ASHESI UNIVERSITY COLLEGE

WEB-BASED PHARMACIST EXPERT SYSTEM FOR SUPPORTING

COMMUNITY PHARMACY PRACTICE – PREMIER POINT

CHEMISTS

APPLIED PROJECT

B.Sc. Computer Science

Dela Kwami Acolatse

2018

ASHESI UNIVERSITY COLLEGE

Web-Based Pharmacist Expert System for Supporting Community Pharmacy Practice – Premier Point Chemists

APPLIED PROJECT

Applied Project submitted to the Department of Computer Science, Ashesi University College in partial fulfilment of the requirements for the award of Bachelor of Science degree in Computer Science

Dela Kwami Acolatse

April 2018

DECLARATION

I hereby declare that this applied project is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:

……………………………………………………………………………………………

Candidate's Name:

……………………………………………………………………………………………

Date:

……………………………………………………………………………………………

I hereby declare that preparation and presentation of this applied project were supervised in accordance with the guidelines on supervision of applied project laid down by Ashesi University College.

Supervisor's Signature:

……………………………………………………………………………………………

Supervisor's Name:

……………………………………………………………………………………………

Date:

……………………………………………………………………………………………

ACKNOWLEDGMENT

I would like to give special thanks to the almighty God for his guidance throughout my academic journey at Ashesi. I would also like to thank God for seeing me through to the completion of my project.

I would like to extend my thanks and gratitude to my supervisor, David Ebo Adjepon-Yamoah, for his encouragement and support in the development of this project. His advice and ideas helped cement core components of this project and so helped a lot in the development of this project.

I would also like to extend my thanks and gratitude to my parents and family for their support, encouragement and dedication in seeing me through to the end of my Ashesi journey.

ABSTRACT

Community pharmacies are well positioned to be the first port of call for healthcare in the community. The services they provide improve the health and well-being of customers and therefore affirms their role as establishments for trusted health advisory. The daily demand for health consultation and advice from customers imply that community pharmacies get very busy. Some customers with health concerns cannot make it to pharmacies during working hours due to their busy schedules and exigencies of workload. This can compel them to look elsewhere for their health needs such as searching the internet, talking to family and even friends in a matter of urgency or when necessary. However, in most cases, it is difficult to assert the accuracy and reliability of the information found or given. With the possibility of false, misleading or incomplete health information available and provided, customers may not be directed to take appropriate measures for their health conditions. In this project, a web-based pharmacist expert system is implemented for the community pharmacy context, specifically for Premier Point Chemists located at North Labone, Accra, Ghana. The system is implemented to support and provide an around the clock healthcare access for Premier Point Chemists to attend to customers who need health consultation on common occurring minor ailments in instances where the pharmacy is closed or not operating.

Table of Contents

LIST OF FIGURES

Chapter 1: Introduction

1.1 Background and Motivation

Community pharmacies are an integral part of health service providers in the community. They are well positioned to deliver drug therapy, education and counsel as well as health consultation and support on how to handle common occurring ailments. The provision for treatment and advice on common occurring ailments is increasingly becoming popular as many developed and developing countries are integrating schemes that handle these health scopes into the community pharmacy setting (Ayele et al., 2018). Community pharmacies also provide health screening for the monitoring of blood pressure and other indicators to cater for community members suffering from hypertension and other chronic conditions (Erku & Mersha, 2017). In a long run, this improves and contributes significantly to the health service provisions in the community and therefore strengthens the role of community pharmacies as establishments for trusted health advisory.

The responsibilities of community pharmacies are very demanding and implies that they are always busy attending to customers' health issues daily. Nevertheless, some customers with health concerns cannot make it to pharmacies during working hours due to their busy schedules and exigencies of workload. This can compel them to look elsewhere for their health needs such as searching the web, talking to family and even friends in a matter of urgency or when necessary. However, in most cases, it is difficult to assert the accuracy and credibility of the information found or given. With the possibility of false and inaccurate health information available and provided, customers may be misled or not be directed to take appropriate measures for their health concerns and conditions. This means that despite the growing popularity and integration of the internet as a convenient source for

information, there is a need to be cautious of health-related information acquired and consumed online primarily because findings could be misleading and difficult to comprehend. Research has shown that online health-related information varies in substance and quality and seekers of such information, who are mostly non-health experts, do not possess the critical skills for evaluating and applying their findings into the context of their health conditions or situations (Tan & Goonawardene, 2017). In view of this, it is imperative that pharmacies have an around the clock healthcare access to attend to customers who need health consultation at times when pharmacies are closed. By so doing, pharmacies can provide healthcare access to a vast array of customers or patients and improve their customer base.

Against this backdrop, this project develops a web-based expert system for the community pharmacy context specifically for Premier Point Chemists located at North Labone, Accra, Ghana. Expert systems are applications that can provide advice and services based on heuristic knowledge provided by experts. In this project, the expert system will be available to support and provide instant expert advice on minor ailments and will support the pharmacist of Premier Point Chemists. The system would provide predictions on probable ailments based on inputs from the patient or customer. This system is intended to support and boost the health services of the pharmacy. The customer or patient will be required to input their symptoms and answer some questions for a prediction to be given. This system is implemented to tackle minor ailments of common occurrence.

1.2 Benefit of Proposed System

The internet is widely used by many people for the acquisition of health-related information. Despite the huge wealth of informational sites and resources on health related-matters on the internet, seekers are still not guaranteed that the information provided by

some of these resources are complete or substantial. Moreover, basic evaluation of sites and resources such as checking the date the resource or site was created or published to make sure the information provided is not outdated is mostly overlooked by seekers (White & Horvitz, 2009). There is a possibility of getting misleading or inaccurate information pertaining to health matters on the internet (White & Horvitz, 2009). The proposed web-based pharmacist expert system draws on expertise directly from a pharmacist or health professional of Premier Point Chemists who have been trained to handle matters of health and manage the provision of treatments on ailments of common occurrence.

Profitable businesses and companies are those that maximize on their opportunities by tapping into and making efficient use of their resources (Colquhoun, 2014). The incorporation of innovative and creative ideas into a pharmacy's practice has the potential to drive the pharmacy business forward and give it a steady advantage over other pharmacies in the industry (Colquhoun, 2014). As a result, employing such an expert system into Premier Point Chemists' operations would give it an edge over other pharmacies in Ghana.

1.3 Problem Statement

Health is vital for human survival. Health conditions can be addressed if reported or treated immediately. A community pharmacy performs a lot of functions such as drug therapy, the dispensing of medications, health consultation and support for minor ailments. These functions are limited by the constraint of time and work. A community pharmacy cannot provide health services when it is closed for the day. As a result, those that need health support when pharmacies are closed resort to the internet for solutions and are in danger or at risk of not being directed to seek appropriate help for urgent ailment conditions. This is because it is difficult to assert how complete and substantial health-related information is on the internet. Community pharmacies must find a way to develop an around

the clock healthcare access and presence. This way customers and patients can still acquire some healthcare facility and advice they need even when the pharmacy is not operating.

1.4 Related Works

In the scope of health, there are many intuitive ways technology has been used to provide health services and health access to people that needed it. Expert systems employed to provide health consultation and medical reasoning are numerous. In this section, a number of them are discussed.

The first related work can be found with an expert system that provides diagnostics and treatment recommendations on diseases associated with the endocrine system. The endocrine system helps with the regulation of endocrine hormones that control the chemical activities of the body (Abu-Naser, El- Hissi, Abu-Rass & El- khozondar, 2010). Like all expert systems, this system is implemented to operate in a narrow field or domain which is with endocrine-related disorders. The system is implemented using an expert system development tool referred to as the Java Expert System Shell (JESS). The system is not web-based but rather operates using a Java Applet. This puts a cap on the system's level of availability. Having it online eliminates this boundary since it would mean easy accessibility and a wider user coverage. However, the proposed system in this project utilizes the power of the internet to deliver its services to its users anywhere and at any time. Nevertheless, the relevance of this related work to the proposed project is the approach to which the knowledge is acquired for the system's development. The documentation of this related work gives a lot of insight into how to gather information pertaining to health and how to translate them into a form that can be easily transferred into computer understandable language to implement an expert system. Also, the related work gives insight into how rule-based expert systems are developed using expert system development tools. This was particularly important because the use of expert system tools for the development of this

project was a consideration and as a result, it was insightful seeing how one can be incorporated into development.

With the tremendous growth of the internet, more developments and implementations of expert systems online or in the web setting are emerging.

An expert system developed in Malaysia functions as an online alternative for the consultation and treatments of skin diseases prevalent in children (Yusof, Aziz & Fei, 2013). A rule-based inference engine is used for the implementation of this system following a forward-chaining inferencing scheme. The system diagnosis seven common skin diseases associated with children in Malaysia (Yusof, Aziz & Fei, 2013).

Moving away from human health conditions, a fish expert system was developed in China to handle diagnostics of fish diseases. China is primarily considered the biggest country that is well accustomed to the practice of fish farming (Li, Fu & Duan, 2002). Motivated by the threat of diseases to the farming of fishes in China and the limited number of fish disease experts that can diagnosis these diseases, this system uses a collection of images that give some insight into the varying fish diseases accompanied with a well compiled knowledge base to effectively perform an online diagnosis for identifying fish diseases. The three-level architecture together with a variety of web technologies are used for the implementation of the system (Li, Fu & Duan, 2002).

In all, these expert systems give relevance to the proposed project since they seek to solve issues pertaining to specific domains such as the fish expert system seeking to contribute to the shortage of fish disease experts in China and the diagnostics for children skin diseases seeking to support parents in identifying and determining the severity of skin disorders that manifest on the skin of their children. It is worth pointing out that expert systems are intended to support and not designed to undermine the need for actual health

experts. The support is necessary for circumstances or situations where there is a shortage of experts in a specific field or some amount of speed is needed in providing healthcare. The downside to these online expert systems discussed is that these systems require users to answer a wave of questions which can become tiresome for someone who just wants to have his or her health concerns addressed or answered as quickly as possible. The proposed system for this project is expected to provide users with a user-friendly and hectic free interface for receiving predictions and healthcare services. As such, the proposed system will capitalize more on ways to make the acquisition of a prediction and recommendation hectic free and as quick as possible. Another distinction that can be noted is the fact that the proposed system of this project is expected to be operational within the community pharmacy practice tackling minor ailments of common occurrence. Endocrine and skin diseases are mostly reserved for doctors and physicians. Minor ailments are those health conditions that can be treated at the pharmacy level with some support and guidance (Ayele et al., 2018). Some minor ailments include indigestion, common cold, sinusitis, acute cough and diarrhoea.

1.5 Objective

The core objective of the web-based Expert System is:

To support health professionals of Premier Point Chemists in attending to customers or patient's needs. The system would provide an around the clock healthcare access to customers by giving responses based on their inputs. Outside working hours, the system would assume the role of the health professional to provide the necessary services of health consultation and advice pertaining to minor ailments.

1.6 End Product

The product is a web-based pharmacist expert system that will allow for an around the clock healthcare access to customers or patients in and around the community pharmacy known as Premier Point Chemists. The system will allow for users to get quick ailment predictions and recommendations for handling those ailments.

Chapter 2: Requirements

This chapter provides a detailed description of the users of the proposed system, procedures used in requirement gathering, an overview of the requirement analysis made and the deduced requirement specification of the web-based pharmacist expert system, from here on referred to as Premier Health Access (PHA). Premier Health Access, PHA or expert system would be used interchangeably to refer to the web-based pharmacist expert system being developed.

2.1 User Classes and Descriptions

The user classes for this system are the community, that is the people of Labone, and the health professionals of Premier Point Chemists. The administrators of the system are the pharmacist or health professional at Premier Point Chemists

- *Premier Point Chemists* is a community pharmacy in the heart of Greater Accra, specifically Labone. Users in this class consist of the health professionals which are the medicine over-the-counter assistants and the pharmacist.
- The community consists of persons who live in and around Labone. These people have different levels of computer and technology experiences.

Why Premier Point Chemists?

Premier Point Chemists is a bold attempt to be a truly community centred pharmacy and establishment in Labone and their tagline which is "for the well-being of our community" affirms this.

2.2 Requirement Gathering

The data collection schemes used for gathering requirements for this project are observations, questionnaires and interviews. In this project, data collection is done using

triangulation which involves using a variety of methods and schemes to gain an in-depth understanding of an investigated topic. Triangulation also guarantees better accuracy of the data acquired since you are presented with a variety of sources to facilitate comparisons and validations.

- Observing the daily activities and transactions that occur on a daily at Premier Point Chemists brought more strength and validity to the requirement gathering process.

- A series of interviews, two hours every week for six weeks, were conducted with the domain experts to gather information and specifications for the system. The domain experts were the health personnel or pharmacist under Premier Point Chemists. Refer to Appendix A for the interview Guidelines used.

- Questionnaires were administered to the community and to customers that came to the pharmacy. The questionnaires served as tools for affirming the need for the web-based pharmacist expert system and the kind of features the system should have. This work sampled 35 customers of Premier Point Chemists within the period of two weeks. Refer to Appendix B for the interview Guidelines used.

2.3 Requirement Analysis

This section explores the analysis process in determining the various user expectations of the web-based Expert system known as Premier Health Access.

The use of questionnaires gave insight into the necessity for a system that can provide some around the clock healthcare services to community members. The diagrams below illustrate the responses from 35 respondents who filled the questionnaires.
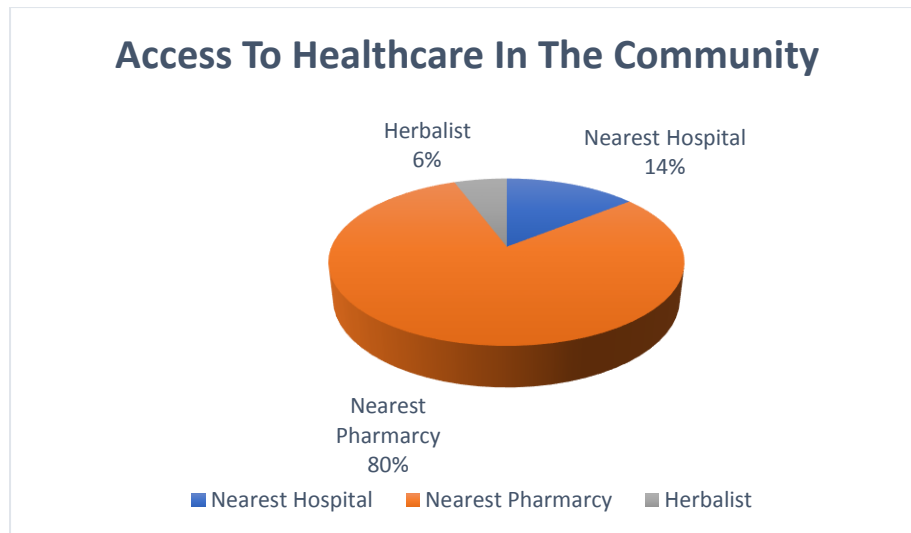
Fig 2.1 Access to healthcare in the community

From Fig 2.1, it can be observed that 80% of respondents rely on the community pharmacy for healthcare services. 14% of respondents go to nearest hospitals or clinics and 5% to herbalist respectively. It can, therefore, be deduced that community pharmacies are indeed the first port of call for healthcare in the community.
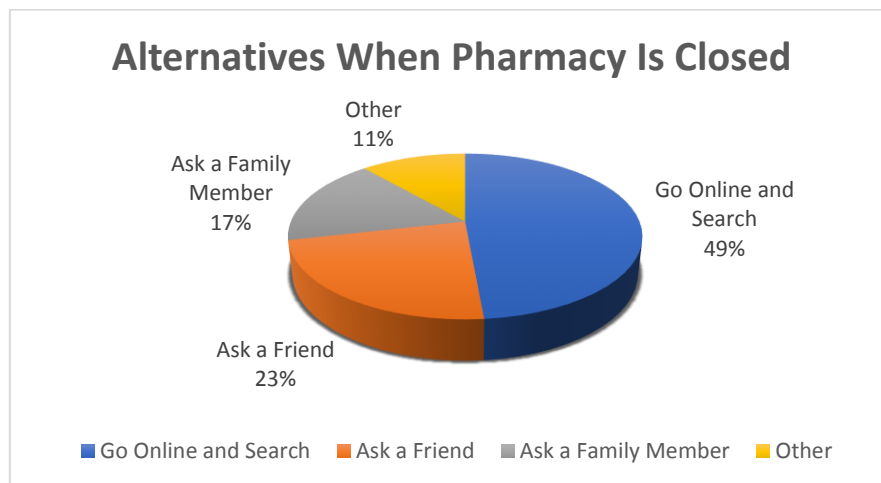

Fig 2.2 Alternatives when pharmacy is closed

From Fig 2.2, it can be observed that 49% of respondents rely on the internet for a solution to their health issues in instances when the pharmacy is closed. 23% of respondents ask friends, 17% of respondents ask family members they believe have some health-related knowledge while 11% of respondents look for other alternatives such as basically enduring

and waiting till the pharmacy opens amongst others. It can, therefore, be deduced that the internet is indeed a tool for acquiring health information especially when there is lack of healthcare access due to time and work constraints.
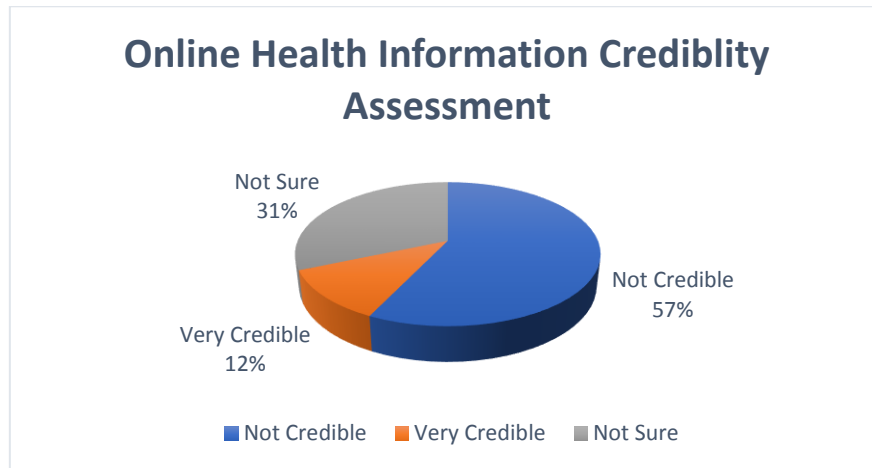

Fig 2.3 Online health information credibility assessment

From Fig 2.3, it can be observed that 57% of respondents believe that online health-related material is not credible and subject to varying accuracy and quality. 31% of respondents are not sure and 12% believe the online health-related materials are credible. It can, therefore, be deduced that people in the community are sceptical about online health information and believe that they are not credible.
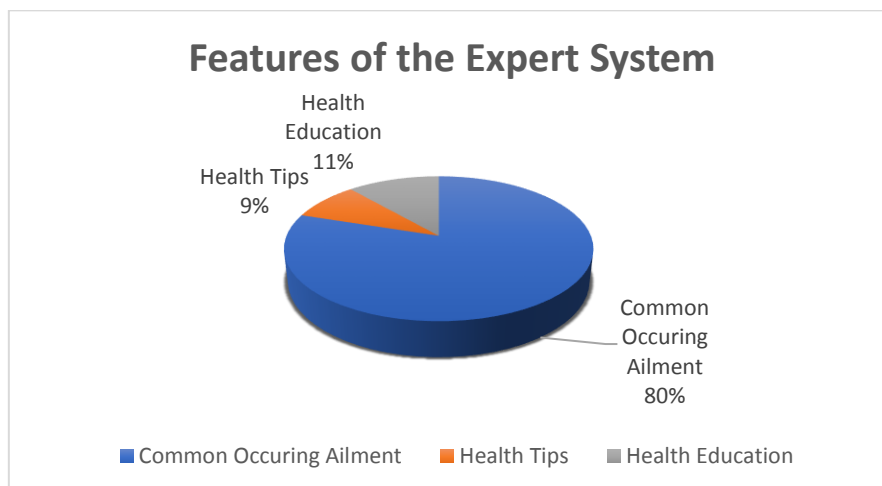

Fig 2.4 Features of the expert system

Respondents responded with functions and features that should be considered in an around the clock service. From Fig 2.4, it can be observed that 80% of respondents believe common occurring ailments should be a major feature in an around the clock health service of a community pharmacy. 11% of respondents prefer health education whiles 9% prefer health tips. It can, therefore, be deduced that consultation for common occurring ailments is a primary feature to be included in the development of the expert system.

Interviews with the health professional or pharmacist helped identify some specific minor ailments that are addressed by Premier Point Chemists on a regular basis. Major reported ailments according to the pharmacist fall under three broad classifications.

Table 2.1 Broad Classification of Ailments

Broad Classification	Ailments observed
Gastrointestinal disorders	• Infectious diarrhoea • Non-Infectious diarrhoea • Constipation • Indigestion
Nasal conditions	• Common Cold • Sinusitis
Cough conditions	• Wet Cough • Dry Cough

The pharmacist emphasized a series of steps that are taken when dealing with minor ailments. The steps to take are outlined below:

Step 1: The first step is to undergo an assessment. Allow the patient to express how they feel by giving you the various symptoms they are suffering from.

Step 2: From there, a diagnosis is made and recommendations are given

Step 3: A treatment plan is drawn up based on diagnostics. A treatment plan involves coming up with the drugs or medication the patient must follow. If conditions do not improve after the patient is through with the treatment, then the patient must be referred to a doctor.

From the analysis or examination of steps outlined above, Premier Health Access is implemented to interface with users to gather information on how they feel as per the symptoms they provide or the answers given to certain questions about their symptoms. After which the system would generate predictions of the ailment the user suffers from. Recommendations on how to tackle the ailment would be provided to cater for the user's discomfort if necessary.

The key ailments identified for each broad classification is documented in a table form. The pharmacist expressed that the diagnostics should not include heavy scientific or biological terms so it can be easily understood by all users. Furthermore, to cater for instances that the pharmacy is not in operation, the pharmacist proposed that recommendations be provided in the form of natural and home remedies that customers can easily administer or follow. In each table, there are four fields. The determinant field shows the indicators or determinants necessary to confirm the prevalence of an ailment. Premier Health Access provides diagnostics for the following:

Gastrointestinal disorders: These disorders are associated with the stomach and intestines.

Ailments: Non-infectious and infectious diarrhoea, constipation and indigestion

General symptoms of the classification: The constant need to have a bowel movement, dehydration, stomach discomfort or pain in the lower abdomen, heartburn, bloated feeling and feeling of having excessive gas causing belching or burping.

Determinants: Duration of condition and characterization of stools from the bowl movement.

Table 2.2 Gastrointestinal Disorders

Ailments	Determinants	Causes	Recommendations
Non-infectious diarrhoea	Any of the general symptoms including loose or watery stools when you have bowel movements. Duration is two weeks or less	Caused by infectious agents (bacteria, viruses, and parasites) and are usually self-limiting.	Mix salt and sugar solution, drink coconut water. Rehydrate by taking a lot of fluids (ordinary water). This is self-limiting which means that it may go by itself. Avoid substances such as alcohol, caffeine and diary items when in this condition because they stimulate the feeling to have a bowel movement. If symptoms persist, come see and consult the pharmacist
Infectious diarrhoea	Any of the general symptoms including bloody stools, phlegmy stools or both when you have bowl movements. Duration is for more than two weeks	Causes include irritable and inflammatory bowel syndrome and chronic infections.	Mix salt and sugar solution, drink coconut water. Rehydrate by taking a lot of fluids (ordinary water). Avoid substances such as alcohol, caffeine and diary items when in this condition because they stimulate the feeling to have a bowel movement. See pharmacist immediately or as soon as possible
Indigestion	Any of the general symptoms primarily heartburn	Overeating or eating too fast, lying down after eating, eating spicy or fatty food are all causes of indigestion.	Reduce coffee and alcohol intake and make sure to eat small meals. Eat slower when having meals and avoiding lying down after eating. See pharmacist if symptoms persist
Constipation	Any of the general symptoms including having hard lumpy stools when you have bowel movements and having fewer than three stools in a week.	Caused by sedentary lifestyle and poor diets.	Take in more water. Eat food rich in fibre (oats, wheat amongst others), take vegetables and exercise more. See pharmacist if symptoms persist

Nasal conditions: Nasal conditions are ailments associated with the nose.

Ailments: Common cold and sinusitis

General symptoms of the classification: A sore throat, running nose, blocked nose, sneezing and some pain or irritation around the nose

Determinants: Duration of condition and severity of pain especially around the nose or upper part of the nose which is the sinuses.

Table 2.3 Nasal Conditions

Ailments	Determinants	Causes	Recommendations
Common Cold	Any of the general symptoms including little or no pain around nose. Duration is a week or less since it is self-limiting	Usually caused by a virus or infection.	Usually self-limiting and resolves within a few days. Keep hydrated by drinking adequate fluids. Do a Steam inhalation which is essentially inhaling warm water. Avoid chilled drinks. Avoid smoking during this time
Sinusitis	All general symptoms including severe pain or inflammation in sinuses (upper part of nose). Duration is more than a week	Caused by infections which is usually bacteria.	Inhale warm water also known as steam inhalation. Keep hydrated by drinking adequate fluids. See pharmacist if symptoms persist

Cough conditions: This classification is associated with your airways.

Ailments: Wet and Dry cough

General symptoms of the classification: A sore throat, chest pain, irritations in airways, hoarse voice.

Determinants: The presence of phlegm and the colour of the phlegm.

Table 2.4 Cough Conditions

Ailments	Determinants	Causes	Recommendations
Wet cough	Any of the general symptoms including the production of phlegm upon coughing. If phlegm is whitish or clear, then non-infectious wet cough. If phlegm is creamy or yellow, then infectious wet cough	Caused by bronchitis, asthma and allergies.	For non-infectious: Take in more fruits, ginger home remedy also brings relieves. Have more rest. For infectious: Take in enough fluids, avoid chilled fluids. Maintain warm environment, inhale warm water also known as steam inhalation. See pharmacist immediately or as soon as possible
Dry cough	Any of the general symptoms excluding the presence of phlegm when one coughs	Caused by viral infections from common cold and flu. Allergies and the intake of medication for treating high blood pressure can cause dry cough. These are considered side effects of those medications	Take in enough fluids, avoid chilled fluids. Maintain warm environment, inhale warm water also known as steam inhalation

2.4 Requirement specification

2.4.1 Background on requirements

The requirement for the system is divided into functional and non-functional requirements.

2.4.2 Functional Requirements

- **Sign Up and Sign In:** Customers are required to sign up if they are new to the system or login to have access to the expert system facility.

- **Health consultation**: Customers or patients receive quick and immediate expert responses to a health condition based on their inputs. After which recommendations on how to handle those ailments would be provided.

- **User account management**: Pharmacist and health professionals of Premier Point Chemists (administrators) can manage and make some modifications to the account information of users on the system.

- **Management of Explanatory Information**: The pharmacist can add, edit and delete a cause or recommendation pertaining to an ailment.

- **Review of recommendation**: The pharmacist can review the necessary information on predictions provided to customers or users. This information includes the time of access and prediction as well as the predicted ailment that was provided to users.

2.4.3 Non-Functional Requirements

Performance Requirements

- The system is quick when providing users with the response they require.

Security Requirements

- The system permits returning users to login to gain access to the system's functionality. New users cannot access the system's functionality until they register.

- The system protects user information from unauthorized or malicious attacks.

Navigation

- The user interface of the system is simple so users can easily navigate and interact with it.

2.5 Use Cases

2.5.1 Use Case Diagrams

Users must sign up and then sign in to get access to the system's functionality. After registration, they can access the expert system directly. Accessing the expert system enacts an interactive platform for users to communicate their health conditions and be provided with ailment predictions and recommendations. This is illustrated in Fig 2.5

The administrator can manage user accounts from the system. The administrator can review recommendations for each patient or customer that used the expert system. This is illustrated in Fig 2.6
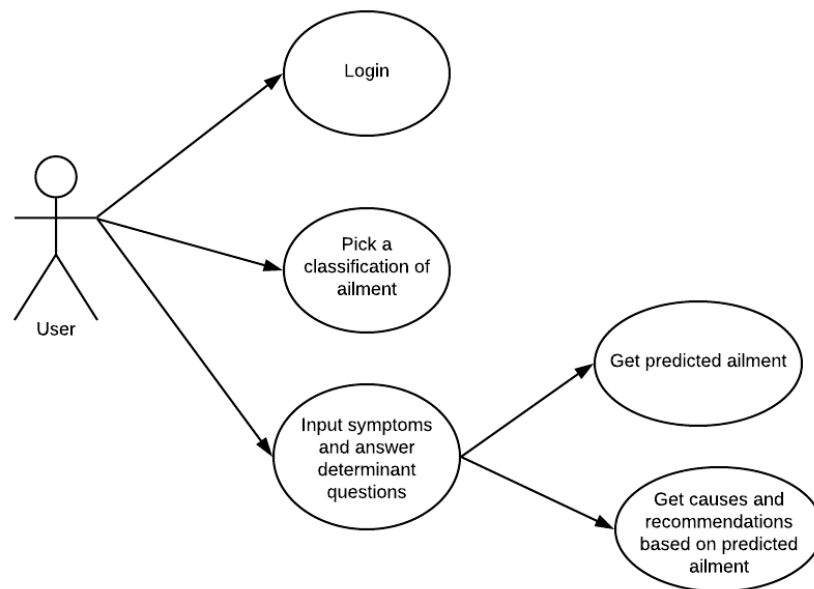
Fig 2.5 Use Case Diagram for Users
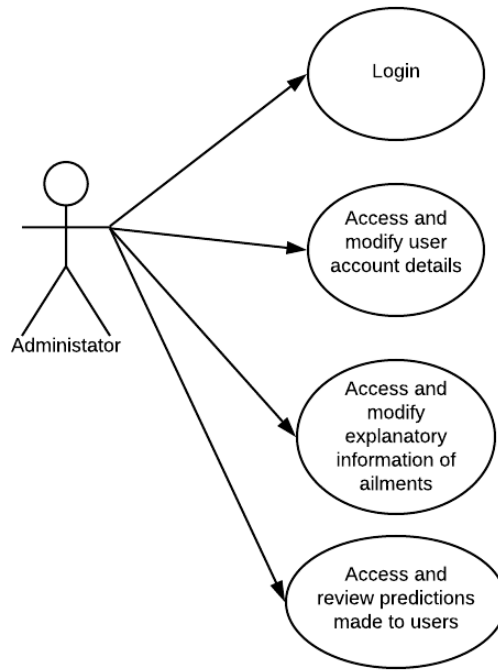
Fig 2.6 Use Case Diagram for Administrators

Chapter 3: Architecture and Design

This chapter presents the design and structure of Premier Health Access (PHA). This system architecture consists of all components or layers of PHA brought together in a cohesive form. Premier Health Access is developed using a rule-based approach. Pyknow, a Python library that follows the rule-based approach for building expert systems as well as a web framework for Python known as flask are adopted to develop Premier Health Access. Pyknow and Flask are used for the back-end of the system and bootstrap's HTML, CSS and JQUERY for front-end. The incorporation of Pyknow and Flask will be shown in the next chapter.

3.1 System Architecture

The system architecture for Premier Health Access is illustrated in Fig 3.1. The components of this architecture are the user interface, the inference engine, the knowledge base and the database. The combination of the inference engine and the knowledge base form the expert system engine.
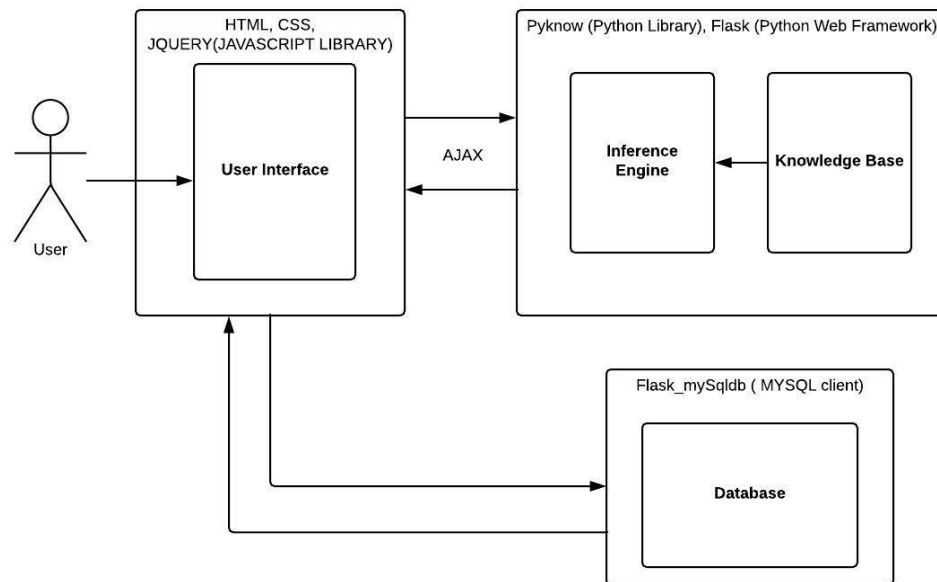
Fig 3.1 System Architecture of Premier Health Access

3.1.1 User Interface

The user interface of Premier Care Access allows for communication and interactions between users and the expert system engine. User requests are received at the user interface and forwarded to appropriate components or modules of the expert system.

3.1.2 Knowledge Base

This component of the expert system stores the knowledge the pharmacist uses to provide healthcare for minor ailments. For this project, the knowledge base consists of information pertaining to an ailment or ailments recorded as facts and used to define rules to be accessed by the inference engine to predict ailments. General symptoms pertaining to an ailment are represented as facts and then rules are composed using these facts.

3.1.3 Inference Engine

This component handles the reasoning behind the predictions of the system. The knowledge base enacts the help of the inference engine to translate its rules into a form that can be easily presented to the user as a prediction or probable ailment when necessary.

3.1.4 Database

The database represents the storage facility for the system. The database stores user credentials and facilitates registration and login into the system. Explanatory information about predictions of a minor ailment and recommendations made by the expert system are stored in the database and fetched to be presented to the pharmacist for review upon request.

3.2 Design

This section deals with the design approach adopted for the development of the system as well as an overview of the system's flow considerations used to create the best user interface experience for the users of PHA. Here, sequence diagrams, activity diagrams, entity relationship diagrams and mock-up designs are outlined and discussed. These

elements show an abstraction of how the system ought to operate and look like without the development of the system in its entirety.

3.2.1 Sequence Diagram

The use of a sequence diagram is to give an abstraction of the various interactions with key components of the system that are needed to execute the main functionalities of the system. This sequence diagram shown in Fig 3.2 shows a user's interaction with Premier Health Access in a series of sequences. A user logs in and gains access to the expert system functionality. The user communicates what he or she is going through by selection some symptoms and answering a series of questions. After which, he or she is provided with a predicted ailment and recommendations to deal with that ailment until they can successfully get healthcare service from the pharmacy during working hours.
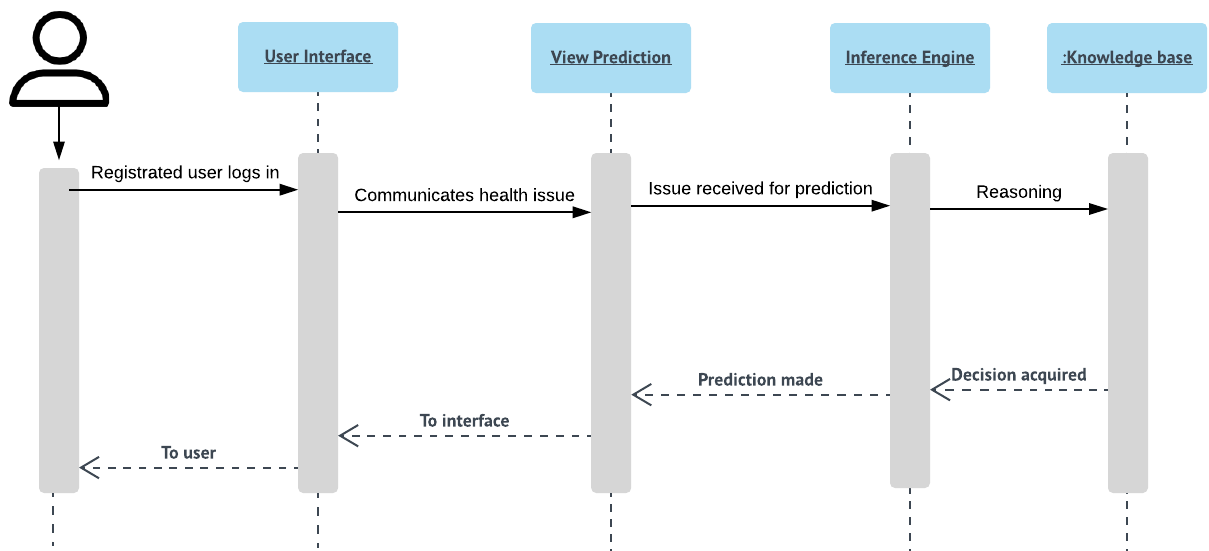
Fig 3.2 Sequence Diagram for User Interactions with Premier Health Access

3.2.2 Activity Diagram

The activity diagram in Fig 3.3 shows the flow of accessing the system from a user perspective.
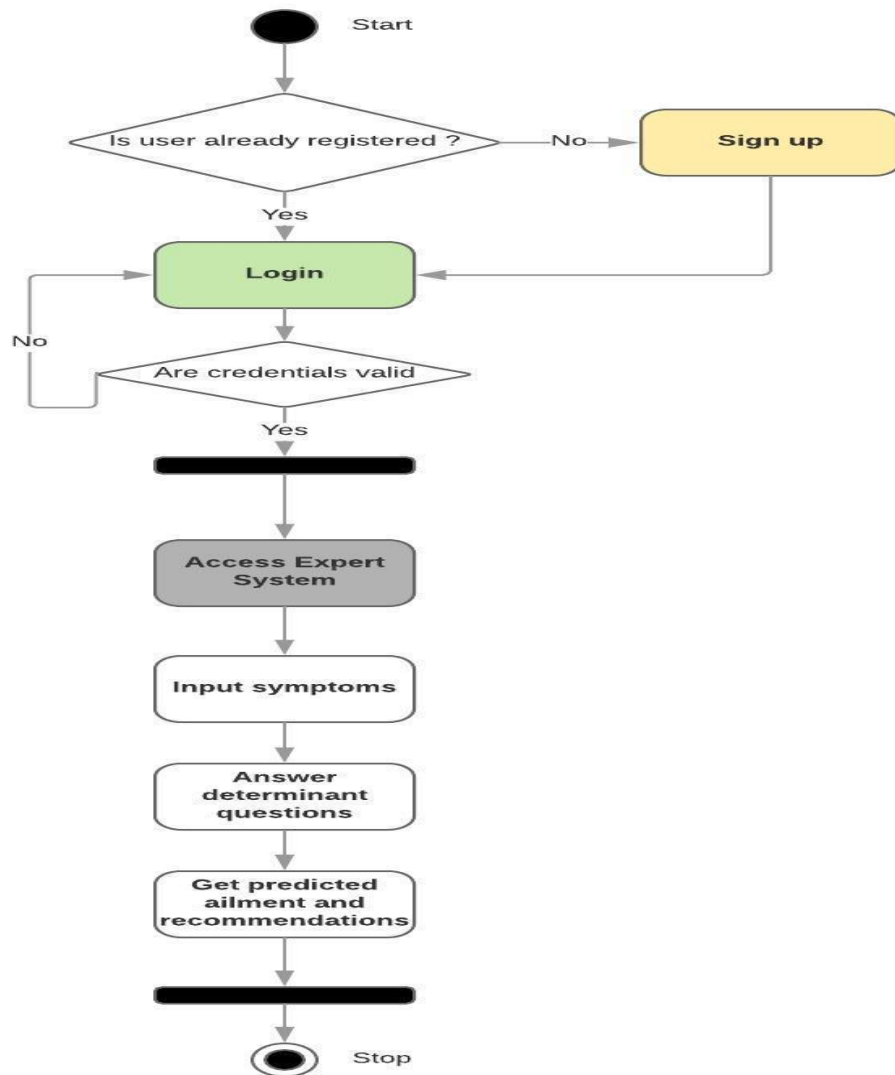
Fig 3.3 Activity Diagram for Users of Premier Health Access

3.2.3 Entity Relationship Diagram

The entity diagram below shows the various entities in the database and the relationships between them.
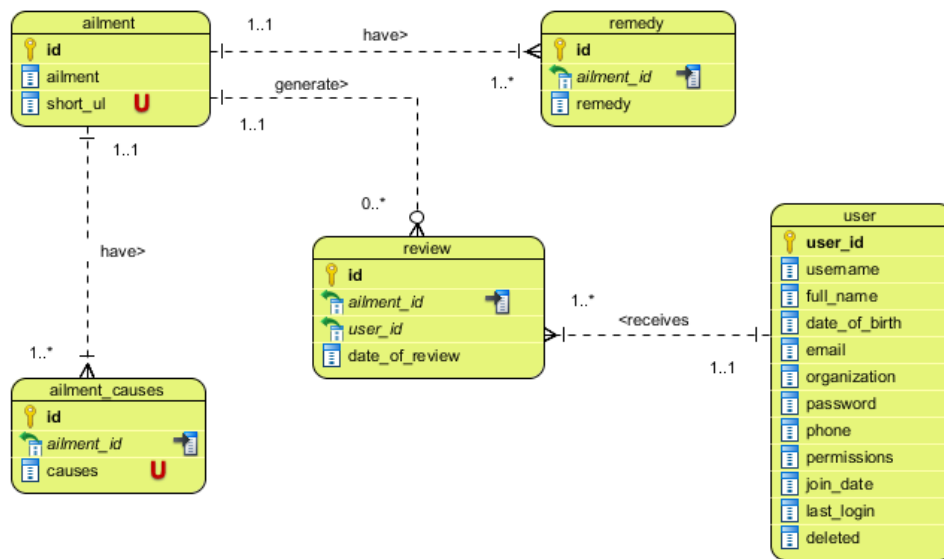
Fig 3.4 Entity Relationship Diagram for the Database

3.2.4 Expert System Engine

The expert system engine handles three broad classifications of ailments. As a result, the expert system engine makes use of three modules, each tackling one of the broad classifications. Each module enacts the inference engine and contains a knowledge base consisting of the knowledge on the broad classification it represents. Fig 3.5 illustrates this.
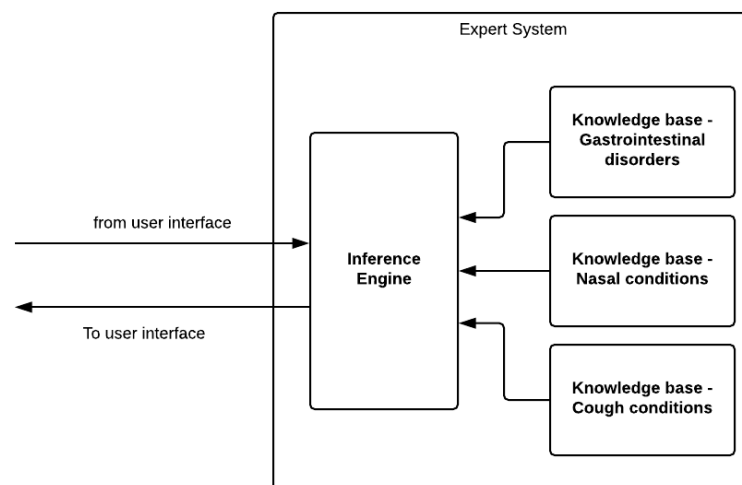
Fig 3.5 Expert System Engine

23

3.2.5 Process of Premier Health Access

This diagram shows the logic and processes rendered to achieve the goal of Premier Health Access.

A user interacts through the user interface, signs up and signs in to access the expert system's services. In accessing the service, the user picks a classification of ailments, then selects symptoms and answers determinant questions. After which a request is sent to the expert system engine for a prediction

Request from user interface >

The expert system engine receives the request and compares rules from the appropriate knowledge base and return a prediction if a match is found

< Prediction sent to user interface

The database is queried to return the cause and recommendation of the predicted ailment to the user interface

< Cause of ailment and recommendation sent to user interface

Fig 3.6 Process of Premier Health Access

3.2.6 UI Palette

When designing a user interface, it is important to select a palette or a colour scheme that reflects moderation and balance. There is also a need to be mindful of the colours you select because they have meaning and different connotations. Fig 3.7 shows the palette of the main colours adopted for the development of the user interface. The meanings behind these colours chosen give users a sense of assurance and confidence that their health concerns can and will be catered for.

	Green signifies life and safety. It is also representative of natural growth.
	White signifies new beginnings and purity
	Blue signifies faith and confidence

Fig 3.7 UI Palette

24

3.2.7 Descriptive Icons

The use of descriptive icons makes it easy for users to absolve and process the necessary information from the system's user interface. In this project, icons are used to make it easy for users to absolve and process the necessary information from the system's user interface. Icons make this possible by summarizing information that would otherwise have required long texts. Fig 3.8 shows some of the descriptive icons used for the design of the systems interface. For example, the icon on the far left indicates pain around the lower abdomen or stomach.

Fig 3.8 Descriptive Icons

3.2.8 Index page

Mock-up designs aided in determining what the index page should look like. The idea was to make the index page as simple as possible with easy navigation. Two mock-up designs were made for this intended purpose. Fig 3.9 shows the first design whiles Fig 3.10 shows the second design for the index page. These designs are simple and straight to the point. They give an overview of what the system entails in the features column and allow for users to quickly dive into the functionalities the system provides by either signing up or signing in.
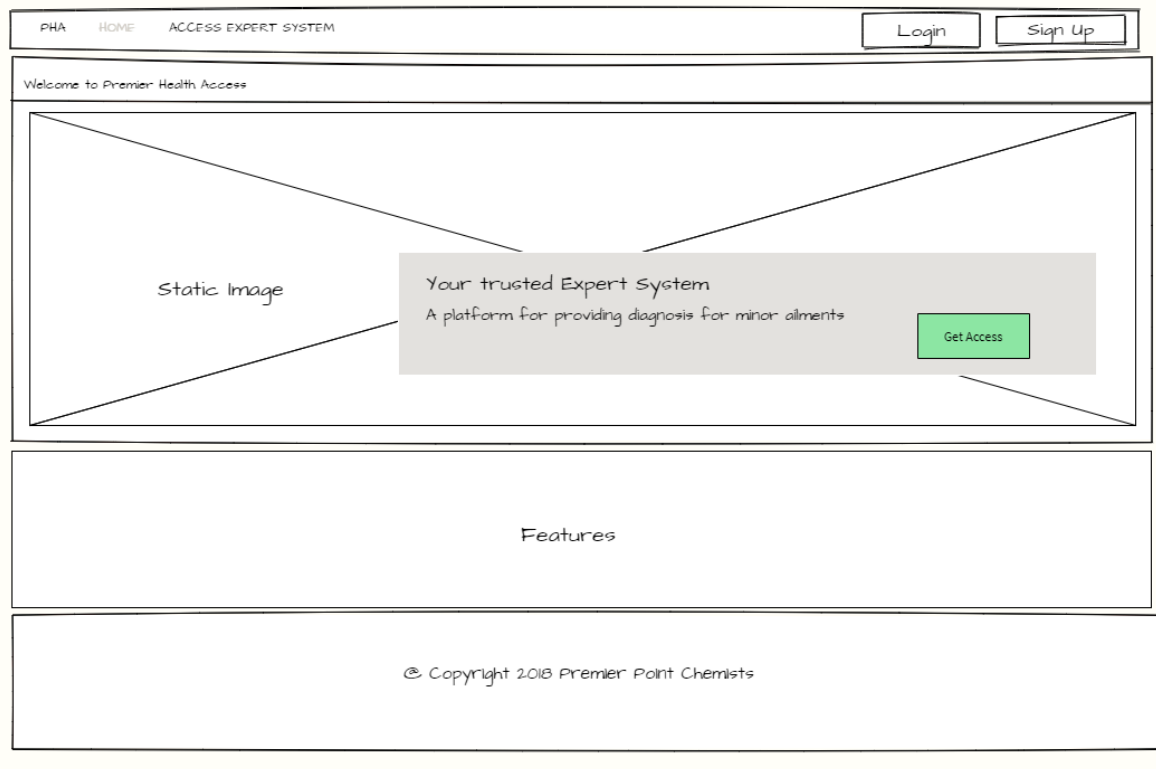
Fig 3.9 First Design for Index Page
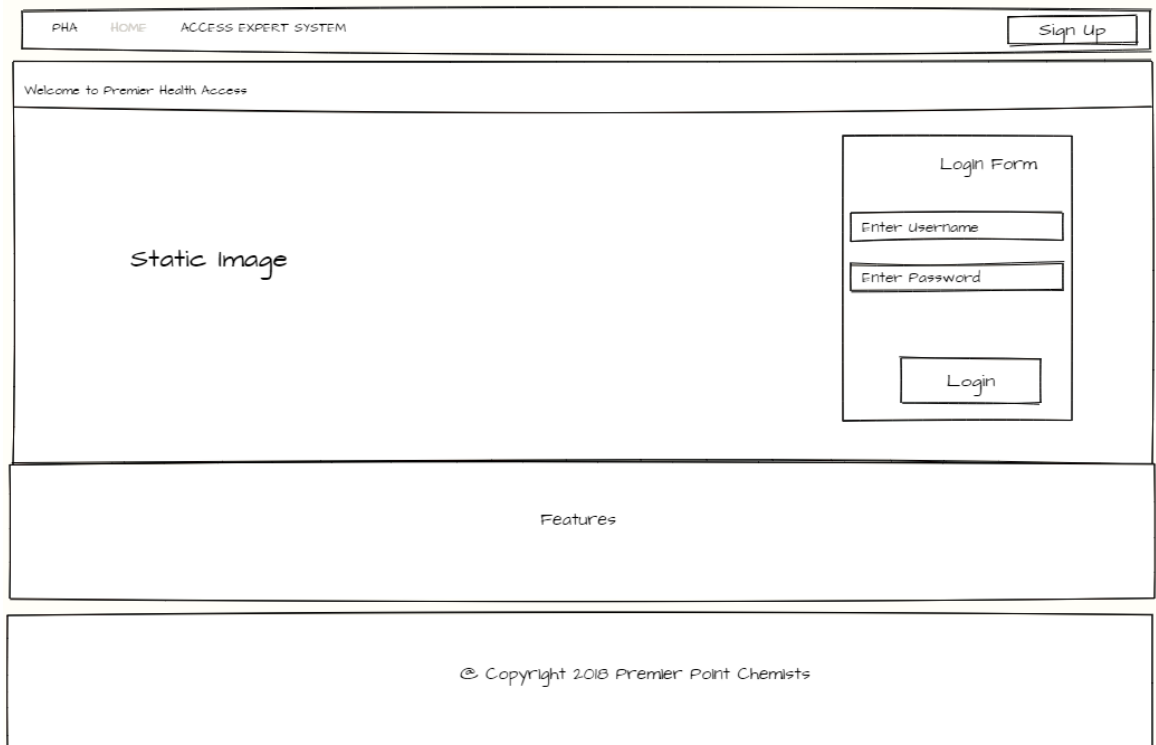
Fig 3.10 Second Design for Index Page

3.2.9 Consultation page

There is a need to design the page that collects the data from the users for processing and prediction. This page facilitates the collection of information a user provides for processing to return a prediction and recommendation of an ailment based on the collection. As a result, users should not struggle to express how they are feeling. Fig 3.11 shows the first design consideration and Fig 3.12 shows the second design consideration for the consultation page. The decision revolved around picking between users clicking buttons or checking a box. Clicking on buttons as opposed to checking a box seemed ideal because checking boxes resembled filling a form or some survey and the idea was to have users express themselves with no hustle. As a result, more considerations to make the process of taking information about user health conditions more interactive were considered as well. One consideration was to mimic interactions similar to how one would consult with an actual pharmacist at the pharmacy. Hence the introduction of questions in addition to specifying the symptoms identified with. This is because in the assessment of an ailment, pharmacist asks customers or patients leading or determinant questions that help narrow down on what exactly their health condition is or could be.

Fig 3.11 First Design of the Consultation Page

Fig 3.12 Second Design of the Consultation Page

3.3 Prototypes

The creation of prototypes was essential in the design process for this expert system. A series of prototypes with incomplete functionalities were made to test a concept and some functionalities to serve as a learning process. These prototypes helped develop incomplete products that were refined and perfected to develop the final system, Premier Health Access.

3.3.1 Back-End Prototype

This prototype was developed to test the viability of the use of the Pyknow library for building expert systems. The results were fascinating. This prototype is basic and was developed with no connection to a user-friendly interface yet and so it prints to the console. It interacts with the user to get inputs to make a prediction on the console. Fig 3.13 shows the console output from a typical interaction with the Pyknow expert system. Headaches, fever and throwing up or vomiting are dominant symptoms of malaria. As a result, by looking at Fig 3.13, the system was right in its prediction or diagnosis. Also from Fig 3.13, you can see how rules are derived by creating a pattern consisting of a number of facts.

```python
@Rule(Fact(action='greet'), NOT(Fact(wrong=W())))
def ask_what_wrong(self):
    self.declare(Fact(wrong=input("What is wrong with you?")))

@Rule(Fact(action='greet'), Fact(head='yes'), Fact(have='yes'), Fact(fever='yes'))
def you_malaria(self):
    print("You probably have malaria")

@Rule(Fact(action='greet'), Fact(wrong='sick'), Fact(have='no'), Fact(head='no'), Fact(fever='no'))
def you_sick(self):
    print("Maybe nothing is wrong with you")

engine = Greetings()
engine.reset()
engine.run()
```

```
Greetings  >  you_malaria()
exp3
    What is wrong with you?sick
    Do you vomit?yes
    Do you have a fever?yes
    Do you have headaches?yes
    You probably have malaria

    Process finished with exit code 0
```
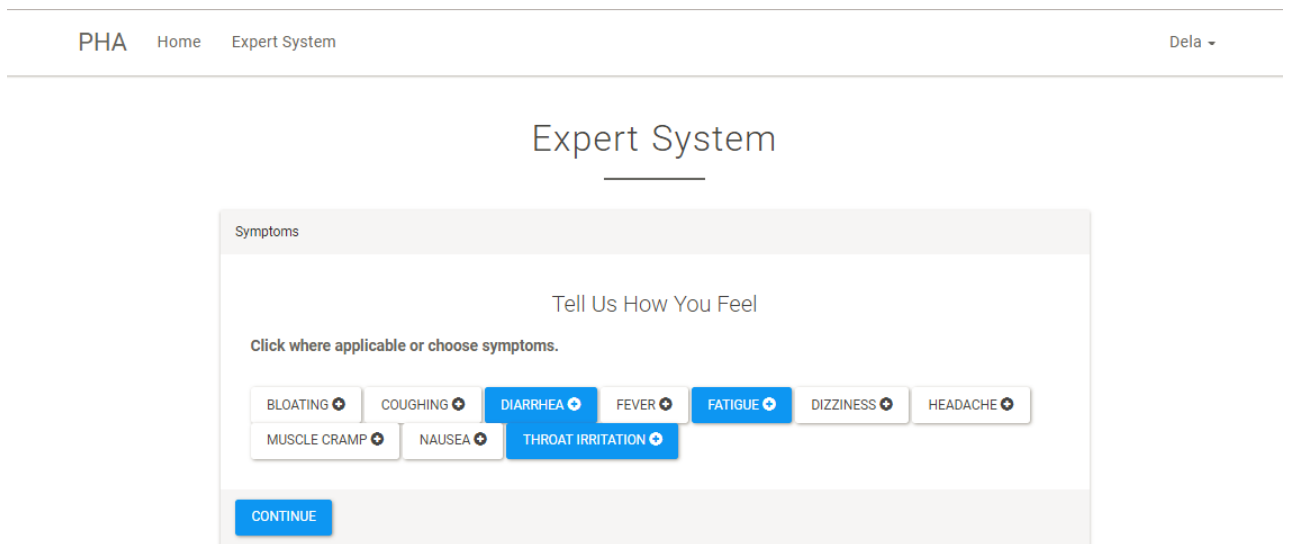
Fig 3.13 Back-End Prototype of the System in Pyknow

3.3.2 Front-End Prototype

This prototype was developed to test the basic functionality of login, registration and access to the consultation page to get a sense of the general flow of the system for future developments. Fig 3.14 shows the consultation page that collects the user's symptoms as inputs. In Fig 3.14, when a user chooses a symptom, the button switches colour to show that that symptom has been selected. Clicking that symptom again means you decline your initial choice.

Fig 3.14 Front-End Prototype of the Consultation page

Chapter 4: Implementation

This chapter talks about the various technologies and tools used in developing the web-based expert system known as Premier Health Access. The description of the implementation of every component of the system architecture discussed in Chapter 3 of this research report is shown in this chapter. The individual task for each component is made clearer in this chapter as well.

4.1 Tools and Technologies

4.1.1 Front-End

- **Bootstrap:** This is a popular hypertext mark-up language (HTML) and Cascading Style Sheet (CSS) framework used in this project to create and give the web-based system, a presentable and responsive design.

- **Flat icon:** This is a free web resource with a wide array of icons. This resource provided icons which aided in the developing of the user interface of the system.

- **WTforms:** This Python library aids the creation of the validation properties for registration and login forms ((WTforms, 2017).

- **Passlib:** This is a library for Python that consist of a wide array of hashing algorithms for the effective hashing of user passwords (Passlib, 2017). The library aids the hashing of user passwords upon registration.

- **Flask-mysql_db:** This is a MySQL client modified for flask to enable the coding of MYSQL in Python and to allow for connections to MySQL server (Ferland, 2018). This is used for storing user credentials, predictions given to users and the time of predictions needed to have a complete review by the pharmacist.

- **AJAX and JSON:** AJAX is used to make the web-based system dynamic. This is done by allowing communication between the front-end and the back-end of the

expert system. This communication is done by taking inputs or user data from the front-end in JSON format, and then sending it to the back-end for operation. This helps the expert system to make predictions using AJAX, and the results returned is displayed without reloading or refreshing the page.

4.1.2 Back-End

- **Python:** In this project, Python is used significantly to code most of the system's functions. The choice for Python lies in its simplicity in allowing for easy readability and the execution of concepts and functions without the need for typing a lot of code. It also has a wide array of libraries with specific purposes such as Passlib and WTforms.

- **Flask:** Flask is a Python web framework used for creating web application in Python (Grinberg, 2014). This framework helps in creating the back-end code for login and registration authentication, database communication (Create, Read, Update and Delete), routing and requests such as POST and GET.

- **Pyknow:** This is a Python library for creating expert systems. This library draws inspiration from the CLIPS which is another tool for building expert system written in the C language (Pérez, 2018). The Pyknow library is rule-based. Like most expert system tools, an inference engine is provided so there is no need to develop an inference engine of your own. The inference engine is instantiated and then provided with the necessary facts which are used to generate rules to those facts needed for reasoning. These facts and rules are constructed in a knowledge base implemented in the module for each of the three broad classification of ailments the system caters for. The entire library for Pyknow can be found on GitHub or by using pip command to install it from your terminal or command line, provided you have Python interpreter and pip installed.

4.2 Development Model

The prototyping model was adopted for the development of the expert system. The primary reason for adopting this model was because the development of the expert system required regular interactions with stakeholders. Using this model meant stakeholders can be actively involved in the development process. The model processes are shown in the diagram below.
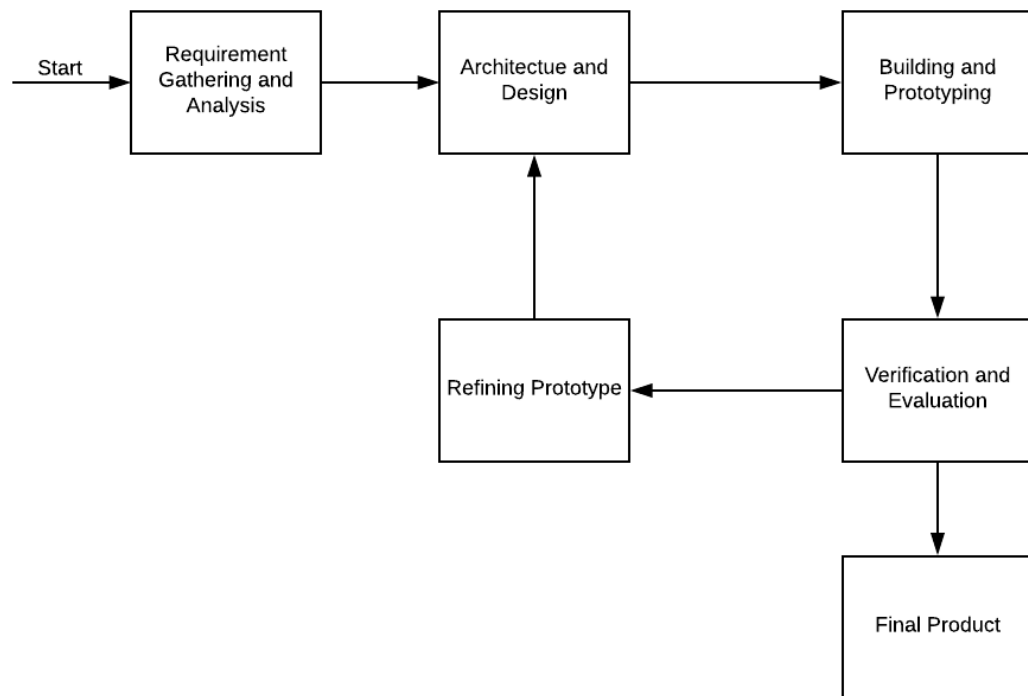
Fig 4.1 Prototyping Model

4.3 Components implementation

4.3.1 User Interface

All actions of the expert system start out from interactions with the user interface: This component responds to user clicks or inputs. When the user makes an interaction, the expert system is either enacted or the database depending on what the user wants to do. As stated earlier, the user interface which is at the front-end made use of bootstrap framework

which contains HTML and CSS classes as well as Passlib and WTforms libraries for validation and security.

If a user is registering into the system, a call to the database is made to insert user information into the database. Similarly, if the user wants to login into the system, a call to the database is made to retrieve user credentials to verify user identity before being given access into the system. Validation was done primary to ensure users entered the correct data to make sure only qualified data could enter the system. Similarly, security was taken into consideration to hash user passwords instead of storing them as plain text. The python library known as WTforms helped with validation of the forms whiles the python library known as Passlib helped with hashing user passwords.

4.3.2 Expert System Engine - Knowledge Base and Inference Engine

Users interact with the system through the user interface. For predictions, users are required to pick a broad classification, either gastrointestinal disorders, nasal conditions and cough conditions. After which they must input their symptoms and answer a series of questions to determine factors like the duration of symptoms identified and any other bit of information needed to make a better health judgement. From there, the inference engine is enacted and inputs entered are compared against rules in the knowledge base for a match. If a match is found, a prediction can be made about the ailment the user has. Predictions are sent from the expert system which is the back-end onto the user interface for the user to see. Predictions are accompanied by recommendations and explanation of the cause of the ailment pulled directly from the database.

In the expert system engine, each module has a knowledge base representative of one of three broad classification of ailments identified in requirement analysis documented in Chapter 2. For each knowledge base, rules are declared that are made up of facts with conditional elements. Symptoms associated with each classification is represented as facts

in each knowledge base. After which various rules are generated from these facts. Each rule has two segments – the segment consisting of facts developed into a pattern and the segment consisting of the predicted ailment if a rule applies. A dictionary data structure is used to store the predicted ailment of rules in each knowledge base. When a rule is matched with a user's input, the predicted ailment of that rule is appended to the dictionary. A function implemented to return the predicted ailment is used to send the prediction to the user interface. In Pyknow, the rule form is as follows:

```python
class InferenceEngine(KnowledgeEngine):
    output = dict()

    @Rule()
    def concerned_patience(self):
        if self.facts[1]['sick']:
            self.declare(Fact(concerned=True))

    @Rule(Fact(concerned=True))
    def has_gastro(self):
        if sum([
            self.facts[1]['bowel_movement'],
            self.facts[1]['dehydration'],
            self.facts[1]['abdominal_pain'],
            self.facts[1]['heart_burns'],
            self.facts[1]['bloating'],
            self.facts[1]['belching']
        ]) >= 1:
            self.declare(Fact(has_gastro=True))

    @Rule(Fact(has_gastro=True), Fact(is_loose_stool=True), Fact(is_bloody_stool=True))
    def has_infectious_diarrhea(self):
        print("Infectious Diarrhea")
        self.output["Infectious Diarrhea"] = "Infectious Diarrhea"

    def show(self):
        return self.output
```

Fig 4.2 Code snippet from the knowledge base for gastrointestinal disorders.

The rule named "has_infectious_diarrhoea" shown above checks for infectious diarrhoea. As stated in this rule, if the condition for any of the general symptoms associated with gastrointestinal disorders is true and loose stools and blood in stools are true, then the predicted ailment is infectious diarrhoea. "Output" is the name of the dictionary instance being used. The predicted ailment is appended to output and sent as JSON to the user interface using AJAX.

4.4 Implementation Screenshots

This section shows the actual implemented user interfaces (Fig 4.3 – Index Page, Fig 4.4 – Registration Page, Fig 4.5 – Login Page, Fig 4.6 – Welcome Page, Fig 4.7 – Consultation Page, Fig 4.8 – Recommendation Page, Fig 4.9 – Account Management Page, Fig 4.10 – Explanatory Information Management Page, Fig 4.11 – Review Page) of the system.
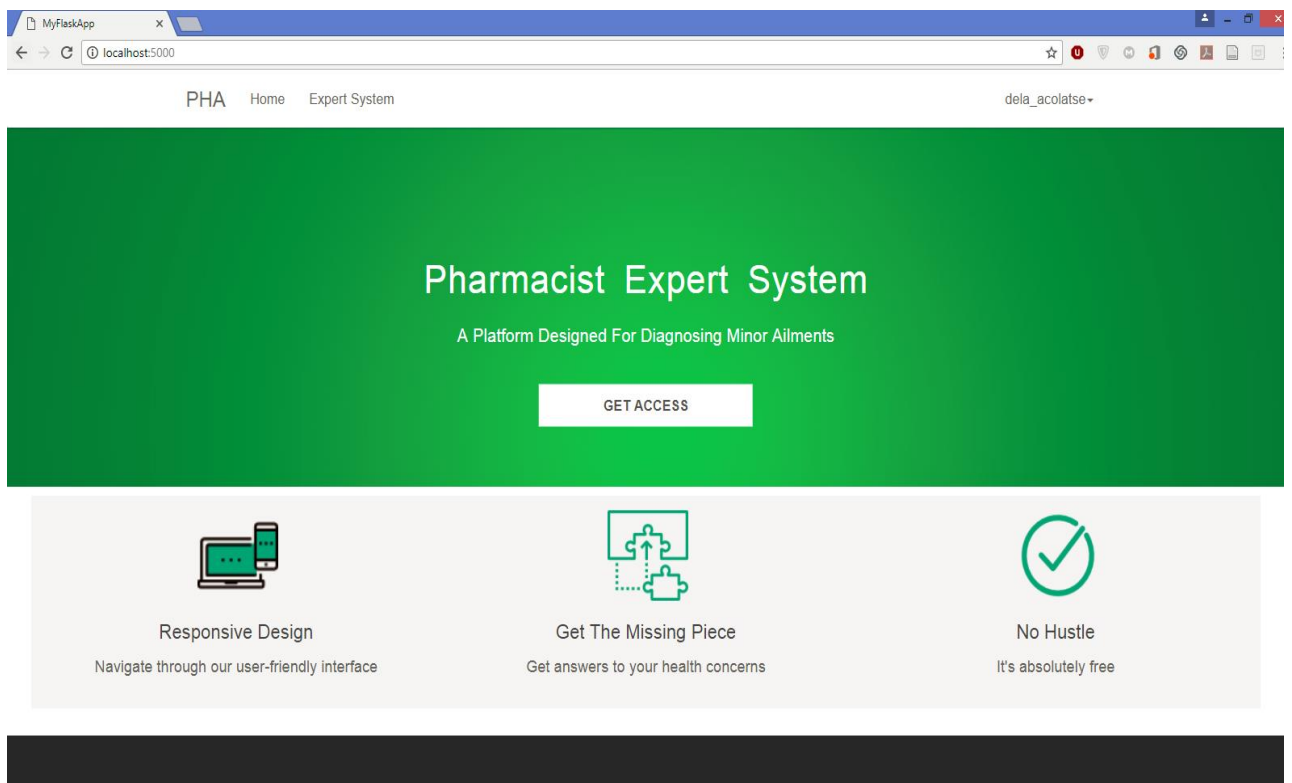
Fig 4.3 Index page

Fig 4.4 Registration page

Fig 4.5 Login page
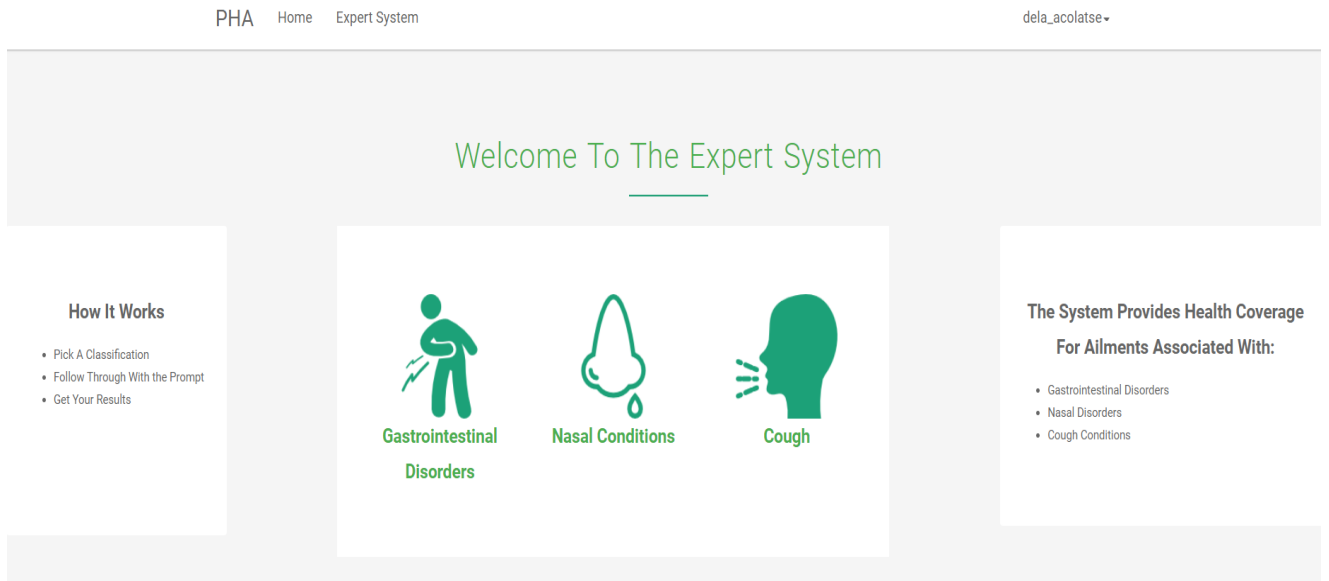
Fig 4.6 Welcome page

Nasal Conditions

Fig 4.7 Consultation page

In Fig 4.7, users communicate their health issues by selecting symptoms and answering questions. This is the consultation page.

Fig 4.8 Recommendation Page

Fig 4.8 shows the cause and recommendations for a particular ailment that is accessed after a prediction is given.

Fig 4.9 Account Management Page

Fig 4.9 shows the account management page for all registered users of the system. Here, the administrator can edit, add and delete registered accounts from the system.

Fig 4.10 Explanatory Information Management Page

Fig 4.10 shows the management page of the explanatory information pertaining to an ailment. A management page exists for all ailments that the system handles

Fig 4.11 Review page

Fig 4.11 shows the review page for all ailments predicted to users of the system. Here, the administrator can see the ailment predicted for each user of the system and the date and time of access.

40

Chapter 5: Testing

Testing is the most important and crucial aspect of any system development process. It ensures that the developed system meets the needs of its users. As a result, this chapter outlines the various test mechanism conducted and used for determining the effectiveness of the system.

5.1 Unit Testing

For unit testing, all methods of the system were tested. Unit testing was first done on the system's login and registration functionalities. These functionalities performed as desired with no errors or challenges. The next bit of unit testing was done on the expert system. Different inputs were entered into the system to get responses to determine how viable the inference engine and knowledge base were in their operation of providing predictions for the user of the system.

5.2 Component Testing

For component testing, several steps or scenarios were considered to aid in the testing process. These are as follows:

Users express their health concerns by inputting symptoms and answering some questions. After which they are given an immediate response pertaining to their inputs in the form of minor ailment predictions. They are also given information on the causes and recommendations of the predicted ailment from the database.

The administrator or pharmacist views all registered users and makes modifications of user details in the system. The administrator temporarily deletes a user's account and can then retrieve the account from user archives when a change of mind is made or permanently delete the account. Similarly, the administrator modifies the explanatory information of ailments by adding, editing and deleting causes and corresponding recommendations of an ailment.

The administrator accesses and reviews all recommendations made by the system and to whom. The execution of all these actions successfully testifies that all components of the system work accordingly and efficiently. The figures below illustrate the effectiveness of the some of the components tested.

Fig 5.1 Prediction of an ailment at the consultation page

Fig 5.2 Temporary deletion of user accounts into User Archives

5.3 System Testing

This mechanism was used to make sure PHA met all its user requirements. All requirements of the expert system are met as the system's functionalities work wonderfully and reflect exactly what is expected. The table below shows the results of this form of testing.

Table 5.1: Showing results from system testing for users

Functionality	Action	Observed results
Login	• Enter account credentials (username and password)	• User is logged into the system and automatically directed to the welcome page of the expert system
Registration	• Enter details needed	• An account is created and credentials are stored in the database • User is redirected to login page to sign in and then automatically directed to the welcome page of the expert system
Consultation	• Select symptoms • Answer leading questions	• User gets a predicted ailment • User gets recommendations
Management of accounts	• Administrator signs in • Administrator modifies user account details by editing user details or deleting a user	• Administrator see all modification taking effect on the page for management of user accounts
Management of explanatory information of an ailment	• Administrator signs in • Administrator modifies the cause and recommendation of an ailment by either editing or adding a new cause and recommendation	• Administrator sees all causes and recommendation associated with an ailment and also the updates that have been made
Review	• Admin signs in • Admin reviews predictions by system	• Administrator sees all users that have had recommendations from the system and the verdicts given
Log out	• Log out	• User is logged out of the system

The figures below show the confirmations of some of the functionalities shown in Table 5.1
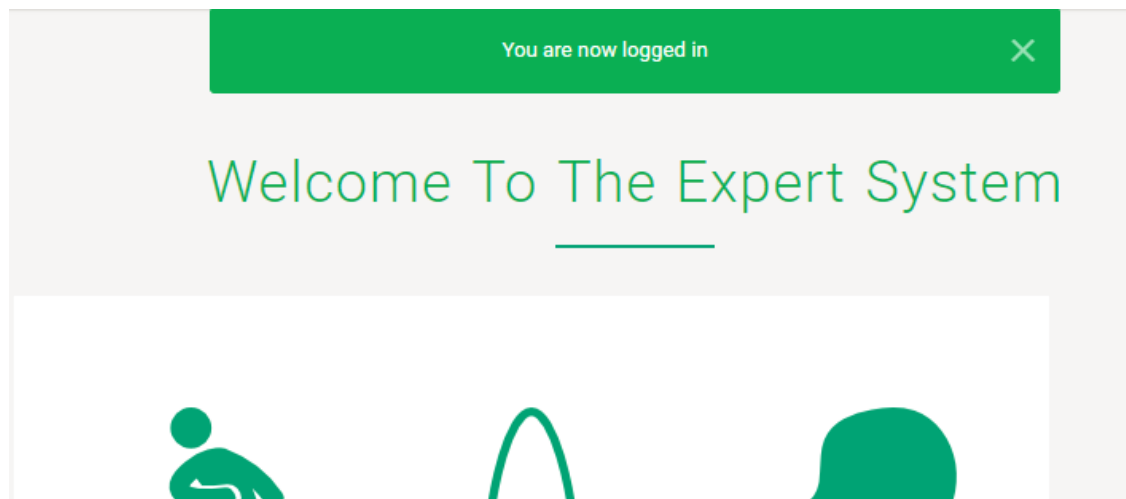
Fig 5.3 Login confirmation
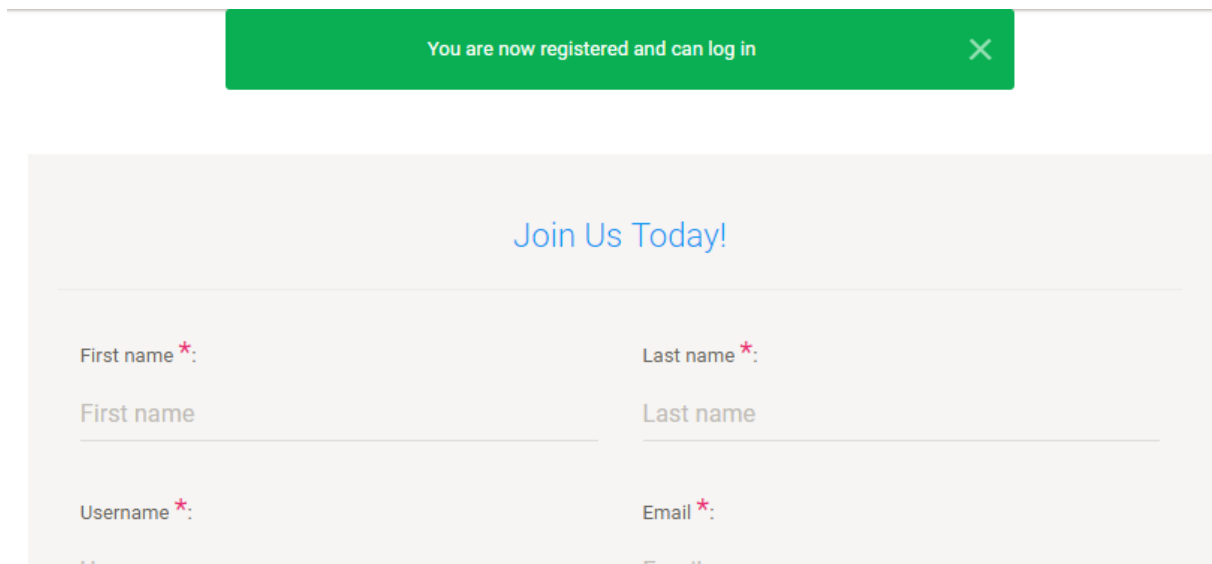
Fig 5.4 Registration confirmation

Fig 5.5 Adding a recommendation to the explanatory information of an ailment

Fig 5.6 Editing a recommendation of an ailment
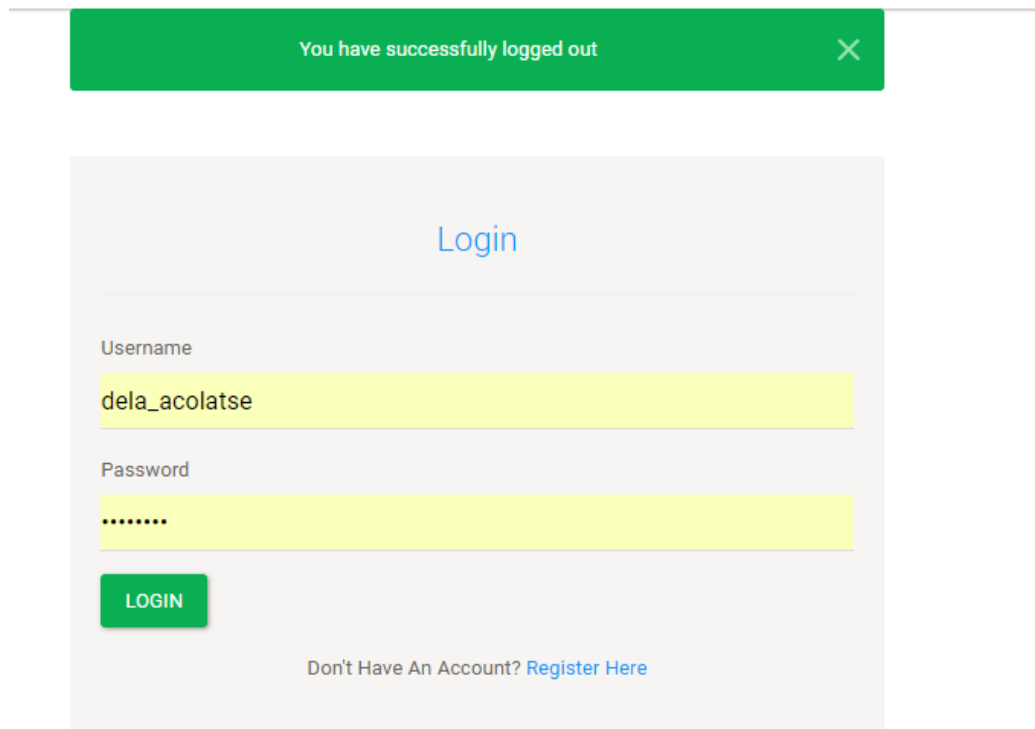
Fig 5.7 log out confirmation

5.4 Acceptance Testing

This testing mechanism is done by the various users of the system for acceptability. This test is conducted for users to affirm whether system is functioning as intended. The system was made available to users for this testing. Some customers that came to the pharmacy were given the opportunity to use the system or to give it a test run. Likewise, the pharmacist or health professionals of Premier Point Chemist also tested the system. All these users accessed the system and test results were promising. The table below shows some results and feedback from the testing parties who came to the pharmacy.

Table 5.2: Showing some results of acceptance testing

User type	Feedback
Gender: Male **Experience: Moderate computer knowledge**	The user navigated through the system easily and was surprised at how quickly the system predicted an ailment for him. He was impressed with the response time and minimal design of the interface indicating that it was simple, straight to the point and clear. His predicted ailment was common cold which was equivalent to what he was told after a consultation with the pharmacist. This means the system predicted the same ailment the pharmacist suggested. He gave the system a thump up
Gender: Female **Experience: Basic computer knowledge**	The user could navigate through the system without much support. The user's health issue was not listed in the system. Her issue was more on general body pains while the system was focused on stomach related issues, nasal and cough conditions. Her feedback was to add more classifications in the future if possible. Nevertheless, she was impressed with the initiative. She gave the system a thump up.
Gender: Female **Experience: Moderate computer knowledge**	This user needed minimal assistance in navigating through the system. She expressed that she considered this system very viable because she is mostly busy and finds it hard coming to the pharmacy even when she has some concerns she needs addressed.
Gender: Female **Experience: Basic computer knowledge**	This user needed some help in navigating the system. Nevertheless, she was impressed with the initiative. Her feedback was to add a FAQ functionality to cater for questions that users must have about the system's functionalities and other relevant information.
Gender: Male **Experience: Moderate computer knowledge**	This user tried accessing the system without registration and was prompted to sign up or register. He had an argument that if he was in a hurry to get a diagnosis, he would be infuriated by having to sign up. After it was explained that registration is needed for the pharmacist to be aware of the recommendations that the expert system so to adjust, monitor or contact you when the pharmacist feels the prediction could be serious. After the explanation, he navigated through the system with a breeze.

The table shows a few of the results from acceptance testing of the system. In all, general feedback was that the system was viable and needed. Some people expressed the need for an FAQ functionality while others requested that a mobile app version should be developed to allow for users to have video-based consultations with the pharmacist when and if they are online. The user type column gives an overview of the experience level of users that tested the system for acceptance and the feedback column shows the comments given after engagement with the system.

Chapter 6: Conclusion and Future Works

This chapter concludes on the entirety of this capstone project. This web-based expert system known as Premier Health Access is developed to allow Premier Point Chemist to have an around the clock health access for customers or patients in and around the community, Labone. This system has the potential to do more and so there is a need to look at recommendations and future projections of works and improvements that would be made on the system.

6.1 Conclusion

Premier Health Access is a good pilot for Premier Point Chemists in providing an around the clock healthcare access to customers or patients in the community, Labone. Leveraging on the power of the internet, this system will provide good health coverage to all community members.

6.2 Recommendation

6..2.1 Limitations

The identified limitations of this project are as follows:

- The system is limited to some minor ailments and users are restricted to choose symptoms provided by the system and it puts a cap on the user's ability to express and describe what is wrong with them.

- The system is limited by its inflexibility. To cater for exceptions or to improve and update the knowledge base for ailments requires some manual coding. You cannot dynamically update the knowledge base. Here, the knowledge base would have to be visited and adjustments would have to be made manually.

- Another limitation is the fact that the system cannot judge the urgency that comes with seeking health consultation. For instance, the system can say that a user has malaria after the user has followed through with a consultation. However, the degree of urgency of the ailment might be at a critical level that poses a life or death situation that the system cannot make sense of at this moment.

6.2.2 Future Works

A future projection is to have an expansion on minor ailments the system caters for. To include more indicators relative to demographics such as age, gender amongst others to improve on the diagnostics of the system

A future projection of the project is to have a portal functionality for the publication of health tips. Pharmacy is a growing field with new ailments and new ways of treating ailments and health complications being discovered regularly. Pharmacist are widely read and would need an avenue to share health-related tips with the community. This functionality would allow for them to be able to do that with ease. Likewise, people like to read on ways to improve their health and what not to do to hinder their health. This would allow for them to be able to do that especially from a trusted source.

Another future projection is to add an FAQ functionality. As per the testing phrase, some feedback from users revolved around having a facility to answer questions and concerns from users pertaining to the operations of the system.

References

Abu-Naser, S. S., El- Hissi, H., Abu-Rass, M., & El- khozondar, N. (2010). An expert

system for endocrine diagnosis and treatments using JESS. *Journal of Artificial*

Intelligence, 3(4), 239-251. doi:10.3923/jai.2010.239.251

Ayele, A. A., Mekuria, A. B., Tegegn, H. G., Gebresillassie, B. M., Mekonnen, A. B., &

Erku, D. A. (2018). Management of minor ailments in a community pharmacy

setting: Findings from simulated visits and qualitative study in Gondar town,

Ethiopia. *PLoS ONE*, *13*(1), 1-8. https://doi.org/10.1371/journal.pone.0190583

Colquhoun, A. (2014). Think outside the box so you can drive your pharmacy business

forward. *The Pharmaceutical Journal.* doi:10.1211/PJ.2014.11134176

Erku, D. A., & Mersha, A. G. (2017). Involvement of community pharmacists in public

health

priorities: A multi-center descriptive survey in Ethiopia. *PLoS ONE*, *12*(7), 1-9.

http://doi.org/10.1371/journal.pone.0180943

Ferland, A. (2018). Flask-MySQLdb documentation. Retrieved from

https://media.readthedocs.org/pdf/flask-mysqldb/latest/flask-mysqldb.pdf

Grinberg, M. (2014). *Flask web development: developing web applications with python*.

California: O'Reilly Media, Inc.

Li, D., Fu, Z. and Duan, Y. (2002). Fish-Expert: a web-based expert system for fish disease

diagnosis. *Expert Systems with Applications*, *23*(3), 311-320. doi:10.1016/S0957-

4174(02)00050-7

Passlib. (2017). *Passlib 1.7.1 documentation*. Retrieved from

https://passlib.readthedocs.io/en/stable/

Pérez, R. A. (2018). *pyknow documentation.* Retrieved from https://media.readthedocs.org/pdf/pyknow/stable/pyknow.pdf

Tan, S. S.-L., & Goonawardene, N. (2017). Internet health information seeking and the patient-physician relationship: a systematic review. *Journal of Medical Internet Research*, *19*(1), e9. http://doi.org/10.2196/jmir.5729

White, R. W., & Horvitz, E. (2009). Experiences with web search on medical concerns and self diagnosis. *AMIA Annual Symposium Proceedings*, *2009*, 696–700.

WTforms. (2017). *Forms*. Retrieved from https://wtforms.readthedocs.io/en/stable/forms.html

Yusof, M., Aziz, R. and Fei, C. (2013). The development of online children skin diseases diagnosis system. *International Journal of Information and Education Technology*, *3*(2), 231-234. doi:10.7763/ijiet.2013.v3.270

Appendices

Appendix A – Interview Guidelines

Name of interviewer:

……………………………………………………………………………

Place of interview:

………………………………………………………………………………

Date of interview:

………....………………………………………………………………………

Questions:

1. What do you see as your most important **responsibility and task** of a pharmacist in the pharmacy?
    - Describe this responsibility and task
    - Elaborate on why it is important
2. What are the general functions provided by a pharmacist?
    - List the functions
    - Briefly describe what each function entails
3. What are top 3 major illnesses (minor ailments) reported at the pharmacy?
4. What are the individual symptoms to look out for with the illnesses identified above?
5. Do you care to tell me the health recommendations and treatment procedures associated with these symptoms?
6. What would you say are the basic injuries that first aid training and knowledge can handle?
7. Do you care to give any details or knowledge on how to address the injuries stated earlier?
8. What would you consider as the major challenges or problems pharmacist face at work?
    - Describe challenges or problem experienced
    - Elaborate on how these problems are being tackled now
9. How well do you think this project meets the needs of the community pharmacy?

Appendix B – Questionnaire for Community members

Web-Based Pharmacist Expert System Questionnaire

Aim: To sample community views concerning the use of a web-based pharmacist expert system to support major services of the pharmacy and to hold the fort during periods that the community pharmacy is closed.

Desired Outcome: To determine the viability of a pharmacist expert system as an innovative way to support pharmacies to render their daily services and actions. Also, to determine the features the expert system should have.

Note: Please note that this exercise is voluntary and so you may redraw at any time without negative consequences. This questionnaire doesn't require any sensitive and confidential information. This questionnaire seeks to collect information based on your unique respective and opinions on the research study topic.

Q1. How easily can you access the internet?

☐ Very easily accessible

☐ Quite easily accessible

☐ Hardly accessible

☐ Not easily accessible

Q2. What form of internet connection do you use?

☐ Broad Band

☐ Mobile data

☐ Wireless

☐ Modem

Others ……………………………………………………………………..

Q3. Where do you go to access healthcare in the community?

☐ Nearest hospital/clinic

☐ Nearest pharmacy

☐ Herbalist

Q4. What do you do when you need some health consultation or advice but your local pharmacy has closed for the day?

☐ Go online and search

☐ Ask a friend

☐ Ask a family member

Others: …………………………………………………………………..

Q5. What is your level of agreement with the following statement?

A web-based pharmacist expert system is convenient and needed to support the work of the pharmacist and give health consultation especially when the pharmacy is closed for the day?

☐ Disagree

☐ Agree

☐ Strongly agree

Q6. What sort of health issues and consultations would you want the expert system to provide?

☐ Minor ailment

☐ Health tips

☐ Health education

Others: …………………………………………………………………………

Q7. How would you rate the health information obtained from a search online as opposes to health information obtained from a qualified health professional or pharmacist?

☐ Not credible

☐ Not sure

☐ Very credible

Q8. Please indicate any comments you might have on the research study

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………