



# UNIVERSITY OF TORONTO

## Lightbulb

Final Report

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# Table of Contents

<b>Table of Contents</b>	<b>2</b>
<b>Introduction</b>	<b>3</b>
Why	3
What	3
<b>Statement of Functionality</b>	<b>4</b>
Sign in and Sign Up	4
Patient Profile	4
BMI Calculator	5
Risk Calculator	7
Food Diary	8
Screening	8
Charting	9
Chat	10
Physician Profile	11
<b>Overall Design</b>	<b>12</b>
<b>Specialist Context</b>	<b>14</b>
<b>Contribution by Each Group Member</b>	<b>14</b>
<b>Reflection</b>	<b>14</b>
<b>Future Work</b>	<b>15</b>
<b>Posting on the Course Website:</b>	<b>16</b>
<b>References</b>	<b>17</b>

# Introduction

## Why:

Almost 10% of Canadians live with type 2 diabetes [1], which is a major risk factor for many serious health conditions such as strokes, heart attacks, kidney failure, and blindness. Furthermore, another 20% of Canadians have prediabetes, which can develop into type 2 diabetes if unmanaged [1]. Consequently, managing diabetes or the risk of diabetes is important for the preventive healthcare of many Canadians [2]. For those without type 2 diabetes or prediabetes it is still important to stay informed about potential risk factors that may develop as well as effective preventive health measures.

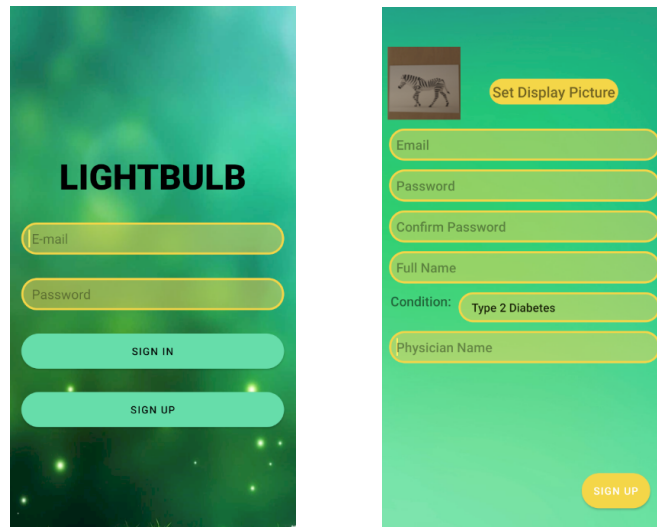
## What:

Lightbulb provides users with type 2 diabetes and prediabetes resources to help monitor their condition with tools such as diabetes test result tracking and charting, a food diary, and screening test scheduling. Users with neither condition can also use the app to schedule screening tests as well as assess their diabetes risk through questionnaires that provide helpful preventive health tips throughout. The app also provides a means of connecting patients with their physicians through a chat interface as well as functionality that allows physicians to monitor and view patients' logged diabetes test result data and diet in the form of charts and food diaries.

## Statement of Functionality

### 1) Sign in and Sign Up

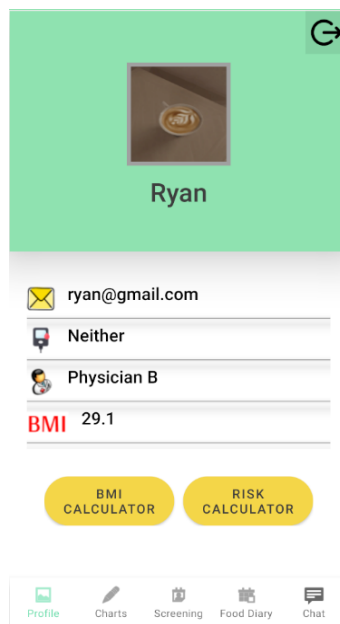
When a patient signs up, they need to provide their email, password, and full name as well as select their current physician using an autocomplete textbox that fills in the names of physicians registered with Lightbulb (Figure 1). Patients also have to select their current condition (type 2 diabetes, prediabetes, neither), which will impact the content displayed in other activities. Physician accounts cannot be created in the app and are instead created using the Firebase console.



**Figure 1.** Sign In (Left) and Sign Up (Right) Activities.

## 2) Patient Profile

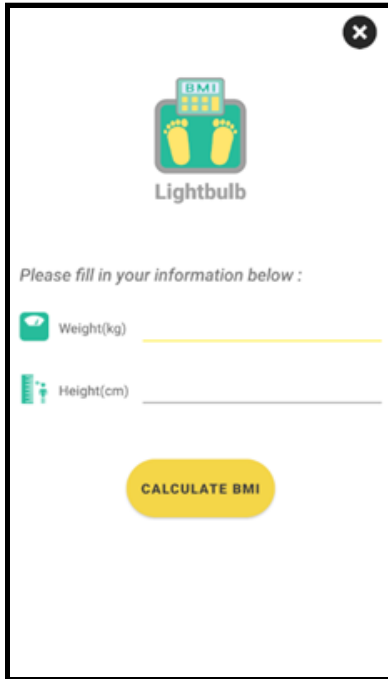
After a patient signs in or signs up, they will be redirected to the profile page (Figure 2). The profile page displays their basic information and acts as a portal to other activities. From this page they can access the BMI calculator and risk calculator activities. The bottom navigation menu is available in most activities and provides links to the profile, charts, screening, food diary, and secure chat activities. The user can sign out using the button at the top right.



**Figure 2.** Patient Profile Page

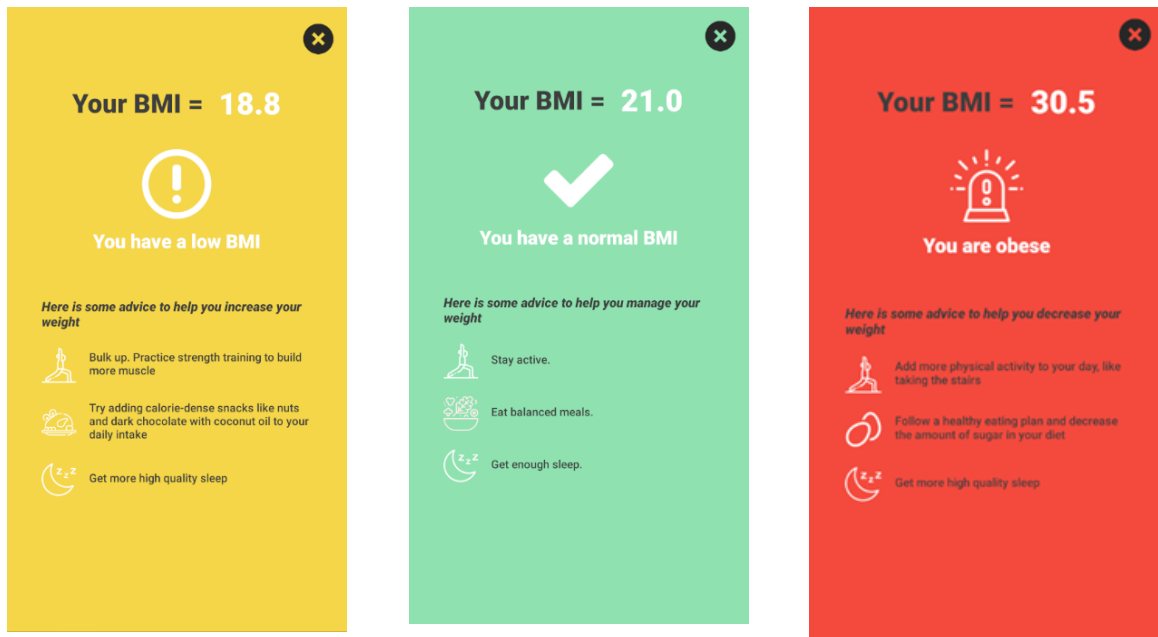
### 3) BMI Calculator

The BMI (Body Mass Index) calculator (Figure 3) asks users to input their weight and height to compute their BMI value [3]. High BMI is a risk factor for type 2 diabetes and knowing this value helps users better understand the impact of their weight on their risk of developing diabetes (Figures 4 -6).



The screenshot shows a mobile app interface for a BMI calculator. At the top, there is a close button (X) and a logo featuring a lightbulb with 'BMI' above it and two footprints below. The text 'Lightbulb' is centered below the logo. Below this, the instruction 'Please fill in your information below :' is displayed. There are two input fields: 'Weight(kg)' with a scale icon and 'Height(cm)' with a person icon. A yellow button labeled 'CALCULATE BMI' is positioned at the bottom.

Figure 3. BMI Calculator.



The figure displays three vertical panels representing different BMI results. Each panel has a close button (X) in the top right corner.

- Low BMI (18.8):** The background is yellow. It features a white exclamation mark icon and the text 'Your BMI = 18.8' and 'You have a low BMI'. Below this, it says 'Here is some advice to help you increase your weight' and lists three items: 'Bulk up. Practice strength training to build more muscle' (with a person icon), 'Try adding calorie-dense snacks like nuts and dark chocolate with coconut oil to your daily intake' (with a bowl icon), and 'Get more high quality sleep' (with a zzz icon).
- Normal BMI (21.0):** The background is green. It features a white checkmark icon and the text 'Your BMI = 21.0' and 'You have a normal BMI'. Below this, it says 'Here is some advice to help you manage your weight' and lists three items: 'Stay active.' (with a person icon), 'Eat balanced meals.' (with a bowl icon), and 'Get enough sleep.' (with a zzz icon).
- Obese BMI (30.5):** The background is red. It features a white lightbulb icon and the text 'Your BMI = 30.5' and 'You are obese'. Below this, it says 'Here is some advice to help you decrease your weight' and lists three items: 'Add more physical activity to your day, like taking the stairs' (with a person icon), 'Follow a healthy eating plan and decrease the amount of sugar in your diet' (with a bowl icon), and 'Get more high quality sleep' (with a zzz icon).

Figure 4 - 6. BMI Calculator Results.

## 4) Risk Calculator

The risk calculator is based on the Canadian diabetes risk questionnaire [4]. It contains a total of 13 questions for which the user must either select the best fit option or type in the answer (Figures 7-9). After completing the assessment, they then obtain a final score that represents their risk of developing diabetes. Suggestions and tips for preventive health corresponding to their assessment result are also provided (Figures 10 - 12).

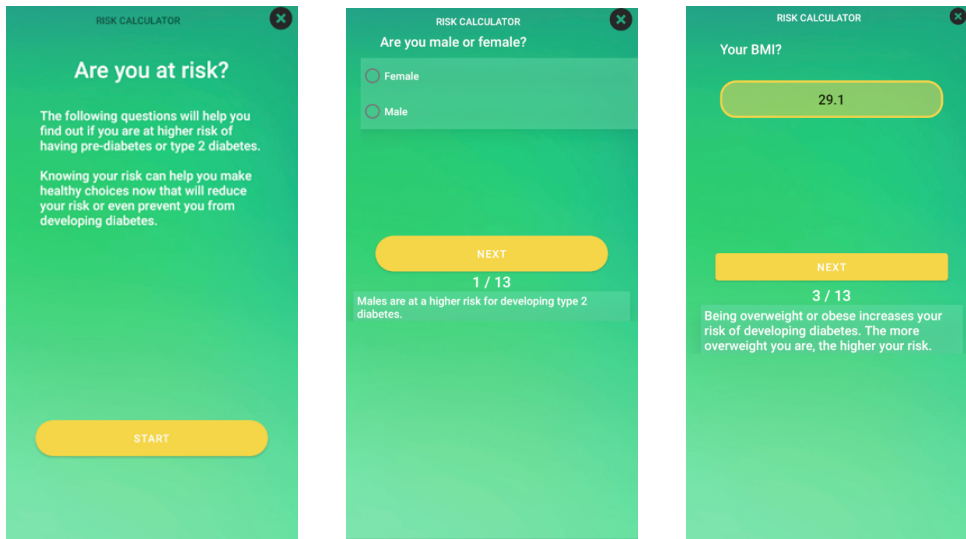


Figure 7 - 9. Risk Calculator Questionnaire.

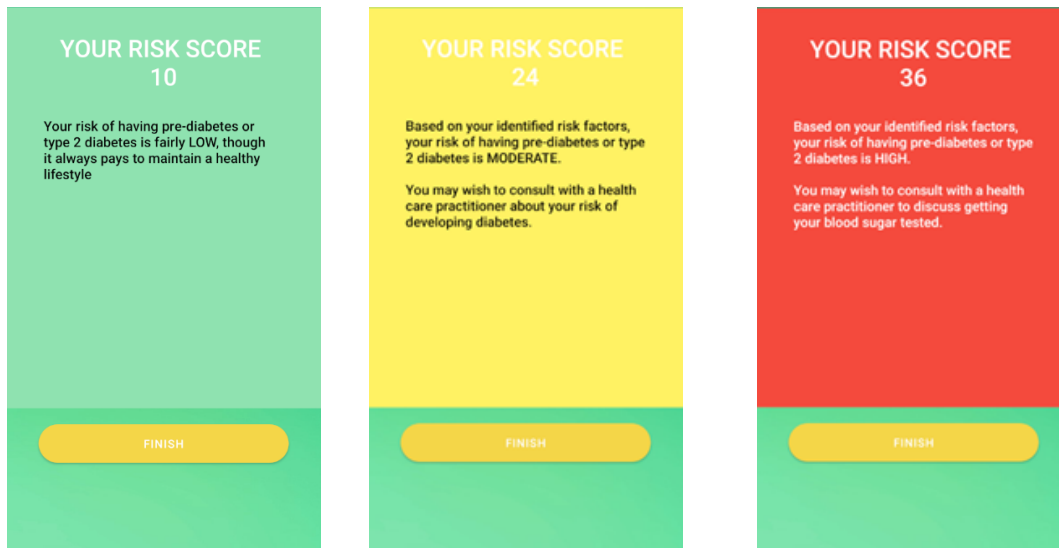
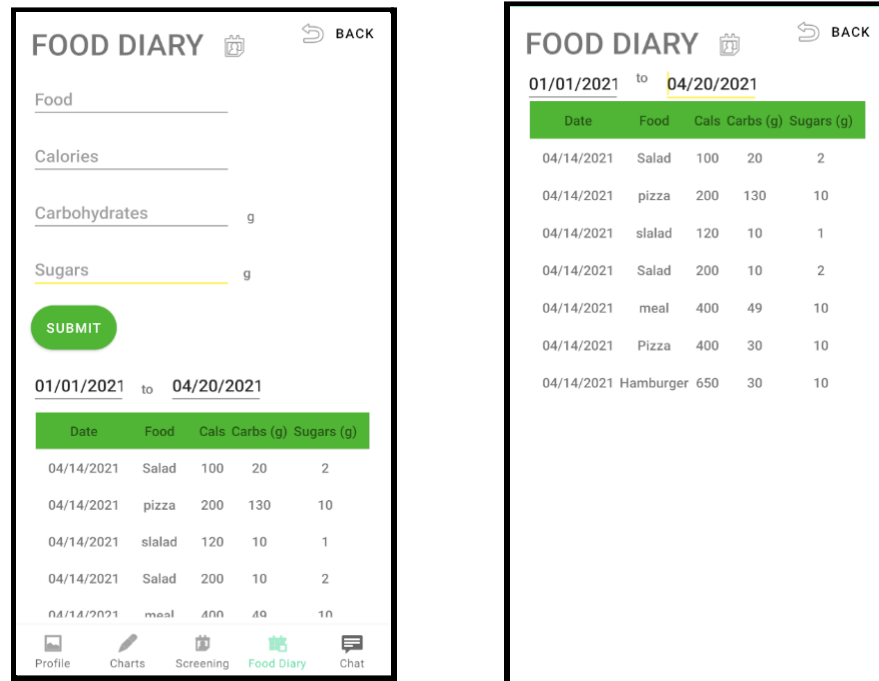


Figure 10 - 12. Risk Calculator Assessment Scores.

## 5) Food Diary

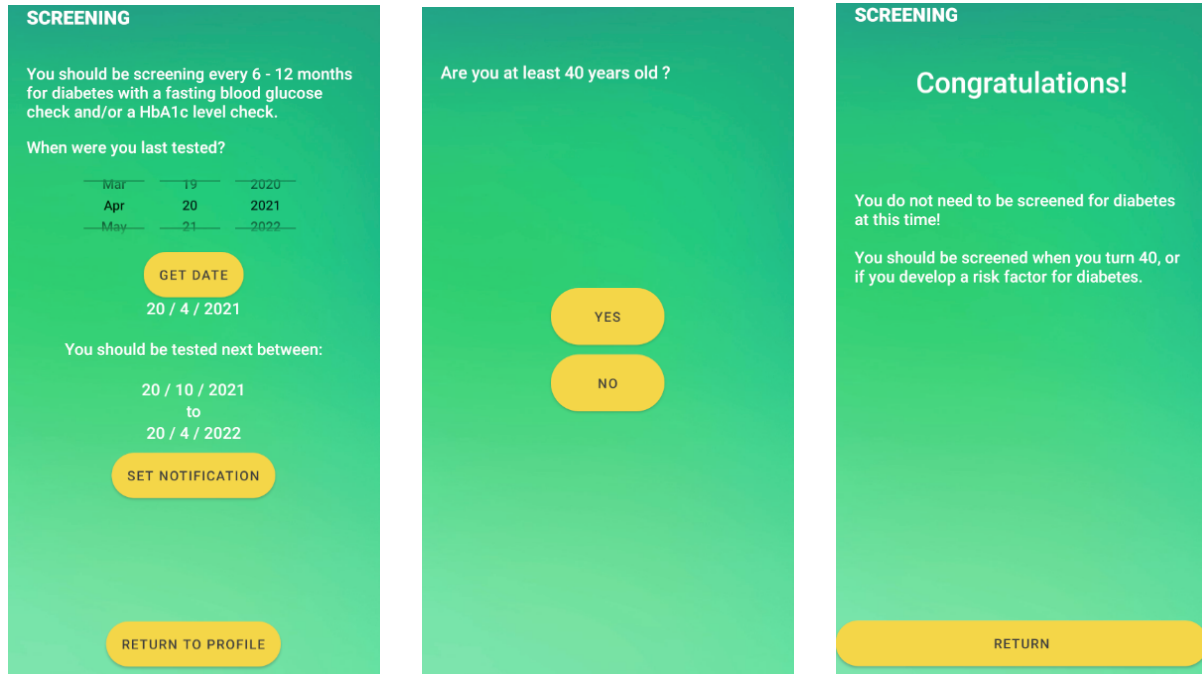
The food diary helps patients and their physician keep track of the patient's nutritional intake meal-by-meal. Users can enter and save the category and nutritional data of the food they eat. A list of meals that the user logged is saved into the Firestore Realtime Database and is displayed in a scrollable table. The table can be filtered by date. A patient's food diary can also be viewed by their assigned physician.



**Figure 13 - 14.** Food Diary Activity. Patient View (Left). Physician view (Right).

## 6) Screening

The screening activity displays a different set of questions and input fields based on the current condition of the user (type 2 diabetes, prediabetes, neither) [5]. Based on their response, the user will be provided with a range of dates during which they should have their next diabetes test (HbA1c, blood glucose, etc.). The user can then choose to set a push notification that will remind them when the dates are approaching. This suggested date range is also automatically sent to the user's physician as a message via the secure chat function.



**Figures 15 - 17.** Screening Activity.

## 7) Charting

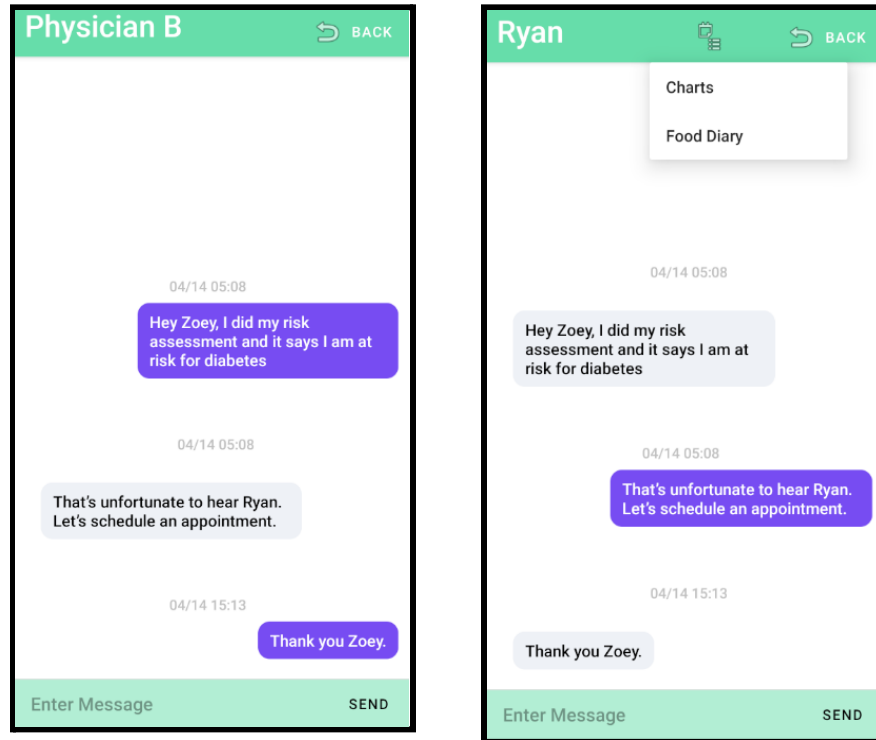
The charting activity allows users to keep track of and view their previous diabetes testing results, such as HbA1c and blood glucose levels. A spinner is used to select the metric to display. Similar to the food diary, these results are stored in the remote Firestore Realtime Database and can be viewed by the patient's assigned physician. Users can enter an appropriate value and click submit to save it to the database. An example plot is shown in figures 18 & 19.





## 8) Chat

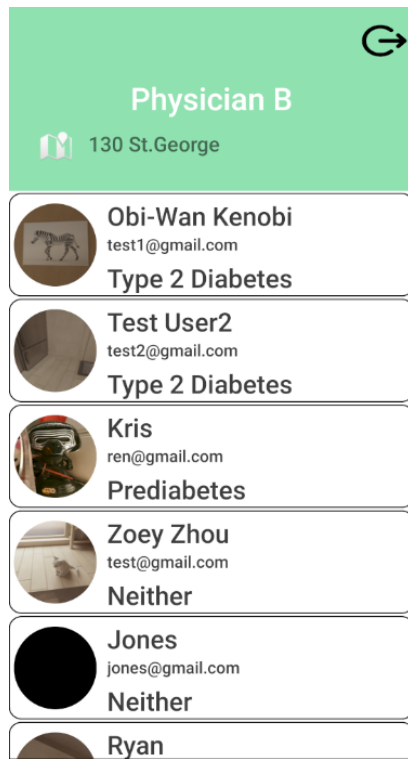
The secure chat activity enables communication between users and their physicians. For physicians, there is a button with a calendar icon in the top bar that they can click to view the patient's logged diabetes test result charts or food diary.



**Figure 20- 21.** Patient Chat Interface (Right). Physician Chat Interface (Left).

## 9) Physician Profile

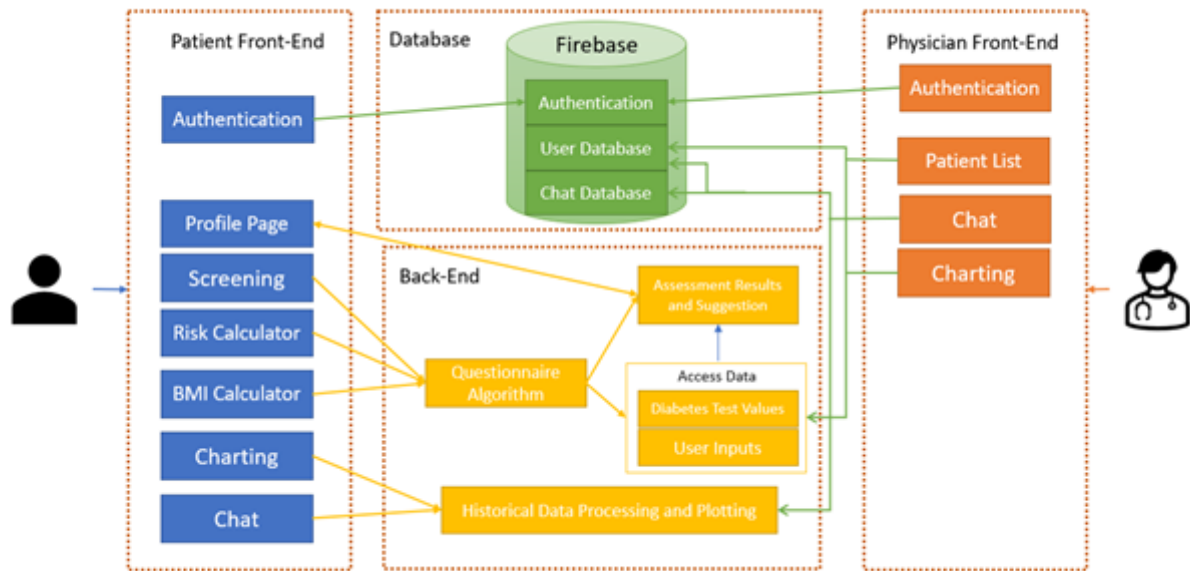
The physician profile page (Figure 22) is less sophisticated than the corresponding patient page and shows only a list of patients that are assigned to the physician. The physician can enter a chat with each patient by clicking on that patient's entry. The button at the top right is used to log out.



**Figure 22.** Physician Profile Page

## Overall Design

The design of the system structure can be divided into four segments, as illustrated in the figure below.



**Figure 23.** Structure of the LightBulb App Design.

The leftmost block in the block diagram is the patient front-end, which is responsible for the patient user interface as well as patient data collection and presentation. Users can register as a patient in the app and access all features from the patient interface once they complete authentication.

On the rightmost side of the block diagram is the physician front-end that is responsible for providing the physician interface. The physician can view a list of his/her patients and select any one to enter a chat with them. The patient front-end and physician front-end communicate with each through the Firebase Database and the physician can retrieve patient data, such as their diabetes test result charts and food diary data, to view and analyze.

After an activity is launched by the user, it communicates with the local backend to retrieve or store relevant patient data. In the case of diabetes test result charting and the food diary, data entered by the patient is stored in the Firebase Realtime Database. With the exception of users' profile photos, which are stored in Firebase Storage, most other user data is stored remotely in the Firestore Database. There are two primary collections in the Firestore Database: "users" and "chat". The "users" collection contains user documents that are identified by each user's unique id. The "chat" collection contains all instant messages sent between patients and physicians, with each document containing fields indicating the users' ids and the message timestamp.

# Specialist Context

Due to the covid-19 pandemic our specialist, Neil Dattani, was not available to write a specialist context section for this report. A special exception was granted by Dr. Rose in an email sent on April 1st 2021 at 1:16 pm Eastern Time.

## Contribution by Each Group Member

### **Neil Dattani (Specialist)**

1. Conceptualized the lightbulb app and functionality.
2. Provided expertise as a physician and worked with programmers to design the functionality of the app.
3. Designed risk assessment and screening questions/tips.
4. Provided UI design mockup for the app.

### **Ming Hou (Programmer)**

1. Implemented diabetes test result charting, food diary, screening push notifications, bottom navigation bar, and authentication.
2. Created activity for physicians to browse patient data.
3. Database design and setup.

### **Xueqian Zhou (Programmer)**

1. Implemented patient profile page, physician profile page, BMI calculator, risk calculator, screening, and chat activities.
2. Modified the overall UI layout and color scheme.
3. Designed the algorithm to link the physician and corresponding patients.

## Reflection

Our group learned a great deal about one another's occupations as well as project management over the course of this semester. One aspect of the course we found valuable to learn was the agile development framework that was followed. Agile development helped us set achievable goals and made it easier to respond to and adapt to feedback for each spiral. Constructive discussions were held after each spiral was completed to discuss feedback and come to an agreement on changes to the overall vision of the project.

There were also various roadblocks encountered during development. In particular, we encountered difficulties early on in clearly defining and narrowing the scope of our app.

The initial vision of the app was to provide preventive healthcare options and tips for a wide variety of conditions, not just type 2 diabetes, as well as travel guidelines. Consequently, we had difficulties designing the app to accommodate all of preventive health due to the wide variety of needs and use-cases that were potentially entailed. Had we identified the need to narrow the scope and limited it to Type 2 Diabetes earlier, we could have saved significant amounts of time in the early parts of the course.

For the programmers, one significant lesson learned was the importance of thoroughly planning out the UI design beforehand and maintaining consistency in UI implementation throughout development and between programmers. As we added new activities and features it was sometimes discovered that the UI and navigation options at the time did not accommodate for the additions effectively. As a result, several unplanned UI reworks had to be done throughout the course of the project such as the addition of a bottom navigation bar and visual overhauls. In the future we would set out to carefully design and come to an agreement on the UI to ensure that such oversights and conflicts are resolved before any technical debt is accrued.

## Future Work

### **Food Diary Expansion**

The food diary activity could be expanded upon through additions such as automated nutrition data entry, which would automatically fill in nutrition fields using a food database rather than relying on manual entry. Other possibilities include additional analytical tools, such as charts and graphs of nutritional data to help patients and their physicians better understand and manage the patient's diet in order to mitigate the risk or effect of diabetes.

### **Activity Tracking**

Regular physical activity is a crucial aspect of lowering blood sugar levels in order to manage type 2 diabetes or prediabetes risk [6]. Consequently, a physical activity tracker would be a useful feature to add. Possible implementations could include using the phone's accelerometer to track activity throughout the day, using external fitness tracking sensors, or manual entry. The nature, intensity, and duration of the activities could then be stored in the database and used to aid in preventive health plans set by the patient and physician.

### **Replication for Other Medical Conditions**

The Lightbulb app could be either replicated or expanded to encompass other medical conditions such as hypertension and cancer. Many of the core functionalities of Lightbulb, such as screening scheduling, risk assessment, test result tracking, and

patient-physician communication, are applicable and helpful towards the management of these other conditions. Each different condition would still require its own unique set of additional features as well that would have to be designed and adapted for the specific condition.

## Posting on the Course Website:

I agree to have the following posted on the course website:

	Video of final presentation	Report	Source code
Xueqian Zhou	Yes	Yes	No
Ming Hou	Yes	Yes	No
Neil Dattani	Yes	Yes	No

All members agree to posting the video of the final presentation and the final report online.

# References

[1] *Canada needs a nation-wide diabetes strategy now*. DiabetesCanadaWebsite. (n.d.). <https://www.diabetes.ca/>.

[2] Green, M. E., Shah, B. R., Slater, M., Khan, S., Jones, C. R., & Walker, J. D. (2020, August 17). *Monitoring, treatment and control of blood glucose and lipids in Ontario First Nations people with diabetes*. CMAJ. <https://www.cmaj.ca/content/192/33/E937>.

[3] WebMD. (n.d.). *BMI Calculator for Men & Women: Calculate Your Body Mass Index*. WebMD. <https://www.webmd.com/diet/body-bmi-calculator>.

[4] Health Canada, G. of C. (2017, March 29). The Canadian diabetes risk questionnaire. <https://www.healthycanadians.gc.ca/en/canrisk>.

[5] Centers for Disease Control and Prevention. (2019, May 15). *Diabetes Tests*. Centers for Disease Control and Prevention. <https://www.cdc.gov/diabetes/basics/getting-tested.html>.

[6] Centers for Disease Control and Prevention. (2018, April 24). *Get Active!* Centers for Disease Control and Prevention. <https://www.cdc.gov/diabetes/managing/active.html>.