ECE1778H - Creative Applications for Mobile Devices (Winter 2015)
Prof. Jonathan Rose

FINAL REPORT

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INTRODUCTION:

Why: Patients with cancer can struggle with side effects of chemotherapy and symptoms of the cancer itself. The number and magnitude of symptoms they experience can result in an unnecessary worsening of their quality of life. Patients can suffer in silence, not realizing that their side effects are easier to mitigate when they are mild. Managing side effects earlier also prevents worsening to the point of requiring hospitalization.

The second consideration is the difficulty patients have in tracking their side effects using conventional methods, such as pen and paper, or using smartphone apps that require manual data entry. Detailed information about the patient experience is essential for healthcare professionals to adequately manage a patient's condition. Passive symptom tracking allows for quantification of the patient experience without burdening the patient with unnecessary data entry, while still providing health care providers with necessary information.

What: This app helps patients track their bowel movements. Bowel movements are tracked using a SensorTag© placed in the patient's washroom which then connects to the smartphone application to track a patient's bathroom visits. Patients are then asked screening questions in order to determine the appropriateness self-care for constipation and diarrhea, and the app directs patients to contact their healthcare team when needed. This improves the quality of their lives by providing basic self-treatment information and referring patients for medical attention in a timely fashion.

OVERALL DESIGN

Block Diagram:

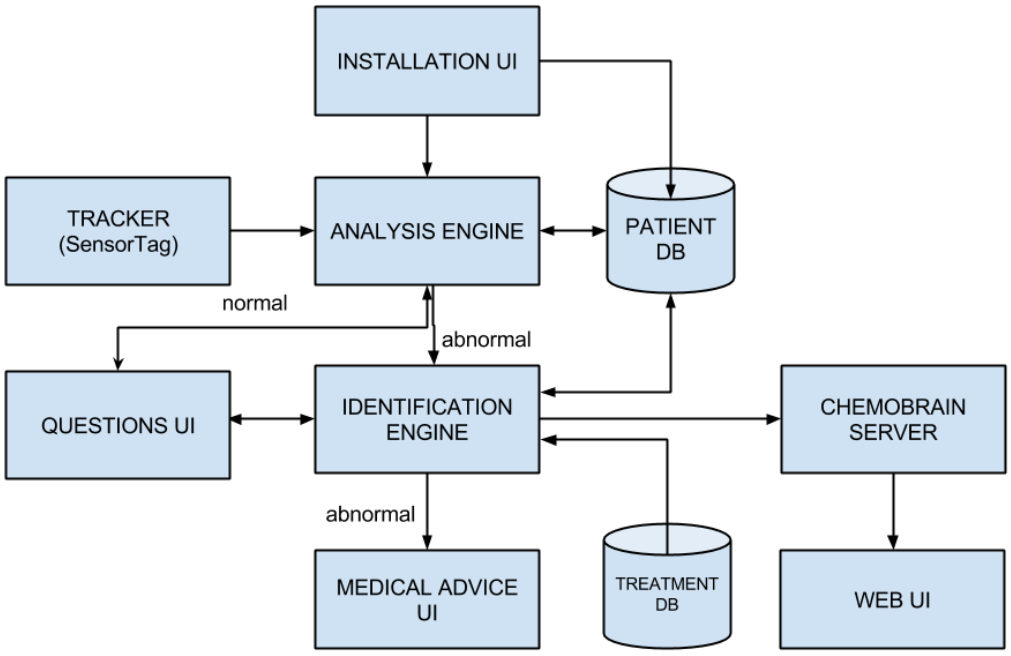


Image 1: Block Diagram of ChemoBrain

Installation UI

When the application is first installed, the InstallationUI is displayed. Users enter their personal information which includes age, gender, medications taken, other medical conditions, cancer type, chemotherapy type, normal number of bowel movement per day, etc. This data is pushed to the PatientDB. The application also calculates a baseline risk score of constipation and diarrhea based on the provided information.

Tracker

The Tracker module is responsible for keeping track of how many times the user is using the washroom per day. It uses the signal (bluetooth) intensity sensor data corresponding with timer stamps from the SensorTag (a bluetooth external sensor made by Texas Instruments) located in the washroom to measure the number and duration of washroom visits.

Analysis Engine

The Analysis Engine gathers data from the Tracker module. Based on this data and the retrieved data from the PatientDB, the Analysis Engine will determine if the health of the

patient appears normal or abnormal (based on the number of bowel movements the patient has recorded with the Tracker, and their baseline calculated risk of constipation/diarrhea). If it is normal, a set of questions are asked at a fixed time interval to increase confidence in the analysis. If abnormal, the information (analyzed Tracker data with information from PatientDB) is passed to the Identification Engine.

Identification Engine

Based on the information obtained from the Analysis Engine and the QuestionsUI, the Identification Engine will identify whether the patient is suffering from diarrhea or constipation, as well as determine the severity of the symptoms experienced. The TreatmentDB information is retrieved to aid in identification of the condition. If a condition is identified, the Identification Engine pushes the relevant treatment to the Medical Advice UI.

Questions UI

When the user confirms the tracked bowel movements, the QuestionsUI asks questions about stool consistency and colour. This information is forwarded to the Analysis Engine, which uses this information in tandem with its other parameters to determine the patient's condition.

Medical Advice UI

The Medical Advice UI presents information specific to the condition the patient is experiencing as determined by the Identification Engine.

Patient Database (PatientDB)

The PatientDB is responsible for recording the patient's demographic information, Tracker data, Analysis and Identification Engines results, treatment given, screening questions asked, and the corresponding answers.

Treatment Database (TreatmentDB)

The TreatmentDB contains all the possible treatment/advice cases. Healthcare providers will be able to add additional advice and treatment cases over time.

ChemoBrain Server

When the Identification Engine determines that a patient has a severe abnormal condition meriting healthcare provider intervention, all the information from the PatientDB is pushed to the ChemoBrain Server in order to ensure the health care provider will have access to user data.

Web UI

The WebUI allows healthcare providers to view all the data stored in the ChemoBrain server. The WebUI displays a list of all patients on the server. Upon selecting a patient, the healthcare provider can view all the patient's information.

STATEMENT OF FUNCTIONALITY WITH SCREENSHOTS:

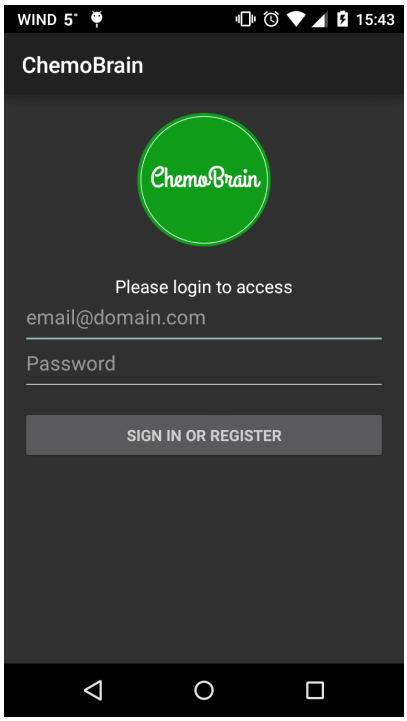
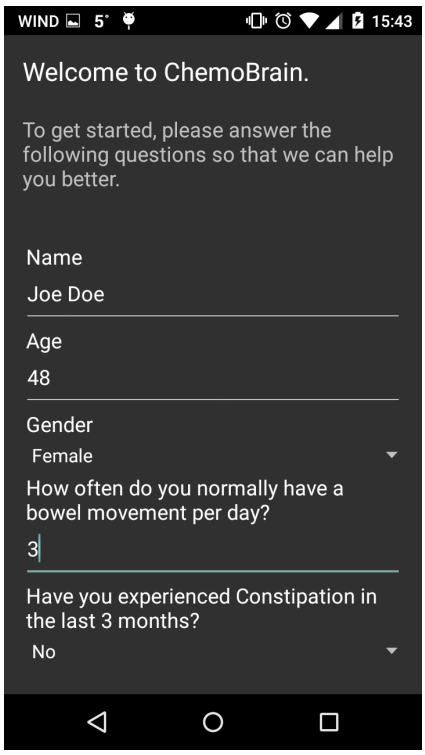
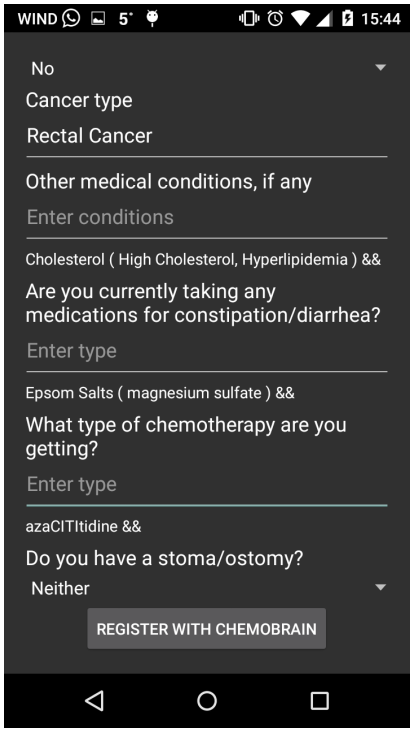


Figure 2: Login, Authentication

Figure 2 is the ChemoBrain login page. The app authenticates the user ID and password before providing access to the application.
The functionality to register new patients has not been built yet, users must authenticate with a predefined username/password combination.





Figures 3-4 : InstallationUI

After the first user sign-on, the user is shown the InstallationUI (Fig 3 and 4). The user fills in all the required baseline information. When the user clicks on the registration button, the application analyses all the given information and calculates a patient's baseline risk score for constipation and diarrhea. This information is used to determine if the patient is suffering from constipation or diarrhea on an ongoing basis. These screens are shown only once at the time of application installation.

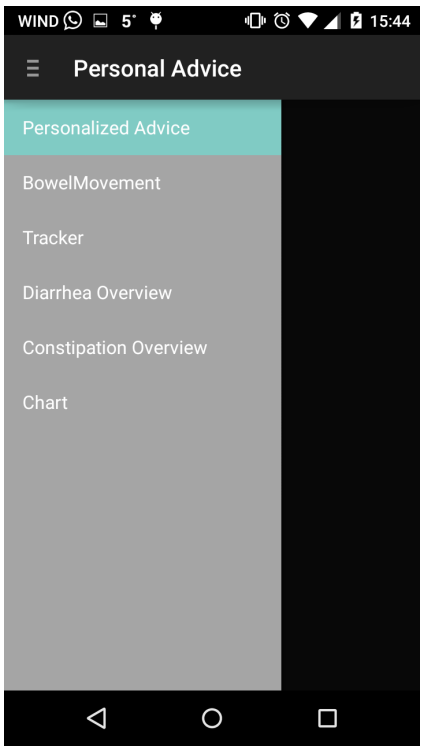


Figure 5: Main App Overview

Upon successful registration, the user is directed to the main application page. This page contains all the tabs in a sliding menu. Users can access the different components of the app by clicking the top left corner or by sliding in from the left to right.

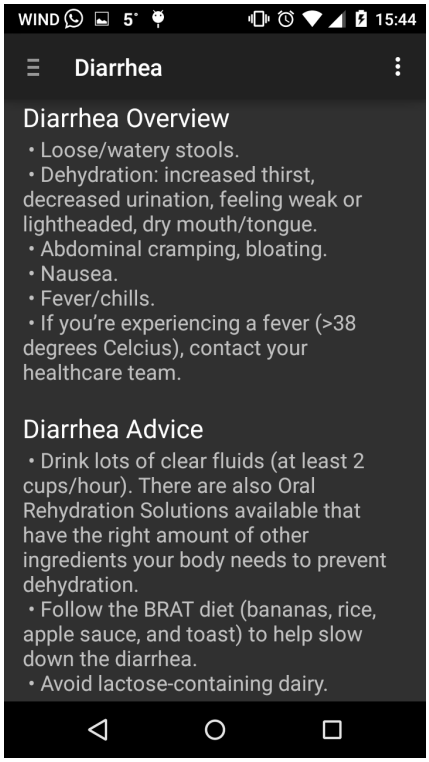


Figure 6: Diarrhea Overview

From *Figure 5*, if the user selects "Diarrhea Overview" they are directed to *Figure 6.* This screen contains basic overview information regarding diarrhea and provides basic advice on how to avoid or self-manage mild diarrhea. This information is critical to provide patients with a baseline understanding of what is generally defined as "diarrhea", and to empower patients to self-manage mild cases of diarrhea effectively.

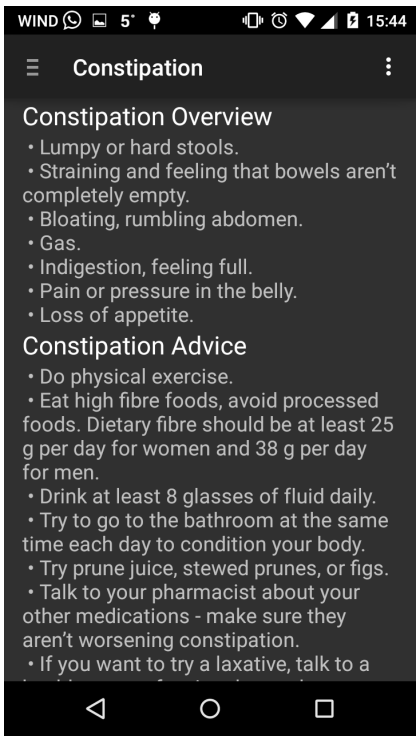


Figure 7: Constipation Overview

Similar to *Figure 6*, this screen provides information pertaining to constipation and provides general medical advice to users.

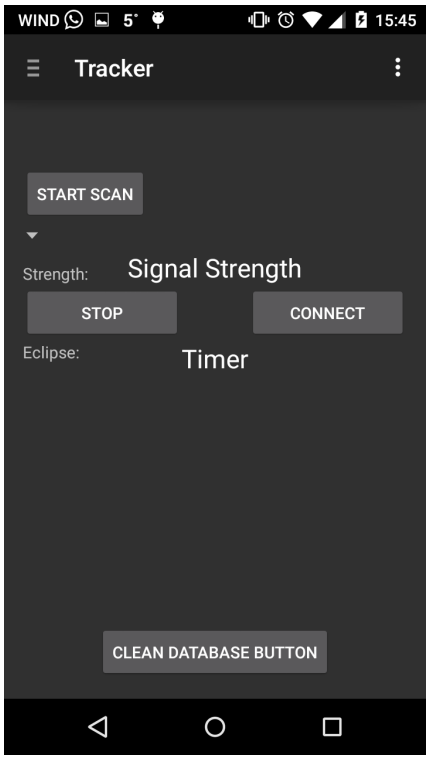


Figure 8: SensorTag Simulation

Figure 8 simulates interfacing the SensorTag with the app and allows the team to simulate washroom visits in order to test and demonstrate the app in a time efficient manner. It will *not* be part of the real-world application of the app.

In order to simulate a visit to the washroom, we press StartScan button, upon which the app searches and connects to the nearest SensorTag. In the absence of a SensorTag, a washroom visit can be simulated using the Connect button. The Timer is started, and it only stops when the phone is out of range of the SensorTag or the Stop button is pressed. The app then saves the tracked information into bowel movement list.

When the app is ready for real-world application, Figure 8 would be replaced with a tutorial for the user to set-up the SensorTag and leave it in their washroom, with washroom visits being solely identified using the sensors.

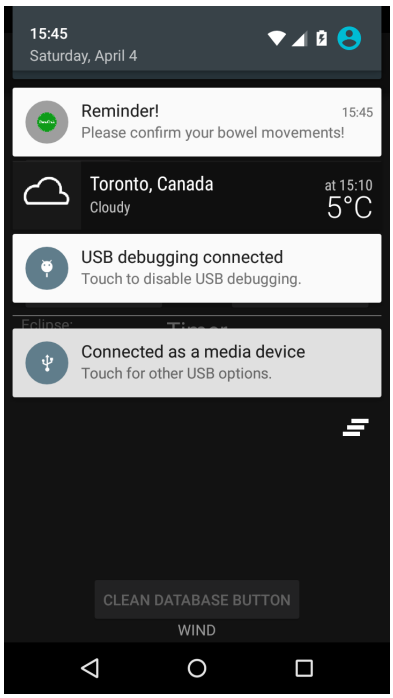


Figure 9: Notification

Once users set-up the SensorTag and the application starts tracking SensorTag washroom visits, the application pop-ups a notification if the user hasn't confirmed bowel movements in the past 24 hours.

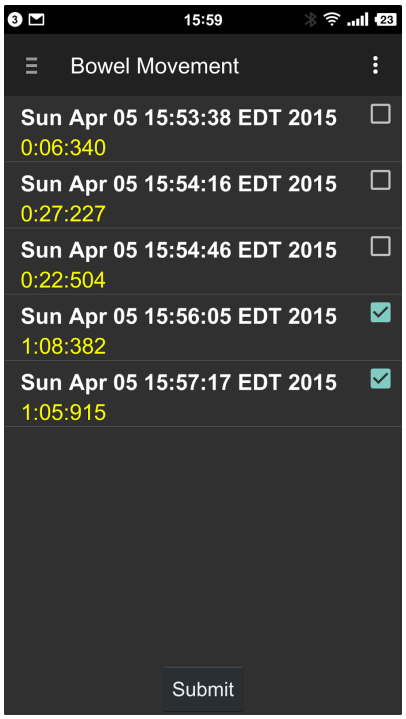


Figure 10: Bowel Movement Confirmation

After click on the notification (*Figure 9)*, the user is presented with all the washroom visits the SensorTag has tracked. This can also be accessed by clicking the "Bowel Movement" link on *Figure 5.* Users then check each visit which actually included a bowel movement and click the submit button. The list is then cleared and the checked entries are logged in the PatientDB.

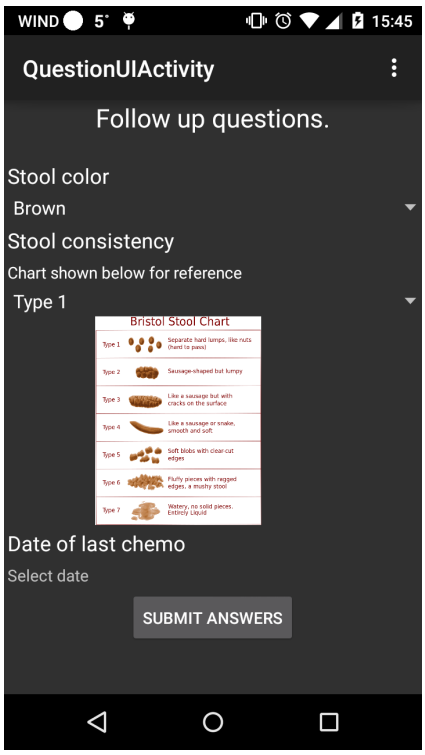


Figure 11: QuestionsUI

After the submit button is clicked (*Figure 10),* the QuestionsUI is displayed (*Figure 11)* to ask questions regarding the newly confirmed bowel movements.

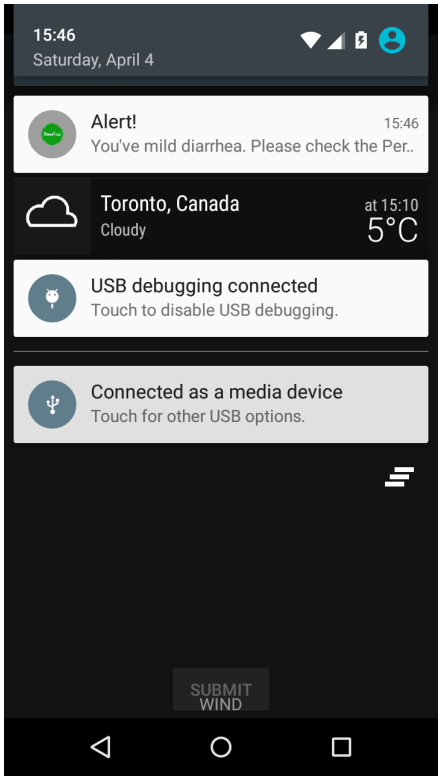


Figure 12: Personal Advice Alert

After *Figure 11* questions are submitted, the app determines the presence and severity of constipation/diarrhea, then alerts the user if there is personalized advice available for viewing.

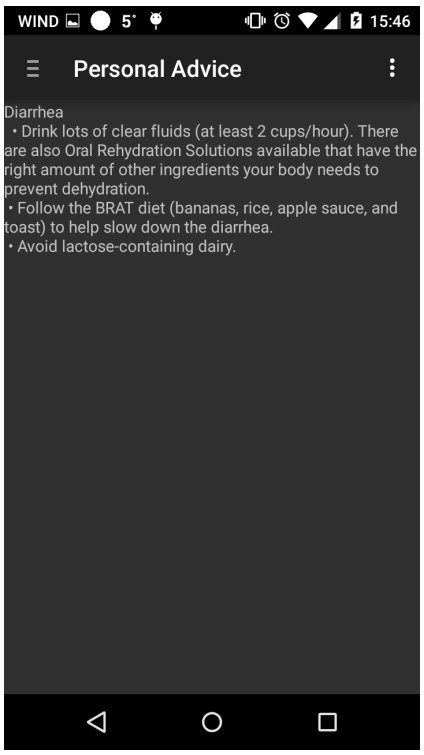


Figure 13: Personalized Advice

When the user clicks the notification (*Figure 12)* they are directed to *Figure 13* to view their personalized advice. This can also be accessed through *Figure 5.*

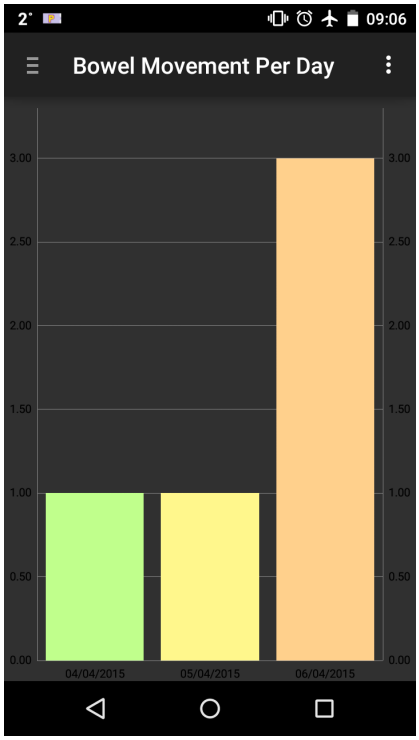


Figure 14: Chart View

Finally, the user can choose the Chart view from *Figure 5* to view the number of bowel movements recorded over time (the x-axis shows the date and the y-axis denotes the number of bowel movements/day).

If the application identifies that the user is suffering from severe diarrhea/constipation, the mobile application pushes all the user's information along with all the tracked bowel movement information to the ChemoBrain server. The ChemoBrain server is currently hosted on the Azure cloud with a SQL Server database backend. Healthcare providers log in and are able to view user information (*Figures 15-17*)

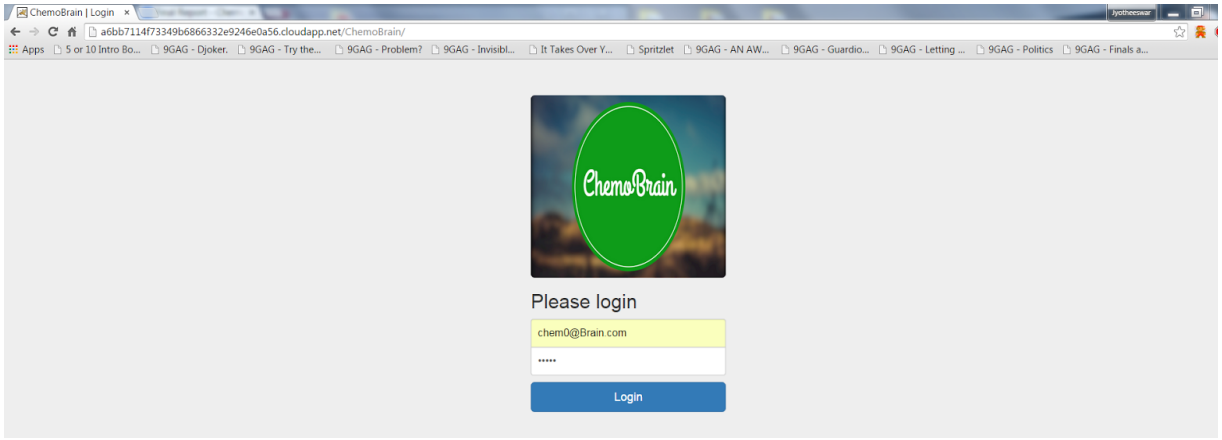


Figure 15: ChemoBrain web server login.

This is the basic login screen for the healthcare provider to access the information stored in the ChemoBrain server.

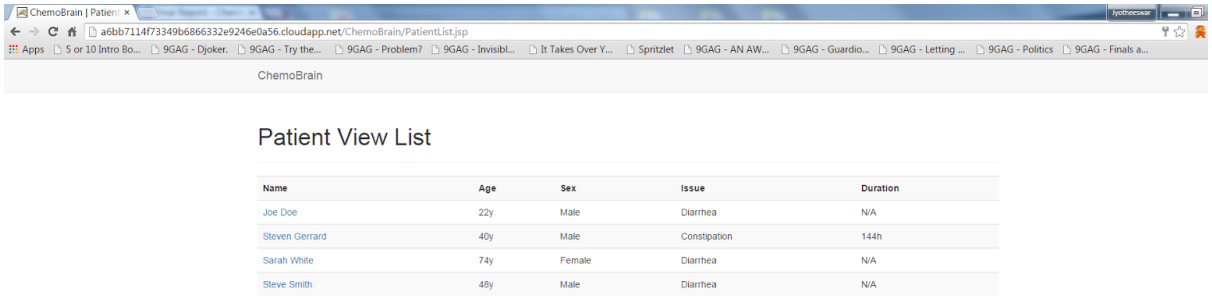


Figure 16: ChemoBrain server patient list

Upon logging in, the healthcare provider can see the list of all users with severe diarrhea/constipation, along with relevant demographic information. Clicking on any patient's name opens detailed information in a new screen (*Figure 17)*.

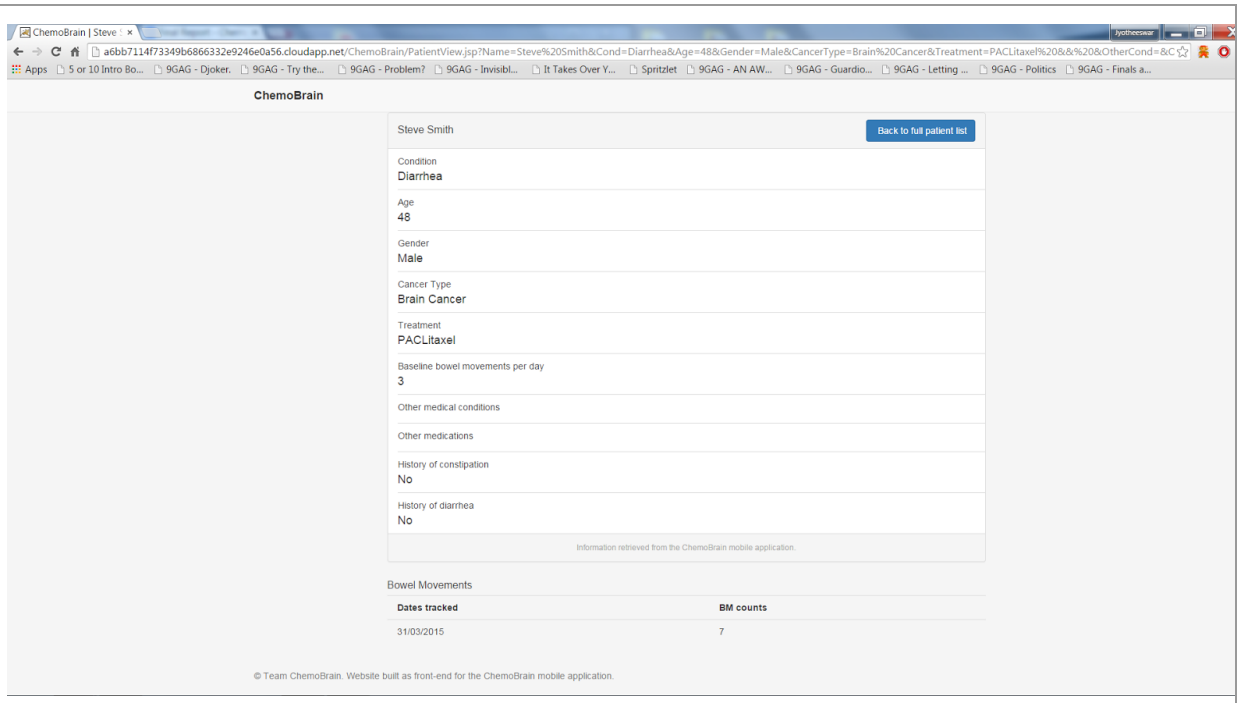


Figure 17: Detailed Patient View.

This page displays all information that was previously stored in the PatientDB. This page also shows a table with the list of all the bowel movements that the patient has confirmed from the day the app has been installed, allowing the user to view trends easily.

WHAT WE LEARNED:

We learned how to communicate complex health information in a way that would allow for application programming. Originally, the Apper had created flowcharts of logic in order to detect constipation and diarrhea, but upon further discussion, tables were created that assigned numerical values of risk for each side effect, and users would accumulate these values until they reached thresholds that were deemed to be actually experiencing the side effect.
Currently, the team needs to learn the nuances of legal issues around providing patients with medical advice.

INDIVIDUAL CONTRIBUTION:

Jyotheeswar created the Login page, Installation UI, the baseline patient risk scoring system, the notification system, the Questions UI and the Analysis/Identification Engines. He converted the information provided by the Apper into the medical

information databases. He also programmed the server side of the application completely and hosted it on the Azure cloud with a SQL Server backend.

Soha created the wireframe for the app and website, created the logo, provided all the medical content and logic for diagnosing constipation/diarrhea and determining severity of the condition. She also provided tables of medications and medical conditions which included weighting of risk of constipation/diarrhea.

Wuyue created Tracker module, interfaced the SensorTag and created all necessary APIs and functions. He also created the Main Activity layout with the different menu components, the Charts screen and the Bowel Movement confirmation screen. He created the database and the functions to manipulate the data for all the tracked bowel movements.

APPER CONTEXT:

This application is meant to be used in the clinical setting of an outpatient cancer centre, where I work. The app can be given to all patients starting/receiving chemotherapy.

When patients are given chemotherapy, they get one follow-up phone call/ clinic visit with a pharmacist or nurse within a week of the first treatment. They also have access to a nursing hotline if they experience issues at any point during their treatment.

Unfortunately, usually patients are found to be suffering from a side effect for days before they let their healthcare provider know at their first follow-up. The second issue that needs consideration is that after their first follow-up, there is no active follow-up program in place to contact the patient. Essentially, it becomes up to the patient to determine when to contact their healthcare team. Too often, patients let their side effects escalate because of fear that chemotherapy will be stopped, or because they don't realize that a side effect can be well-managed with very simple interventions at home. Providing patients with a passive means of tracking their side effects and receiving interventional notifications to ensure proper management of side effects early on can go a long way to ensuring their chemotherapy experience is as smooth as possible.

Our cancer centre is searching for better ways to educate patients. One of the most promising ways to do this is to provide information on a need-to-know basis. Currently, patients are bombarded with information about their treatment, all the potential side effects, and how to manage all side effects right at the beginning of treatment. This

education is rarely repeated unless patients take an active role and request re-education. Technology can become a powerful tool for the majority of patients that are less active in their treatment, providing education and tips on side effects that actually become relevant to them as they begin to experience them.

FUTURE WORK:

The SensorTag device used for tracking the bowel movements tends to auto switch-off itself. This is not ideal for the application to function smoothly as the it would force regular user intervention. In the future, we aim to explore other sensors or make modifications to the SensorTag API to ensure that the device remains on continuously. Another drawback with using the SensorTag would be its limited battery. Future work can be done in coming up with a sensor that is connected to a power outlet.

We feel there is a lot of potential for this application, and the team would like to explore using further sensors like the temperature sensor, camera to detect heart rate and others to further enhance and extend the capabilities of the application and begin tracking additional side effects.

The server side can also be extended by allowing the healthcare personnel to add notes and summaries while contacting the patient, which can be pushed to the mobile app so that the user has a record of the conversation for future reference.

The ChemoBrain team requests that the video be posted online. However, we would not like for the source code to be made available online as yet as we are considering moving forward with this project.