Automated VTE Prophylaxis Surveillance and Quality Assurance Tool

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Background and Problem

Venous Thromboembolism (VTE) is a disease process that includes both Deep Vein Thrombosis (DVT) and Pulmonary Embolism (PE). DVT is caused by blood clots forming in the deep vein. The associated symptoms include pain, redness, and swelling in that region. ⅓ of the time, DVT may suddenly lead to PE which can be fatal. PE happens when the blood clot detaches from the deep vein and makes its way over to the pulmonary vein, obstructing the blood flow through the lungs. Symptoms include difficulty breathing, heart palpitations, and abnormally low blood pressure. ⅓ of patients with DVT will get PE. This is a disease that is difficult to diagnose, with DVT having diffuse symptoms that gets significantly more serious and deadly once the disease evolves to PE. In fact this is the case for the almost 800,000 patients who die from VTE each year worldwide. In the United States, VTE is responsible for 100,000 deaths. Diagnosis is mostly done through imaging modalities like ultrasound and CT. The normal course of treatment involves anticoagulants and surgical operation.

⅔ of the cases for VTE happen in the hospital environment where patients are often limited in their mobility. The best way to prevent VTE is to perform preventative measures for patients who are deemed "at-risk" before a blood clot even forms. However, this can be difficult to enact as policy in hospitals. In 2005 at the Johns Hopkins Hospital, it was found that only 33% of 322 patients were receiving risk-appropriate prophylaxis. This led to the formation of a paper smart order set that later became computerized. Even with the smart order set, the level of compliance was still not optimal.

This led to the recent establishment of a monthly report (fig. 1) that is sent to the clinicians each month, ranking their monthly as well as cumulative compliance. However, this monthly report is laborious to create and lacks additional features that clinicians as well as administrators may be interested in.

Rank	UID	CURRENT MONTH			OVERALL ACADEMIC YEAR		
		February 2015			July 2014 – February 2015		
		Compliant Orders	Number of Orders	Compliance	Compliant Orders	Number of Orders	Compliance
1	A071	2	2	100%	60	60	100%
1	A241	3	3	100%	53	53	100%
1	A001	5	5	100%	44	44	100%
1	A024	4	4	100%	43	43	100%
1	A031	4	4	100%	40	40	100%
1	A161	3	3	100%	38	38	100%
1	A271	10	10	100%	36	36	100%
1	A004	6	6	100%	27	27	100%
1	A014			n/a	27	27	100%
1	A041	3	3	100%	26	26	100%
1	A074	8	8	100%	23	23	100%
1	A051	11	11	100%	22	22	100%
1	A013			n/a	18	18	100%
1	A131	5	5	100%	14	14	100%
1	A111			n/a	4	4	100%
16	A191	9	10	90.0%	75	76	98.7%
17	A054	10	10	100%	72	73	98.6%
18	A034	9	9	100%	59	60	98.3%
19	A062	2	2	100%	52	53	98.1%
20	A011	5	6	83.3%	49	50	98.0%
21	A301	1	1	100%	38	39	97.4%
22	A044	1	1	100%	30	31	96.8%

Fig. 1: Current clinician ranking pdf

Technical Approach

We propose to automate this monthly report while adding additional features into the system, allowing for us to create a rich database of information. Ultimately, this tool is intended to give individualized performance feedback to residents and customized education based on historic performance.

We started off with getting the certifications that allowed us to view sensitive patient information. They were: “HIPAA for Research”, “Basic Human Subjects Research”, and “Conflict of Interest and Commitment”.

Our technical approach to achieve this goal was to use Ruby on Rails as a web development platform to create a web tool that will allow clinicians to login and access personalized statistics based on VTE compliance. We use Sqlite as a development database with the ability to convert to PostGreSQL upon deployment of the web tool. Additionally, we use Bootstrap to beautify our web tool.

We first start with the Excel data that is automatically output every month. We import this Excel data onto the web tool in CSV format. The data that is imported is separated into the relational database (fig. 2) that we created where the attributes are separated into either the provider or the order. The final product will have user authentication from JHU log in order to achieve confidentiality and personalization of views. After login, the user is presented with our various views starting with the Overview screen.

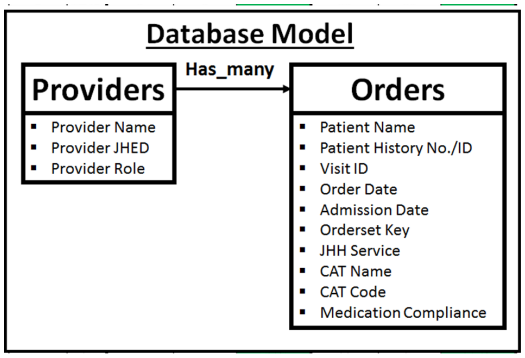

Fig. 2: Model of relational database

Overview

The overview screen is meant to give a busy clinician a quick snapshot of his or her statistics. It shows the cumulative rank, cumulative compliance, as well as the past month compliance. The items in the compliance list are color coded based on whether or not the values fall between specific intervals that the Deans of Johns Hopkins Hospital deemed appropriate

(greater than 96 as green, between 96 and 90 as yellow, and below 90 as red).

Ranking

This is a replication of what the current monthly pdf report that is sent to each provider looks like. We beautify it with Bootstrap elements and include an easy way for the user to figure out which row he belongs to, doing away with assigned user ids that can oftentimes be ambiguous. The information that is listed involve the monthly as well as cumulative prophylaxis record of both the provider who is logged in as well as the other members of the provider's cohort. Additionally, the list is sorted by rank based on cumulative compliance so the provider can see where he or she physically falls on the compliance spectrum. The user can also click on the row to find out more information on the patients that received inappropriate VTE prophylaxis (Compliance screen).

Trends

This trends screen shows the historical cumulative prophylaxis per month. It allows the provider to visually assess the compliance of prophylaxis treatment that he or she has been prescribing to patients.

Compliance

The compliance screen lists the times when the provider was noncompliant complete with patient name (redacted in the report due to patient privacy). It includes identified patient data as well as what the patient risk category was.

Development and Validation

On the front end, our GUI went through numerous design iterations. Our first iteration (fig. 3) was figuring out the general idea of how we wanted the web tool to look. The screenshot on the left was a basic GUI with all of the elements on the same page. The screenshot on the right was a more interactive GUI that was less cluttered.

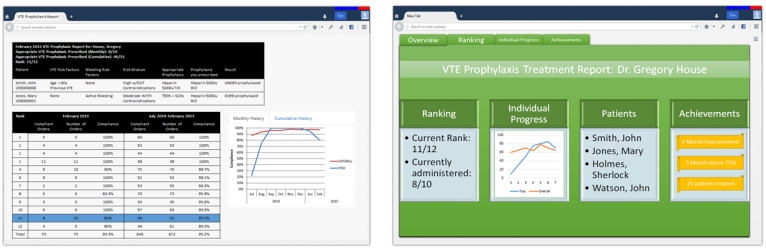

Fig. 3: Initial graphical user interface

After the first iteration, we talked with Brandyn Lau, our mentor, who suggested additional changes which were implemented in our second GUI iteration (fig. 4). This design used official Bootstrap elements and colored rows to effectively convey the information that needed to be presented. We created this mockup with HTML, using static data to represent the dynamic compliance statistics that could be pulled from the back end after it was developed. We used *morris.js* to plot the trend lines correctly.

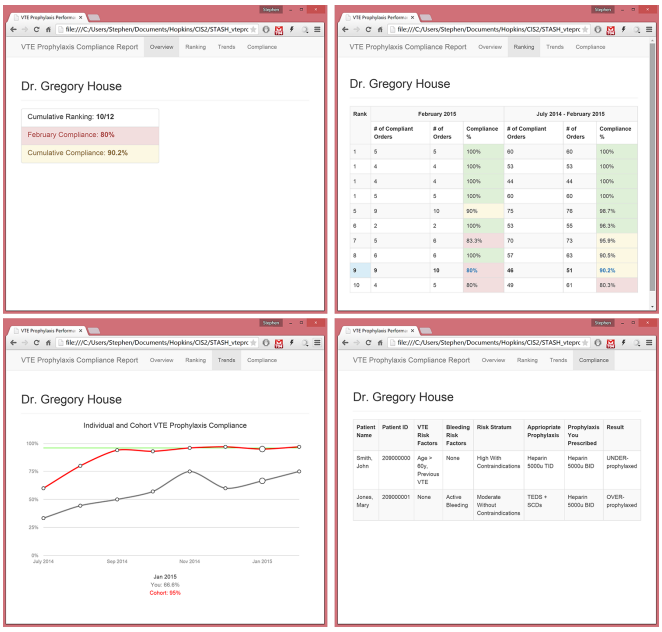

Fig. 4: Second design iteration

Our most recent iteration of the graphical user interface (fig. 5) was a result of additional interviews with clinicians. We shifted over to using the *chartkick* gem on Rails as well as made other stylistic changes to reduce clutter.

We implemented the relational database that we designed which works for both SqLite (for development) and PostgreSQL (for deployment) to create the dynamic display of information. This was the big step for us as our web tool finally had the capability of displaying the statistics to whatever raw data the user input.

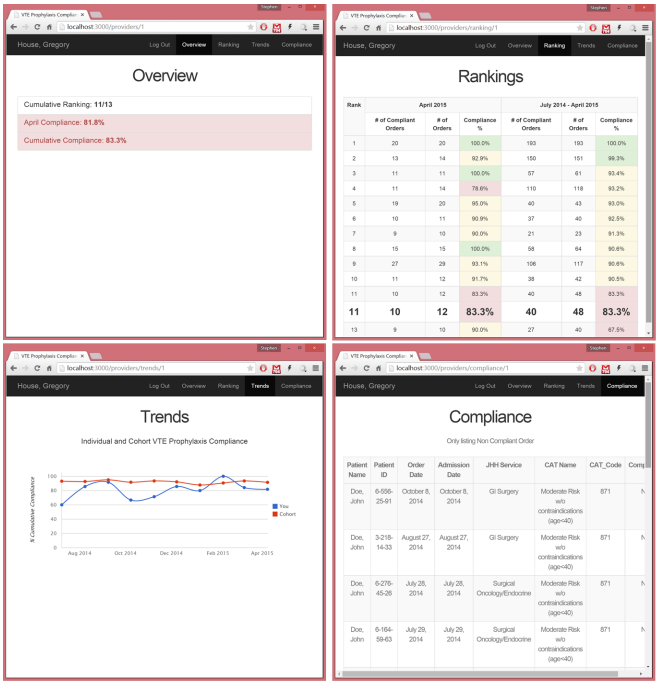

Fig. 5: Most recent design iteration

Our designs throughout the process went through multiple validations such as usability from our interviews with clinicians as well as valuable input from two of our mentors Brandyn

Lau (who gave us general information on what was needed on each page) as well as Michael Cohen (who advised us on the back-end component of the project). We first developed the most recent iteration of the web tool on just a few points of data that we made up. We then input 13 providers each with tens if not hundreds of order to test our web tool's ability to process a larger dataset. In the future, we will submit the webtool for QA testing as well as inputting larger datasets to test for performance.

Conclusion

We partially met our expected deliverable of creating a web tool that ranks clinical provider compliance and incorporates some advanced features. We implemented all of the functionality that we had planned for except the educational component of our *compliance* tab--this was due to data not becoming available in time as well as a lack of time on our end. In terms of our expected functionality, our tool automates the comparison of the compliance history of the provider with the overall compliance of the cohort, replicating the current pdf report that is generated by hand. By tracking the recent compliance trends the tool provides tangible feedback to the provider that incentivizes them to prescribe risk-appropriate prophylaxis. Measured by this primary goal, we consider our project a success.

Our maximum deliverable of creating achievements for a positive reinforcement system was not reached--this was partly due to further discussion with our mentors concluding that it would be not effective.

There is still more work to be done on the application (such as going through the expected deliverable of QA) before it can be deployed and we will continue work on refining and adding additional features while going through the proper channels to make sure that our app will be ready to go.

Management Summary

Both of us collaborated evenly on the entire project. Our initial layout of responsibilities had Stephen in charge of the front-end and Vamsi in charge of the back-end of the web tool. This meant that during the first stage of our project Stephen worked on developing the Bootstrap GUI mockups and figured out how to model the web page using static data. Vamsi worked on

building the Ruby on Rails databases and developing the data models. When we came together, we each learned all the necessary information for creating the full-fledged web tool and managed to effectively bridge the gap between the front-end and the back-end. In terms of accomplishments, our current web tool is an effective proof of concept. However, while it has most of the necessary functionality, it is not ready to be launched immediately as there are additional features that still need to be implemented and refined.

Further Directions

We will actively work towards refining the webtool in the coming days. We will keep contact with our mentors to figure out how to best ensure that the web tool will be ready to go live this upcoming month.

We have some more steps that need to be achieved before the final launch. First, we need to properly automate VTE prophylaxis data acquisition. Currently, we need to parse the data into multiple CSV files to load each Provider's orders into the database. The ultimate goal is to make it so that a single CSV file can be used to update the entire database. Second, we need to incorporate an administrator view so that the managing director of the department can monitor the provider compliance performance as well as keep track of how often providers check their status. Finally, we need to connect this web tool with the Johns Hopkins authentication system to provide network security as well as user authentication.

Official quality assurance testing also needs to be done and we will be prioritizing that as well.

Lessons Learned

Through this project we learned the necessary skill set for sophisticated web server development with Ruby on Rails. A major challenge we faced was fulfilling all of the developmental dependencies for Rails. Because Rails is difficult to fully utilize on a non-Unix system, it was very difficult to establish the Rails environment correctly. Furthermore, we both learned how to collaborate within a software development context, which was made exceptionally difficult due to both of our lack of expertise and knowledge in both Ruby on Rails as well as databases. We underwent a large number of online resources to gain the knowledge to create this web tool. All in all, we would say that our knowledge of web development using

modern tools exponentially increased throughout the entirety of this project.

Acknowledgements

We would like to thank our mentors Brandyn Lau, Gorkem Sevinc, and Michael Cohen. Brandyn Lau was our VTE Expert and provided us with a lot of content support. Gorkem Sevinc, the manager of Johns Hopkins Hospital Technology Innovation Center (TIC), was the head mentor and he was very helpful in developing the overall picture of the project. Michael Cohen, TIC Senior Engineer, was our technical mentor and was extremely helpful, willing to give feedback and provide knowledge even at late hours. Travis Poulsen, also from TIC, was enough to step in when Michael was unavailable and provide us with valuable and timely technical support. Needless to say, we would not have been able to do our project with any one of them, and we are extremely thankful for this opportunity.

We would also like to acknowledge Dr. Elliot Haut, JHU surgeon, for contributing to the VTE research that lead to this project. Last but not least, we would like to thank the clinicians who gave feedback on our design throughout the process and were instrumental in coming up with the features that ultimately formed our design model.

Publications

Lau BD, Haider AH, Streiff MB, et al. Eliminating Health Care Disparities With Mandatory Clinical Decision Support: The Venous Thromboembolism (VTE) Example. Med Care. 2015;53(1):18-24.

Streiff MB, Carolan HT, Hobson DB, et al. Lessons from the Johns Hopkins Multi-Disciplinary Venous Thromboembolism (VTE) Prevention Collaborative. BMJ. 2012;344:e3935.

Office of the Surgeon General (US); National Heart, Lung, and Blood Institute (US). The Surgeon General's Call to Action to Prevent Deep Vein Thrombosis and Pulmonary Embolism. Rockville (MD): Office of the Surgeon General (US); 2008. Available from: http://www.ncbi.nlm.nih.gov/books/NBK44178/

Appendix

Code Repository: https://integration.johnshopkins.edu/stash/projects/VTEP/repos/vte/browse
(Note that due to presence of patient-identified data, access is restricted).