

Visualization of Medicare Utilization Data



HCDE 511
Spring 2014

Abstract:

This project takes a look into the Center for Medicare & Medicaid Services (CMS) public Medicare utilization data set for 2012, and aims to create a useful interactive visualization for the payment data by embedding Tableau visualizations in a website. Because the data includes personally identifiable information for medical providers we set out to create customized visualizations both for doctors and the patients who see them. A provider could look at a visualization tailored to their perspective with more technical information, and a patient, or loved one acting on behalf of a Medicare patient, could look at a tailored experience containing more information on the out of pocket expenses across procedures. This paper details how we transformed a data set into a useful and customized online experience for end users by undergoing a user-center design process to create the visualizations.

Introduction

In 2014, as part of the Obama administration's initiative to improve healthcare by reducing costs as well as to improve transparency and quality, the Centers for Medicare and Medicaid services (CMS) released a new public data set: the Medicare Provider Utilization and Payment Data including the Physician and Other Supplier Public Use File (PUF). This data set contains information “on services and procedures provided to Medicare beneficiaries by physicians and other healthcare professionals.” For the first time, CMS has provided a view focusing on the care provided by healthcare professionals to patients across the country. This data allows interested individuals to compare both the costs and volume of Medicare claims made by various providers.

This data is collected from CMS’s National Claims History Standard Analytic Files covering 100% of the “final-action physician/supplier Part B non-institutional line items for the Medicare fee-for-service population” for 2012. Provider demographic information comes from the National Plan and Provider Enumeration System (NPPES) and includes name, credentials, gender, address, and entity type. In addition the NPPES generates unique National Provider Identifiers (NPIs) to all health care providers. The NPI number forms the fundamental key to organize all of the information in the dataset allowing all data elements to be linked back to the individual provider.

In addition to the demographic data, the Physician and other Supplier PUF contains the data elements required to highlight the financial claims submitted by individual healthcare providers. The data can be grouped into nominal and quantitative elements (Table 1). In total this information is represented across 9,153,273 rows, with each row representing the number of claims submitted by a specific healthcare provider for a unique service.

Table 1 - Data elements in the Physician and Other Suppliers PUF

Nominal	Quantitative
<ul style="list-style-type: none">• Provider Names• NPI (unique ID)• Specialty• Gender• Provider Type• Address• Place of Service• HCPCS Codes (CPT)	<ul style="list-style-type: none">• Line service count• Unique benefit count• Average Medicare allowed amount• Average submitted charge amount• Average Medicare payment

Even though there is a tremendous wealth of information in the Physician and Other Supplier PUF, there are some limitations that need to be considered prior to its use. It is important to recognize that the database only contains billing information for Medicare payments and may not represent a provider’s entire practice. In addition, given the variable complexity associated with different diseases and populations, the data is not intended to indicate the quality of care provided. Finally, the dataset excludes any aggregated records that come from ten or fewer beneficiaries in order to protect patient privacy.

Despite these limitations the Physician and Other Suppliers PUF still has the potential to be useful for a variety of different audiences and use cases. For this work we decided to focus on two different audiences with different needs: practitioners and consumers of healthcare services.

Previous work

The data itself was not available to the general public prior to 2014, so previous work specific to this topic was fairly limited.

First on the scene was an example of an interactive experience (not a visualization per se) using this dataset was published in The New York Times on April 9, 2014.

The New York Times

SHARE

How Much Medicare Pays for Your Doctor's Care

Use the form below to find a doctor or other medical professional among the more than 800,000 health care providers that received payments in 2012 from Medicare Part B, which covers doctor visits, tests and other treatments. Payments may also cover overhead, such as staff salaries and drug costs. In some cases, when doctors work as salaried employees of group practices, the payments that show up under their names go to their institutions. **Related Articles:** [Silver of Medicare Doctors Get Big Share of Payouts](#), [The Medicare Data's Pitfalls](#) APRIL 9, 2014

Name

wojnarski

Specialty

All Specialties

City or ZIP Code

SEARCH

Results: 2 health care providers named "wojnarski"

Wieslaw Wojnarski

4801 W. Peterson Ave., Chicago, IL

Internal Medicine

\$30,017

SERVICE	PATIENTS	TIMES PERFORMED	AVG. BILLED	AVG. REIMBURSED
EKG for initial prevent exam	24	24	\$23	\$16
Electrocardiogram, routine ECG with at least 12 leads; with interpretation and report	19	25	\$23	\$16
Initial preventive exam	25	25	\$182	\$165
Office or other outpatient visit for the evaluation and management of a new patient, which...	43	43	\$237	\$113
Office or other outpatient visit for the evaluation and management of an established patient,...	22	23	\$164	\$87
Office or other outpatient visit for the evaluation and management of an established patient,...	32	72	\$52	\$34
Office or other outpatient visit for the evaluation and management of an established patient,...	39	107	\$83	\$56
Office or other outpatient visit for the evaluation and management of an established patient,...	27	34	\$126	\$88
PPPS, initial visit	39	39	\$194	\$176

The Times alludes to the limitations of the data but leaves it up to the user to read the [accompanying article](#) and sources to get the full story on how to best interpret the data:

In terms of the visualization itself, it appears simple at first. Only three touch points are initially presented: two text boxes and one dropdown. If the user types into either text box (the dropdown is optional) and clicks Search, she is presented with a list of all providers that meet the selected criteria. If the user clicks on a provider's name, it shows a crosstab view of their specific Medicare data listed in alphabetical order:

Results: 1 certified registered nurse anesthetist in 98133

TOTAL REIMBURSED
BY MEDICARE IN 2012

Kathryn Bushfield

Certified Registered Nurse Anesthetist

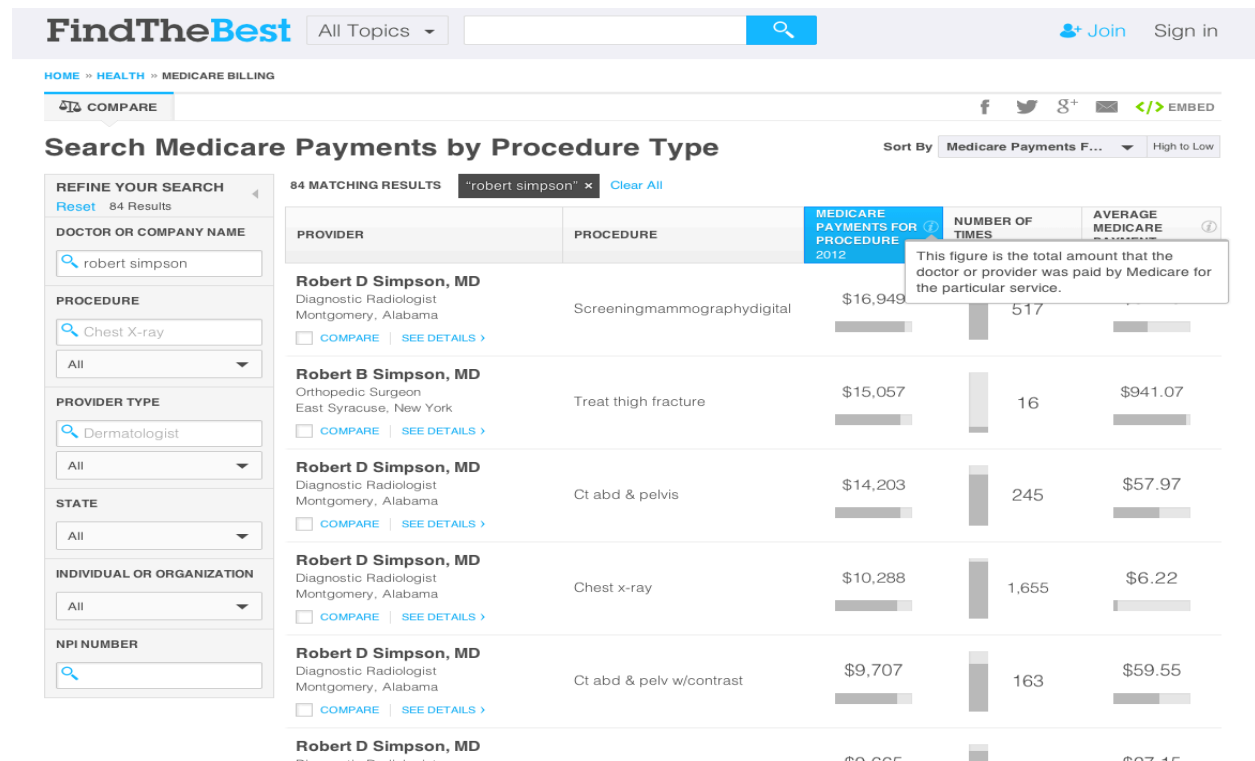
\$80,844

10330 Meridian Ave N, Seattle, WA

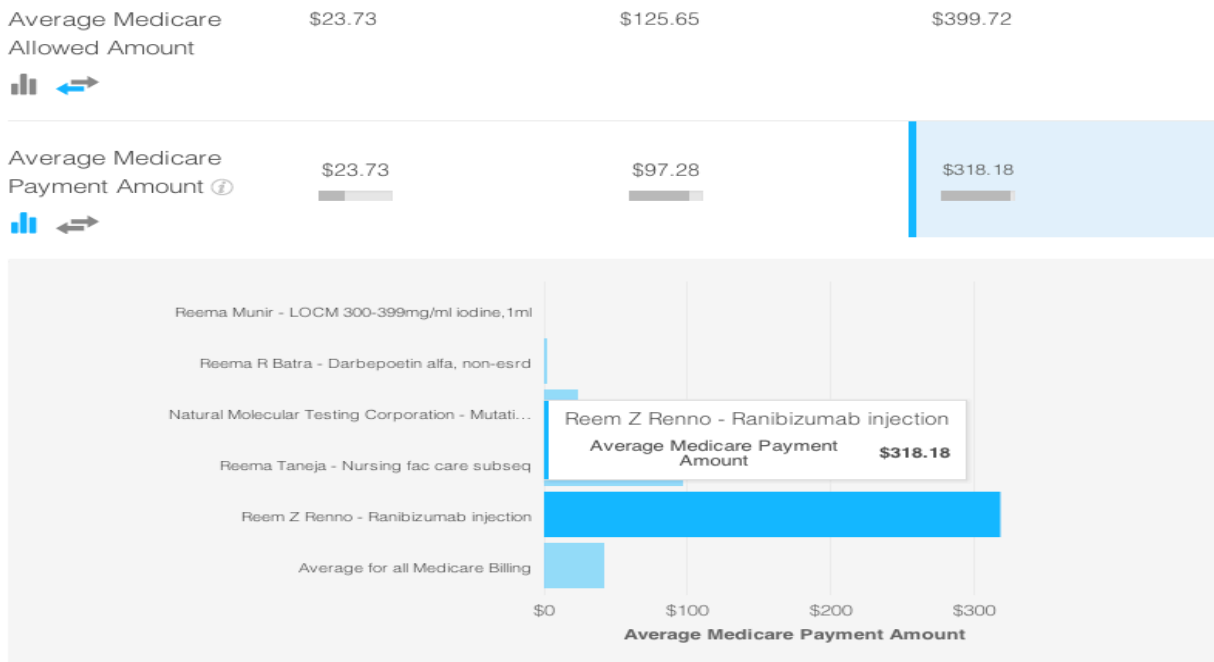
SERVICE	PATIENTS	TIMES PERFORMED	AVG. BILLED	AVG. REIMBURSED
Anesthesia for procedures on eye; corneal transplant	11	11	\$537	\$139
Anesthesia for procedures on eye; lens surgery	475	668	\$368	\$91
Anesthesia for procedures on eye; not otherwise specified	77	97	\$452	\$115
Anesthesia for reconstructive procedures of eyelid (eg, blepharoplasty, ptosis surgery)	56	56	\$520	\$131

If the user clicks on a procedure, she is directed to the AMA login page, which doesn't seem useful unless the user is a medical provider, because a login is required.

Another interesting example *Search Medicare Payments by Procedure Type* surfaced while we were well into the final design phase of our interactive visualization. This example, from website FindTheBest.com, includes some interactive elements that were not present on the example from The Times.

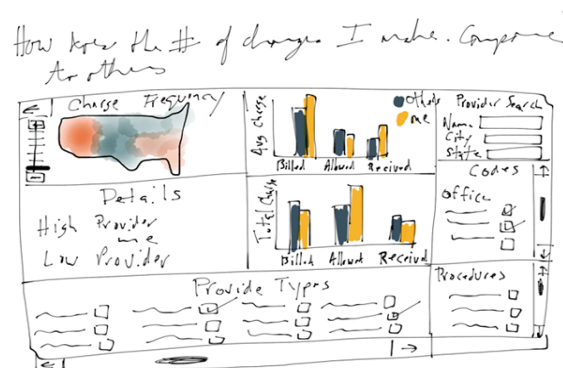
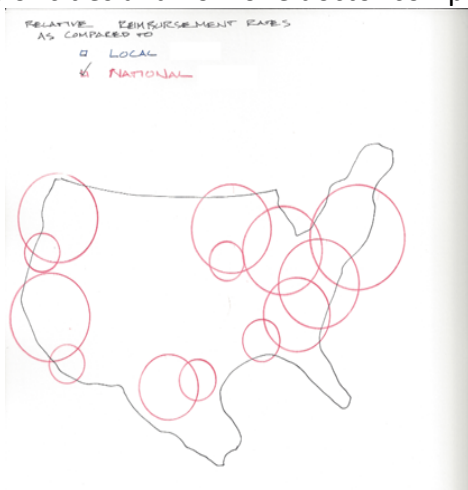


Overall, this visualization was highly interactive in nature and seemed to encourage exploration. Three columns of bar graphs on the right show how the providers compare to the dataset overall. This was confusing and seemed oversimplified at first, but if the user wants to she can select multiple providers and drill down and view a detailed bar chart complete with details on demand.



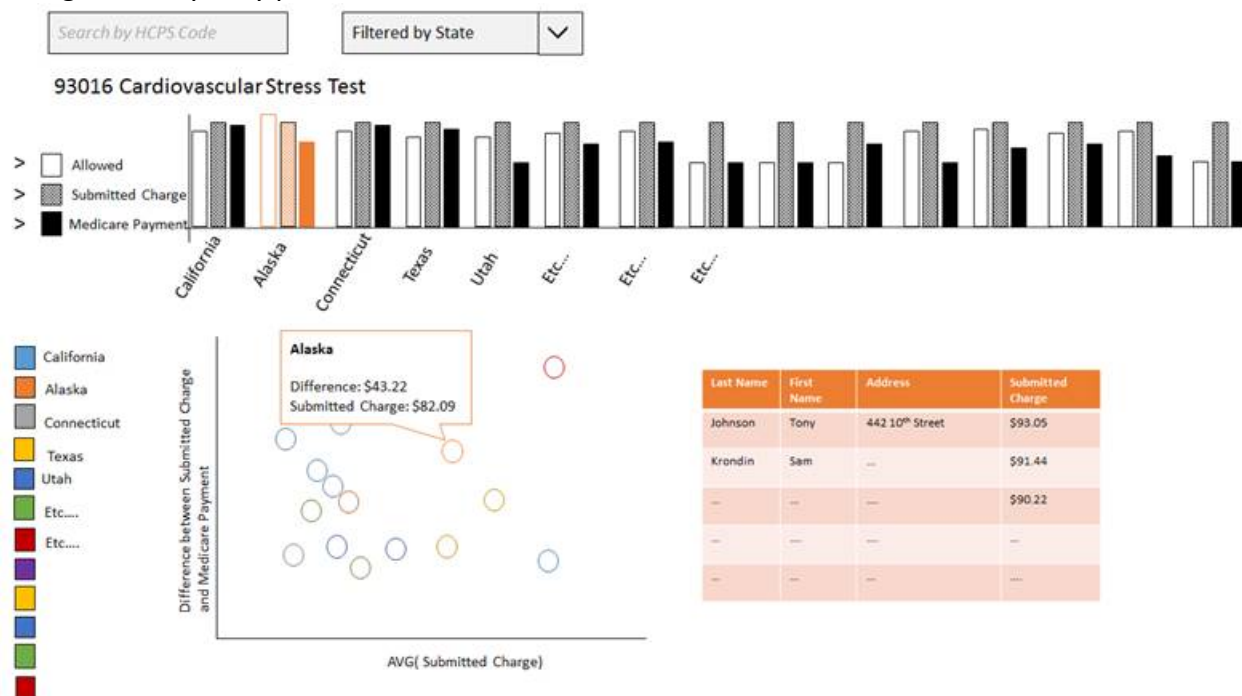
Design process

Understanding the kinds of visualization made by others about this data set was important to begin our design process. We based our preliminary sketches on an analysis of what kinds of dimensions and measures the data offered and what we thought users would find useful. There was location based information so some of our sketches included maps. Using this geographical information could help users see how spending was distributed across states, regions or cities and how one doctor compared to another.



We kept coming back to the idea of showing some type of comparison, so whether a doctor or patient was looking at the visualization they could make a decision about the current

payments and whether as patients they wanted to change doctors or as doctors they wanted to change the way they practice.



These early sketches were based on the data and previous work by the NYTimes, but next we needed to understand what real users wanted and how to create the next iteration of a useful visualization.

To understand what kind of visualization to build we first wanted to define our target users. Because the data actually included individually identifiable information like first and last names of doctors, we wanted to create a useful tool for the doctors themselves and the patients who see them.

We thought these two groups would find the visualization useful and so we created two personas: Pamela the Practitioner and Tom the Taxpayer.

Pamela the Practitioner

Dr. Pamela Jacobs, M.D. is the managing partner of an independent cardiology practice in Bellevue. Over the past few years it has become increasingly more difficult for the practice to remain independent due to a reduction in payer compensation, as well as increasing competition from multispecialty practices. Pamela has been spending time reviewing the recently released Provider Utilization and Payment Data Physician and Other Supplier Public Use data set. She is very interested in comparing the reimbursement rates for other cardiologists in the region as well as across the state and country to her own. It is Pamela's hope that this data set will help provide some additional context she and her partners can use in deciding if they should remain independent or not.

Tom-the-Taxpayer Persona

Tom Filborn has been working for nearly a decade on successful projects at Microsoft as an engineer and makes \$250,000 per year in addition to additional financial and healthcare

benefits packages. He is married, has two children and his wife of several years, Sara, runs a local non-profit agency and earns \$60,000 annually without any benefits. Given the large ordinary income, the Filborn family has a very large tax burden.

The family is generally healthy, however Sara's mother is ill and in hospital care. Sara and Tom have been helping to pay the medical bills which are not covered by Medicare. With the recent release of the Provider Utilization and Payment Data Physician and Other Supplier Public Use File by CMS, Tom is interested in exploring this data to see how his mother-in-law's providers billing data compares to other local as well as national providers. In addition, given his general frustration with his large tax burden, he is interested in looking at Medicare spending in general in order to get a better understanding of spending in this area.

We conducted interviews with two Tom-the-Taxpayer users and three Medicare providers to understand their needs and use cases for this data set. We quickly learned that Tom-the-Taxpayer interviewees were somewhat interested in understanding national Medicare spending, but overwhelmingly told us their needs were more local and practical and based on knowing how much they would owe out-of-pocket or whether they should switch providers. Because of this we decided it would be appropriate to amend and iterate our Tom-the-Taxpayer persona to focus more on the fact that these were the loved-ones of an aging parent who took responsibility for helping them make healthcare decisions. Tom-the-Taxpayer became Louis the Loved One of an Aging Parent. We recruited our usability study participants based on this updated user profile.

After interviewing the three physicians, it confirmed that we were on target with our current Medicare provider persona. They indicated that having the ability to perform comparisons at a variety of different levels was going to be a very important part of the tool. The interviews allowed us to understand their specific needs and ensure that we included functionality to meet these needs. Through the interviews we also learned that providers wanted to see details on their own practice patterns, allowing them to gain insight on the services they provide and how they are compensated for these services. With this information they hoped to develop a better understanding of whether they were maximizing their revenue potential or not.

As we were in the process of conducting the interviews, another finding early in our user-centered design process, was that the needs of loved ones of an aging parent and providers were different. Initially, we thought we could create one visualization for both personas, but it became clear that customizing two different visualizations would be more meaningful to each target user. For example, cardiologists wanted to view themselves against other cardiologists and get specific data by comparing themselves to specific colleagues or competitors. Loved ones of Medicare patients were concerned with whether the data for their individual doctor would lead them to switch if they were paying too much. They would not have a doctor in mind, but would want the visualization to give them some suggestions based on out-of-pocket expenses and provider proximity. The providers on the other hand may have another doctor in mind; one that they compete with or are curious to compare themselves against.

Methods, results and discussion

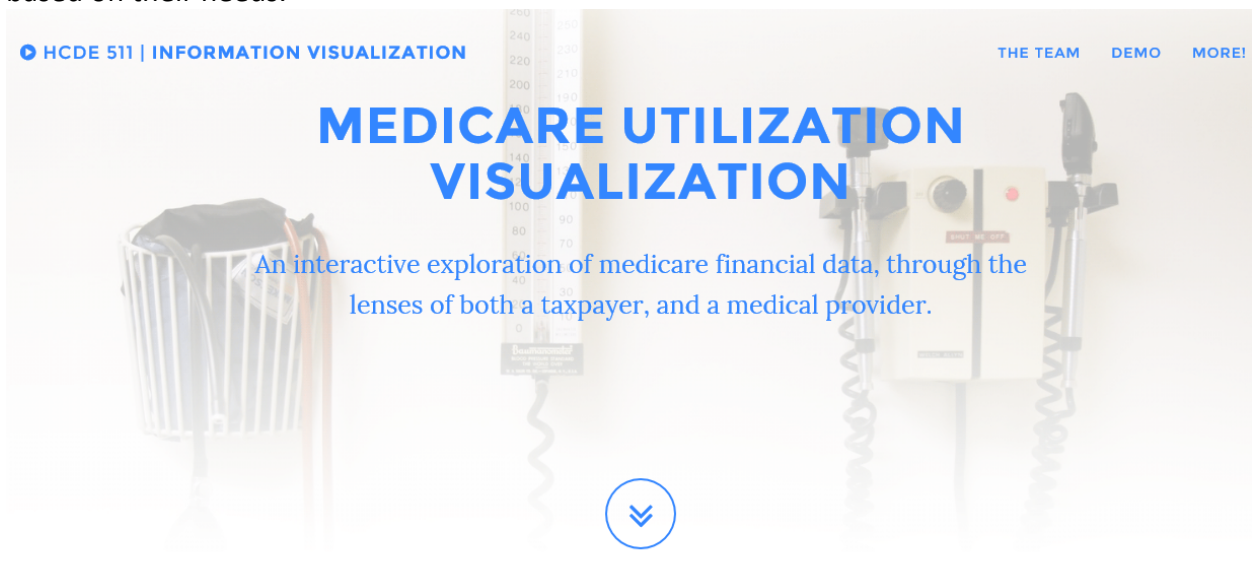
Based on what we learned about our target users, we began to transform their needs into specific tasks that we could test on the visualizations. The tasks for loved-ones were:

- 1) look up your loved one's provider
- 2) find an alternative doctor with a lower out-of-pocket expense for a particular procedure and
- 3) contact the doctor's practice to continue the decision making process.

The tasks for the providers were:

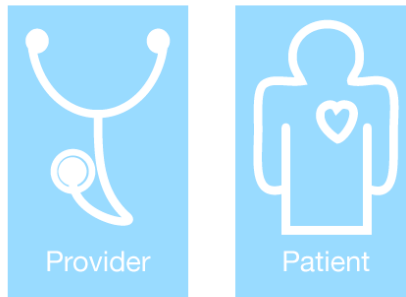
- 1) look up yourself
- 2) compare your charges to other providers in your specialty, and
- 3) explore and understand the types and number of your claims.

We began to create early views of two visualizations and constructed a web page using HTML, CSS, JavaScript and Adobe Illustrator to welcome either user type to explore the data based on their needs.



Users would enter the visualization by selecting which user profile they best fit to give them a customized experience.

WHICH ONE ARE YOU?



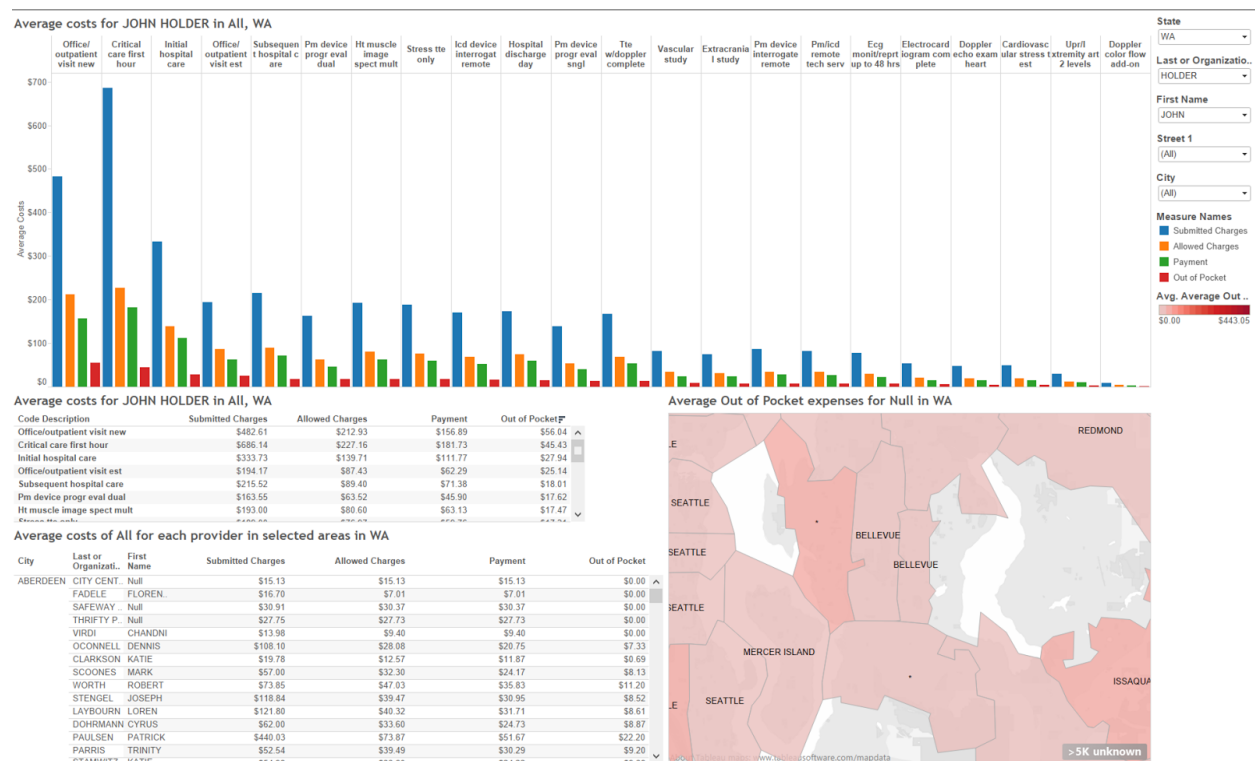
We embedded the visualizations in line so users could access the visualization on the web, without requiring Tableau software.

We conducted usability testing with six users of the visualizations we created using Tableau 8.1 Software. Three of them were part of the “Loved One” persona and three of them were medical professionals. We used this set list of tasks and prompted users with each task and asked them to think aloud as they moved through and used the visualization. After the tasks, we conducted a post-study interview to understand what users found difficult, easy and what they would change. A discussion of our initial views, results and final visualizations follows.

Patients and Loved Ones Visualization Creation and Usability Testing

To create the patient and loved-one visualization, we paid close attention to the user need of knowing how much the Medicare patient and their loved one owes out-of-pocket. The raw data needed to be transformed to make it easy to view out of pocket expenses, associated with the various services and procedures performed by individual practitioners. This information is not directly contained within the dataset though can be calculated by subtracting the Medicare payments from the allowed Medicare charges. We made this calculation a critical measure in our view.

Based on the three tasks specific to the needs of loved ones, we built and tested the visualization below on three participants who fit our “Loved One” persona using Tableau.



Along the right side users could use filter including state, first and last name and address, to narrow down the bar chart and crosstab table directly below it to the data specific to that doctor across medical procedures he performs and receives Medicare reimbursements for. Each submitted charge (blue) is listed along with what the allowed payment (orange) is for that procedure, the payment (green) the doctor gets and the remainder that the patient determines how to pay for, out-of-pocket (red).

The table below lists all other doctors in the state who utilize Medicare. This table updates based on selections made in the bar chart to compare specific medical procedure payments across only those doctors who utilize Medicare for those procedures. Additionally it is linked to the map on the right. Users could use the map to zoom in on their area and select one or many nearby zip code regions, labeled by city to filter down the accompanying table to doctors only from those areas. The red shading intends to match the red color used in the Average Out-of-Pocket measure for visual consistency. The darker red a region the more expensive the average out-of-pocket procedure for doctors who practice in that zip code.

There were a few usability issues with this design when put to the test with users. Below is a prioritized summary of the findings ordered by a count of how many of our participants experienced or expressed the issues or feedback during the tasks or in the post-study interview.

Priority	Usability Findings	Count of Participants
1	The map's zoom controls and selection is frustrating to use.	3
2	Users say they don't need a map and used the city dropdown filter.	3

3	Users liked the ability to look up contact information on hover.	3
4	Users don't realize they need to continue filtering when there is more than one provider with the same last name.	2
5	Users don't know what the red on the map is trying to show.	2
6	Having the bar chart and the table of payments are both useful.	2
7	Filter labeling. "Last" should say "Last Name."	1

We addressed all of these issues in the final visualization. We removed the map, because although it was visually pleasing users thought it was more trouble than it was worth. One user looked for an alternative and thought to use the "City" filter. During the post interview she said, "I was really frustrated by the map because it didn't work like Google. Besides, I know where I live, I don't need a map to tell me." Users were easily able to search for neighboring cities that they said they would be willing to drive to for a cheaper provider and did not need the map. If the map feature auto-zoomed and was easier to use, users may be more open to having it in the visualization.

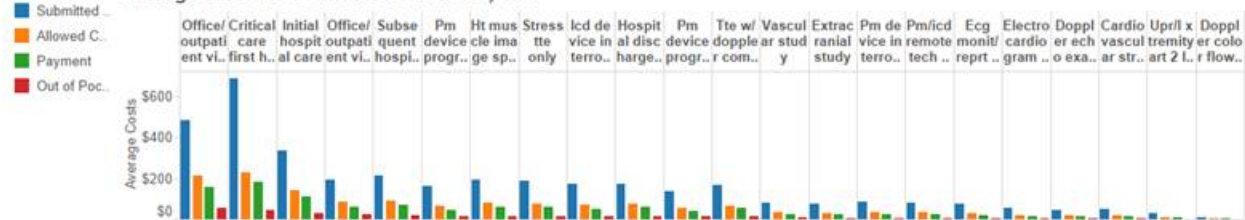
One of the greatest delighters of the visualization was that they could do a search for the provider with a built-in link on the tooltip. One user said, "That was so easy. I really like that." Three out of the three users said they would use it again. They confirmed that the tasks were realistic and useful to what they would actually do to look up their loved one's provider.

Final "Loved One" Visualization

Look up your medical provider.

State:
 Last Name or Organization:
 First Name:
 Street 1:
 City:

Measure Na.. Average costs for JOHN HOLDER in All, WA



Average costs for JOHN HOLDER in All, WA

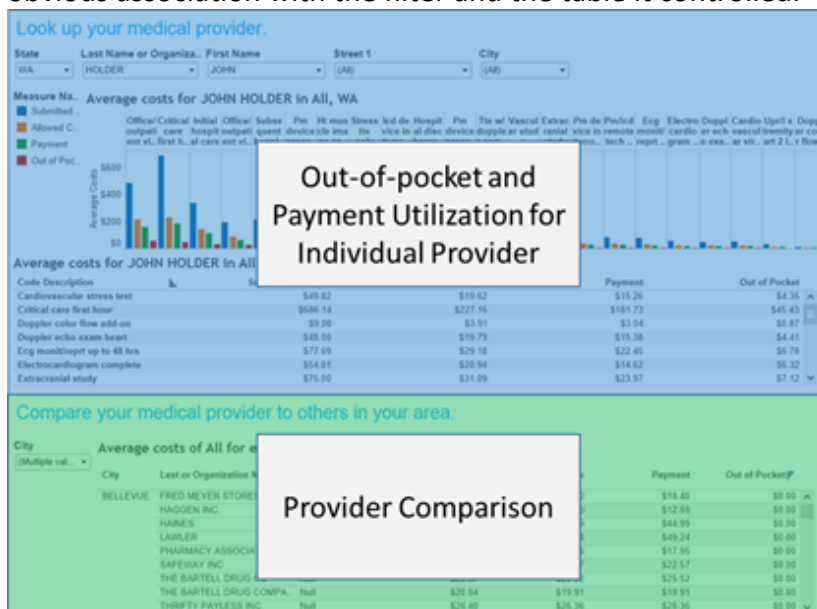
Code Description	Submitted Charges	Allowed Charges	Payment	Out of Pocket
Cardiovascular stress test	\$49.82	\$19.62	\$15.26	\$4.35
Critical care first hour	\$686.14	\$227.16	\$181.73	\$45.43
Doppler color flow add-on	\$9.00	\$3.91	\$3.04	\$0.87
Doppler echo exam heart	\$48.00	\$19.79	\$15.38	\$4.41
Ecg monitor/rept up to 48 hrs	\$77.69	\$29.18	\$22.40	\$6.78
Electrocardiogram complete	\$54.01	\$20.94	\$14.62	\$6.32
Extracranial study	\$75.00	\$31.09	\$23.97	\$7.12

Compare your medical provider to others in your area.

City Average costs of All for each provider in selected areas in WA

City	Last or Organization Name	First Name	Submitted Charges	Allowed Charges	Payment	Out of Pocket
BELLEVUE	FRED MEYER STORES INC	Null	\$18.40	\$18.40	\$18.40	\$0.00
	HAGGEN INC	Null	\$12.64	\$12.59	\$12.59	\$0.00
	HAINES	JAMES	\$79.50	\$44.99	\$44.99	\$0.00
	LAWLER	MICHAEL	\$83.00	\$49.24	\$49.24	\$0.00
	PHARMACY ASSOCIATES INC	Null	\$19.49	\$17.95	\$17.95	\$0.00
	SAFEWAY INC	Null	\$22.58	\$22.57	\$22.57	\$0.00
	THE BARTELL DRUG CO	Null	\$25.57	\$25.52	\$25.52	\$0.00
	THE BARTELL DRUG COMPA	Null	\$20.04	\$19.91	\$19.91	\$0.00
	THRIFTY PAYLESS INC	Null	\$26.40	\$26.36	\$26.36	\$0.00

The final “loved-one” visualization mirrors the user needs of users and splits them accordingly: a) understand current provider payments and out-of-pocket expenses and b) compare against other doctors to make an informed decision on whether to switch providers. Both the individual half as well as the comparison section are clearly labeled and position filters and controls in a way that makes it obvious which section they are linked with. Because we removed the map and maintained a filter for the cities, we needed to make sure there was an obvious association with the filter and the table it controlled.



The visualization begins in the upper left hand corner and purposefully asks the user to determine their state first, from left to right reading order. By positioning these filters here it is clearer to the user which visualization these filters control. This is intentional from a database perspective and quickly helps

to limit the rest of the filters to only the relevant data. This is the same thinking for putting “Last Name or Organization” next, so that the number of providers can quickly filter down and we can maintain a higher level of performance. First name, Street and City filters can help users ensure they have the right provider. All of the filters enable typing to speed up finding a specific entity in the filters.

The bar graph is organized by the medical procedures that doctor performed and submitted Medicare payments for in the year 2012. The average Submitted Payment, Allowed Payment and Actual Payment, as well as the Out-of-pocket Payment, denoted by blue, green, orange and red bars respectively, give users of the a visual summary of their doctor’s Medicare utilization. The bar graph is purposefully sorted left-to-right, by medical procedure based on the highest Out-of-Pocket payments to the lowest. From user interviews we know that loved ones of a Medicare patient want to know this practical information to make healthcare decisions.

Below the graph is a crosstab summarizing the chart above, but sorts the medical procedures in alphabetical order. A user with a Medicare bill in front of them would already know which procedure they may want to know more about and therefore finding a provider’s payment data for that procedure is easier when it’s organized in an alphabetized list. This is a nod to the New York Times tool, which also alphabetized the list of medical procedures. If a user knew they wanted to know more about “Critical care first hour” then hovering over the row in the crosstab would highlight it, but also highlight the accompanying bars for the procedure in the chart above. This brushing technique makes it easy to see the data of interest amongst its peer medical procedures for that provider.



Finally after exploring their loved one’s provider data they can compare them to other doctors in the area. We learned from our users that there is a predictable pattern for what loved ones of Medicare patients want to know: should I switch providers? Is there a provider nearby who may have lower out-of-pocket expenses? The key is that the data needs to be scoped to what is realistic for the user. In this case, users just needed to see data for providers they could realistically get to, not ones in other states around the country. The final visualization links the state the user chooses in the top half and labels the crosstab of all doctors across all cities from that state. Users may choose one or many neighboring cities to include in the crosstab. Here they can also utilize Tableau’s automatically available sorting to see which provider has the lowest out-of-pocket expenses.

Compare your medical provider to others in your area.

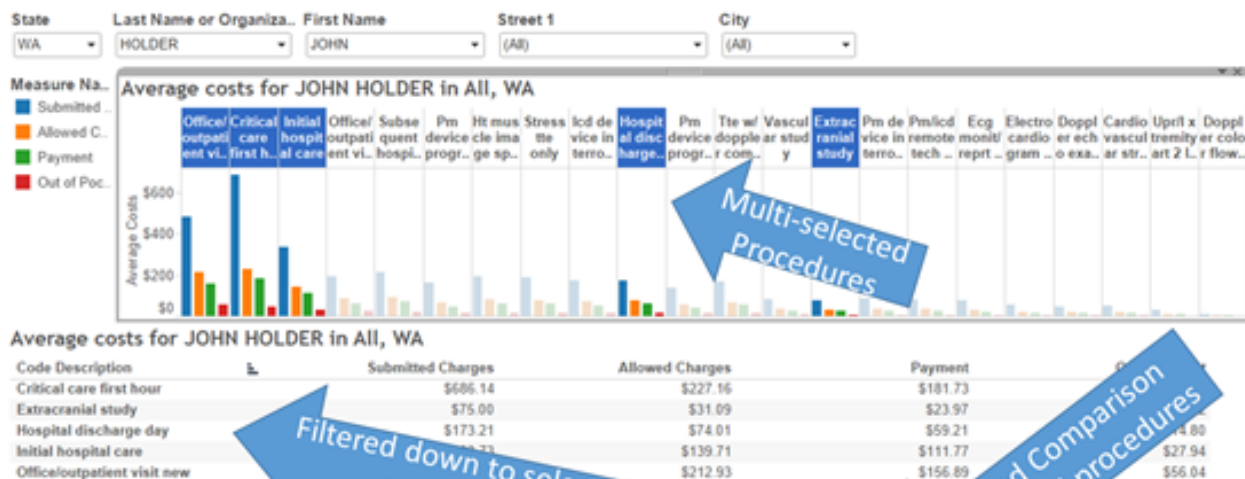
City (Multiple val...)

Average costs of All for each provider in selected areas in WA

City	Last or Organization Name	First Name	Submitted Charges	Payment	Out of Pocket
BELLEVUE	FRED MEYER STORES INC	Null	\$18.40	\$18.40	\$0.00
	HAGGEN INC.	Null	\$12.64	\$12.59	\$0.00
	HAINES	JAMES	\$79.50	\$44.99	\$0.00
	LAWLER	MICHAEL	\$83.00	\$49.24	\$0.00
	PHARMACY ASSOCIATES INC.	Null	\$19.49	\$17.95	\$0.00
	SAFEWAY INC	Null	\$22.58	\$22.57	\$0.00
	THE BARTELL DRUG CO	Null	\$25.57	\$25.52	\$0.00
	THE BARTELL DRUG COMPA.	Null	\$20.04	\$19.91	\$0.00
	THRIFTY PAYLESS INC	Null	\$26.40	\$26.36	\$0.00

Customized Crosstab Title to Identify the State

To personalize the data they are seeing, users can select one or many of the medical procedures by clicking on them in the chart. Armed with their loved one's Medicare statement, they can highlight all the procedures that applied to them to get a full summary of the procedures they care about. The crosstab below the chart, filters down to just showing the relevant procedures and the comparison crosstab shows how doctors in the selected cities who also perform those same procedures, compare monetarily. A doctor who performed only one of the five selected procedures for example would not appear.



Multi-selected Procedures

Filtered down to selected procedures

Updated Comparison for selected procedures

Compare your medical provider to others in your area.

City: BELLEVUE

Average costs of Critical care first hour, Extracranial study, Hospital discharge day and 2 more for each provider in selected areas in WA

City	Last or Organization Name	First Name	Submitted Charges	Allowed Charges	Payment	Out of Pocket
BELLEVUE	PROW	HAROLD	\$78.00	\$31.09	\$23.97	\$7.12
	LOWE	PHILIP	\$78.00	\$31.09	\$23.76	\$7.33
	ENGELBRECHT	DIANE	\$78.00	\$31.09	\$23.60	\$7.49
	CRENSHAW	WILLIAM	\$78.00	\$31.09	\$23.57	\$7.52
	ZOBEL	MARK	\$78.00	\$31.09	\$23.46	\$7.63
	MATTHIES	RICH	\$78.00	\$31.09	\$23.15	\$7.94
	PFLERGER	MARK	\$78.00	\$31.09	\$23.15	\$7.94
	SPEHLING	STEVEN	\$78.00	\$31.09	\$23.00	\$8.09

Finally, based on user interviews we learned our users were skeptical of the data. One user in our interview said, "You just assume there's a lot of fraud in there. I'm sure there is." Because users came to the data set with preconceived notions about the accuracy or completeness of the data, we wanted to take this into account. To respond to this user sentiment and feedback we included an on-hover capability to look up and contact a specific

provider. This way users can use the data as a starting point and continue their healthcare decision making process with the real medical offices and providers themselves.

Compare your medical provider to others in your area

City: BELLEVUE

Average cost per provider in

4 items selected - SUM of Measure Values: 140

PROW
Contact information for HAROLD PROW in BELLEVUE, WA

Keep Only X Exclude

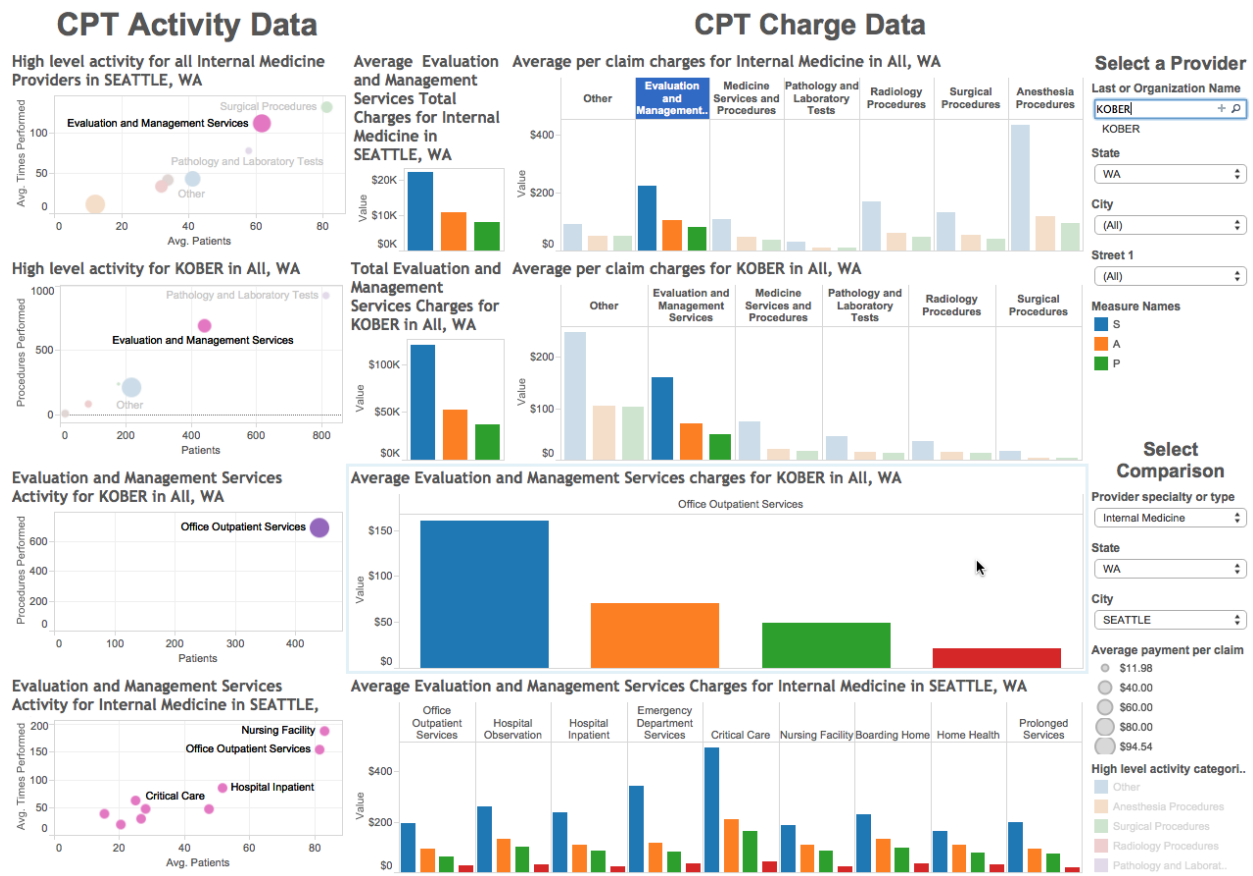
City	Last Name	First Name	Allowed Charges	Payment	Out of Pocket
BELLEVUE	PROW	HAROLD	\$78.00	\$31.09	\$23.97
	LOWE	PHILIP	\$78.00	\$31.09	\$23.76
	ENGELBRECHT	DIANE	\$78.00	\$31.09	\$23.60
	CRENSHAW	WILLIAM	\$78.00	\$31.09	\$23.57
	ZOBEL	MARK	\$78.00	\$31.09	\$23.46
	MATTHIES	RICH	\$78.00	\$31.09	\$23.15
	PFLEGER	MARK	\$78.00	\$31.09	\$23.15
	SPERLING	STEVEN	\$78.00	\$31.09	\$23.00

Hospital discharge day and 2 more for each

Providers Visualization Creation and Usability Testing

To create the provider specific visualization, first we needed to prepare the data for the visualization we wanted our medical provider participants to try. Medical professionals understand medical procedures by grouping and we wanted to provide that in the view. For the most part the Physician and Other Provider PUF didn't require much cleaning and preparation for us to use it for our intended purposes. The main curation activity took place with the procedural codes included in the dataset. Current Procedural Terminology (CPT) codes have a hierarchical organization with 7 high level groupings: 1) Anesthesia Procedures, 2) Evaluation and Management Services, 3) Medicine Services and Procedures, 4) Pathology and Laboratory Tests, 5) Radiology Procedures, 6) Surgical Procedures, 7) Other. We assigned each code within the dataset to one of these categories to order to provide a sense of the utilization of various services at a higher level than allowed by investigating single code data. In addition, to provide one more layer of granularity below this higher categorization we further subdivided the categories into 99 sub groupings. We ultimately decided that both groupings were helpful based on the feedback during our design sessions and user interviews.

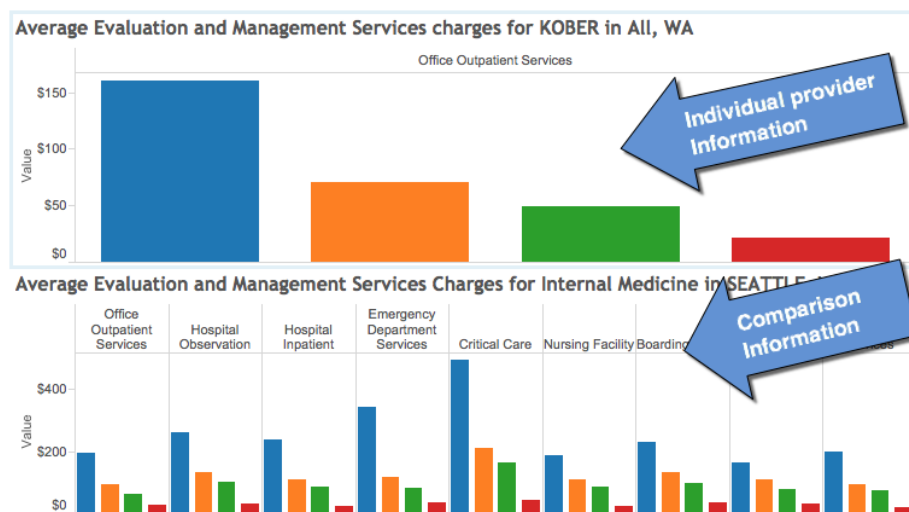
After completing these groupings we tested the following early provider visualization:



It was very clear from our early tests that this visualization was not going to be very successful. Through a talk out loud task assessment we quickly realized that the visualization had missed the mark. Not only did it not effectively address the needs and tasks our users told us they needed but also they felt the visualization was busy and not visually pleasing. We found that it took our testers a large amount of time to first orient themselves to the information as well as understand what it was trying to communicate. In addition, we noticed that the testers didn't initially see the filtering controls located on the right hand side of the page and therefore didn't know how to interact with the visualization. Finally from the design perspective the legends were confusing and too far away from their respective sections of the visualization.

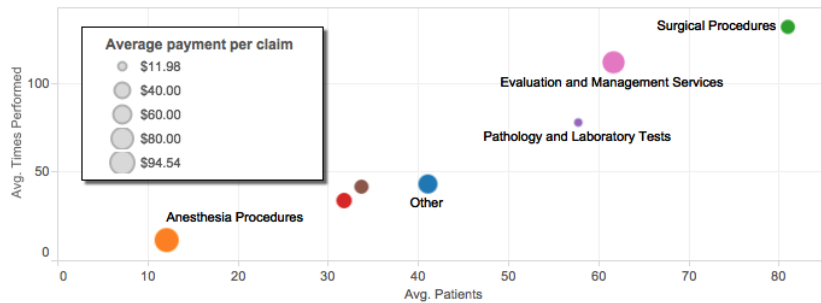
After taking the time to orient the users to the visualization and providing them with instructions on its use, we began to delve a little deeper into the content and tasks themselves. Again it became clear that we had not successfully addressed the user's needs. In

the early prototype the data was represented in bar graphs with the provider data and comparison data separated into different rows. With this layout it was hard for the users to



compare the two sets of data and therefore challenging to generate any valuable conclusions.

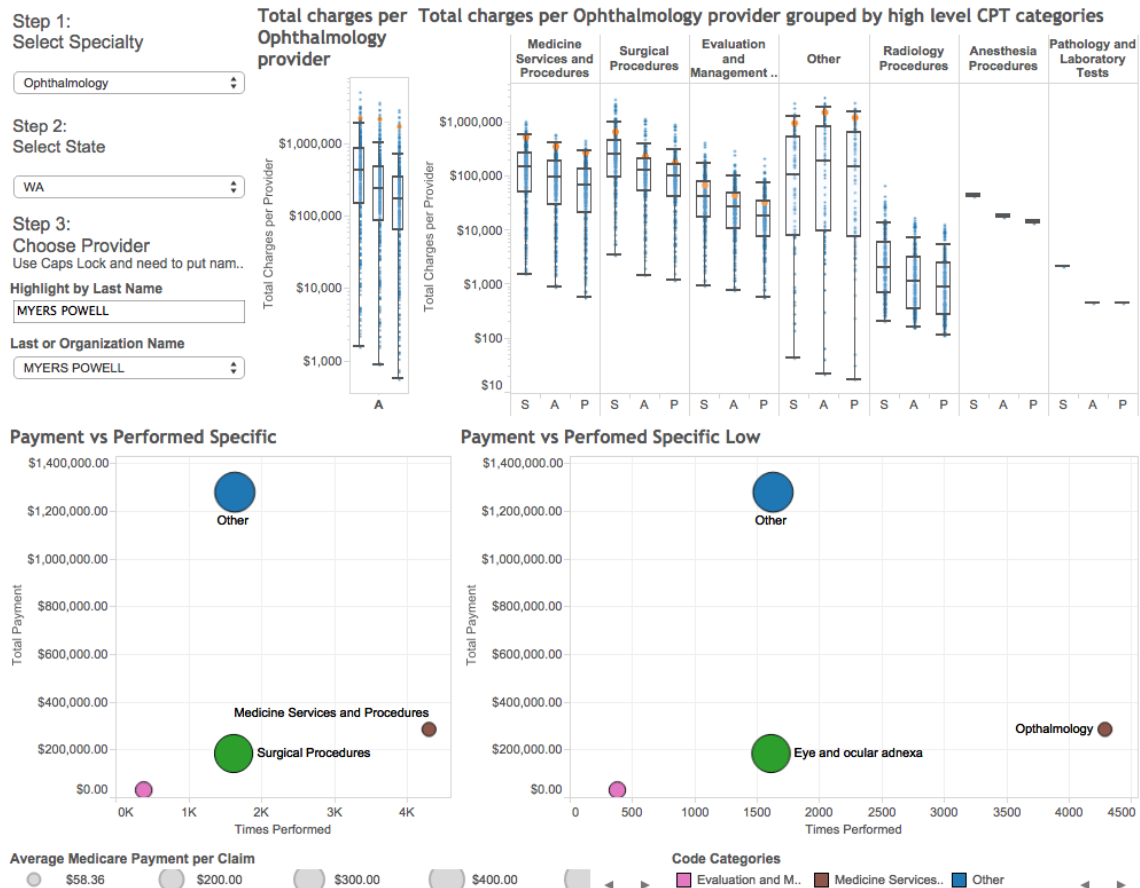
Our participants found the scatter plots visually appealing, but didn't find the content particularly insightful. In this version the plots showed the average number of times a particular service was performed as a function of the average number of patients that the service was performed on. In addition we encoded some cost data into the graph by altering the size of the circle. However, since there is an obvious co linear relationship between these



two variables (if more patients get a procedure, then that procedure is performed more often) and therefore wasn't too insightful and didn't accomplish our task of "explore and understand the types and number of your

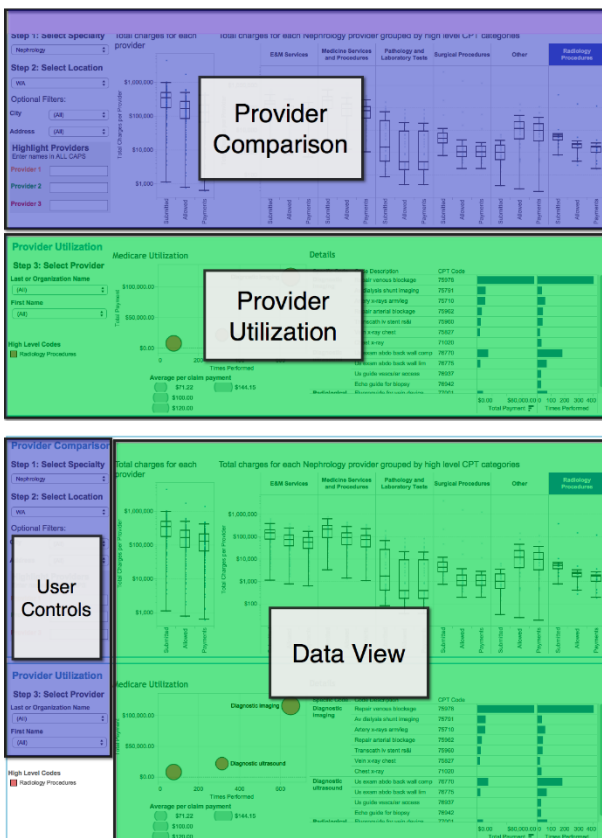
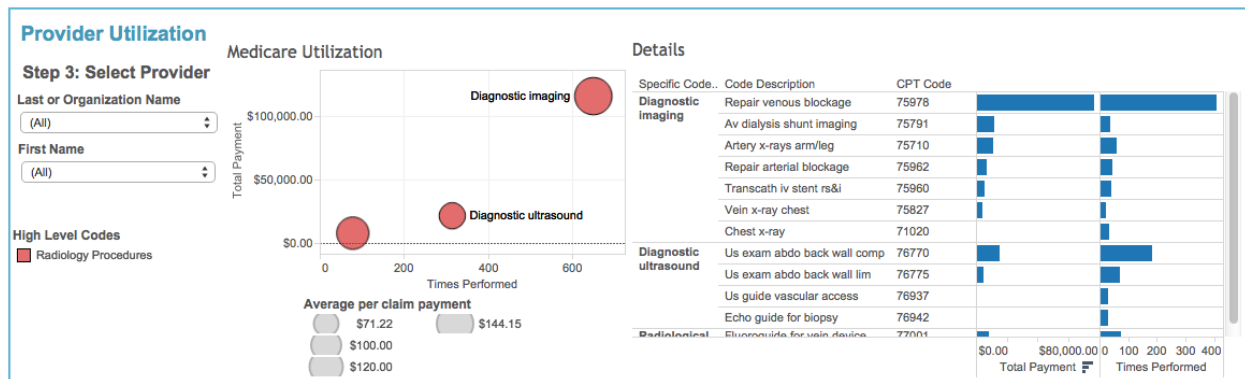
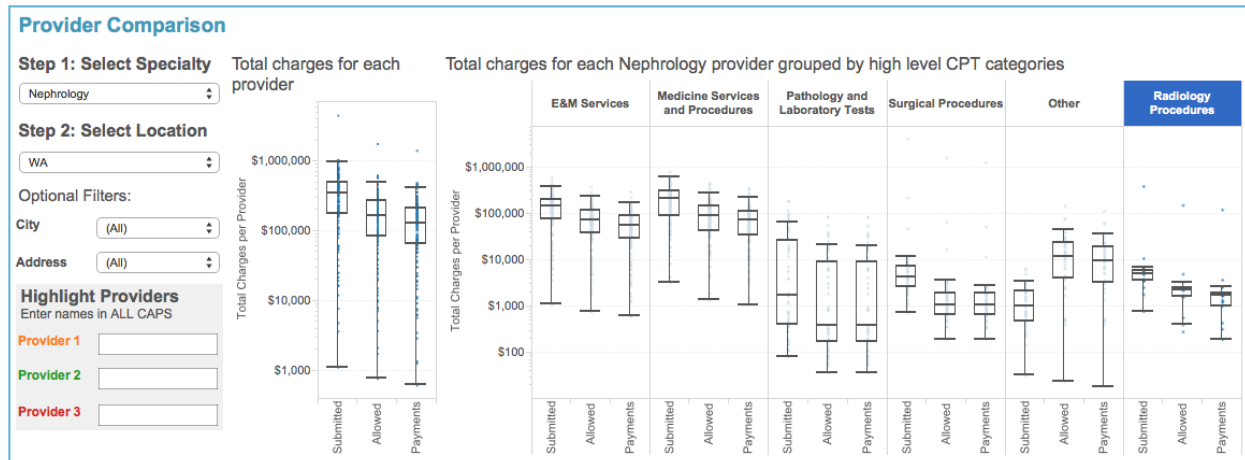
claims." The users also mentioned that they didn't want to see a comparison between different providers in this section, but instead only wanted to see data for themselves. Finally the users felt these sections were too small and should be a larger focus of the final product.

After conducting our initial rounds of testing we regrouped and redesigned our visualizations based on the feedback we obtained. We continued to iterate and refine our designs based on additional user testing. Here is an example of early prototype of the final provider visualization:



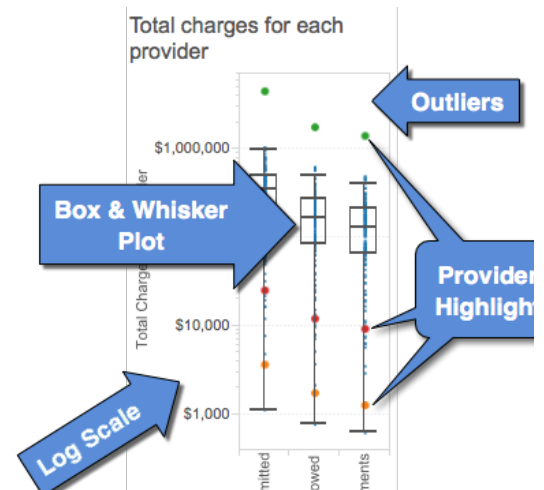
We moved away from the bar chart design and decided to utilize a box and whisker plot. This new approach allowed the direct comparison required by our users. In addition, we altered the content in the scatter plots again to satisfy our desired tasks. Finally we also to redesign the layout of the page to be more intuitive as well as provide instructions to the user.

Final Provider Visualization



The final provider visualization can be broken into two sections based on the goals and tasks we set out to address: provider comparison (upper half) and provider utilization (lower half). In addition the layout can also be grouped into control and view sections, with the control section located in the upper left hand corner of the screen to improve functionality for English speaking users.

The provider comparison section of the page allows users to see the

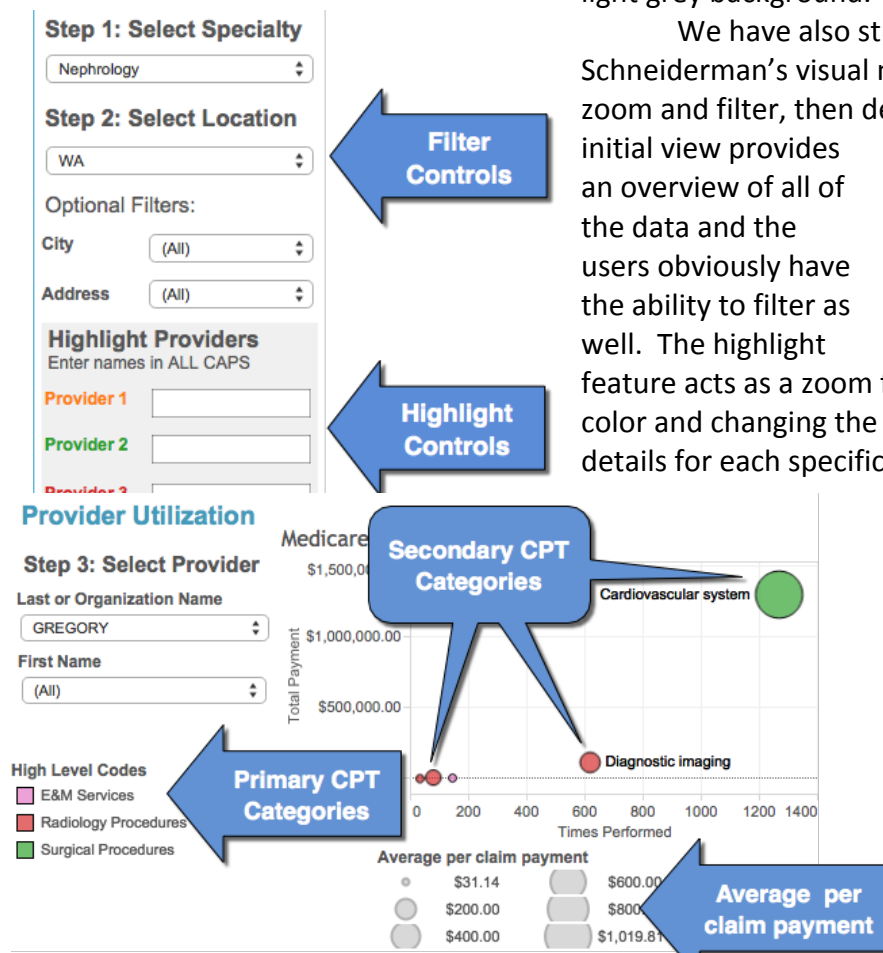


distribution of charges (submitted, allowed, and received) for providers included in the filter controls. This view shows both the total charges as well as the distribution of charges based on the highest Current Procedural Terminology (CPT) code categories. In order to represent this information we decided to implement a box and whisker plot, which is a great way to visualize a distribution of values as it shows the median value as well as the interquartile values. In addition we made a conscious decision to not extend the whiskers to include the entire range of values in order to identify outliers in the data. Given the large range of data covering multiple orders of magnitude, we decided to utilize a logarithmic scale to ensure the full range could be easily identified.

In order for the visualization to accomplish its main task of allowing a user to compare a provider to other providers, we have added a highlight control. The user first selects the appropriate comparison group through the use of the filter controls, selecting the specialty as well as the state. In addition, should the user so choose, they can further refine their focus by selecting a city and address for a specific practice. Once the filters have been applied, the user then can type in the name of up to three providers they would like to see highlighted on the visualization. Due to limitations with Tableau and the underlying data, the user must type the specific provider's name utilizing all capital letters and cannot select from a pre-compiled list. After this information has been entered, the providers points in the figure will be highlighted by both a color change as well as increasing the size of the point. In addition the search field labels are colored orange, green, and red to also provide a visual clue to user that these controls will perform a highlight action, labelling that point with the corresponding color. In order to distinguish between the filter and highlight controls, the latter appear only a light grey background.

We have also strived to achieve Schneiderman's visual mantra: "Overview first, zoom and filter, then details on demand." This initial view provides an overview of all of the data and the users obviously have the ability to filter as well. The highlight feature acts as a zoom function through the use of color and changing the size of those points. Finally, details for each specific point as well as each box plot are accessible through a cursor hover function.

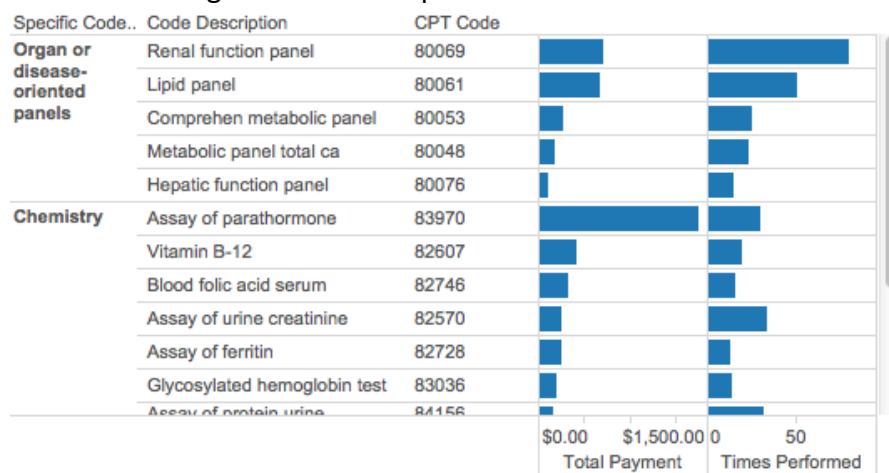
Upper Whisker: **\$413,403**
Upper Quartile: **\$213,332**
Median: **\$131,295**
Lower Quartile: **\$65,996**
Lower Whisker: **\$622**



The second part of the provider visualization is designed to present the distribution and

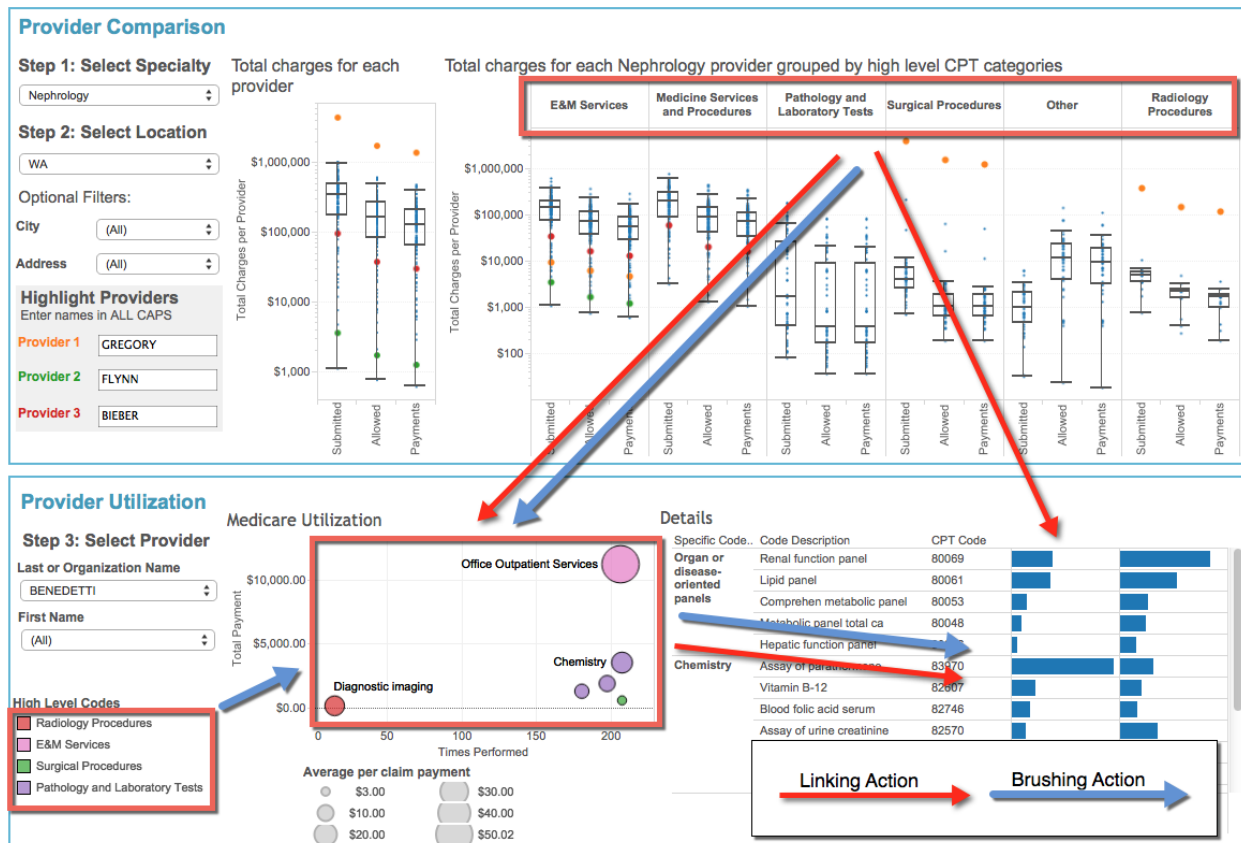
frequency of services offered by a single provider. A provider contained within the filters selected in the upper visualization can be selected from a drop down showing their specific details in a scatter plot. This scatter plot looks at the relationship between the frequency of services and the total Medicare payments these services generate for the selected provider. Each individual circle represents one secondary CPT grouping (described previously and labeled on the chart) however, the color of the circle encodes the primary CPT category. Finally, we have encoded the average per claim payment for a particular group of services by changing the size of the circle. Again we have provided details on demand through a hovering tooltip function which includes the names of the CPT categories as well as the specific values for the number of times the procedure was performed as well as both the average and total payments.

The final section of the provider visualization shows the specific procedures offered by a provider when a CPT category (either primary or secondary) is selected in any of the other sections of the page. Once a category has been selected all of the specific codes or procedures performed by that individual provider are displayed as a bar chart in a visual crosstab layout allowing for a comparison between payment and frequency. This technique again allows the provider to identify procedures where there is a discrepancy between these two variables allowing the provider to again maximize revenue. Again, in this section details on demand are available through a hover tooltip action.

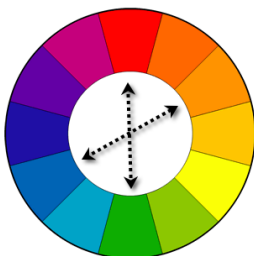


As mentioned above the filter controls the left side of the display control all aspects of the visualization. In addition we have linked the upper and lower parts of the display to facilitate additional filtering and brushing of the

data. When a user selects one of the categories in the upper visualization that category will be displayed in the lower section of the visualization.



In both versions of the visualization we utilized Tableau's default color scheme: Tableau 10. This color scheme works well when encoding up to 10 different categories for a specific variable. With the exception of the provider utilization section, the visualizations only use four colors: blue, orange, red and green. These four hues form two complementary color pairs as they appear opposite of each other in the hue wheel. Complementary color schemes provide contrast allowing the reader to see the differences in the data that we are trying highlight.



Evaluation

Overall, we were able to generate a substantial set of iterations in a short period of time because Tableau allows for quick changes to be made. This ability to make mistakes early and often without losing work and wasting precious time was one of the key factors in our work. However, we sometimes ran into limitations in the Tableau suite that affected our design decisions.

Some of these issues include dialog boxes that are tied to provider data in the database that is formatted in all capital letters. We were not able to find an efficient way of dealing with this limitation, and as a result we decided to include instructions for the user to use all capitals. This was problematic for one of our testers, and as a result he was not able to use some of the primary functionalities of the dashboard without additional guidance. Fortunately, most of the issues we observed in testing were relatively minor and did not appear to have a significant

impact on the ability of the user to complete a given task. Where there were issues like with the map, users quickly found an alternative by using the filters.

On the other end of the spectrum were the things that not only allow the user to complete a task but also sometimes delighted them in the process. One example of this was when the user was asked: “Now that you’ve found a doctor try to get his contact information to make an appointment.” The user would then click on the name of the provider and would be presented with the appropriate page from google.com search results showing that provider’s contact info.

In terms of usability, we discovered early on that it was more intuitive for the user when the dashboard was tailored to their specific goals. We developed a “choose your own adventure” style prompt on the landing page asking the user: “Which are you? Provider or Patient?” As an added bonus, we were able to address specific usability concerns throughout the design process with a much finer level of resolution.

One example of this was exemplified by the use of box and whisker plots to compare relative Medicare utilization for specific procedures per provider. As Few points out: “In most instances, no form of distribution display supports the examination and comparison of several distributions better than box plots.” (Few 233)

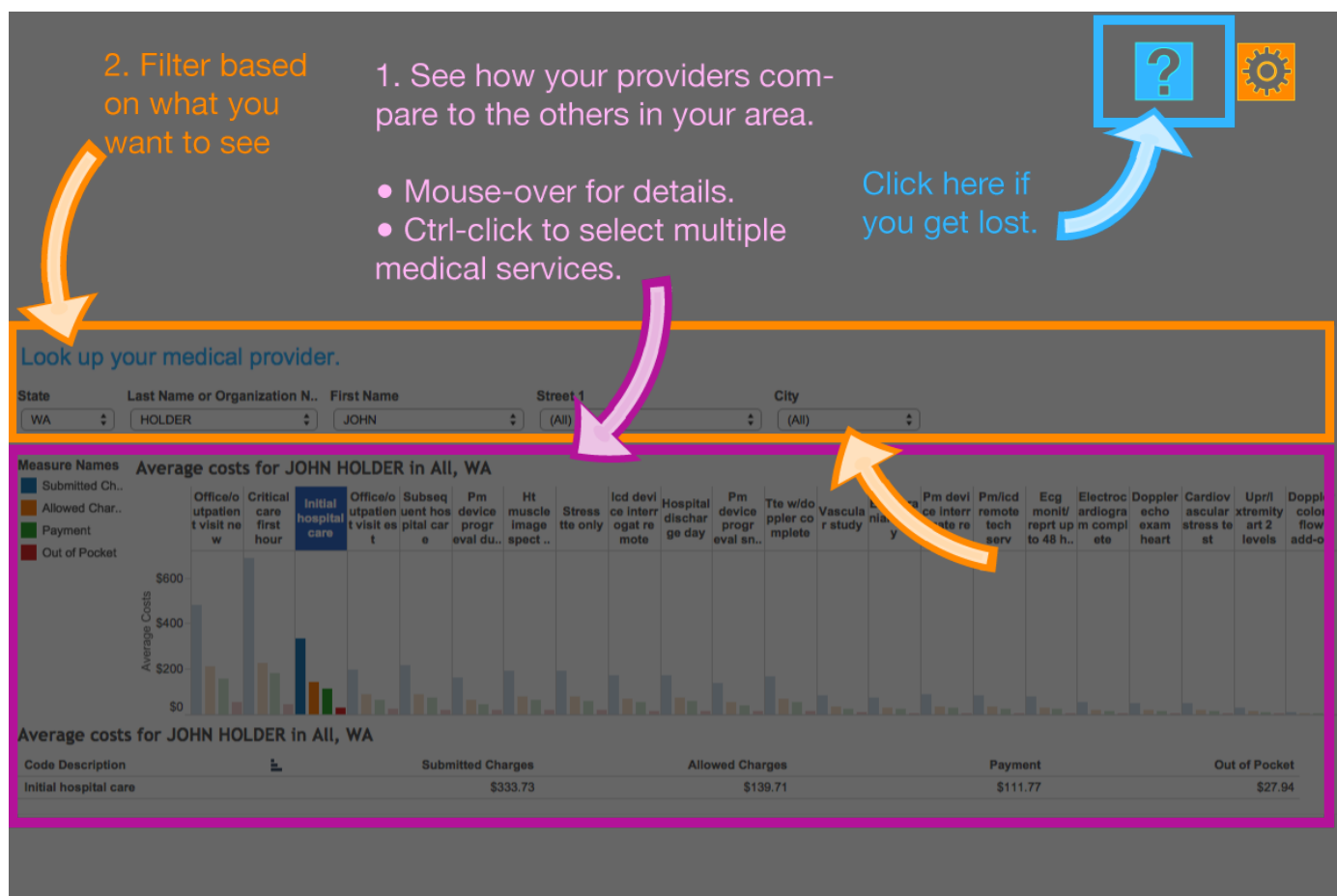
However, while most medical providers are no stranger to box plots, patients may not be familiar with them. This could be a frustrating complication at best, or worse still the user could misinterpret the meaning of the box charts resulting in costly errors. As a result, when a user selects the Patient option, they are directed to a much more accessible and approachable looking dashboard with simpler bar graphs.

Both the Patient and the Provider dashboards adhere to Shneiderman’s infovis task guidelines including overview first, zoom and filter, then details on demand. Then brushing and linking are used in both dashboards to bring the data to life. Finally, with a single click, the user can look up their provider of interest and even contact them with another single click.

While history (undo, redo, list of changes) would have been a nice addition, once again we found ourselves limited by our choice of implementation tools. These features are not enabled in the embedded web dashboards but instead they only work if the user were to download the data and use Tableau Desktop.

Further work

Some of our future includes first a way to improve upon the visualization being used the first time. Our idea is to provide an overlay that shows some “Help” content to the user, before interacting with the Tableau interface. This is because it is not always clear for a user that they can click on a piece of data, or hover over it to reveal more.



At this time there is only data available for 2012. If CMS ultimately decides to release subsequent years we believe incorporating this additional data into the tool has the potential to provide additional insight to both our target user groups as it would allow them to see the current status as well as historical trends in the data.

Given that the Physician and Other Supplier PUF only contains information regarding Medicare claims, it doesn't provide a complete picture of a health care providers practice patterns. In order to address this limitation we would like to include non-Medicare claims data for individual healthcare providers. Having this additional information would allow us to not only provide this complete view but it would also allow us to provide some additional insights not currently possible. For example, we could show the number of times a provider performs a particular surgical procedure over a defined period of time, and allowing a consumer to select the provider in their area with the most experience.

Finally it would be interesting to explore some of the additional features in Tableau 8.2 such as the more robust map functionality to further refine how users visualize regions, and navigate the map itself. In addition we want to explore how other visualization tools can improve the delivery of this information without the limitations of Tableau.

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Medicare Provider Utilization and Payment Data: Physician and Other Supplier Public Use File: A Methodological Overview. Centers for Medicare & Medicaid Services. Centers for Medicare & Medicaid Services, <http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Provider-Charge-Data/Downloads/Medicare-Physician-and-Other-Supplier-PUF-Methodology.pdf>