Design History Workbook

InManage - Inpatient Rehabilitation Management

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Section 1: Executive Summary

INCOMPLETE

Rehabilitation hospitals process a vast amount of patients annually, with Riley children's hospital rejecting 156 referrals in the year 2020 and accepting only 136 [1]. With 2.4 billion people globally in need of rehabilitation and a predicted increase in the coming years, rehabilitation hospitals are likely to see an increase in incoming patients [3][4]. However, many challenges arise with efficient and effective processing as referrals are generally non-standardized, lengthy, and manually processed by admissions directors and clinical nurse navigators [2][5]. With such a high variation in documentation and referral length, it can take hours to process a single patient, which is difficult for large hospitals such as Lafayette Regional that process over 150 referrals a month [2]. Rehabilitation hospital staff need a way to process patients more efficiently, creating a need for a solution that processes and organizes patient referral information to decrease processing time and make the decision-making process faster.

Current EHR softwares have a way to digitally store patient record information, however, since EHR softwares such as Epic and Cerner are competing, rehabilitation facilities end up taking most of their referrals through fax due to a lack of compatibility between EHRs. Allscripts, a middleman software, helps bridge the gap of compatibility by letting hospitals send information securely, however, it doesn't store digital patient information [2]. Beyond EHR and Allscripts, the two best current solutions on the market are Cerner Rehabilitation and Wellsky. Both allow for storing of patient information and Cerner has limited EHR communication, however, neither have any way to process faxed information that rehabilitation hospitals receive [11]. Furthermore, Allscripts and Cerner both lack dashboards and were rated poorly in terms of ease of use [19][20]. Even with current solutions on the market, there's still a vast amount of manual typing of patient information that has to be done. With Wellskys software implemented at Lafayette Regional Hospital, staff have explained that it still takes hours to process a patient due to manual processing [2]. Looking at emerging solutions, there is currently a patent for a concept about processing patient information looking into transferring information from one EHR to another. This patent could help break the barrier between EHRs, but is not rehab specific and still in the early stages of conceptualization [16].

- brief description of the potential market with the target customer identified
- a brief description of the designed solution and its innovative aspects and a summary of the key testing results that demonstrate the designed solution solved the problem posed
- Closing statements should address future work and make recommendations for translation to the medical market

Section 2: PROBLEM STATEMENT AND CLINICAL NEED STATEMENT

2.1 Description of the team's understanding of the problem

The development of an updated inpatient rehabilitation referral system was suggested by Jennifer Bright who works as a clinical nurse navigator at Riley Hospital for Children. For reference, in 2020 alone Riley Hospital for Children in Indiana turned away 156 referrals for inpatient rehabilitation, with 136 referrals being accepted and 113 patients being admitted in total [1]. Looking in the Greater Lafayette area, the Lafayette Regional Rehabilitation Hospital receives around 150 referrals a month, and accepts less than 50% of those patients [2].

2.2 Clinical Need Statement

Approximately 2.4 billion individuals worldwide have a health condition that necessitates rehabilitation, and this figure is anticipated to rise in the coming years as the number of traffic accidents and children with impairments is anticipated to rise [3][4]. Even the existing need for inpatient rehabilitation, nevertheless, is not being satisfied. Processing referrals for rehabilitation may easily turn into a challenging and drawn-out procedure due to the rising demand for inpatient rehabilitation and the scarcity of care facilities. It is challenging to accurately assess and compare patients with regard to their requirement for inpatient treatment since the patient referral procedure is incredibly non-standardized and referral sizes vary greatly across patients (from a few words to several pages) [5]. It is also challenging for rehab staff to swiftly process patients and determine whether they fit the essential criteria since hospitals use a range of different documentation methods for their patients that nurses need to manually decipher and record when processing referrals [5][1].

2.3 Engineering Problem Statement (Statement of Work)

With a growing demand for inpatient rehabilitation and failure to meet current demands efficiently, the number of patient referrals needing to be processed in inpatient rehabilitation units is on the rise [6]. With a lack of standardized documentation between and within hospitals, difficulties arise when trying to process patient referrals, identifying a need for improving these processes. Inpatient rehabilitation hospitals need a better system of processing patient referrals and organizing patient information. A solution to this problem should organize clinical patient information and highlight important criteria, allowing doctors and nurses to more easily review patient information. Ease of use is an important outcome of our solution. Training needed in order for nurses and doctors working in the rehabilitation centers to be able to use our solution should be virtually accessible and be able to be completed in no more than a single workday. Furthermore, the amount of time it takes for patients to be processed should be decreased from the several hours per patient Riley Hospital cited down to 30 minutes +/- 10 minutes as information processing and organization makes the decision-making process easier [5].

Section 3: PROBLEM DESCRIPTION

3.1 Summary of Clinical Problem

Healthcare Engineering Design

The World Health Organization (WHO) defines rehabilitation as, “a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment” [3]. Whether that disability or lack of functioning is due to muscle atrophy from extended time on an ICU ventilator or a traumatic brain injury leading to loss of motor capabilities, rehabilitation needs can come from a wide variety of conditions. Sometimes rehabilitation is needed following a surgery or injury, sometimes it’s needed after aging reduces function, and sometimes it's needed as life-threatening illnesses such as brain cancer begin to impede a person’s ability to function [3].

The current processes for organizing inpatient rehabilitation is inefficient and non-standardized, since there are multiple factors that need to be considered when processing patients. The absence of consistent charting or assessments between hospitals and individual clinicians further slows down the decision-making process for inpatient rehabilitation. It is challenging to swiftly prioritize patients and gain a strong understanding of which individuals are most suited for inpatient rehabilitation.

Referral management systems are in charge of simplifying and increasing transparency across the whole referral process. However, communication breakdowns between hospitals and rehabilitation facilities are a persistent problem for health systems that rely on manual referral management methods. Different kinds of electronic health/medical records are used by numerous primary and secondary healthcare providers. Many of these providers employ hybrid systems as a result of numerous healthcare system acquisitions and mergers. For referral management solutions, interoperability between various EHR/EMR systems is a significant difficulty. This lack of coordination causes a number of issues, including ineffective clinical referral systems, broken referral loops, missing medical data, and delayed treatment [2]. These issues have a negative impact on patients' health outcomes and the standard of treatment they get.

Rehabilitation referrals contain variations in charting and content, making it difficult to quickly prioritize patients and get a good understanding of which patients are most appropriate for inpatient rehabilitation. Non-standardized documentation can lead to patients being admitted into inpatient rehabilitation without an actual need for inpatient care, taking a bed away from a more critical patient.

Web-based EHRs are expected to have an average upfront cost of $26,000 and a monthly cost of $8,000 [7]. The average total cost of ownership over five years is $58,000 [7]. These expenses often result from the possible need to deploy new hardware, such as data servers, or software, such as interface modules [7]. In addition, there are expenses related to installation, maintenance, and training. The typical cost of additional software is $5,900 [8]. Given this knowledge, it will be crucial to provide a solution with a cost below $5,900 so that it would be more appealing to our clients since current solutions are still not meeting their needs.

3.2 Summary of Current Solution Landscape

To manage patient information software systems are used to store patient records, referrals, and communicate between hospital staff. Electronic Health Records (EHR) are the most general way to organize patient records. EHR includes patient vitals, patient demographics, doctor notes, and referrals [9]. There are multiple companies that provide EHR systems, such as Cerner, Wellsky, Epic, and Allscripts. However, in efforts to monopolize the EHR market, different software do not communicate with each other, making it challenging to send documents from healthcare facilities with different systems. At the Lafayette Rehabilitation Hospital, they believe Allscripts is best to securely send information between EHR systems [2]. Likewise, Epic is used by many hospitals in the greater Lafayette region [2] and has multiple additional features that can improve patient processing [10].

Specifically for rehabilitation, there are two main software on the market, Cerner Rehabilitation and WellSky's Inpatient Rehabilitation Solutions Software. Cerner Rehabilitation software is used to display information on patients needing inpatient rehabilitation. The software is used to store information on the patient and the rehabilitation unit. Information for the hospital on the physicians, referrals, and treatment plan is stored as well as information for the rehabilitation unit on the therapists, scheduling, and workflow. The Cerner software can communicate limitedly with other EHR providers enabling documents to be transferred electronically, minimizing errors, and expediting the referral process [11]. However, based on the limited information Cerner provides to the public, it appears the rehabilitation software has no dashboard display or pdf scanning technology to process referrals. As a result, it may still be challenging for the rehabilitation staff to determine who meets the requirements for inpatient rehabilitation.

Similarly, WellSky's Inpatient Rehabilitation Solution Software is a software available for purchase that documents patients, manages scheduling, and manages workflow for the inpatient rehabilitation unit. Figure 1 displays an example of WellSky's software.WellSky uniquely provides professionals who can educate the hospital staff to optimize hospital efficiency. Their program stresses teamwork and good communication, which means their software prioritizes displays that make communication and scheduling easy [12]. Additionally, it is integratable with eRehab Data and the Inpatient Rehabilitation Facility Quality Reporting Program (IRF-PAI) submissions [12]. eRehab Data is a system that hospitals can use to complete patient rehabilitation assessments electronically [13]. Likewise, IRF-PAI is a standardized data management system that is used to assess the quality of care for an inpatient rehabilitation unit [14]. Both of the databases enable medicare and hospitals to compare and evaluate their inpatient centers.

WellSky's Inpatient Rehabilitation is used by the Lafayette Rehabilitation Hospital. It is not compatible with many other EHR and does not have any features that can scan referral documents and extract needed information, forcing the staff to manually fill out information [2]. As a result, there is much room for human error when transferring information from long referrals.

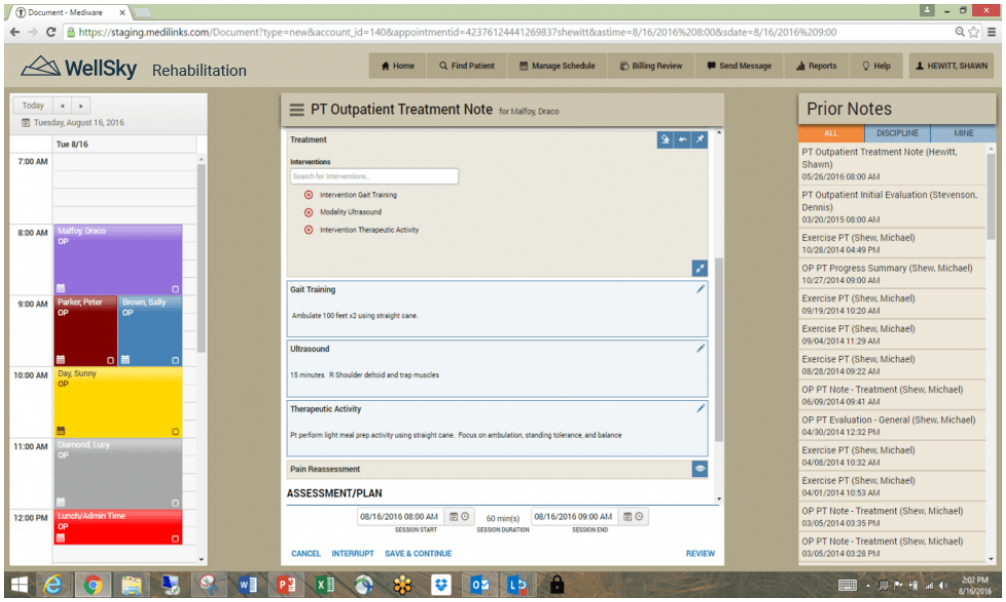


Figure 1: WellSky Rehabilitation Software example view for a hospital staff member [15].

3.3 Assessment of Emerging Technology

Since inpatient rehabilitation is managed through EHR there is no FDA approval needed. Any application programming interfaces (API) used will be from a public domain and the owner of the API will be contacted to avoid any copyright issues.

The most relevant existing Intellectual property is US patent 10,896,745 submitted by Merge Healthcare Solutions Inc. This patent is the concept of moving the patient information stored in Electronic Health Records (EHR) from one EHR system to a second EHR system. Since EHR systems do not communicate with each other, a middle software is needed to transfer the data. The patented concept is for automatically filling patient information into a specific hospital's EHR format to make for easier use. It also enables the hospital to determine what patient information they want displayed in their system, while hidden patient information is still stored in RAM memory [16].

Based on the patent, it appears InManage's concept of automatically transferring information is not novel. However, Merge Healthcare Solutions Inc's patent does not contain any IP relating to the specific code or algorithm needed to complete this data transfer. Likewise, the patent is not specific to inpatient rehabilitation. Therefore, InManage must protect the algorithm behind the inpatient rehabilitation EHR documentation transfer.

Table 1. Summary of Existing Patents

Patent Number	Summary	Similarities	Differences
US 10,896,745 B2 [16]	System for transferring information between different EHR	-Automatically fills information from one EHR to the location in the second EHR	-Patented system works for EHR in any electronic form (doc, pdf, XML, etc.) -The patented system enables parameters displayed to user to be are editable -Patented system contains no code/algorithm
US 2015/0294.088 A1 [17]	System for organizing patient EHR and summaries medical conditions/diagnosis	-Manages patient electronic health information -Allows for any type of machine learning techniques to summarize data	-Patented system does not use any PDF processing -Patented system includes probabilities of a patient having a disease
10,997,186 B1 [18]	System for processing optical EHR into text	-Processes faxed and pdf information -Pulls information from EHR and organizes it into a easy to view form	-Patented system can produce a XML file

3.4 Gap Analysis

A gap analysis was completed on the software specific to rehabilitation, as well as Allscripts, because Allscripts is used to transfer medical documents at the Lafayette Rehabilitation Hospital. To analyze the different softwares' successes, online software review sites are used. There are limited software samples available for free for individuals to view due to their nature. Selecthub is an online review site where data analysts review softwares and process user feedback to determine rankings for the current softwares [19]. It was used to determine the rankings for current solutions displayed in Table 2.

Table 2. Gap Analysis for Inpatient Rehabilitation Solutions

Existing and Emerging Solution	Brief Description	Ease of use	Accurate scanning and interpretation of pdf referrals	Compatible with different EHRs	Customer Satisfaction
WellSky Inpatient Rehabilitation Solutions Software	A rehabilitation management system, which includes a software system and support team	+/-	-	+/-	+/-
Cerner Rehabilitation	A rehabilitation software used to manage patient records and scheduling	-	-	+/-	+/-
Allscripts	An EHR system that transfers information between non-compatible EHR systems	-	-	+	+/-

Table 2 summarizes the current inpatient rehabilitation software solutions. A positive mark indicates a satisfactory result and a negative mark indicates a poor result according to user feedback. A positive and negative mark indicate a neutral response. It is clear that both WellSky and Cerner are only compatible with certain EHR records. WellSky Inpatient Solution is given a neutral rating in both ease of use and satisfaction since it prioritizes team communication with its displays. However, information must be manually filled in and there is no standardized dashboard format for each patient record [12]. As a result, the display should be improved to maximize patient processing speed and overall ease of use.

Likewise, according to Selecthub, the software solution Cerner Rehabilitation does not provide a dashboard, and requires many page refreshes, resulting in a time-consuming process to read patient information. 74% of software reviewers stated the software is time-consuming to use and the data reporting is bad, resulting in poor ease of use [20]. As a result, it will take time for a nurse and social worker to read a long convoluted doctor referral, taking invaluable time away from other patients. Thus, software that includes a clear organization of information to manage patient records and improves ease of use and efficiency of the hospital rehabilitation unit is needed.

Section 4: DESIGN SPECIFICATIONS

4.1 Target Customer and Rationale

The target customers and beneficiaries for a rehabilitation software are inpatient rehabilitation facilities, such as Lafayette Rehabilitation, and hospitals with inpatient rehabilitation units, such as Riley Children Hospital. At these facilities there are directors and managers who research EHR and purchase EHR licenses for the facilities' staff.

Likewise, the users of the software are the clinical nurse navigators or admissions personnel who receive the rehabilitation referral and determine which patients meet the requirements for inpatient rehabilitation. The rehabilitation facilities' physician may also use the software to read over the patient and determine the patient's needs. If a patient is incorrectly placed into a rehabilitation facility the admissions personnel and physician are at fault; thus, it is paramount that the software clearly displays all needed patient information.

4.2 Summary Table and Discussion of Design Specifications

Table 3 below lists the design criteria and weight for the rehabilitation software solution. Ease of use, pdf scanning, and pdf interpretation are given higher weight as these are the most desired features for the Lafayette Rehabilitation Hospital. The software satisfying the customer and decreasing the processing time of a patient are given lower weights because there are many confounding variables which affect these design criteria. For example, processing time for a patient can vary depending on a person's reading speed.

Table 3. Design Criteria Specifications

User Need	Design Criteria (Customer or societal need)	Design Specification	Weight
U1	Software must be easy to use	Obtain a score of 80 or higher out of 100 on the System Usability Scale	5
U2	Software must satisfy the customer	Obtain a customer satisfaction survey score greater than 0	2
U3	Software must improve processing time of patients	Processing of an individual patient should take 30 minutes +/- 10 minutes	3
U4	Program must be easy to train users	Employee training should take less than one workday and should be accessible virtually	1

U5	Software must accurately scan PDF information	Scan referral documents with 90% accuracy or higher	4
U6	Software must accurately interpret scanned information	Interpret documents with 90% accuracy or higher	4

Ease of use and customer satisfaction

Ease of use will be measured using the System Usability Scale (SUS). SUS is a standardized test used to measure the usability of a software using a Likert Scale. The equation is shown below [21]. Customer satisfaction will be measured using a net promoter score (NPS) and additional questions about the software. Like the SUS, NPS and the survey measures how satisfied a user is on a Likert Scale of 1 to 10. The equation is also shown below [22]. Although all responses are anonymous, at least four admission personnel should all complete the usability testing since these are the end users. The industry standard in usability is a score 80 or above for SUS [23] and 0 for customer satisfaction survey [24].

SUS $= 2.5 * [\Sigma(x) - 5] + 2.5 * [25 - \Sigma(y)]$, where x is the mean score for odd questions and y is the mean score for even questions.

NPS = Σ(% promoter scores) - Σ(% detractor scores), where a promoter score is a score of 9 or 10 and a demoter score is a score of 0-6.

Processing time

The processing time will be measured by performing a one to one usability test with at least four end users. Each person will be asked to go through a referral. A stopwatch will be used to measure the processing time. The timer will start when the user starts to log in to the website and it will end when they make a decision on the referral. The mean processing time will then be calculated using the data gathered from the four users.

*Note that the processing time accounts for the initial admission screening time, and excludes the time it takes to communicate with insurance and hospital staff as this is done independently of the website.

Employee training

An electronic training document will be created and shared with the end users. To assess the training time, instructions will be given to the admissions personnel who complete the SUS and NPS tests. Based on their feedback and the assessment results, the training provided to individuals will be modified to fix any issues.

Software accuracy

To test the accuracy of the pdf processing component of the software, 4 pdf documents which have already been processed to attain a baseline will be scanned and processed. The correct identification and placement of words/information from the pdfs will be counted and the accuracy will be calculated using the equation below.

$$Accuracy = \frac{number\ of\ correct\ words}{Total\ number\ of\ words} \times 100$$

Section 5: SOLUTION STATEMENT

5.1 Overall Solution Statement

In order to satisfy our customer needs and make patient processing easier, we came towards a software solution that could cut down human error and speed up the initial processing of patient medical records and referrals. The features of this software took into account the needs of clinical nurse navigators and admissions directors at Riley Children's Hospital and Lafayette Regional Rehabilitation center, including the need for faxed pdf records to be processed and certain information to be highlighted and easily accessible to nurses, including insurance, diagnostic, and other key information points. When discussing further needs of our user, we came up with a solution that could provide summary statistics, be easily navigable for users, and that could summarize information so it could be easily analyzed for key criteria. An initial brainstorm of user requirements following discussions with Lafayette Regional Hospital can be seen below:

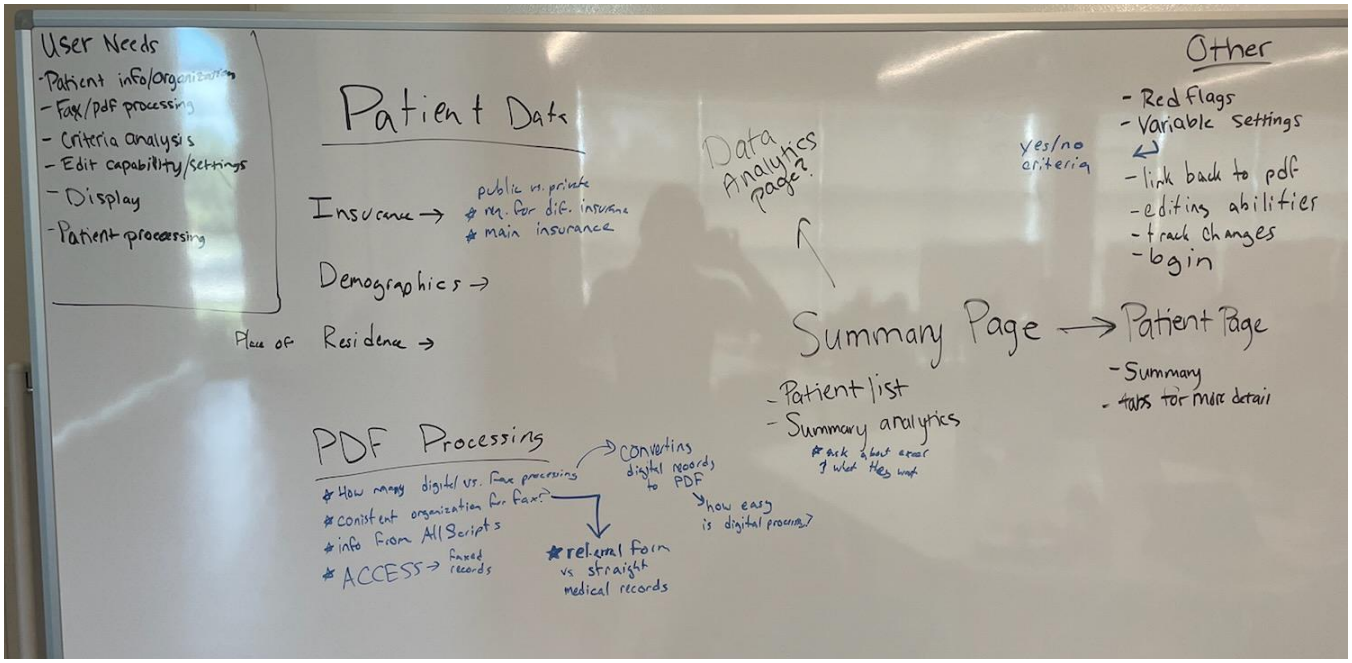


Figure 2: Brainstorm of user requirements

From these user requirements, an architectural design was then developed that could relate the different subcomponents of our software solution needed to meet our user needs, which can be seen in section 5.2.

One user need that was taken into consideration later on was the need for a secure platform that could protect patient privacy. To properly fulfill this user need, another subcomponent of our design was added with regards to keeping information secure, adding a login component to our application interface and ensuring our database is secure. As well as this, firebase hosting with our google domain will make our dashboard more secure, further protecting the patient information that we store from outside access.

Another factor we took into consideration later on was integration. While bootstrap has the ability to easily integrate a web interface and SQL database, issues arose when looking at alternative programs to

handle pdf processing and initial data organization. With the image processing tools available with python, an open source coding language that's user-friendly and contains packages specific to image processing and data analysis, the language is ideal for coding our initial pdf processing. Since bootstrap can't easily integrate with python, we instead looked into Django, a high-level Python web framework that can assist us with integrating our python code with our SQL database for storing patient information to then be accessed by our dashboard design.

5.2 Functional Block/Subcomponent Design

From numerous design discussions of user needs and requirements, an architectural design was developed to highlight the different components of our software solution and how they interact:

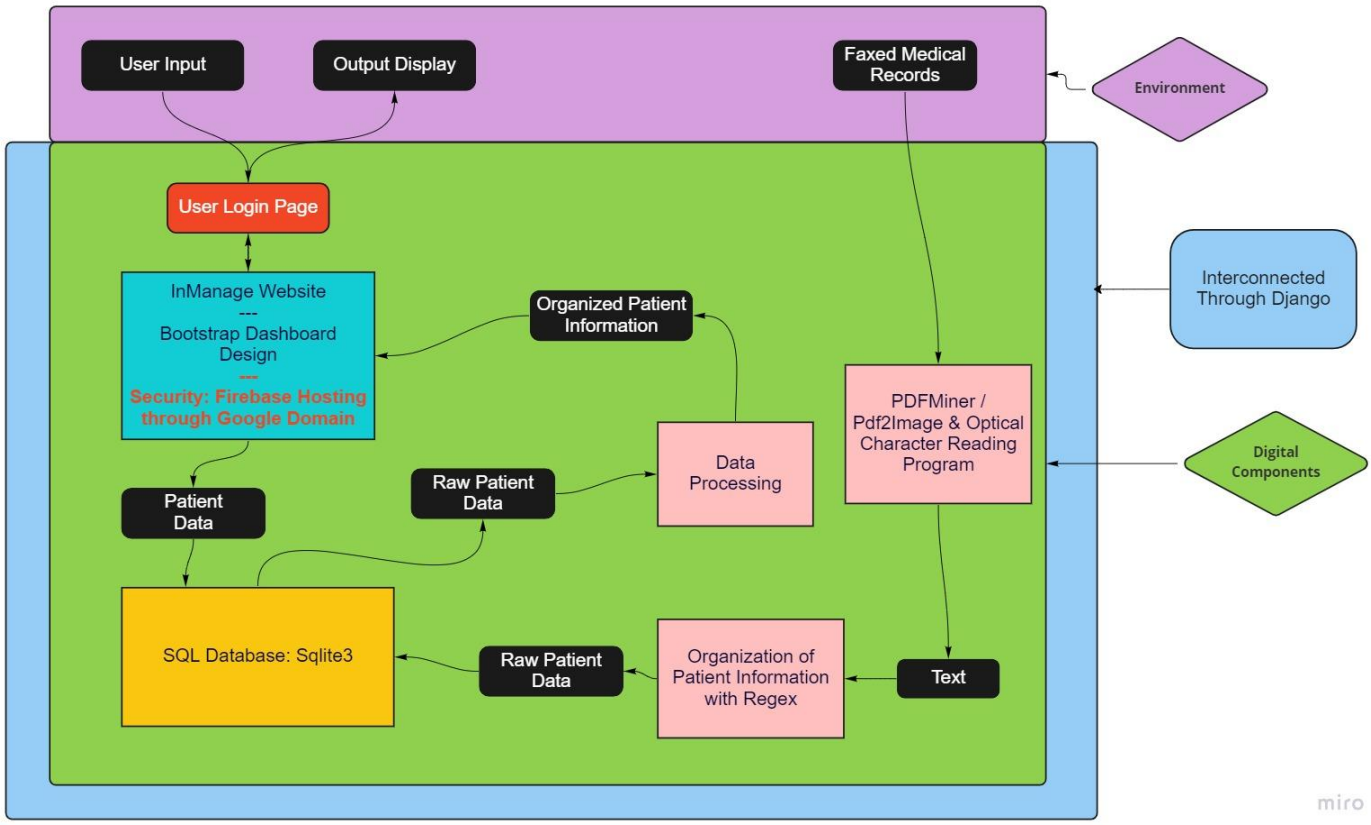


Figure 3: Concept design for the solution

The website application design above includes a variety of components necessary for processing patient information for nurses and admissions directors to easily access and interpret to make a decision with regards to a rehab referral. Currently, our design iteration will be using Django, a high-level python web framework that can integrate our pdf and data processing algorithms, coded in python, with our SQL database, which will be created through sqLite3 to transfer information to Bootstrap, an open CSS framework we're using to develop our dashboard design.

Below, each main component of our software solution is described in further detail and attributed to our specific design specifications.

Table 4. Subcomponent Analysis

Subcomponent Title	Technical Description	Contributing discipline/skill set	Design Specification Addressed
PDF Processing Program	A program that can scan PDF documents and extract text information, organizing information into a table of patient data	Software Engineering / Potentially Artificial Intelligence	U5 & U6 - Software must accurately scan PDF information Software must accurately interpret scanned information
SQL Database	Database to store patient information	Software Engineering	U6 & U2 - Software must satisfy the customer, software must accurately interpret scanned information
Data Processing	A program that can process and organize data from the SQL Database, summarizing information where needed.	Software Engineering	U6 & U3: Software must improve processing time of patients and software must accurately interpret scanned information
Bootstrap Dashboard	Dashboard design for displaying patient information and communicating with users.	Software Engineering	U1, U2, & U4: Software must be easy to use Software must satisfy the customer Program must be easy to train users
Security	Login and data protection to ensure that patient information remains confidential.	Cybersecurity	U2: Software must satisfy the customer

Subcomponent i - PDF Processing Program

The PDF processing component of our software solution involves pulling the information off of faxed PDF medical records and processing the scanned information to then be organized into an SQL database. There are two main features that are involved in this subcomponent that we discussed: text extraction and information interpretation.

With regards to text extraction, pulling the information off of faxed pdfs, python has several libraries specific to pdf processing that we explored. The one most geared towards information extraction that we explored first was PDFMiner, a text extraction tool for pdf documents. Pdf2txt.py is a program included with the installation of PDFMiner that can extract text information from pdfs as well as locations, font names, font sizes, writing direction (horizontal or vertical) for each text segment. For basic information extraction, the PDFMiner tool proves to be effective for processing downloaded pdfs with information stored in them, however, proved to be ineffective at interpreting scanned pdf documents. In our second iteration of our text extraction, we explored Optical Character Recognition (OCR) as an alternative method for extracting information. OCR is a method of image interpretation, pulling characters from jpg or png images, meaning we had to use pdf2image to convert the .pdf file into the proper format. Looking at different options for implementing optical character reading, Tesseract OCR was promising for its accuracy and compatibility with different programming languages [25]. While the method is significantly more time consuming, taking several minutes for processing, the method is effective in analyzing pdf information. One issue is that occasionally a character or two is read incorrectly, such as ‘:’ being read as ‘;’, constraining the ease of interpretation for the second step of our pdf processing method.

If more issues continue to occur with PDFMiner and OCR, alternative libraries to explore include PyPDF2 and pdfrw [26]. If the issue with information extraction proves to be a result of the poor quality of the pdf documents faxed over, another potential design piece of this subcomponent could be adding an initial image enhancement process before the pdf text extraction using PIL or OpenCV, though both libraries are specific to png/jpg processing rather than pdf, meaning the document would have to be converted back and forth [27].

The second main feature of pdf processing is text interpretation. While text may be able to be easily extracted through an open source library, the text then needs to be stored in a sensical manner, allowing for it to be organized with regards to patient information. With a limited amount of data, only having one example patient referral to work with, the interoperability of our text interpretation is limited to documents with the same formatting as our current one. To allow for easy and accurate text interpretation as well as flexibility to incorporate compatibility with other document formats in the future, we used regular expressions (analyzed through the re package in python) to pull key information from the extracted text. Regular expressions allow us to search for key phrases and information formatted in a certain way, allowing our code to easily interpret the mass amount of unorganized information extracted from the pdf documents.

Subcomponent ii - SQL Database

The SQL Database component involves using a database that can store patient information to be pulled for display on the dashboard subcomponent. The database needs to be able to store large amounts of information and be compatible with both python and the bootstrap dashboard. With the dashboard design we chose through bootstrap, we will gain access to an SQL database that can easily interface with the dashboard. However, in order to ease the integration of the python processing with the bootstrap dashboard, we explored using sqlite for python instead, importing the package sqlite3. Since our bootstrap dashboard is managed through Django, which is python-based, using an SQL database that is compatible with python was key, hence we used sqlite3 to create and store and pull information from an SQL database.

Subcomponent iii - Data Processing

The data processing component will be a subcomponent focused on analyzing and organizing the information stored in the SQL database. This will include summarizing information and organizing patient data in categories of where it will appear on the final dashboard. It will also involve summary statistical calculations, such a summary of how many patient referrals have been processed/accepted in the past month/year/etc. to help nurses and admissions directors review a rehabilitation hospital's progress and annual statistics easily and efficiently.

Subcomponent iv - Bootstrap Dashboard

For the dashboard component, we needed to be able to develop an application that could display information in an easy-to-read and analyze format and was easily navigable. In order to meet these user requirements, we chose to use a bootstrap dashboard template to easily create our website design. Through bootstrap, we were able to create a website with different pages containing the necessary information and functions for processing patient information. Individual pages and descriptions of their functions can be seen below.

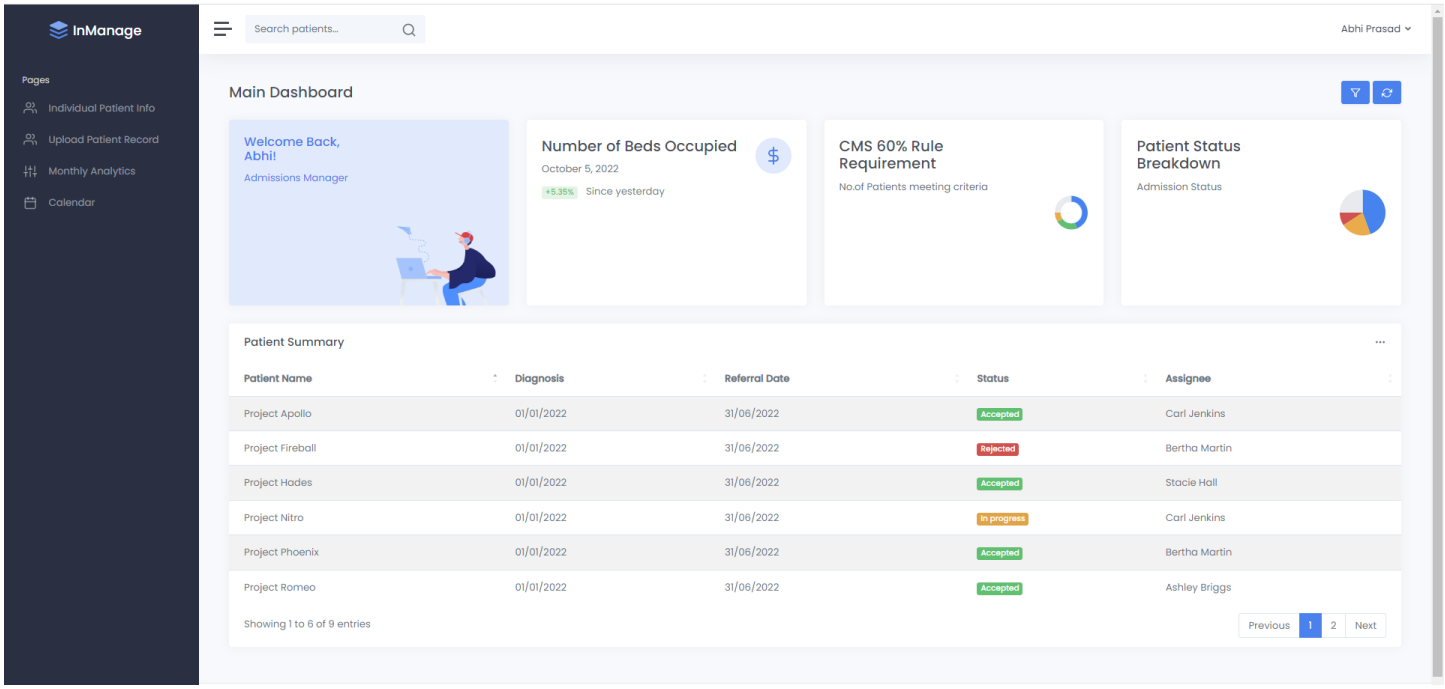


Figure 4: AppStack Bootstrap Dashboard Home Page

The dashboard home page highlights key patient statistics that are important to Lafayette Regional, such as the number of beds at their facility and a list of referred patients with their current status.

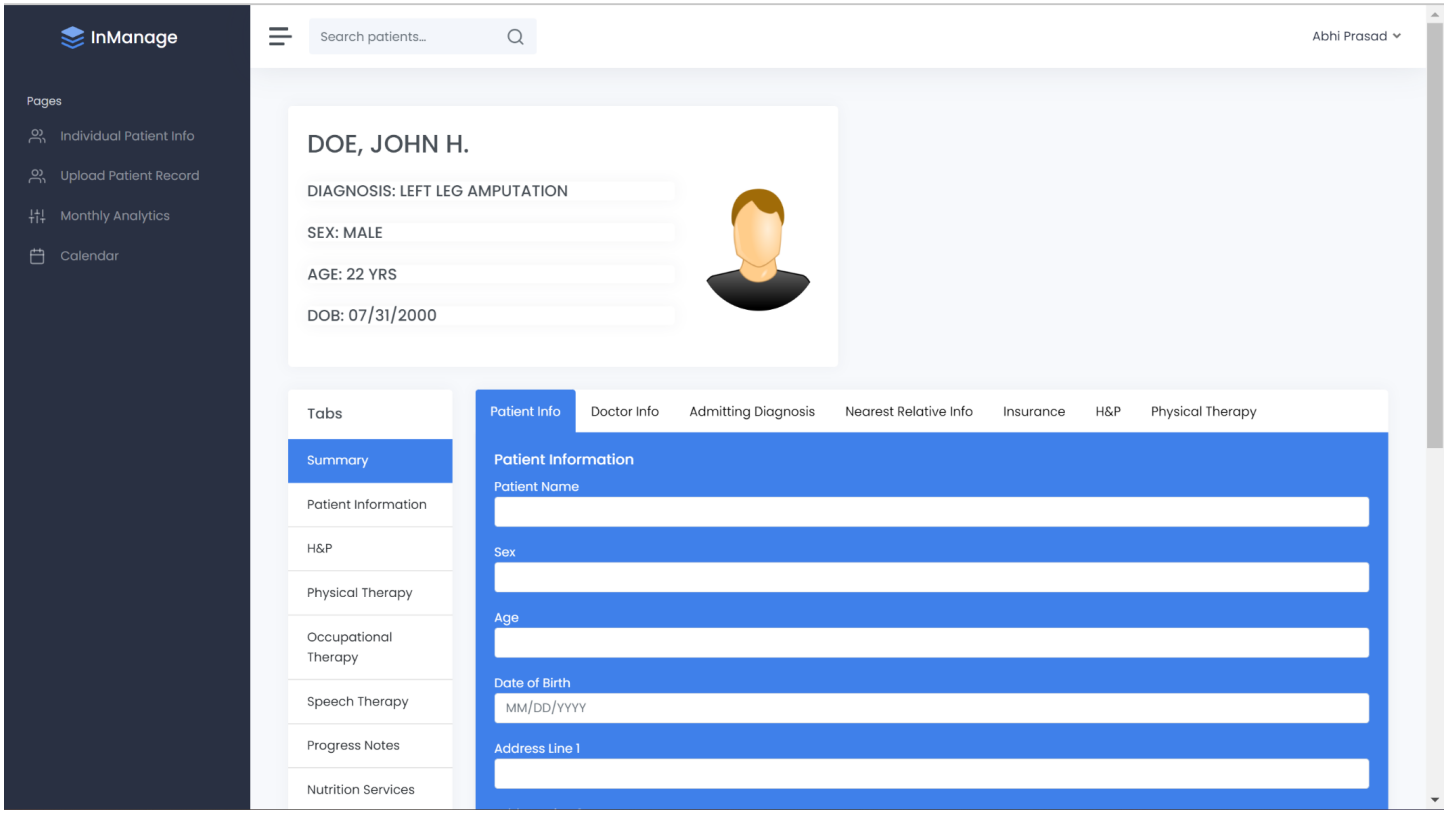


Figure 5: Individual Patient Information Page

The patient information page contains all needed information about an incoming patient, with the information pulled from their scanned referral documentation (see upload patient record page). The first tab contains a summary of key information needed for Lafayette Regional to conduct an initial screening of a patient, followed by additional tabs containing further information about the patient.

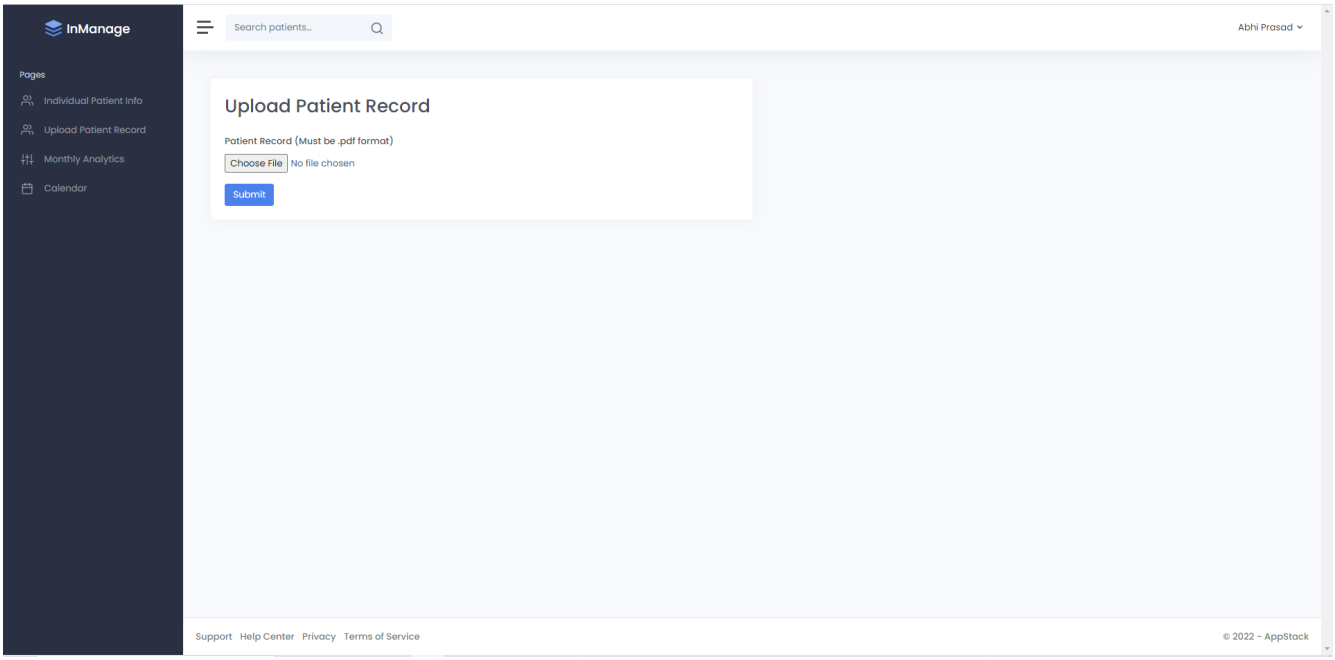


Figure 6: Upload Patient Record Page

The upload page allows admissions directors and clinical nurse navigators at facilities to upload scanned patient records to be analyzed and organized onto the patient information page.

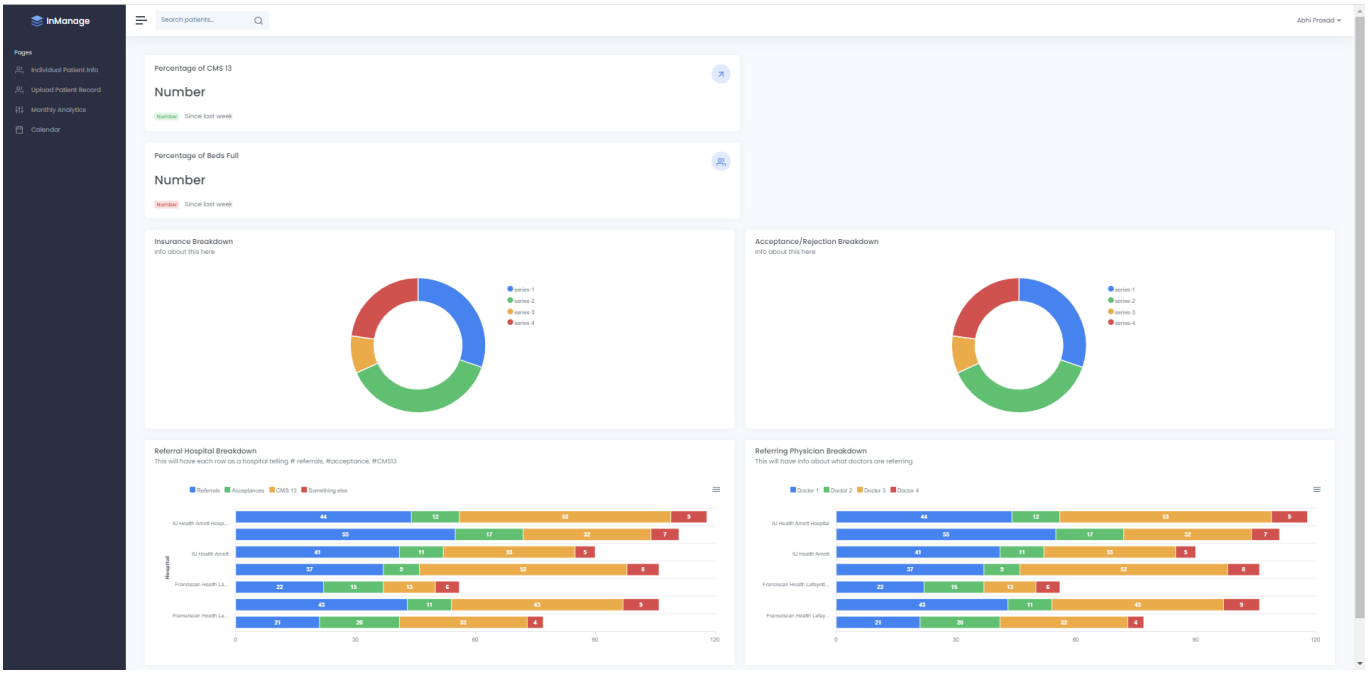


Figure 7: Monthly Analytics Page

The monthly analytics page displays overall statistics with regards to the given rehabilitation facility, including a breakdown of insurances they've accepted and how many patients they've accepted/rejected.

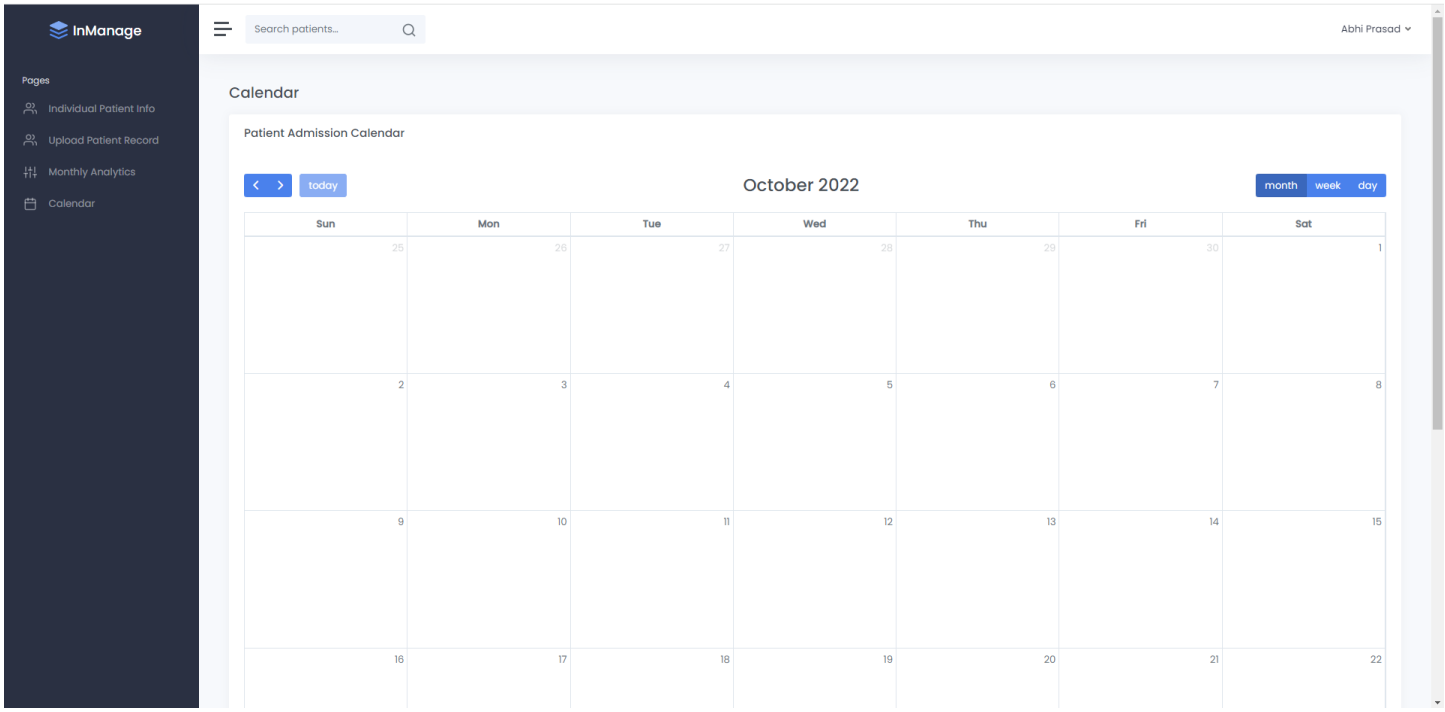


Figure 8: Calendar Page (additional feature)

As an additional feature, our bootstrap design also includes a calendar that rehab facilities may use.

Subcomponent v - Security

With regards to security, this subcomponent can be split into two parts. The first part is a login component of our website, requiring users to login in order to access patient data, making the web application more secure at withholding patient data from unauthorized users. The second component involves using a firebase hosting through google domain to make sure the dashboard is secure. Since our software solution deals with the processing and organization of secure health data, it's important that security be a subcomponent of our overall design.

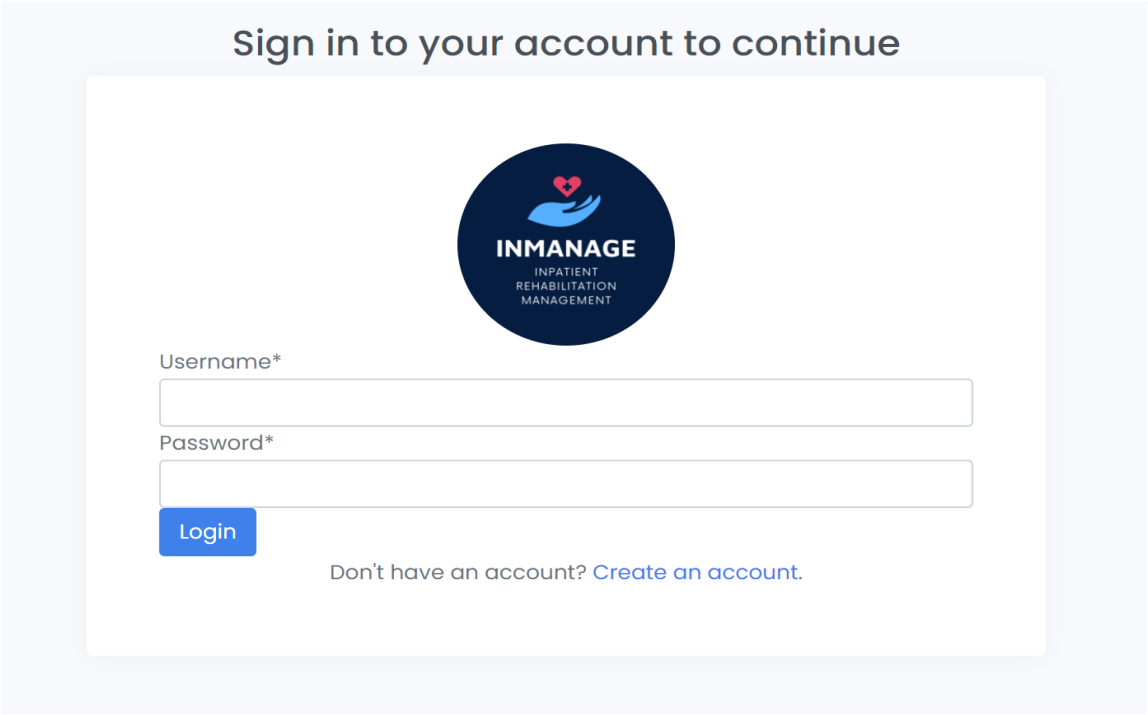


Figure 9: Login Page

5.3 Solution Innovation

With the main form of referral processing being done through reading and manually typing faxed information, there is massive room for human error and an extremely long processing time. While web applications have been developed to assist the process of communicating between doctors and allowing users to manually type in referral information in an organized format, there is no current approach to rehabilitation management that involves automating the processing of faxed medical records. Our design takes an innovative approach to the problem by creating a middle-man application that can breach the gap between electronic medical record (EMR) systems. With EMRs benign unable to communicate between each other and allscripts having a limited range of EMRs it covers, oru approach tackles that communication issue by taking a process that every EMR system uses, faxed medical records, and creating a software that can process the documents from this point.

Instead of rehabilitation hospitals having to invest in multiple EMR systems and middle-man softwares like Allscripts and WellSky, our software eliminates the need for any of them by taking basic faxed information and processing it in a digital format. Ultimately, our software takes a novel approach by working to eliminate the initial processing time for rehab referrals across all EMR systems, cutting down time and error made in current procedures.

Section 6: FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

Table 5 below shows the FMEA analysis for the inpatient rehabilitation management dashboard including 10 potential failure modes. Most of the failure modes mostly address potential failure modes that can come up with the security and pdf processing parts of the dashboard, which affect the main parts of the dashboard display with regards to the patient information.

Table 5. FMEA Analysis for the Proposed Solution, where S =Severity of failure; O=Occurrence likelihood; D=Detectability; RPN=Risk Priority Number=S×O×D.

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	S	Potential Cause(s)/ Mechanism(s) of Failure	O	"Current Process Controls"	D	RPN	Recommended Action(s)
Security	Login page does not let user log in	User is not redirected to the home page, thus is not able to use the dashboard	9	Admin SQLite3 database is not set up correctly, code does not redirect to it properly, login function does not properly read username/password	4	Creating fake users and logging in with those credentials to see if it works	1	36	Test with multiple fake users and non users to see if credentials will work or not
Security	Signup page is not able to register new user	User is not able to log into the dashboard, thus is not able to use it	9	Admin SQLite3 database is not set up correctly, code does not redirect to it properly, signup function does not properly register username/email/password	4	Creating fake users and logging in with those credentials to see if it works	1	36	Create multiple fake users to see if user is created in database and if credentials will work or not
Security	Clicking on the login	Anyone is able to	10	Admin SQLite3	2	Logging in with	1	20	Test with multiple

	button with wrong or no credentials redirects to the main dashboard	access the dashboard, as well as confidential patient information		database is not set up correctly, code redirects to main page without authentication, login function does not read username/password		unauthenticated credentials to make sure it does not log in			fake users and non users to see if credentials will work or not
Dashboard	The home page does not redirect correctly to the patient info page	It can make the time to get specific patient information longer	4	href link in code is misspelled or not present, syntax error	3	Rechecking code to make sure there are no syntax errors	1	12	Recheck code to make sure there are no syntax errors
Dashboard	The patient info page is not easy to navigate	It can make the time to get specific patient information longer	4	Layout design is flawed from the start and coded in that flawed way	8	Getting user feedback before and during the coding of design to ensure it is easy to navigate	2	64	Get feedback from Lafayette Regional as well as survey responses to improve ease of navigation
Dashboard	The upload page does not upload the patient record correctly	The patient information is never processed and displayed, needing the process to be redone	8	The function linked to submit button is incorrect, the pdf processing program is not working	3	Testing with multiple example patient records to see if it is uploaded and the processing algorithm tries to run	3	72	Will testing with our personal patient records to see if it is uploaded correctly and the processing algorithm tries to run
PDF Processing	The pdf processing program does not extract the patient information correctly	The wrong information on the patient is used, leading to a flawed referral decision	10	The pdf processing program has coding errors, puts files in the wrong folders, the text on the patient record is	4	Testing with the patient record we have and comparing extracted text to original text for	6	240	Will test with the patient record we have and compare extracted text to original text for correct information,

				grainy/hard to distinguish		correct information, may create fake records with same template to test as well			will create fake records with our information to test as well
SQL Database	The SQL database does not import the processed pdf patient data correctly	It can make the time to get specific patient information longer as it needs to be manually traced, leading to more errors	9	settings.py file does not have correct database information, pdf processing algorithm does not output table to correct SQL database due to syntax/spelling error	2	Testing with the patient record we have and seeing if the algorithm output follows the database parameters set out/inputs in the right place	3	54	Will test with the patient record we have and see if the algorithm output follows the database parameters set out/inputs in the right place
Dashboard	The patient info page does not display the processed patient data in the correct places	It can make the time to get specific patient information longer as it needs to be manually traced, leading to more errors	8	The patient record page links to wrong row/column in database table, SQL database has wrong data in row/column	3	Manually checking if the dashboard matches the original patient record	2	48	Will manually check to see if the dashboard matches the original patient record
Bootstrap	The style of the dashboard (font, color, etc) is hard to understand	It can make the time to get specific patient information longer, and reading errors	4	Poor choice for Bootstrap template, font sizes, colors chosen, wrong css/js file used	8	Getting user feedback before and during the coding of design to ensure readability	2	64	Get feedback from Lafayette Regional as well as survey responses to improve readability

Section 7: VERIFICATION AND VALIDATION OF DESIGN

7.1 Design Verification Plans for Subcomponent

Subcomponent i - PDF Processing Program

To ensure that the pdf processing is accurate, the scanned document's words, which are considered a text field, are compared to the original document's words. Different formats of a document, i.e. faxed, scanned, electronic, are used to ensure the processing is still accurate. This will allow the user to scan any type of referral document. Likewise, different font types, sizes, and colors are used. The correct number of words processed should be at least 90%. The 10% error is to account for ink which may have been smeared or documents scanned unclearly. Any mistakes should be easily noticed by rehabilitation staff since a text field will be left blank where information could not be extracted. At least four documents are scanned. The test documents do not need to be EHR, since only the word accuracy is being measured.

Subcomponent ii - SQL Database

The output of the pdf processing is an SQL table in a larger SQL database. Each patient has one SQL table within the database. To ensure the correct information is placed in the database and displayed to the user, the EHR data is compared to the original document. The correct number of words placed in the correct location should be at least 90%. Likewise, if there is no data to display in a certain parameter the text field should be left blank. At least four different data tables with different data should be used to test.

Subcomponent iii - Data Processing

To check for accuracy in the data processing, calculations computed independently from the software will be compared to the program calculations displayed. Due to the nature of software, the calculations must match exactly. At least four different sets of data should be entered into the SQL database to compute test calculations with.

Subcomponent iv - Bootstrap Dashboard

To test the user interface of the dashboard, testing should be completed to ensure a user generated text field is saved into the patient database. This testing is completed by typing different characters into different text field locations on the dashboard and making sure that these changes will be visible during a second login. Also, the fields displayed in the dashboard will be checked to make sure that there are no errors and misspellings and that they match the original medical record.

Subcomponent v - Security

To ensure the security of the program, different attempts to login into the system are completed. Different attempts include not entering a password, using incorrect username and password combinations, and creating a password with incorrect parameters are tested. As previously stated, due to the nature of software there should only be one possible way to create and use a password, so any testing is just to ensure the code is functioning correctly.

7.2 Design Verification Subcomponent Testing Results

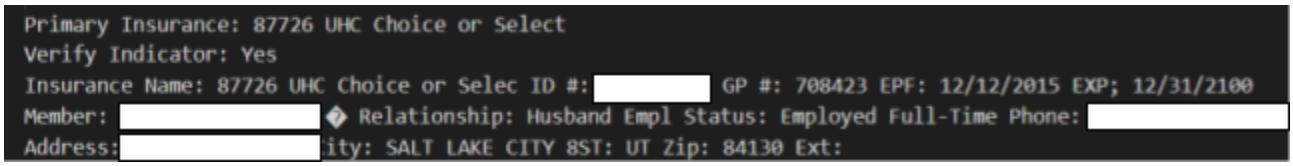
Subcomponent i - PDF Processing Program

The results in Table 6 show the accuracy of the pdf processing. A field is considered an output which is displayed in the user interface.

Table 6. Accuracy of PDF Processing

Test	Description	Original Document (# fields)	Processed Document (# accurate fields)	Accuracy
1	*Ex: White paper, medium font, scanned with printer.*			
2				
3				
4				

Subcomponent ii - SQL Database



The results of the SQL database testing are summarized in Table 7 below.

Table 7. Accuracy of SQL Database

Test	Description	Original Document (# fields)	Processed Document (# accurate fields)	Accuracy
1	*Ex: White paper, medium font, scanned with printer.*			
2				
3				
4				

Subcomponent iii - Data Processing

The results of the data processing are summarized in Table 8 below. All computed values match the expected values; therefore, the data processing is accurate.

Table 8. Accuracy of Data Processing

Test	Description	Expected Value	Computed Value
1	Percentage of CMS 13		
2	Percentage of beds full		
3	Insurance breakdown		
4	Referral hospital breakdown		
5	Acceptance/Rejection breakdown		
6	Referring physician breakdown		

Subcomponent iv - Bootstrap Dashboard

The results of the dashboard testing are summarized below in Table 9.

Table 9. Accuracy of InManage Dashboard (Changing and saving of entries)

Test	Number of changed fields in the dashboard	Number of changed fields in the SQL database	Accuracy	Was the saved data present during the second login?
1				
2				
3				
4				

Table 10. Accuracy of InManage Dashboard (Display of fields)

Tab	Number of errors	Type of error
Summary		

Patient Information		
H&P		
Physical Therapy		
Occupational Therapy		
Speech Therapy		
Progress Notes		
Nutrition Services		
Diagnostics		
Notes		
Additional Documents		

Subcomponent v - Security

The results for testing security are shown in Table 11 below. All tests do not allow entry into the program, unless the login credentials are correct. Thus, the security is accurate.

Table 11. Accuracy of InManage Security

Test	Description	Expected Outcome	Actual Outcome
1	*Ex: Incorrect password*		
2	*Ex: No password entered*		
3			
4			

7.3 Design Verification Plans for Final Prototype

For the verification of our design, we have two different levels of verification of design. Our first level of verification is a survey that will be sent out to different inpatient rehabilitation hospitals to provide feedback on the overall design of our solution and its usefulness, usability, aesthetic, and accuracy. The survey will also be sent out to people who are not end users, but can still provide feedback on the user display. There are two parts to the survey- the Net Promoter Score Survey and System Usability Scale Survey. The System Usability Scale (SUS) Survey contains standardized, predetermined questions listed below and is used frequently for testing the functionality of software [24]. The Net Promoter Score (NPS) Survey contains questions the team created. Pictures of InManage were placed with the survey questions where applicable and the survey taker does not physically use the program. The survey corresponds to user needs U1, U2, and U3. Our survey will have the following questions:

Net Promoter Score Survey

1) The dashboard display is user friendly
2) The dashboard display summarizes the important information effectively
3) The upload patient record page is user friendly
4) The display on the Individual Patient Info tab is user friendly
5) The display on the Monthly Analytics tab is user friendly
6) The login display is user friendly
7) Creating an account is easy to understand and the display is user friendly
8) InManage will help make the rehab referral process faster
9) I am likely are you to recommend InManage to a colleague

System Usability Scale Survey

1) I think that I would like to use InManage frequently
2) I found InManage unnecessarily complex
3) I thought InManage would be easy to use
4) I think that I would need the support of a technical person to be able to use InManage
5) I found the various functions in InManage were well integrated
6) I thought there was too much inconsistency in InManage
7) I imagine that most people would learn to use InManage very quickly
8) I found InManage very awkward
9) I would feel confident using InManage
10) I would need to learn a lot of things before I understand how to use InManage

Our second level of verification will be done through meeting with Lafayette Regional Hospital and conducting an in-person design verification where Lafayette Regional will navigate our website and test our patient processing software. Our verification procedure will be as follows:

1) The user will login to the InManage website by using a temporary login provided by our team. **(U1, U4)**
2) The user will navigate through the webpage, guided by our team to view the overall patient page, summary statistics, and individual patient information. **(U1, U2, U4)**
3) The user will upload a patient file. **(U1, U2, U4)**

4) The user will view the results of the patient file through the “individual patient info” page and verify the information is correct, easy to read, and useful. **(U3, U5, U6)**
5) The user will make a decision on whether to admit the patient into the rehabilitation facility **(U1, U2, U3)**
6) The InManage team will discuss with Lafayette Regional the overall usability, usefulness, and efficiency of our design **(ALL Design Specifications)**

During this verification testing, the time it takes the user to process a patient referral from the time they begin to log into the system to making a final decision is recorded. The time will be recorded for each user during testing and the average will be taken.

These two methods of verification will allow us to verify the overall design and function of our software with a variety of customers and users from different hospitals while also verifying our software on a functional level by working with Lafayette Regional Rehabilitation Hospital to conduct a live testing of our software on-site.

7.4 Design Verification Final Prototype Testing Results

The patient processing time for each user during verification testing at the Lafayette Regional Rehabilitation Hospital is provided in Table 12 below.

Table 12. Patient Processing Time

User	Processing Time (Minutes)
1	
2	
3	

Customer satisfaction data from two groups- end users of InManage and non-end users of InManage was collected. The Net Promoter Score (NPS) for each question area shown in Table 13 a and b and Figure 10 below. The average NPS for end users is 91 and the average NPS for non-end users is 58. Both NPS are greater than 0, meeting the design requirement and indicating a satisfied customer.

Table 13a. Survey Results for InManage End Users Net Promoter Score

Question Number	Number of Responses	NPS Score
1	5	100
2	5	80
3	5	100
4	5	100

5	5	80
6	5	100
7	5	80
8	5	100
9	5	80
Average	5	91.11

Table 13b. Survey Results for InManage Non-End Users Net Promoter Score

Question Number	Number of Responses	NPS Score
1	8	50
2	8	50
3	8	62.5
4	8	75
5	8	12.5
6	8	87.5
7	8	75
8	8	62.5
9	8	50
Average	8	58.33

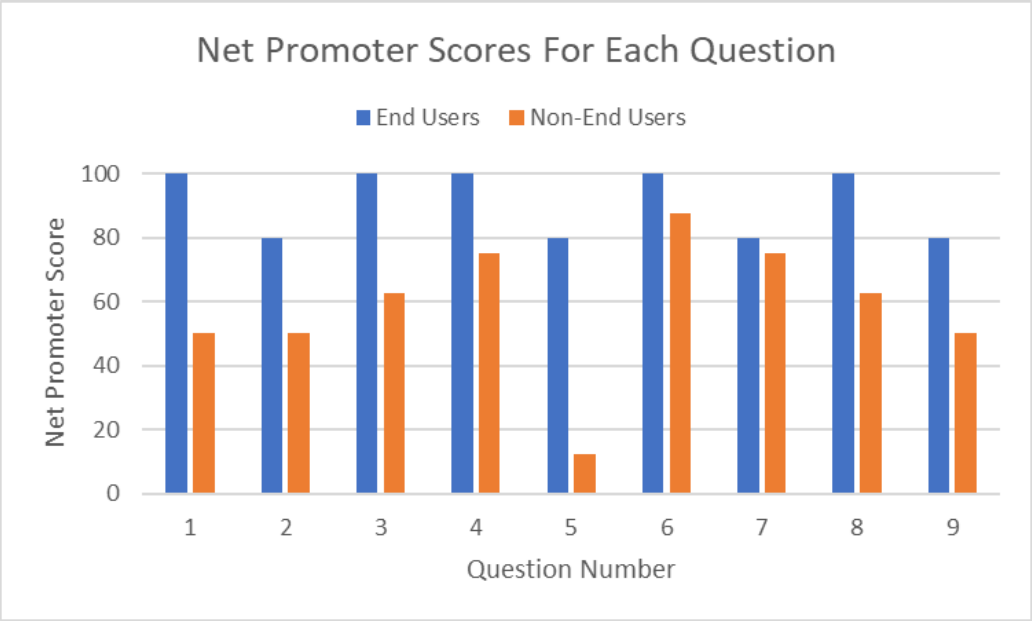


Figure 10: Survey Results for InManage Net Promoter Score

Ease of use and customer satisfaction data from two groups- end users of InManage and non-end users of InManage was collected. Table 14 a and b show the average score of each System Usability Scale question. The System Usability Scale Score is 90 for end users and 84.06 for non-end users. Since the scores are greater than 80, InManage meets the design specification for ease of use and customer satisfaction.

Table 14a. Survey Results for InManage End Users System Usability

Question Number	Number of Responses	Average Score
1	5	4.4
2	5	1
3	5	4.6
4	5	2.2
5	5	4.6
6	5	1
7	5	4.6
8	5	0.8
9	5	4.2
10	5	1.4

Table 14b. Survey Results for InManage Non-End Users System Usability

Question Number	Number of Responses	Average Score
1	8	3.88
2	8	1.75
3	8	4
4	8	1.25
5	8	3.625
6	8	1
7	8	4.25
8	8	0.625
9	8	4.375
10	8	1.875

Table 15. SUS Score

End Users	90
Non-End Users	84.06

Summary of Feedback from Lafayette Regional Hospital:

Qualitative Feedback:
Still need to complete this testing

7.5 Design Validation Plans and Testing Results for Final Prototype

Given the nature of the project, the design specifications were based off of the need statement. Therefore, testing for verification and validation was the same. Throughout the process of creating the website, we talked to the admissions personnel from Lafayette Regional Rehabilitation Hospital and we made sure that the information in the summary page is organized and covers all of the important information they need to be included. We also had them review the entire patient info page to give us feedback and they were pleased with the final result. Ease of use, training, and processing time were all tested using the methods in section 7.3 and the results of these tests are shown in section 7.4.

7.6 Discussion Relating Final Prototype Results to Literature, Design Specifications, and Customer Needs

InManage is used to improve the process of extracting and organizing patient information from Electronic Health Records to determine if a patient meets the criteria for inpatient rehabilitation. The current processes for inpatient rehabilitation is time consuming because manual entry of all patient information is required. Likewise, the current rehabilitation management softwares on the market have no dashboard display and do not satisfy the user [2] [15]. Testing revealed patient records are processed and interpreted accurately using InManage. Additionally, the software decreases the time needed to processes one patient referral to only ** minutes. Testing also suggests InManage is easy to use and the dashboard display satisfies the customer. Thus, InMange is an improved software system for inpatient rehabilitation.

Future testing for InManage should be conducted to test the efficiency of training methods for the software users. Future feedback from other rehabilitation facilities can be used to make improvements to the user display. Likewise, additional pdf processing techniques should be investigated to increase the algorithm speed of the optical character recognition used in the pdf processing. The next step is to use firebase hosting to create a domain to allow users to access InManage and extract more information from patient referrals.

Section 8: FINAL PROJECT SUMMARY

INCOMPLETE

In the world, 2.4 billion people have a health condition that requires rehabilitation, and this number is expected to increase in the upcoming years as more children are expected to be born with disabilities and there are expected to be more traffic accidents [3][4]. However, even the current need for inpatient rehabilitation is not being met. The increased demand for inpatient rehabilitation and the lack of care facilities make it easy for processing recommendations for rehabilitation to become a difficult and drawn-out process. Since the patient referral process is very non-standardized and referral sizes vary substantially among patients, it is difficult to evaluate and compare patients correctly with regard to their need for inpatient treatment [5].

The quantity of patient referrals that must be processed in inpatient rehabilitation units is increasing as a result of an increase in demand for inpatient rehabilitation and an inability to effectively meet present expectations [6]. The inability to handle patient referrals due to inconsistent paperwork between and within institutions highlights the need to enhance these procedures. Hospitals that offer inpatient rehabilitation need a better mechanism for handling patient referrals and compiling patient data. This issue should be resolved by organizing clinical patient data and emphasizing crucial elements so that doctors and nurses may review patient data more quickly.

We looked for a software solution that could reduce human error and hasten initial processing of patient medical records and referrals in order to satisfy our customers' expectations and simplify patient processing. At Riley Children's Hospital and Lafayette Regional Rehabilitation Center, clinical nurse navigators' and admissions directors' needs were taken into consideration when designing the features of this software. These needs included the requirement that faxed PDF records be processed and that specific information, such as insurance, diagnostics, and other crucial information points, be highlighted and made readily available to nurses. We developed a solution after talking about the additional requirements of our customer that could provide summary statistics, be simple for people to navigate, and could condense data so that it could be quickly evaluated for key criteria.

The necessity for a secure platform that could safeguard patient privacy was one user demand that was later taken into account. By including a login feature in our application interface and making sure our database is secure, another subcomponent of our design was added to effectively satisfy this user need. Additionally, hosting our dashboard on firebase with our google domain would increase the security of our dashboard and further shield the patient data we store from unauthorized access. Integration was a subsequent consideration that we also took into account. Despite the ease with which a web interface and SQL database may be integrated using bootstrap, problems arose when looking at different applications to handle pdf processing and initial data structure. Python is a user-friendly open source programming language that has packages specifically for image processing and data analysis, making it the perfect choice for writing our initial pdf processing because it has access to image processing capabilities. We instead looked into Django, a high-level Python web framework, in place of bootstrap because bootstrap can't readily interact with Python. Django can help us combine our Python code with our SQL database for storing patient information so that it can subsequently be accessed by our dashboard design.

Therefore, the 5 components of the design are as follows: the PDF Processing Program. The SQL Database, Data Processing, the Bootstrap Dashboard, and Security. The PDF processing component of our software solution involves pulling the information off of faxed PDF medical records and processing the scanned information to then be organized into an SQL database. There are two main features that are involved in this subcomponent that we discussed: text extraction and information interpretation.

Python has a number of libraries designed specifically for processing pdf files that we looked into in relation to text extraction, or extracting the data from faxed pdfs. We started by investigating PDFMiner, a text extraction program for pdf documents, as it was the one most targeted toward information extraction. The PDFMiner installation package includes a program called pdf2txt.py that can extract text information from pdfs, including the positions, font names, font sizes, and writing direction (vertical or horizontal) for each text segment. The PDFMiner tool is successful in processing downloaded pdf files with information stored in them for basic information extraction, however it is unsuccessful in understanding scanned pdf documents. In our second round of text extraction, we looked into an alternative technique called optical character recognition (OCR). We had to use pdf2image to convert the.pdf file into the appropriate format because OCR is a technique for image interpretation that extracts characters from jpg or png images. Tesseract OCR appeared to be a viable alternative for optical character reading when comparing several optical character reading implementation options [25]. The approach is efficient in analyzing pdf data while being noticeably more time-consuming, processing taking several minutes. One problem is that, occasionally, one or two characters are read erroneously, such as when ':' is read as ';,' which limits the second phase of our pdf processing method's ease of interpretation.

Text interpretation is the second crucial aspect of pdf processing. Although text may be easily retrieved using an open source tool, it must then be saved sensibly to enable it to be structured in relation to patient information. We used regular expressions (analyzed through the re package in Python) to extract important information from the extracted text, allowing for simple and accurate text interpretation as well as flexibility to incorporate compatibility with other document formats in the future. Our code can easily understand the vast amount of disorganized information extracted from the pdf documents thanks to regular expressions, which enable us to search for key phrases and information formatted in a specific way.

Section 9: PROJECT PLANNING

9.1 Project Schedule

GANTT CHART → InManage - Inpatient Rehabilitation Management

PROJECT MEMBERS	Aletea vanVeldhuisen, Marya Aldoukhi, Alexa Eby, Abhinav Prasad		
UNIVERSITY	Purdue University	DATE	11/21/22

WBS NUMBER	TASK TITLE	Week															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	**Project Subcomponents**																	
1.1	User requirement exploration																	
1.2	Architectural Design																	
1.3	Validation of design																	
1.4	Pdf processing																	
1.5	Organization of patient information																	
1.6	SQL database																	
1.7	Data processing																	
1.8	Dashboard design																	
2	**Individual Tasks**																	
2.1	Design Notebook					x										x		x
2.2	Individual Demos						x											
2.3	Individual Coding Components																	
2.4	CATME survey						x				x					x	x	
2.5	Midterm course feedback							x										
2.6	Quizzes				x			x				x					x	
3	**Final Product**																	
3.1	Testing with Patient Data																	
3.2	Conduct Clinical Review																	
3.3	DHF																	x
3.4	Final video																x	
3.5	Final demo																x	
3.6	Present at EXPO																	x
4	**Meetings with mentors**																	
4.1	Meet with Kevin Kidd																	
4.2	Meet with Lafayette Regional Rehabilitation Hospital																	
4.3	Meet with Nick Ramakrishnan																	
5	**Assignments**																	
5.1	preliminary presentation			x														
5.2	DHF scetions 2-5,9,10				x													
5.3	Signed MOU				x													
5.4	Intellectual property assignment						x											
5.5	Abstract draft								x									
5.6	DHF sections 2-7.4,9,10										x							
5.7	Design review presentation										x							
5.8	Regulatory assignment												x					
5.9	Integrated team demo													x				
5.10	DHF updates for instructor feedback														x			
5.11	Ethics assignment															x		
5.12	IP assignment															x		
5.13	final abstract															x		

key	
x	deadline
	Not started
	In progress
	Complete
	Incomplete

Figure 11: Gantt chart for the project (version 3)

The Gantt chart above shows the third version of the project timeline for InManage. The project tasks were divided into 5 main categories: project subcomponents, individual tasks, final product, meetings with mentors, and assignments. The subtasks are listed underneath each of these categories. Planned events that have not started yet are marked with orange as shown in the figure.

Work plan (version 1 and 2)

The first stage of the project involved doing an initial design sketch and validating that with one of the end users (Lafayette Regional Rehabilitation Hospital). After the team confirmed that the initial design meets the user requirements, the team moved on to creating the website. To do that the team divided the subcomponents and assigned each member to a specific subcomponent. This involved working on the PDF processing, organization of patient information in the patient info page, setting up the database and working on the other pages of the website. Instead of working on these tasks one at a time as originally planned in version 1(see the appendix for the original gantt chart), the team decided to work on these sections concurrently, which made the team ahead of the plan on some of the tasks, but at the same time the overall duration for these tasks was extended to week 13. The team was not able to test the website with patient data while it was still being built, so this task was moved to week 10, and will last for a couple of weeks as the team tests the website for different elements. The team is also ahead and scheduled the clinical review with the Lafayette Regional Rehabilitation Hospital for week 10, instead of doing it during weeks 14 and 15. This is the only clinical review session scheduled so far, but if needed, another session might be scheduled in the future. The team will continue working on the different components of the website after the clinical review, while also testing it with patient data.

Work plan (version 3)

Given the nature of the project, the team is continuously improving the solution, adding new features and debugging any errors, therefore, the team decided to extend coding tasks 1.4-1.8 until week 15. The team may need to make minor alterations to the solution after week 15, but they won't be significant. The team conducted 2 clinical reviews with Lafayette Regional Rehabilitation Hospital and a third session will be scheduled with them to get some last minute feedback and to film video clips with them for the final video assignment. The team also met with Nick Ramakrishnan to show him the website and get some feedback. The solution was continuously being tested for its functionality using the available medical record, but testing plans were extended to accommodate for validation and verification testing.

The assignments for the senior design class are divided into two categories: Individual (2) and team (5).Note that individual tasks are only marked as complete once all team members finish their tasks. The meetings with the mentors will be scheduled on a week by week basis, so there aren't many scheduled meetings thus far. Lastly, the final product category involves tasks that need to be completed by the end of the semester.

9.2 Project Budget

i. Cost to Purdue BME (e.g. cost of supplies ordered)

Table 16. Budget for the items that will be purchased by Purdue University

Item	Planned ($)	Spent ($)
Bootstrap template (AppStack)	59	59
Google Domain	12	12
Total	71	71

Currently all of the planned items were bought to complete the project. This was done using a business card that was provided by the university. A list of the purchased items are shown above.

ii. Actual costs if you did this on your own (e.g. including capital equipment, donated items)

Table 17. Budget for the additional items that will be needed and provided by the team

Item	Planned ($)	Spent ($)
Django	0	0
GitHub	0	0
SQLite3	0	0
Laptops	0	0
Total	0	0

Given the nature of the project, a laptop would be required to develop the product. Furthermore, the team will utilize multiple free online platforms like Django, Github and the database engine SQLite3 . All of these items are listed in the table above.

iii. Future costs if the project is implemented

Table 18. Budget for implementing the project in the future

Item	Planned ($)	Spent ($)
Trademark the logo	350	0
Trademark the name ‘InManage’	350	0

Copyright our code	65	0
Total	765	0

If we decide to launch the product and develop it further, we would need to protect our work. We will do that by trademarking the logo and name of our product ‘InManage’ using the TEAS Standard option, since it has fewer requirements compared to the TEAS Plus option [28]. The code we develop will also be copyrighted electronically [29]. The prices for these protection rights are listed above.

SECTION 10: REFERENCES

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SECTION 11: APPENDIX

GANTT CHART →

InManage - Inpatient Rehabilitation Management

PROJECT MEMBERS	Aletea vanVeldhuisen, Marya Aldoukhi, Alexa Eby, Abhinav Prasad
UNIVERSITY	Purdue University
DATE	9/11/22

WBS NUMBER	TASK TITLE	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	**Project Subcomponents**																	
1.1	User requirement exploration																	
1.2	Architectural Design																	
1.3	Validation of design																	
1.4	Pdf processing																	
1.5	Organization of patient information																	
1.6	SQL database																	
1.7	Data processing																	
1.8	Dashboard design																	
2	**Individual Tasks**																	
2.1	Design Notebook					x										x		x
2.2	Individual Demos						x											
2.3	Individual Coding Components																	
2.4	CATME survey						x				x					x	x	
2.5	Midterm course feedback							x										
2.6	Quizzes				x			x				x					x	
3	**Final Product**																	
3.1	Testing with Patient Data																	
3.2	Conduct Clinical Review																	
3.3	DHF																	x
3.4	Final video																x	
3.5	Final demo																x	
3.6	Present at EXPO																	x
4	**Meetings with mentors**																	
4.1	Meet with Kevin Kidd																	
4.2	Meet with Lafayette Regional Rehabilitation Hospital																	
4.3	Meet with Nick Ramakrishnan																	
5	**Assignments**																	
5.1	preliminary presentation			x														
5.2	DHF scetions 2-5,9,10				x													
5.3	Signed MOU				x													
5.4	Intellectual property assignment						x											
5.5	Abstract draft								x									
5.6	DHF sections 2-7.4,9,10										x							
5.7	Design review presentation										x							
5.8	Regulatory assignment												x					
5.9	Integrated team demo													x				
5.10	DHF updates for instructor feedback														x			
5.11	Ethics assignment															x		
5.12	IP assignment															x		
5.13	final abstract															x		

key	
x	deadline
	Not started
	In progress
	Complete
	Incomplete

Figure A.1: Gantt chart for the project (version 1)

GANTT CHART →

InManage - Inpatient Rehabilitation Management

PROJECT MEMBERS	Aletea vanVeldhuisen, Marya Aldoukhi, Alexa Eby, Abhinav Prasad		
UNIVERSITY	Purdue University	DATE	10/19/22

WBS NUMBER	TASK TITLE	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	**Project Subcomponents**																	
1.1	User requirement exploration																	
1.2	Architectural Design																	
1.3	Validation of design																	
1.4	Pdf processing																	
1.5	Organization of patient information																	
1.6	SQL database																	
1.7	Data processing																	
1.8	Dashboard design																	
2	**Individual Tasks**																	
2.1	Design Notebook					x										x		x
2.2	Individual Demos						x											
2.3	Individual Coding Components																	
2.4	CATME survey						x				x					x	x	
2.5	Midterm course feedback							x										
2.6	Quizzes				x			x				x					x	
3	**Final Product**																	
3.1	Testing with Patient Data																	
3.2	Conduct Clinical Review																	
3.3	DHF																	x
3.4	Final video																x	
3.5	Final demo																x	
3.6	Present at EXPO																	x
4	**Meetings with mentors**																	
4.1	Meet with Kevin Kidd																	
4.2	Meet with Lafayette Regional Rehabilitation Hospital																	
4.3	Meet with Nick Ramakrishnan																	
5	**Assignments**																	
5.1	preliminary presentation			x														
5.2	DHF scetions 2-5,9,10				x													
5.3	Signed MOU				x													
5.4	Intellectual property assignment						x											
5.5	Abstract draft								x									
5.6	DHF sections 2-7.4,9,10										x							
5.7	Design review presentation										x							
5.8	Regulatory assignment												x					
5.9	Integrated team demo													x				
5.10	DHF updates for instructor feedback														x			
5.11	Ethics assignment															x		
5.12	IP assignment															x		
5.13	final abstract															x		

key	
x	deadline
	Not started
	In progress
	Complete
	Incomplete

Figure A.2: Gantt chart for the project (version 2)