paying insurance who are in need of high-end care. DRG 291, *heart failure and shock with major complications or comorbidities*, is classified within the Heart & Circulatory MDC. Table 11 shows that DRG 291 has the highest numbers of low-paying patients covered by Medicare. Among these 338 patients: 136 were admitted to the UVMC, 76 were admitted to Rutland Regional Medical Center, 61 were admitted to Southwestern Vermont Medical Center, 45 were admitted to Northwestern Medical Center, and 20 were admitted to Porter Medical Center. Although this table represents low-paying patients, this high-end procedure was concentrated heavily at Vermont's "magnet" hospital, supporting the hypothesis that larger hospitals focus on raising their revenue by providing highly specialized procedures.

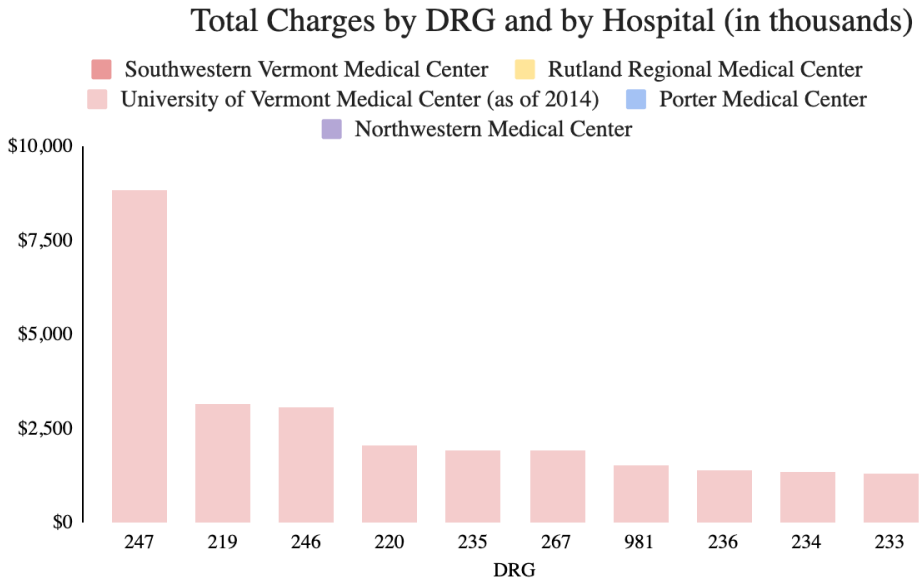
Table 12: Hospital Admissions for DRGs in Vermont for Low Care/ Low Payer

DRG	Northwestern Medical Center	Porter Medical Center	University of Vermont Medical Center	Rutland Regional Medical Center	Southwestern Vermont Medical Center	Total Admissions
470	55	68	301	346	36	**806**
481	7	10	72	36	18	**143**
460	27	0	80	15	8	**130**
552	21	9	63	17	11	**121**
483	10	9	46	15	0	**80**
560	1	0	73	5	0	**79**
563	6	8	30	10	10	**64**
536	5	3	29	10	11	**58**
480	2	4	22	18	7	**53**
482	10	6	21	7	6	**50**
Destination DRG Subtotal:	**144**	**117**	**737**	**479**	**107**	**1584**

Table 12 displays inpatient admissions by DRG for the five biggest hospitals in Vermont for patients with low-paying insurance who are in need of low-end care. DRG 470, *major joint replacement of reattachment of lower extremity without major complications or comorbidities*, is classified within the Musculoskeletal MDC. Table 12 shows that DRG 470 has the highest number of admissions for low-end payers covered by Medicare. For the first time, the majority of admissions was not for UVMC, but rather for Rutland Regional Medical Center (346). In contrast to the same DRG for high-paying patients, low-paying patients were more likely to receive low-end care at a hospital other than the "magnet" hospital in Vermont. This finding indicates that UVMC may not be marketing its low-end services to

low-end patients, such as those in Table 12 who were admitted for DRG 470. Instead, UVMC is focusing on increasing its revenue by increasing the number of high-paying patients in need of the same service.

Figure 5: Total Charges by DRG and by Hospital (in thousands) in ***High Care and High-Payer*** *Group*



As shown in Figure 5 above, of the five hospitals used in this study, the University of Vermont Medical Center is the only one to have catered to the high care and high-payer group; the remaining hospitals appear to be less preferable for this group. In fact, all 181 patients associated with the DRG that is categorized as the percutaneous cardiovascular procedures with the drug-eluting stent, were admitted at the University of Vermont Medical Center for their procedures. The patients admitted for this same procedure also had the highest cost associated with their care, in relation to the other DRGs listed. Next, the patients with the DRG category related to any procedures for cardiac valve, or other major cardiothoracic concerns, were found to be associated with the second highest cost of the other DRGs at this main hospital in Vermont. Thus, as the hospital seeks to increase its revenue, it works to attract a large number of high-paying patients requiring the same high-end service/procedure.

*Figure 6: Total Charges by DRG and by Hospital (in thousands) in **Low Care and High-Payer** Group*

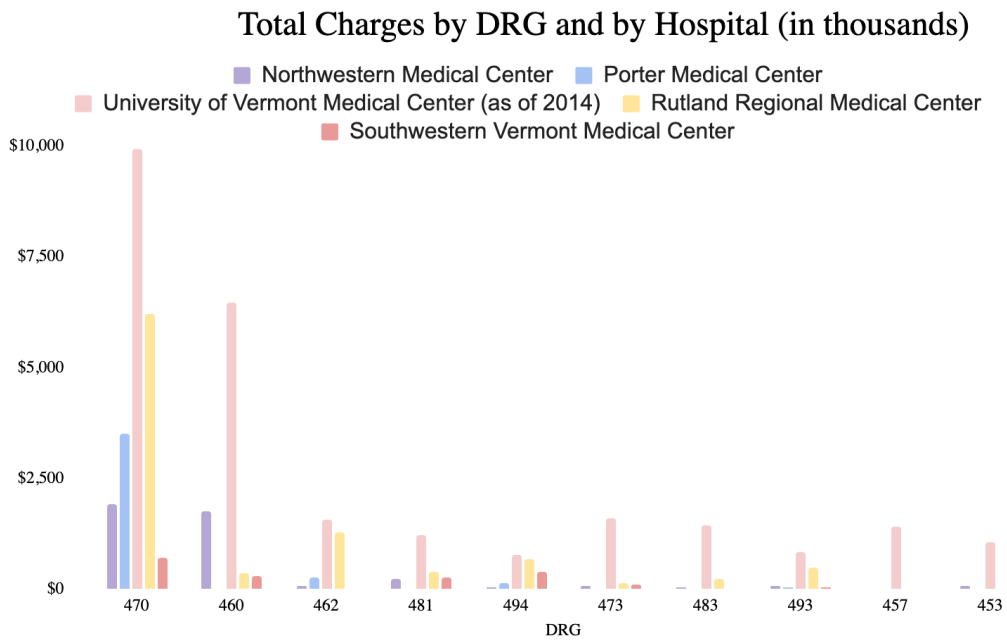


Figure 6 presents the total charges across a variety of DRGs by hospital for low-end care and high-end payers, wherein the highest percentage of costs are concentrated at the University of Vermont Medical Center for the DRG signifying major hip and knee joint replacement or reattachment of the lower extremity procedure. Similarly, this pattern continues as the greatest hospital admission costs occur through the University of Vermont Medical Center, relative to the rest of the hospitals. These data trends further support our hypothesis claiming that the UVMC largely provides care to the high-end payer groups who typically have private insurance coverage.

*Figure 7: Total Charges by DRG and by Hospital (in thousands) in **High Care and Low-Payer** Group*

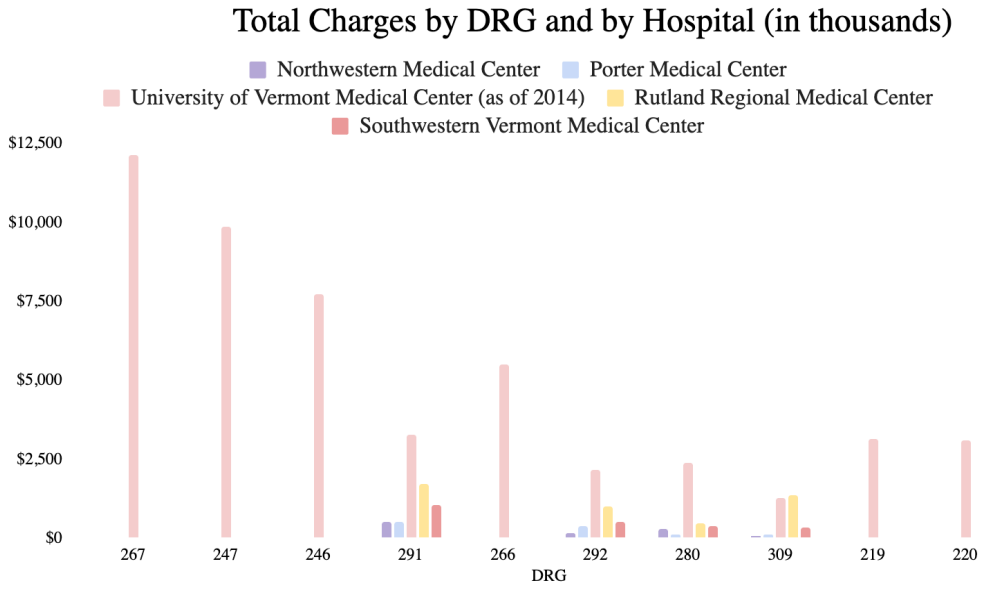
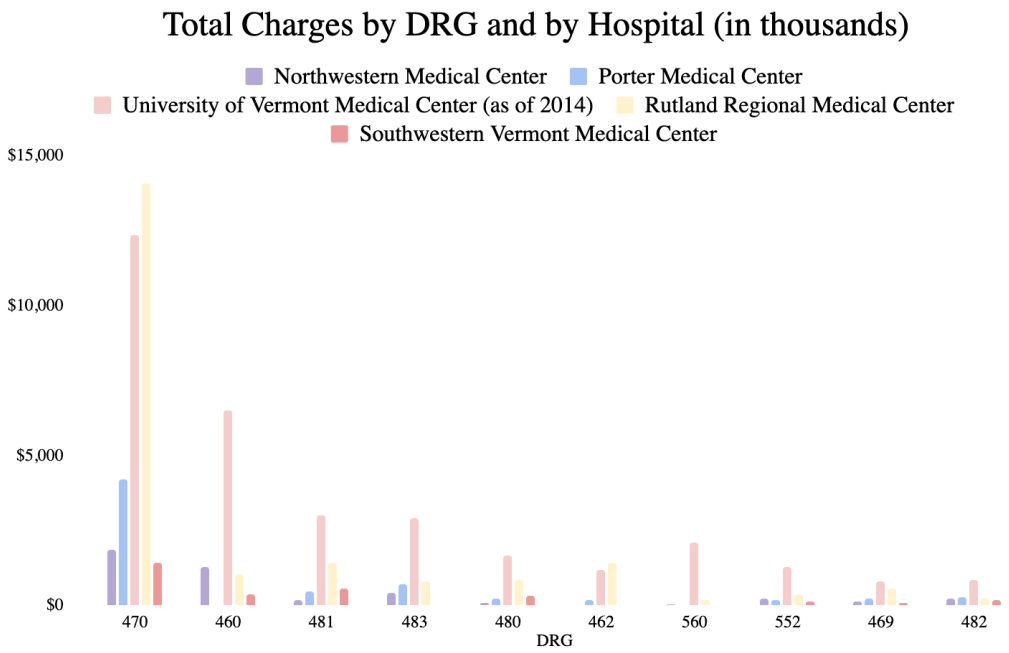


Figure 7 represents the total charges by DRG across the different hospitals where the patients require high-end care, yet are low-end payers, and do not possess private insurance coverage. The DRG 267, denoted as endovascular cardiac valve replacement, appears to have the highest cost of all the DRG's. In fact, patients were not admitted to other hospitals with several of the other DRGs, as many chose to perform their high-end care service at the UVMC. While these services may be more expensive at a magnet hospital like UVMC, their specialized tools procedures allow the hospital to produce high quality delivery services to patients.

*Figure 8: Total Charges by DRG and by Hospital (in thousands) in **Low Care and Low-Payer** Group*



As exhibited in Figure 8, the highest admissions cost for the given DRG's in the low-care and low-payer group shifts to the Rutland Regional Medical Center. This finding is not surprising as this hospital, which is the largest community hospital in the state of Vermont, provided the highest admissions following the University of Vermont Medical Center. It is suggestive that a major community hospital like RRMC attracts low-end care, and particularly, low-payer groups mainly for the DRG 470, which represents a major hip and knee joint replacement or reattachment of the lower extremity. This aligns with the theory that hospitals continue to grow by increasing prices on select procedures, which not only occurs with large private hospitals, but it is clear community hospitals have found a way in on the act. Additionally, community hospitals like RRMC are more inclined to accept low-payer groups' insurance.

Conclusion

With an increasing trend of consolidation and dominance in the market for hospitals in the United States, patients and insurance companies are being charged substantial amounts that would have otherwise been on average 15% cheaper in hospitals not facing major competition. However, unfortunately, there is only a small number of hospitals remaining in a given geographical region that do not possess strong influence over the high cost of care. As demonstrated in the CNBC report, beginning in the 1980's, rising healthcare costs prompted several hospitals to team up to survive. The result of mergers and acquisitions in the hospital industry has both increased prices steeply, and driven several rural hospitals out of business.

Our data reaffirms the hypothesis stating that "magnet" hospitals like the University of Vermont Medical Center tend to attract high-paying patients, typically with commercial insurance coverage, to

further increase their revenue, and remain in power. Patient referral patterns prove that high-paying patients requiring high-end care are most likely to drive long distances to seek care at more advanced hospitals, who have the resources to utilize advanced and complex technology. Similarly, even high-payers needing low-end care are willing to travel across the border to prestigious hospitals, with the highest admission rates seen at the UVMC. On the other hand, our analysis exploring low-paying patients behavior reveals that the greater unwillingness to travel for cross-border care may be indicative of prestigious hospitals choosing to not market their services to this particular population. Additionally, trends with DRG's show that the UVMC provided the largest total number of admissions for selected DRG's, reinforcing our argument that large monopoly hospitals aim to increase their profits by offering and advertising high price, specialized services/procedures, like cardiac care, to well insured patients. Overall, the UVMC maintained its position in securing the largest market share of all the hospitals, proving the old adage that the bigger you are, the more power you have.

Works Cited

CNBC. (2020, February 6). *Why U.S. hospitals are closing*. https://www.youtube.com/watch?v=18kxPz4Z_g8

Cooper, Z., Craig, S., Gaynor, M., & Van Reenen, J. (2015, May). *The price ain't right? Hospital prices and health spending on the privately insured*. Health Care Pricing Project. https://healthcarepricingproject.org/papers/paper-1

Cubit Planning, Inc. (2020). *Vermont Cities by Population*. https://www.vermont-demographics.com/cities_by_population

Harvard School of Public Health. (2015, December 22). *Where there's a hospital monopoly, private health care costs more*. News. https://www.hsph.harvard.edu/news/hsph-in-the-news/where-theres-a-hospital-monopoly-private-health-care-costs-more/

Novak, J. (2020, January 21). *OpEd: Hospital monopolies are making us poorer and sicker*. CNBC. https://www.cnbc.com/2020/01/21/hospital-monopolies-are-making-us-poorer-and-sicker.html

Relevant Coding
Part1

```
import pandas as pd
import numpy as np

df_in= pd.read_csv("VTINP16_upd.txt")
df_in = df_in.apply(pd.to_numeric,errors='coerce')
df_in["CHRGS"] = pd.to_numeric(df_in["CHRGS"])
df = df_in.copy()

df_in_4insurance = df[df['PPAY'].isin([1,6,7])]
df_in_4insurance['PPAY'].replace({1:'MEDICARE',6: 'Commercial Payers',7: 'Commercial Payers'},
          inplace=True)
df_in_4insurance = df_in_4insurance[df_in_4insurance['MDC'].isin([5,8])]

df_in_4insurance_new = df_in_4insurance[['hnum2','intage','sex','CHRGS','PPAY','MDC','DRG','hsa']]
hospitalname= pd.read_excel("CaseStudy_O-D_HospMonopoly.xlsx",sheet_name='Hosp_Destination')
hospitalname.columns = ['hnum2','HospitalName Des','RR Des','RR Name Des']

hsaname = pd.read_excel("CaseStudy_O-D_HospMonopoly.xlsx",sheet_name='HSA_Pt_Origin')
hsaname.columns = ['hsa','HSA Name Org','RR Collapsed Referral Region Org','Name Org','RR Name Org']
df_with_des = pd.merge(df_in_4insurance_new ,hospitalname ,how='left',on=['hnum2'])
df_with_des_org = pd.merge(df_with_des ,hsaname ,how='left',on=['hsa'])
#df_with_des_org = pd.merge(df_in_4insurance_new ,hsaname ,how='left',on=['hsa'])

#df_with_des_org = df[df['PPAY'].isin([1,6,7])]

df_with_des_org['Care_Type'] = np.ones(len(df_with_des_org))
for i in range(len(df_with_des_org)):
   if  df_with_des_org['MDC'].iloc[i]== 5:
      df_with_des_org['Care_Type'].iloc[i] = 'High-end care'
   elif df_with_des_org['MDC'].iloc[i]== 8:
      df_with_des_org['Care_Type'].iloc[i] = 'Low-end care'
   else:  df_with_des_org['Care_Type'].iloc[i] = 'Other care'

df_with_des_org['Payer_Type'] = np.ones(len(df_with_des_org))
for i in range(len(df_with_des_org)):
   if  df_with_des_org['PPAY'].iloc[i]== 'MEDICARE':
      df_with_des_org['Payer_Type'].iloc[i] = 'Low-end Payer'
   elif df_with_des_org['PPAY'].iloc[i]== 'Commercial Payers':
       df_with_des_org['Payer_Type'].iloc[i] = 'High-end Payers'
   #else:  df_with_des_org['Payer_Type'].iloc[i] = 'Other Payers'

#%%
df_with_des_org["CHRGS"]= df_with_des_org["CHRGS"].fillna(0)

Hos_payer_sum = df_with_des_org.groupby([ 'hnum2','RR Name Des','HospitalName
          Des','Payer_Type'])["CHRGS"].apply(lambda x : x.astype(int).sum()) \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)
Hos_payer_sum.columns=['hnum2', 'RR Name Des', 'HospitalName Des','High-end Payer Total
          Expense','Low-end Payer Total Expense']
```

```
Hos_payer_count = df_with_des_org.groupby([ 'hnum2','Payer_Type'])["hnum2"].apply(lambda x :
        x.astype(int).count()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
Hos_payer_count.columns=['hnum2', 'High-end Payers Total Patients', 'Low-end Payer Total Patients']


Hos_payer_mean = df_with_des_org.groupby([ 'hnum2','RR Name Des','HospitalName
        Des','Payer_Type'])["CHRGS"].apply(lambda x : x.astype(int).mean()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
Hos_payer_mean.columns=['hnum2', 'RR Name Des', 'HospitalName Des','High-end payer Expense Per
        Person','Low-end Payer Expense Per Person']


Hos_payer_table = pd.merge(Hos_payer_sum,Hos_payer_count,how='left',on=['hnum2'])
Hos_payer_table = pd.merge(Hos_payer_table,Hos_payer_mean,how='left',on=['hnum2','RR Name
        Des','HospitalName Des'])
Hos_payer_table = Hos_payer_table.iloc[:,1:]

df = Hos_payer_table[["HospitalName Des","High-end payer Expense Per Person","Low-end Payer Expense
        Per Person"]]
print(df)

#%%
Hos_payer_table_order = Hos_payer_table.sort_values('High-end Payer Total Expense', ascending = False)
Hos_payer_table_order5 =Hos_payer_table_order.iloc[:10,:]

import matplotlib.pyplot as plt
import matplotlib
import squarify
sizes = list(Hos_payer_table_order5['High-end Payer Total Expense'])
label = list(Hos_payer_table_order5.iloc[:,1])
value = list(Hos_payer_table_order5['High-end Payers Total Patients'])

norm = matplotlib.colors.Normalize(vmin=min(Hos_payer_table_order5['High-end Payer Total Expense']),
        vmax=max(Hos_payer_table_order5['High-end Payer Total Expense']))
colors = [matplotlib.cm.Blues(value) for value in value]

fig = plt.gcf()
fig.set_size_inches(10, 8)

squarify.plot(label=Hos_payer_table_order5.iloc[:,1],sizes=Hos_payer_table_order5['High-end Payer Total
        Expense'], color = colors, alpha=.6
        ,text_kwargs={'fontsize':7})
plt.title("High-end Payer Total Expense and Admission",fontsize=23,fontweight="bold")

plt.axis('off')
plt.show()
```

```
#%%
ind = np.arange(len(df))
width = 0.4
import matplotlib.pyplot as plt
fig, ax = plt.subplots(figsize=(8, 6))
ax.barh(ind, Hos_payer_table['High-end payer Expense Per Person'], width, color='pink', label='High-end
        payer Expense Per Person')
ax.barh(ind + width, Hos_payer_table['Low-end Payer Expense Per Person'], width, color='purple',
        label='Low-end Payer Expense Per Person')

ax.set(yticks=ind + width, yticklabels=Hos_payer_table['HospitalName Des'], ylim=[2*width - 1, len(df)])
ax.legend()
plt.yticks(size = 15)
plt.show()
#%%

Hos_care_sum = df_with_des_org.groupby([ 'hnum2','RR Name Des','HospitalName
        Des','Care_Type'])["CHRGS"].apply(lambda x : x.astype(int).sum()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
Hos_care_sum.columns=['hnum2', 'RR Name Des', 'HospitalName Des','High-end Care Total
        Expense','Low-end Care Total Expense']

Hos_care_count = df_with_des_org.groupby([ 'hnum2','Care_Type'])["hnum2"].apply(lambda x :
        x.astype(int).count()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
Hos_care_count.columns=['hnum2', 'High-end Care Total Patients', 'Low-end Care Total Patients']


Hos_care_mean = df_with_des_org.groupby([ 'hnum2','RR Name Des','HospitalName
        Des','Care_Type'])["CHRGS"].apply(lambda x : x.astype(int).mean()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
Hos_care_mean.columns=['hnum2', 'RR Name Des', 'HospitalName Des','High-end Care Expense Per
        Person','Low-end Care Expense Per Person']

Hos_care_table = pd.merge(Hos_care_sum,Hos_care_count,how='left',on=['hnum2'])
Hos_care_table = pd.merge(Hos_care_table,Hos_care_mean,how='left',on=['hnum2','RR Name
        Des','HospitalName Des'])
#Hos_care_table = Hos_care_table.iloc[:,1:]


ind = np.arange(len(df))
width = 0.4

fig, ax = plt.subplots(figsize=(8, 6))
ax.barh(ind, Hos_care_table['High-end Care Expense Per Person'], width, color='pink', label='High-end Care
        Expense Per Person')
ax.barh(ind + width, Hos_care_table['Low-end Care Expense Per Person'], width, color='purple',
```

```
        label='Low-end Care Expense Per Person')

ax.set(yticks=ind + width, yticklabels=Hos_care_table['HospitalName Des'], ylim=[2*width - 1, len(df)])
ax.legend()
plt.yticks(size = 15)
plt.show()
```

Part 2

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

df_with_des_org["CHRGS"]= df_with_des_org["CHRGS"].fillna(0)

#%%
def piechart_chrgs(df,regionname):
    table = df[df['RR Des'].isin([regionname])]
    bd = table.groupby(['RR Name Org','HospitalName Des'])["CHRGS"].apply(lambda x : x.astype(int).sum())
            \
                .unstack(fill_value=0) \
                .reset_index() \
                .rename_axis(None, axis=1)
    sumRow = bd.sum(axis = 1)
    bd['Total Charges'] = sumRow
    sumCol = bd.sum(axis = 0)
    bd = bd.set_index(bd['RR Name Org'])
    bd = bd.iloc[:,1:]
    bd.loc['Destination Hosp SubTotal:'] = sumCol

    perc_bd = bd.iloc[-1,0:len(bd.columns)-1]/sumCol[-1]
    fig, ax = plt.subplots(figsize=(5, 5))

    theme = plt.get_cmap('bwr')
    ax.set_prop_cycle("color", [theme(1. * i / len(perc_bd))
                        for i in range(len(perc_bd))])
    ax.pie(perc_bd, labels=perc_bd.index, autopct='%1.2f%%', pctdistance=0.6, explode=(0,0.2,0.2),
       shadow=True, startangle=90)
    ax.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.
    plt.show()
    return bd


#table 1
low_low = df_with_des_org[(df_with_des_org['Care_Type'] == 'Low-end care') &
            df_with_des_org['Payer_Type'].isin(['Low-end Payer'])]
ctable1 = low_low.groupby(['RR Name Org','RR Name Des'])["CHRGS"].apply(lambda x :
            x.astype(int).sum()) \
                .unstack(fill_value=0) \
                .reset_index() \
                .rename_axis(None, axis=1)
sumRow = ctable1.sum(axis = 1)
ctable1['Total Charges'] = sumRow
sumCol = ctable1.sum(axis = 0)
```

```
ctable1 = ctable1.set_index(ctable1['RR Name Org'])
ctable1 = ctable1.iloc[:,1:]
ctable1.loc['Destination Hosp SubTotal:'] = sumCol

c_bd1 = piechart_chrgs(low_low,'RR1')
print(c_bd1)

#table 2
low_high = df_with_des_org[(df_with_des_org['Care_Type'] == 'Low-end care') &
        df_with_des_org['Payer_Type'].isin(['High-end Payers'])]
ctable2 = low_high.groupby([ 'RR Name Org','RR Name Des'])["CHRGS"].apply(lambda x :
        x.astype(int).sum()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
sumRow = ctable2.sum(axis = 1)
ctable2['Total Charges'] = sumRow
sumCol = ctable2.sum(axis = 0)
ctable2 = ctable2.set_index(ctable2['RR Name Org'])
ctable2 = ctable2.iloc[:,1:]
ctable2.loc['Destination Hosp SubTotal:'] = sumCol

c_bd2 = piechart_chrgs(low_high,'RR1')
print(c_bd2)

#table 3
high_low = df_with_des_org[(df_with_des_org['Care_Type'] == 'High-end care') &
        df_with_des_org['Payer_Type'].isin(['Low-end Payer'])]
ctable3 = high_low.groupby([ 'RR Name Org','RR Name Des'])["CHRGS"].apply(lambda x :
        x.astype(int).sum()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
sumRow = ctable3.sum(axis = 1)
ctable3['Total Charges'] = sumRow
sumCol = ctable3.sum(axis = 0)
ctable3 = ctable3.set_index(ctable3['RR Name Org'])
ctable3 = ctable3.iloc[:,1:]
ctable3.loc['Destination Hosp SubTotal:'] = sumCol

c_bd3 = piechart_chrgs(high_low,'RR1')
print(c_bd3)

#table 4
high_high = df_with_des_org[(df_with_des_org['Care_Type'] == 'High-end care') &
        df_with_des_org['Payer_Type'].isin(['High-end Payers'])]
ctable4 = high_high.groupby([ 'RR Name Org','RR Name Des'])["CHRGS"].apply(lambda x :
        x.astype(int).sum()) \
            .unstack(fill_value=0) \
            .reset_index() \
            .rename_axis(None, axis=1)
sumRow = ctable4.sum(axis = 1)
ctable4['Total Charges'] = sumRow
```

```
sumCol = ctable4.sum(axis = 0)
ctable4 = ctable4.set_index(ctable4['RR Name Org'])
ctable4 = ctable4.iloc[:,1:]
ctable4.loc['Destination Hosp SubTotal:'] = sumCol

c_bd4 = piechart_chrgs(high_high,'RR1')
print(c_bd4)


#%% Optional DRG

def piechart_DRG_chrgs(df,regionname):
    table = df[df['RR Des'].isin([regionname])]
    bd = table.groupby(['RR Name Org', 'DRG'])["CHRGS"].apply(lambda x : x.astype(int).sum()) \
                .unstack(fill_value=0) \
                .reset_index() \
                .rename_axis(None, axis=1)
    sumRow = bd.sum(axis = 1)
    bd['Total Charges'] = sumRow
    sumCol = bd.sum(axis = 0)
    bd = bd.set_index(bd['RR Name Org'])
    bd = bd.iloc[:,1:]
    #bd = table.sort_values(by= 'CHRGS', ascending = False).head(10)
    bd.loc['Destination Hosp SubTotal:'] = sumCol

    perc_bd = bd.iloc[-1,0:len(bd.columns)-1]/sumCol[-1]
    fig, ax = plt.subplots(figsize=(5, 5))

    theme = plt.get_cmap('bwr')
    ax.set_prop_cycle("color", [theme(1. * i / len(perc_bd))
                        for i in range(len(perc_bd))])
    ax.pie(perc_bd, labels=perc_bd.index, autopct='%1.1f%%',
       shadow=True, startangle=90)
    ax.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.
    plt.show()
    return bd


#table 1 #HospitalName Des
#By Areas
low_low1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'Low-end care') &
            df_with_des_org['Payer_Type'].isin(['Low-end Payer'])]
ctable_drg1 = low_low1.groupby(['DRG','RR Name Des'])["CHRGS"].apply(lambda x : x.astype(int).sum()) \
                .unstack(fill_value=0) \
                .reset_index() \
                .rename_axis(None, axis=1)

sumRow = ctable_drg1.sum(axis = 1)
ctable_drg1['Total Charges'] = sumRow
ctable_drg1 = ctable_drg1.set_index(ctable_drg1['DRG'])
ctable_drg1 = ctable_drg1.iloc[:,1:]
ctable_drg1  = ctable_drg1.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg1  = ctable_drg1.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
```

```
sumCol = ctable1.sum(axis = 0)
ctable_drg1.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg1)

#c_bd5 = piechart_DRG_chrgs(low_low,'RR1')
#print(c_bd5)


#By Hopsital
low_low1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'Low-end care') &
          df_with_des_org['Payer_Type'].isin(['Low-end Payer'])]
ctable_drg1 = low_low1.groupby(['DRG','HospitalName Des'])["CHRGS"].apply(lambda x :
          x.astype(int).sum()) \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)

ctable_drg1 = pd.DataFrame(ctable_drg1, columns=['DRG', 'Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])


sumRow = ctable_drg1.sum(axis = 1)
ctable_drg1['Total Charges'] = sumRow
ctable_drg1 = ctable_drg1.set_index(ctable_drg1['DRG'])
ctable_drg1 = ctable_drg1.iloc[:,1:]
ctable_drg1  = ctable_drg1.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg1  = ctable_drg1.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
#ctable_drg1 = ctable_drg1.sort_values(by = [470.0, 460.0], axis = 1, ascending = False).head(10)
sumCol = ctable_drg1.sum(axis = 0)
ctable_drg1.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg1)

#c_bd5 = piechart_DRG_chrgs(low_low,'RR1')
#print(c_bd5)


#%%table 2
#By Areas
low_high1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'Low-end care') &
          df_with_des_org['Payer_Type'].isin(['High-end Payers'])]
ctable_drg2 = low_high1.groupby(['DRG','RR Name Des'])["CHRGS"].apply(lambda x : x.astype(int).sum()) \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)

sumRow = ctable_drg2.sum(axis = 1)
ctable_drg2['Total Charges'] = sumRow
ctable_drg2 = ctable_drg2.set_index(ctable_drg2['DRG'])
ctable_drg2 = ctable_drg2.iloc[:,1:]
ctable_drg2 = ctable_drg2.sort_values(by= 'Total Charges', ascending = False).head(10)
##ctable_drg2  = ctable_drg2.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
#ctable_drg2 = ctable_drg2.sort_values(by = [470.0, 460.0], axis = 1, ascending = False).head(10)
```

```
sumCol = ctable_drg2.sum(axis = 0)
ctable_drg2.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg2)

#c_bd6 = piechart_DRG_chrgs(low_high1,'RR1')
#print(c_bd6)


#By Hopsital
low_high1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'Low-end care') &
          df_with_des_org['Payer_Type'].isin(['High-end Payers'])]
ctable_drg2 = low_high1.groupby(['DRG','HospitalName Des'])["CHRGS"].apply(lambda x :
          x.astype(int).sum()) \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)

ctable_drg2 = pd.DataFrame(ctable_drg2, columns=['DRG', 'Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])


sumRow = ctable_drg2.sum(axis = 1)
ctable_drg2['Total Charges'] = sumRow
ctable_drg2 = ctable_drg2.set_index(ctable_drg2['DRG'])
ctable_drg2 = ctable_drg2.iloc[:,1:]
ctable_drg2 = ctable_drg2.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg2  = ctable_drg2.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
#ctable_drg2 = ctable_drg2.sort_values(by = [470.0, 460.0], axis = 1, ascending = False).head(10)
sumCol = ctable_drg2.sum(axis = 0)
ctable_drg2.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg2)

#c_bd6 = piechart_DRG_chrgs(low_high1,'RR1')
#print(c_bd6)


#%%table 3
#By Areas
high_low1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'High-end care') &
          df_with_des_org['Payer_Type'].isin(['Low-end Payer'])]
ctable_drg3 = high_low1.groupby(['DRG','RR Name Des'])["CHRGS"].apply(lambda x : x.astype(int).sum()) \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)

sumRow = ctable_drg3.sum(axis = 1)
ctable_drg3['Total Charges'] = sumRow
ctable_drg3 = ctable_drg3.set_index(ctable_drg3['DRG'])
ctable_drg3 = ctable_drg3.iloc[:,1:]
ctable_drg3 = ctable_drg3.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg3  = ctable_drg3.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
sumCol = ctable_drg3.sum(axis = 0)
```

```
ctable_drg3.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg3)

c_bd7 = piechart_DRG_chrgs(high_low1,'RR1')
print(c_bd7)

#By Hopsital
high_low1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'High-end care') &
          df_with_des_org['Payer_Type'].isin(['Low-end Payer'])]
ctable_drg3 = high_low1.groupby(['DRG','HospitalName Des'])["CHRGS"].apply(lambda x :
          x.astype(int).sum()) \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)

ctable_drg3 = pd.DataFrame(ctable_drg3, columns=['DRG', 'Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])

sumRow = ctable_drg3.sum(axis = 1)
ctable_drg3['Total Charges'] = sumRow
ctable_drg3 = ctable_drg3.set_index(ctable_drg3['DRG'])
ctable_drg3 = ctable_drg3.iloc[:,1:]
ctable_drg3 = ctable_drg3.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg3  = ctable_drg3.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
#ctable_drg3 = ctable_drg3.sort_values(by = [470.0, 460.0], axis = 1, ascending = False).head(10)
sumCol = ctable_drg3.sum(axis = 0)
ctable_drg3.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg3)

#c_bd7 = piechart_DRG_chrgs(high_low1,'RR1')
#print(c_bd7)


#%%table 4
#By Areas
high_high1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'High-end care') &
          df_with_des_org['Payer_Type'].isin(['High-end Payers'])]
ctable_drg4 = high_high1.groupby(['DRG','RR Name Des'])["CHRGS"].apply(lambda x : x.astype(int).sum())
          \
              .unstack(fill_value=0) \
              .reset_index() \
              .rename_axis(None, axis=1)
sumRow = ctable_drg4.sum(axis = 1)
ctable_drg4['Total Charges'] = sumRow
ctable_drg4 = ctable_drg4.set_index(ctable_drg4['DRG'])
ctable_drg4 = ctable_drg4.iloc[:,1:]
ctable_drg4 = ctable_drg4.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg4  = ctable_drg4.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
sumCol = ctable_drg4.sum(axis = 0)
ctable_drg4.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg4)
```

```
#c_bd8 = piechart_DRG_chrgs(high_high1,'RR1')
#print(c_bd8)


#By Hopsital
high_high1 = df_with_des_org[(df_with_des_org['Care_Type'] == 'High-end care') &
          df_with_des_org['Payer_Type'].isin(['High-end Payers'])]
ctable_drg4 = high_high1.groupby(['DRG','HospitalName Des'])["CHRGS"].apply(lambda x :
          x.astype(int).sum()) \
             .unstack(fill_value=0) \
             .reset_index() \
             .rename_axis(None, axis=1)

ctable_drg4 = pd.DataFrame(ctable_drg4, columns=['DRG', 'Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])
#'North Country Hospital And Health Center'

sumRow = ctable_drg4.sum(axis = 1)
ctable_drg4['Total Charges'] = sumRow
ctable_drg4 = ctable_drg4.set_index(ctable_drg4['DRG'])
ctable_drg4 = ctable_drg4.iloc[:,1:]
ctable_drg4 = ctable_drg4.sort_values(by= 'Total Charges', ascending = False).head(10)
#ctable_drg4  = ctable_drg4.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
#ctable_drg4 = ctable_drg4.sort_values(by = [470.0, 460.0], axis = 1, ascending = False).head(10)
sumCol = ctable_drg4.sum(axis = 0)
ctable_drg4.loc['Destination DRG SubTotal:'] = sumCol
print(ctable_drg4)

#c_bd8 = piechart_DRG_chrgs(high_high1,'RR1')
#print(c_bd8)


#inpatient = pd.read_csv('VTINP16_upd.csv')
df_in = pd.read_csv("VTINP16_upd.txt", low_memory = False)
df = df_in.copy()

df_in_4insurance = df[df['PPAY'].isin([1,6,7])]
df_in_4insurance['PPAY'].replace({1:'MEDICARE', 6: 'Commercial Payers',7: 'Commercial Payers'},
          inplace=True)

df_in_4insurance_new = df_in_4insurance[['hnum2','intage','sex','CHRGS','PPAY','MDC','DRG','hsa']]
hospitalname= pd.read_excel("CaseStudy_O-D_HospMonopoly.xlsx",sheet_name='Hosp_Destination')
hospitalname.columns = ['hnum2','HospitalName Des','RR Des','RR Name Des']

hsaname = pd.read_excel("CaseStudy_O-D_HospMonopoly.xlsx",sheet_name='HSA_Pt_Origin')
hsaname.columns = ['hsa','HSA Name Org','RR Collapsed Referral Region Org','Name Org','RR Name Org']

#merge
#Hosp_Destination
df_with_des = pd.merge(df_in_4insurance_new ,hospitalname, how='left',on=['hnum2'])

#HSA_Pt_Origin
```

```
df_with_des_org = pd.merge(df_with_des ,hsaname ,how='left',on=['hsa'])


df_with_des_org['Care_Type'] = np.ones(len(df_with_des_org))
for i in range(len(df_with_des_org)):
    if  df_with_des_org['MDC'].iloc[i]== '5':
        df_with_des_org['Care_Type'].iloc[i] = 'High-end care'
    elif df_with_des_org['MDC'].iloc[i]== '8':
        df_with_des_org['Care_Type'].iloc[i] = 'Low-end care'
    else:  df_with_des_org['Care_Type'].iloc[i] = 'Other care'


df_with_des_org['Payer_Type'] = np.ones(len(df_with_des_org))
for i in range(len(df_with_des_org)):
    if  df_with_des_org['PPAY'].iloc[i]== 'MEDICARE':
        df_with_des_org['Payer_Type'].iloc[i] = 'Low-end Payer'
    elif df_with_des_org['PPAY'].iloc[i]== 'Commercial Payers':
         df_with_des_org['Payer_Type'].iloc[i] = 'High-end Payers'
    else:  df_with_des_org['Payer_Type'].iloc[i] = 'Other Payers'

#print(df_with_des_org)

origin = df_with_des.copy()
destination = df_with_des_org.copy()

origin['hsa'].replace({1:'RR2', 2:'RR1', 3:'RR2', 4:'RR4', 5:'RR3', 6:'RR3', 7:'RR1', 8:'RR1', \
                    9:'RR5', 10:'RR5', 11:'RR4', 12:'RR4', 13: 'RR4', 98:'Z_OutState', 99:'Missing'}, inplace=True)

origin['hnum2'].replace({1:'RR1', 2:'RR3', 3:'RR3', 4:'RR2', 5:'RR1', 6:'RR2', 8:'RR5', \
                     9:'RR1', 10:'RR4', 11:'RR4', 12:'RR4', 14: 'RR4', 15:'RR4', 16:'RR5'}, inplace=True)

origin = origin.rename(columns = {'hsa':'RRName'}, inplace = False)

def piechart(df,regionname):
    table = df[df['RR Des'].isin([regionname])]
    bd = pd.crosstab(index = table['RRName'], columns = table['HospitalName Des'])
    sumRow = bd.sum(axis = 1)
    bd['Total Admission'] = sumRow
    sumCol = bd.sum(axis = 0)
    bd.loc['Destination Hosp SubTotal'] = sumCol
    print(bd)

    perc_bd = bd.iloc[-1,0:len(bd.columns)-1]/sumCol[-1]
    fig, ax = plt.subplots(figsize=(5, 5))

    theme = plt.get_cmap('bwr')
    ax.set_prop_cycle("color", [theme(1. * i / len(perc_bd))
                        for i in range(len(perc_bd))])
    ax.pie(perc_bd, labels=perc_bd.index, autopct='%1.1f%%',
        shadow=True, startangle=90)
    ax.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.
    plt.show()
    return bd
```

```
#High-end care(circulatory) * High-end Payers(commercial)
#origin['MDC'].unique()
highcare_highpayer = origin[(origin['MDC'] == '5') & origin['PPAY'].isin(['Commercial Payers'])]
table1 = pd.crosstab(index = highcare_highpayer['RRName'], columns = highcare_highpayer['RR Name Des'])

table1 = table1.loc[['RR1', 'RR2', 'RR3', 'RR4', 'RR5', 'Z_OutState', 'Missing'], :]
#or drop these two rows
#table1 = table1.drop(['Missing', 'Z_OutState'])
sumRow = table1.sum(axis = 1)
table1['Total Admission'] = sumRow
sumCol = table1.sum(axis = 0)
table1.loc['Destination Hosp SubTotal:'] = sumCol
print(table1)

a_bd1 = piechart(highcare_highpayer,'RR1')
print(a_bd1)


#Low-end care(musculoskeletal) * High-end Payers(commercial)
lowcare_highpayer = origin[(origin['MDC'] == '8') & origin['PPAY'].isin(['Commercial Payers'])]
table2 = pd.crosstab(index = lowcare_highpayer['RRName'], columns = lowcare_highpayer['RR Name Des'])
table2 = table2.loc[['RR1', 'RR2', 'RR3', 'RR4', 'RR5', 'Z_OutState', 'Missing'], :]
#or drop these two rows
#table2 = table2.drop(['Missing', 'Z_OutState'])

sumRow2 = table2.sum(axis = 1)
table2['Total Admission'] = sumRow2
sumCol2 = table2.sum(axis = 0)
table2.loc['Destination Hosp SubTotal:'] = sumCol2
print(table2)

a_bd2 = piechart(lowcare_highpayer,'RR1')
print(a_bd2)


#High-end care(circulatory) * Low-end Payers(medicare)
highcare_lowpayer = origin[(origin['MDC'] == '5') & origin['PPAY'].isin(['MEDICARE'])]
table3 = pd.crosstab(index = highcare_lowpayer['RRName'], columns = highcare_lowpayer['RR Name Des'])
table3 = table3.loc[['RR1', 'RR2', 'RR3', 'RR4', 'RR5', 'Z_OutState'], :]
#or drop this row
#table3 = table3.drop(['Z_OutState'])

sumRow3 = table3.sum(axis = 1)
table3['Total Admission'] = sumRow3
sumCol3 = table3.sum(axis = 0)
table3.loc['Destination Hosp SubTotal:'] = sumCol3
print(table3)

a_bd3_1 = piechart(highcare_lowpayer,'RR1')
print(a_bd3_1)
```

```
## RR5 Breakdown
a_bd3_5 = piechart(highcare_lowpayer,'RR5')
print(a_bd3_5)


#Low-end care(musculoskeletal) * Low-end Payers(medicare)
lowcare_lowpayer = origin[(origin['MDC'] == '8') & origin['PPAY'].isin(['MEDICARE'])]
table4 = pd.crosstab(index = lowcare_lowpayer['RRName'], columns = lowcare_lowpayer['RR Name Des'])
#table4 = table4.loc[['RR1', 'RR2', 'RR3', 'RR4', 'RR5', 'Z_OutState'], :]
#or drop these two rows
table4 = table4.drop(['Z_OutState'])

sumRow4 = table4.sum(axis = 1)
table4['Total Admission'] = sumRow4
sumCol4 = table4.sum(axis = 0)
table4.loc['Destination Hosp SubTotal:'] = sumCol4
print(table4)

a_bd4 = piechart(lowcare_lowpayer,'RR1')
print(a_bd4)


#%% Optional DRG
def piechart_DRG(df,regionname):
    table = df[df['RR Des'].isin([regionname])]
    bd = pd.crosstab(index = table['RRName'], columns = table['DRG'])
    #bd = table.sort_values(by='RR1--Burlington', ascending = False).head(10)
    sumRow = bd.sum(axis = 1)
    bd['Total Admission'] = sumRow
    sumCol = bd.sum(axis = 0)
    bd.loc['Destination Hosp SubTotal'] = sumCol
    #print(bd)

    perc_bd = bd.iloc[-1,0:len(bd.columns)-1]/sumCol[-1]
    fig, ax = plt.subplots(figsize=(5, 5))
    theme = plt.get_cmap('bwr')
    ax.set_prop_cycle("color", [theme(1. * i / len(perc_bd))
                        for i in range(len(perc_bd))])
    ax.pie(perc_bd, labels=perc_bd.index, autopct='%1.1f%%',
        shadow=True, startangle=90)
    ax.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.
    plt.show()
    return bd

#%% High-end care(circulatory) * High-end Payers(commercial)
#origin['MDC'].unique()
#origin['DRG'].unique()
#By Areas
highcare_highpayer1 = origin[(origin['MDC'] == '5') & origin['PPAY'].isin(['Commercial Payers'])]
table_drg1 = pd.crosstab(index = highcare_highpayer1['DRG'], columns = highcare_highpayer1['RR Name
            Des'])
table_drg1  = table_drg1.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
```

```
sumRow5 = table_drg1.sum(axis = 1)
table_drg1['Total Admission'] = sumRow5
sumCol5 = table_drg1.sum(axis = 0)
table_drg1.loc['Destination DRG SubTotal:'] = sumCol5
print(table_drg1)

## RR1 Breakdown
#a_bd5 = piechart_DRG(highcare_highpayer1,'RR1')
#print(a_bd5)


#By Hopsital
highcare_highpayer1 = origin[(origin['MDC'] == '5') & origin['PPAY'].isin(['Commercial Payers'])]
table_drg1 = pd.crosstab(index = highcare_highpayer1['DRG'], columns =
          highcare_highpayer1['HospitalName Des'])
table_drg1 = pd.DataFrame(table_drg1, columns=['Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])

sumRow5 = table_drg1.sum(axis = 1)
table_drg1['Total Admission'] = sumRow5
table_drg1 = table_drg1.sort_values(by= 'Total Admission', ascending = False).head(10)
sumCol5 = table_drg1.sum(axis = 0)
table_drg1.loc['Destination DRG SubTotal:'] = sumCol5
print(table_drg1)


#%% Low-end care(musculoskeletal) * High-end Payers(commercial)
#By Areas
lowcare_highpayer1 = origin[(origin['MDC'] == '8') & origin['PPAY'].isin(['Commercial Payers'])]
table_drg2 = pd.crosstab(index = lowcare_highpayer1['DRG'], columns = lowcare_highpayer1['RR Name
          Des'])
table_drg2  = table_drg2.sort_values(by= 'RR1--Burlington', ascending = False).head(10)

sumRow6 = table_drg2.sum(axis = 1)
table_drg2['Total Admission'] = sumRow6
sumCol6 = table_drg2.sum(axis = 0)
table_drg2.loc['Destination DRG SubTotal:'] = sumCol6
print(table_drg2)

## RR1 Breakdown
#a_bd6 = piechart_DRG(lowcare_highpayer1,'RR1')
#print(a_bd6)

#By Hopsital
lowcare_highpayer1 = origin[(origin['MDC'] == '8') & origin['PPAY'].isin(['Commercial Payers'])]
table_drg2 = pd.crosstab(index = lowcare_highpayer1['DRG'], columns = lowcare_highpayer1['HospitalName
          Des'])
table_drg2 = pd.DataFrame(table_drg2, columns=['Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])

sumRow6 = table_drg2.sum(axis = 1)
```

```
table_drg2['Total Admission'] = sumRow6
table_drg2 = table_drg2.sort_values(by= 'Total Admission', ascending = False).head(10)
sumCol6 = table_drg2.sum(axis = 0)
table_drg2.loc['Destination DRG SubTotal:'] = sumCol6
print(table_drg2)


#%% High-end care(circulatory) * Low-end Payers(medicare)
#By Areas
highcare_lowpayer1 = origin[(origin['MDC'] == '5') & origin['PPAY'].isin(['MEDICARE'])]
table_drg3 = pd.crosstab(index = highcare_lowpayer1['DRG'], columns = highcare_lowpayer1['RR Name
        Des'])
table_drg3  = table_drg3.sort_values(by= 'RR1--Burlington', ascending = False).head(10)
#table_drg3  = table_drg3.sort_values(by= 'RR5--Rutland', ascending = False).head(10)

sumRow7 = table_drg3.sum(axis = 1)
table_drg3['Total Admission'] = sumRow7
sumCol7 = table_drg3.sum(axis = 0)
table_drg3.loc['Destination DRG SubTotal:'] = sumCol7
print(table_drg3)

## RR1 Breakdown
#a_bd7_1 = piechart_DRG(highcare_lowpayer1,'RR1')
#print(a_bd7_1)
## RR5 Breakdown
#a_bd7_5 = piechart_DRG(highcare_lowpayer1,'RR5')
#print(a_bd7_5)

#By Hopsital
highcare_lowpayer1 = origin[(origin['MDC'] == '5') & origin['PPAY'].isin(['MEDICARE'])]
table_drg3 = pd.crosstab(index = highcare_lowpayer1['DRG'], columns = highcare_lowpayer1['HospitalName
        Des'])
table_drg3 = pd.DataFrame(table_drg3, columns=['Northwestern Medical Center',
     'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
     'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])

sumRow7 = table_drg3.sum(axis = 1)
table_drg3['Total Admission'] = sumRow7
table_drg3 = table_drg3.sort_values(by= 'Total Admission', ascending = False).head(10)
sumCol7 = table_drg3.sum(axis = 0)
table_drg3.loc['Destination DRG SubTotal:'] = sumCol7
print(table_drg3)


#%% Low-end care(musculoskeletal) * Low-end Payers(medicare)
#By Areas
lowcare_lowpayer1 = origin[(origin['MDC'] == '8') & origin['PPAY'].isin(['MEDICARE'])]
table_drg4 = pd.crosstab(index = lowcare_lowpayer1['DRG'], columns = lowcare_lowpayer1['RR Name Des'])
table_drg4  = table_drg4.sort_values(by= 'RR1--Burlington', ascending = False).head(10)

sumRow8 = table_drg4.sum(axis = 1)
table_drg4['Total Admission'] = sumRow8
sumCol8 = table_drg4.sum(axis = 0)
```

```
table_drg4.loc['Destination DRG SubTotal:'] = sumCol8
print(table_drg4)

## RR1 Breakdown
#a_bd8 = piechart_DRG(lowcare_lowpayer1,'RR1')
#print(a_bd8)

#By Hopsital
lowcare_lowpayer1 = origin[(origin['MDC'] == '8') & origin['PPAY'].isin(['MEDICARE'])]
table_drg4 = pd.crosstab(index = lowcare_lowpayer1['DRG'], columns = lowcare_lowpayer1['HospitalName
            Des'])
table_drg4 = pd.DataFrame(table_drg4, columns=['Northwestern Medical Center',
      'Porter Medical Center', 'University of Vermont Medical Center (as of 2014)',
      'Rutland Regional Medical Center', 'Southwestern Vermont Medical Center'])

sumRow8 = table_drg4.sum(axis = 1)
table_drg4['Total Admission'] = sumRow8
table_drg4 = table_drg4.sort_values(by= 'Total Admission', ascending = False).head(10)
sumCol8 = table_drg4.sum(axis = 0)
table_drg4.loc['Destination DRG SubTotal:'] = sumCol8
print(table_drg4)
```