ATILIM ÜNİVERSİTESİ

# SE/ISE/CMPE 494 Senior Project Report

# Pharmacy Decision Support and Tracking System

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## Abstract

The demand for information and communication technology-based solutions is rising rapidly in the healthcare industry, which is one of the most crucial sectors of our modern-day. The pharmaceutical industry, in particular, is seen as a critical industry for the modern world due to its financial impact and direct impact on people's health. Detection of interactions such as food-food (FDI) and drug-drug (DDI) is very crucial in the healthcare industry to minimize harm to patients and allow pharmacists to work more systematically and safely. Several nations have begun to build tracking and tracing systems for medications to prevent harmful DDI and FDI interactions. These databases and systems are of critical importance for the pharmaceutical industry, as they enable the detection and tracking of potentially harmful DDI and FDI interactions. A successful and accurate decision support and tracking system mechanism can minimize the difficulty in verifying and controlling the suitability of drug-drug (DDI) interactions and food-drug (FDI) interactions systematically. Therefore, the Pharmacy Decision Support System project is an example of such software designed and developed for the solution of these difficulties. In addition, to meet the requirements of the system, various methods and technologies such as Visual Studio and Visual Studio Code for the source code editor, C#, Asp.Net Core and MVC for logical operations, PostgreSQL for the database, and ReactJS for the interface of the system are used in this project. Moreover, Trello is used for methodical project planning and task distribution among team members. As a result, the pharmacy decision support system is designed to meet the requirements of pharmacists with a rule-based decision support mechanism.

Keywords: Pharmacy Decision Support System, Tracking System, Drug Interactions, Drug Food Interactions, Pharmacy Recommendation, Pharmacy Intelligence

## Acknowledgments

In the research and development process during the realization of this study, we would like to express our sincerest appreciation to our academic mentor and supervisor Dr. Güler KALEM and Dr. Selma NAZLIOĞLU for their invaluable guidance and support throughout this project. Their feedback and encouragement played a vital role in refining our concepts and bringing this work to fruition.

We would also like to acknowledge the generous support of our school, Atılım University who provided funding and resources that made this project possible.

Finally, we would like to express our appreciation who participated in our study and generously gave their time and effort, which was essential to the accomplishment of our work. Additionally, we extend our gratitude to the numerous volunteers who assisted with data collection and other components of this project.

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## Definitions, Acronyms and Abbreviations

| Term | Definition |
|---|---|
| ATC | ATC (Anatomical Therapeutic Chemical) is a special code given to a drug, based on the organ or system it affects and how it functions [1]. |
| CSS | It is a simple design language intended to simplify the process of making web pages. |
| CDSS | Clinical decision support systems (CDSS) are a collection of tools designed to improve clinical workflow decision-making. |
| DDI | Drug-drug interactions |
| EHR | An electronic health record (EHR) is a digitally recorded systematized collection of patient and population health information. [2]. |
| ERD | Entity Relationship Diagram |
| FDA | The Food and Drug Administration (FDA) is a federal agency of the Department of Health and Human Services that is in charge of preserving and promoting public health by controlling and supervising food safety, dietary supplements, and prescription and over-the-counter pharmaceutical medications [3]. |
| FDI | Food-drug interactions |
| HIE | Health information exchange is the electronic interchange of clinical and administrative information between healthcare providers [4]. |

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| HIPAA | Health Insurance Portability and Accountability Act (HIPAA) is a piece of American legislation that establishes data privacy and security safeguards for medical records [5]. |
| HTML | It is a typical markup language used to create web pages. |
| iOS | An operating system used in Apple phones. |
| NDC | The National Drug Code (NDC) is an FDA standard for uniquely identifying drug items marketed in the United States [6]. |
| OS | An operating system (OS) is part of system software that controls computer components such as hardware and software resources and offers standard services to programs. |
| OTC | Over-the-counter is a drug that is available without a prescription. |
| PBM | Pharmacy benefits managements (PBMs) create, implement, and manage outpatient drug benefit plans for employers, managed care organizations, and other third-party payers [7]. |
| PDSS | Pharmacy Decision Support System. |
| Rule-Based System | A rule-based system is a particular kind of expert system that consists of a series of if-then rules and is used as a decision support system in many fields, including security, transportation, and healthcare [8]. |
| SGK Medula | SGK Medula is an integrated system between general health insurance and health facilities in Turkey, created to electronically collect billing |

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| | information and pay for services without interfering with the internal processes of health facilities. |
| SRS | Software Requirements Specification |
| Stakeholder | A person, group, or organization whose interests are affected by the success or failure of a project or business initiative. |
| UI | User Interface. |
| Web-Based Application | Any software that is accessed via a network connection using HTTP rather than being stored in a device's memory is referred to as a web-based application. |

## 1. Introduction

Information and communication technologies are described as a group of technologies that make it possible to gather, store, analyze, transfer, and access data between users. With the innovations brought by constantly developing technology, information-based systems are needed in many sectors. Therefore, in one of the most crucial sectors of our modern-day which is the healthcare industry, the demand for information and communication technology-based solutions is rising rapidly as well. Since it results in financial losses and produces drugs that have a direct impact on people's health, the pharmaceutical industry is seen as a critical industry for the modern world. In addition, the detection of interactions such as food-food (FDI) and drug-drug (DDI) is very crucial in the healthcare industry in terms of minimizing harm to patients as well as allowing pharmacists to do their work more systematically. Therefore, several nations have begun to build tracking and tracing systems for medications, particularly to prevent harmful DDI and FDI interactions.

While tracking refers to the capacity to ascertain a product's present condition at any time, traceability is frequently interpreted as the capacity to ascertain a product's origin and various phases of the production and distribution processes. The history of a product is based on traceability data, which includes past locations, processing, maintenance history, and usage history [9]. However, track-and-trace systems allow users to view a product's location at any moment in the distribution system and allow for the tracing of previous road maps. Hence, the databases required for detecting and tracking potentially harmful DDI and FDI interactions and systems that will work in direct proportion with them are of critical importance for the pharmaceutical industry.

Consequently, with a successful and accurate decision support and tracking system mechanism, difficulty in verifying and controlling the suitability of drug-drug (DDI) interactions, and food-drug (FDI) interactions can be minimalized in a systematic way.

## 2. Literature Review

In this section of the report, the systematic gathering of detailed data on specific topics relevant to our study was carried out through a methodical investigation. By conducting a literature review in the relevant field, a course of action was established. This section outlines the similarities and differences between the articles found in the literature and our study.

### 2.1. Clinical Decision Support System Studies

In a study conducted in Switzerland, a clinical decision support system called electronic expert support (EES) was developed in order to minimize the problems of drugs and analyze them accordingly. 20 web-based questions were asked to pharmacists and 1500 randomly selected pharmacists were provided with this questionnaire. The data of the alarm and warning systems that occur when the prescriptions in the Swedish pharmacy prescription repository are met in pharmacies were collected. When the data from pharmacies were analyzed in sps and excel format and the results were collected, the effects of using EES on national intervention were found to be positive. The opinions and comments of pharmacists on the EES were determined by means of a questionnaire. 74% reported that they used EES more than usual for customers aged 75 years or older and 11% reported that they used it less than usual for pharmacy customers younger than 75 years. As a result, effects of national intervention, alerts being resolved, Pharmacists' Perceptions and Experiences with EES, Using CDSSs to Improve Medication Safety were found. The practice of community pharmacy as well as the role of the pharmacist are evolving as a result of a number of variables, such as digitalization, new pharmacy services, and increasing knowledge. Thus, it is crucial to conduct research in neighborhood pharmacies and to create plans for applying new knowledge to practice. As the pharmacy business was reregulated in Sweden, there was a decline in pharmacy research. It's encouraging that the current study described an intervention as a collaborative effort amongst all Swedish pharmacy chains. Future research should look into the clinical impacts of CDSS use and how it might be impacted by the removal of the consent requirement or other forms of EES integration in the dispensing systems [10].

Clinical decision support (CDS) tools are designed to enhance the efficiency and effectiveness of patient care, particularly in the domain of pharmacotherapy. However, current CDS systems for pharmacotherapy have limitations that impede the achievement of the goal of safe and effective pharmacotherapy. These guidelines focus on commercially available

medication interaction, allergy, and dose monitoring CDS warning systems for pharmacotherapy, collectively known as "database-driven CDS". These systems rely on drug database vendors to build alert associations, which are then incorporated as alerts in electronic health record (EHR) systems by EHR vendors. CDS systems can be classified as passive or active, with various subtypes of active CDS available.

There are two types of active CDS: interruptive and non-interruptive. Interruptive CDS generates an alert that requires immediate action from the healthcare provider. In contrast, non-interruptive CDS provides information to the healthcare provider without disrupting the workflow. Active CDS requires patient-specific data to generate alerts, such as the interaction between two medications, the patient's age, and the ordered dose. In contrast, passive CDS guides the user towards best practices using population data or clinical recommendations, but does not make patient-specific decisions. This responsibility rests with the healthcare provider. Examples of passive CDS include order sets and constrained options in drop-down lists or check boxes. These alerts make use of a sizable database with information on drug interactions, dosage parameters, and allergy-related interactions. ii. Rule-based, free-form notifications. All practice settings now have more flexibility to construct additional decision models and the traits of patient-specific messages thanks to the alerts. Future free-form CDS rules should frequently be able to access the content of commercially available pharmaceutical CDS databases.

Institutions should have the ability to customize and create "drug groupings" that can be used as alert triggers or criteria in database-based clinical decision support systems. These groupings should be defined by lists of specific pharmaceutical items, generic or therapeutic categories, and should have the ability to encompass other drug groups. Individual prescription products should be able to be included in multiple drug groups. Real-time alerts should be tailored to the patient's unique condition, utilizing data such as age, gender, weight, test results, radiological procedures, dietary requirements, diagnosis, and current problem list. This study provides valuable insights into the capabilities of database-driven CDS systems and can guide future research in this area.

This study aimed to identify the research being conducted in the field of electronic decision support systems for pharmacists in hospital or community settings. The researchers conducted a thorough review of the Cochrane Reviews Database, journals that publish decision support articles, databases like PubMed, specific websites, and conference proceedings to find

relevant literature. To be included in the study, electronic decision support systems had to meet certain criteria such as being regularly used, providing clinical support, and not being embedded into a medical device. From a total of 386 references, only four articles met the criteria, with three of them discussing alerting systems for pharmacists, and one focusing on how these systems affected the workflow of pharmacists when it comes to electronic prescription. These findings demonstrate the limited research being conducted in this area and highlight the need for further studies to improve the effectiveness of electronic decision support systems for pharmacists in different practice settings.

Electronic decision support systems that directly assist pharmacists or pharmacy practice in either a hospital or community setting. The researchers conducted a thorough review of several databases, journals, websites, and conference proceedings to find relevant literature. Out of 386 references, only four articles met the criteria for inclusion. The study found that there is little literature documenting electronic decision support system activities specifically for pharmacies or pharmacists, despite the increasing patient-focused roles of pharmacists. While there are some initiatives and systems supporting traditional pharmaceutical functions, the development of suitable decision support technologies requires a better understanding of pharmacist requirements. Overall, the study highlights the need for more research and development in this area to improve the quality of healthcare [11].

This study aimed to investigate the effect of an advanced clinical decision support system (CDSS) on the number of high-quality clinical pharmacist recommendations in a medication treatment management (MTM) call center environment. The study utilized a pre-test/post-test design with a comparison group, and the clinical skills evaluation scores of certified MTM pharmacists were compared before and after the implementation of the CDSS. The Wilcoxon Signed Rank test was used to analyze the pre- and post-test results of both groups. The study's results are not yet presented and labeled as the impact of an advanced clinical decision support system (CDSS) on the number of relevant clinical recommendations made by certified medication therapy management (MTM) pharmacists in a call center setting. The study involved a small sample size of 20 participants, mostly under the age of 40 and with a doctorate in pharmacy, and only one national MTM provider group of pharmacists was used. The results showed a significant increase in the volume of pertinent clinical recommendations with the use of an advanced CDSS. However, the study has limitations such as not considering

the type of CDSS used and not including Board of Pharmacy Specialties-certified pharmacists in the trial. Therefore, the findings may not be applicable to all pharmacists in a call center MTM scenario. Nonetheless, the study suggests that an advanced CDSS, coupled with systematic training, can aid pharmacists in preventing improper drug usage, adverse drug events, and polypharmacy [12].

The study indicates that pharmacists who utilized the advanced CDSS were better equipped to provide accurate and evidence-based clinical recommendations compared to those who only used DISS in a call center MTM setting. The findings underscore the need for pharmacists to have a thorough understanding of how drug-drug interactions (DDIs) impacted by cytochrome P450 (CYP) can affect medication pharmacokinetics and patient response. The study also highlights the importance of evaluating CYP DDIs in predicting clinical outcomes.

This article is a study on drug-drug interaction, and according to this study, the drugs that affect each other the most have been identified. According to the results obtained, the most commonly used software vendors are QS/1, PDX and Health Business Systems. As a result of the research conducted, patients trust pharmacists about drug-drug interaction, and it has been determined that the information provided may be insufficient if pharmacists do not use computer systems and programs. This article is important because it shows drug-drug interactions in a detailed way [13].

In this work, a data-driven predictive decision support model system developed and applied to improve inventory management policy discussed. From the pharmacy staff's view, the new tool developed to increase their safety and confidence when setting up orders, making them aware of the risks involved. Accordingly, the order and risk tables provided by a data-based model predictive decision support system are much richer than the information provided by current information systems used in hospitals, allowing pharmacists to make better use of decisions. In the same way, the proposed method reinforces the role of pharmacists within inventory management and simple implementation, it does not change the workflow in pharmacy services. Additionally, this contribution represents an improvement to other methods are applied, namely simple predictive model predictive controller and common policy of the pharmacy department. In particular, stocks the level has been lowered, and the number of orders has also been reduce. Consider that the hospital administers more than 1300 different drugs and that the unit cost of some of them exceeds one thousand euro, any performance improvement

to maintain quality service levels translate into significant savings. In addition, model predictive control also indicates that it is possible to improve performance, for example by filter out past extreme demand peaks from the data. Therefore, the application of database-based policies in this context can be considered as easy to implement and promising. Due to its positive effect in pharmacy, reducing both inventory levels and employee workloads. This method is considered by the pharmacy department as a high value-added support system which is needed in the context of inventory management and for this reason, it should increase the number of drugs controlled in this way by integrate other vendors into the software. The article provided us a great example of data-driven predictive decision support model system [13].

Hospitals have included a range of clinical decision support systems (CDSSs) into their hospital information systems (HISs) to decrease medical errors, enhance patient care, and increase patient safety. 1-4. The Minister of Health and Welfare in Korea issues official DDI notifications, which are examined by the Korea Food & Drug Administration (FDA). According to this official law, a doctor must provide a valid justification for a prescription before it can be filled if it contains an absolutely contraindicated medicine pair [14]. In general, hospitals are using clinical decision support systems (CDSSs) more often to enhance patient care and safety. The Korea Food & Drug Administration (FDA) closely monitors official DDI notifications issued by the Minister of Health and Welfare in Korea, and doctors are required to cite a legitimate reason for any prescription that includes a medicine pair that is absolutely contraindicated in accordance with established rules.

### 2.1.1 Needs of Pharmacy Decision Systems According to Pharmacists

The study found that the participating pharmacists used the medication tracking system actively. When asked if using ITS made their jobs more convenient, 48.6% (184) of the pharmacists who responded said it improved the quality of their work. The simplicity of tracking and controlling medications received the highest percentage of ITS's expressed contributions to pharmacists' work (27.1%). 53 pharmacists specified this ITS contribution, making up 27.6% of all contribution statements. With 16.7% of the total mentions, the expression of combating counterfeiting came in second. The majority of a pharmacist's daily working hours are spent preparing and presenting medications to patients. The pharmacists who participated in some study claimed that ITS improved efficiency by speeding up procedures, saving time, and giving patients more time. In line with the research's conclusions, it is asserted

that using technical tools or software allows pharmacists to work more efficiently and save time [15]. By looking at the findings of this study, Clinical decision support and tracking systems are very important in terms of allowing pharmacists to work more efficiently. Thus, for future systems in this area, some recommendations could be made according to findings of this research:

- The pharmacist should be able to provide a list of the medications that they currently own. Pharmacists should be trained on how to use the software.
- The program should be simplified.
- The drug should be completely removed from the program immediately in cash sales.
- The vendor company's and warehouse's stock levels for medications should be visible to the pharmacist.

### 2.2 Interaction Between Pharmacy and Patient

This article describes the relationship between the websites of pharmacies in Spain with the customer and whether they are customer-oriented during sales and what they use when doing these methods. The directorate in Spain says that Spanish pharmacies can sell over-the-counter medicines via the website and this sales rate will increase in the future, but these online sales can only be made by legally authorized pharmacies, and these pharmacies must also be physically active pharmacies. Websites in Spain are now using product-based marketing according to customer needs tomorrow, the goal here is to provide the most suitable product to the customer rather than marketing a product and to market the most suitable product according to the needs. This survey research was conducted by the government of Spain and, according to the rate of use of the web site with the web site and pharmacies to measure the customer relationship for the purposes of this study were asked geographic region, the Spanish autonomous community of the Canary Islands was named, according to research pharmacies are very similar to each other, and the differences has been identified as less. Most of the research has used only to sell your products pharmacy the Web page according to the results, and many of them than has been marketing the product for the needs of the user.as a result of research of the busiest areas in the town square and close to the web pages of the ratio of the number density of pharmacies according to customer shows wrong physical , and with it, close to the center of the pharmacies that are not near the center of the web pages which have been

identified as relevant to the customer and is more attentive to web pages. The application here is based on online sales between pharmacists and customers who are the last retail sellers of medicines via the web page, our application is based on the drug-drug relationship rather than online sales, unlike this application, and decently the goal is to meet the needs of the customer. According to our practice, if the drugs the customer takes affect each other or have a bad reaction, he tells the pharmacist not to give the drugs and shows the equivalent drugs that he can give instead [16]. The purpose of using this text is to get information about the level of interaction between pharmacies and customers, the decrees surrounding online sales and the marketing strategies used by these websites.

E-pharmacy sector with the covid-19 pandemic, the interest in e-pharmacy has increased, due to the increase in online sales, this has led to an increase in cybercrime. Online drug sales cause cyber security vulnerabilities including over-the-counter medicines, counterfeit medicines, wrong medicines, consumer fraud and information privacy. E-pharmacy is a very useful and convenient application for people with chronic diseases. E-pharmacy has seen high demand in high-income countries at first, while in recent years it has seen high demand in middle-income countries and low-income countries. Unlike this article, our application is not for online sales, but is an application used by pharmacists, the purpose of our practice is to provide the pharmacist with the best product to meet the needs of customers in the easiest way possible [17]. From this article we get information about the e-pharmacy sector and its impact on the healthcare sector, online drug sales, potential risks and challenges related to cyber security.

Anyone can contact pharmacies online by using the PHARNC's website, which also includes their address and phone number. This method offers instant communication as a result. The capability for online drug ordering provided by PHARNC is another benefit. In the event of an emergency, the PHARNC database is set up to offer all relevant contact information online. In case of an emergency at night, a daily list of pharmacies that are open must be provided. [18]. By looking at the results of this study, it can be said that being able to contact with patients in case of any problem about the drugs they use is very important. Therefore, online medicine tracing systems can also be implemented to track patients in case of any risky DDI and FDI interactions.

## 2.3 Potential Drug-Drug Interaction Studies

This paper outlines a methodology for developing a potential drug-drug interaction (pDDI) clinical decision support system (CDSS) in the field of kidney transplantation. The study involved prospectively recording prescriptions from five nephrologists for two months, using the Medscape multi-drug interaction checker tool to detect pDDIs, and consulting with clinicians to assess the clinical relevance of detected pDDIs. Semi-structured interviews with five nephrologists and one nurse informant were conducted, and clinically relevant pDDIs were checked with the Dutch "G-Standard". A multidisciplinary team was involved in deciding the design characteristics of pDDI-alerts in the CDSS, taking into account international recommendations and inputs from the clinical context. The CDSS's performance in detecting DDIs was evaluated iteratively by a multidisciplinary research team. The methodology aimed to address the issue of workflow interruptions and alert fatigue caused by alerts with little or no clinical relevance, ultimately improving the effectiveness of CDSSs. Collected and analyzed medication data from 595 patients with 788 visits and identified 52 common types of potential drug-drug interactions (pDDIs) that made up 90% of all pDDIs. Of these, 33 were considered clinically relevant and included in the clinical decision support system (CDSS) knowledge-base. However, upon further analysis with the Dutch G-standard, 73% were found to be either pseudo duplication of drugs or not a pDD[19]. The study highlights the need to understand the complexities of clinical work to improve the effectiveness of pDDI-alerts in CDSS. Clinicians' input on the clinical relevance of pDDIs is critical, and the system should allow for customization of alerts based on clinical context.

This article describes the types and prevalence of drug-drug interaction given in a hospital setting in Zabol, Iran.In general, less than half of prescriptions have DDI, the most common type of interaction is type C. Pharmacies hospital pharmacies drug interaction of the drug free rate is lower than the rate of interaction. And with it, the rate of medical professionals is higher than the rate of drug interaction drug interaction of general practitioners, physicians prescribing medical professionals to their patients that as the explanation for the practitioner prescribing to their patients interact with each other and this interaction because it is heavier than on his impact is huge. This article was used to get information about the types of drug-drug interactions, the most common drug-drug interactions, and the reasons for drug-drug interactions. [20].

In this paper, the expected effect of a drug can be changed if used with another drug or some foods. Understanding drug interactions is crucial to minimize side effects and maximize treatment effectiveness are discussed. With an increasing number of drugs available, extracting information from drug-related databases to predict possible interactions efficiently would be valuable. Artificial intelligence has been used to predict drug effects through machine learning and deep learning. Machine learning can extract hidden criteria and predict drug side effects based on drug-metabolizing enzymes, drug similarity, and drug targets. In addition to drug-drug interactions, drug-food interactions and drug-microbe interactions can also occur. Artificial intelligence can predict interactions between inactive ingredients and generally recognized as safe compounds, and enteric bacterial species capable of converting drugs into biological compounds. However, current predictions lack a systematic method for predicting multiple interactions. Therefore, a comprehensive review of artificial intelligence interactions is needed to promote accurate and rapid prediction of multiple interactions. This article describes drug-food interactions, and it really helped us to design our app [21].

This study shows that significant decrease in drug-drug interaction burden can been achieved by using simple contextual modulators. Based on this study additional more sophisticated contextual modulators don't seem to be a top priority for a general hospital setting. Analysis of the residual false positives also showed that many false positives could be traced back to workflow-related technical issues, most of which were resolved by implementing an auto-refresh function and waiting for the clinical decision support to display the alert after all meta-rules had been executed. Gaston Pharma has been shown to be easily combined with different knowledge bases and providing contextualized clinical decision support linked to several different computerized physician order entries and/or electronic health records. The greatest benefit as it comes to time savings in the current study was removing the pharmacy technician from the primary drug-drug interaction alert evaluation on no absorption time-dependent drug-drug interaction and replacing them by the contextualized clinical decision support system and the other way around for absorption time-dependent drug-drug interactions. Basic pairwise drug-drug interaction and clinical decision support systems in hospital practice are common in Western countries. In the Netherlands, computerized physician order entry including basic pairwise drug-drug interaction and clinical decision support is mandatory in all medical settings as of January 1, 2014. No reference found use of contextualized clinical decision support and drug-drug interaction systems in clinical practice bigger scale. Since

October 2020, Holland has switched his drug-drug interaction knowledge base from a pairwise combinatorial model to a model-comparable decision tree model. As a result, for the study, all healthcare providers can benefit from contextualized drug-drug interaction management in a clinical context. This article shows us the difference between traditional interaction and contextual interactions. It helped us to analyze interactions in a different way [22].

This article discusses the integration of scientific and clinical skills in healthcare education, particularly in the context of drug-drug interaction understanding. The authors argue that teaching drug-drug interaction through a project-based approach provides a more engaging and relevant learning experience for students than separate courses. In addition, this approach has a positive impact on instructors, as it allows them to learn from the experiences of others and build their own skills. The project-based approach used in this study included analysis of drug-drug interaction case reports, which the authors considered a level of complexity appropriate for the student. However, the authors note that students may have difficulty associating quantitative scientific data with clinical effects. Furthermore, they found that the most difficult step for students was to suggest appropriate management of drug-drug interaction, given their lack of knowledge in various therapeutic areas. The authors conclude that the drug-drug interaction module can be implemented in a variety of delivery modes and encourage educators from other health professions to consider this approach. They plan to use the same method in several courses over the next school year and collect data to analyze its effectiveness. This article helped us to design user friendly application [23].

This work discusses a comprehensive approach to signaling drug-drug interaction safety issues has been developed in the Netherlands. This best practice includes recommendations for 57 diseases and conditions, and in primary care, at least one disease or condition that could lead to a drug-drug interaction safety issues was registered by pharmacists in about half of the patient records. The largest group of diseases that can lead to a drug-drug interaction safety issues was the group of cardiovascular diseases. In the near future, more patient data will become available at point of care, which could lead to more personalized and time-saving alerts for drug-drug interaction safety issues. The possibilities of this best practice to contribute to medication safety of over-the-counter drugs depend on the countries' health care system setting. Inter professional communication between pharmacists and physicians is essential for resolving drug-drug interaction safety issues. A strength of the practice concerning drug-drug interaction safety

issues in the Netherlands is the wide body of pharmacological knowledge and recommendations, and the experience of pharmacists with implementation in daily practice. Three barriers for wider implementation and adoption in other countries of this best practice need to be discussed. Alert fatigue may occur, a lack of specificity or sensitivity of alerts could contribute to alert fatigue, and multidisciplinary agreements on exchange of essential data are required. This article provided us an example of drug-drug interaction in Netherlands [24].

Drug-drug interaction (DDI) occurs when two or more medications are taken concurrently. This can alter how one or more medications behave in the body and increase the risk of medical mishaps. In addition to reading the medication instructions, it is challenging for clinicians to quickly analyze drug interactions. As a result, two widely used techniques are used to comprehensively study drug interactions: examining DDI-related medical literature and scanning scientific databases [25]. Overall, the challenges associated with analyzing drug interactions have led clinicians to rely on established techniques, such as examining DDI-related medical literature and scanning scientific databases, to comprehensively study potential drug interactions and minimize the risk of medical mishaps when multiple medications are taken concurrently.

In recent years, supplement sales have significantly increased as a result of extensive media coverage of the possible health advantages of vitamin D supplementation. Yet, the possibility of drug-vitamin D interactions is rarely taken into account. To determine how much vitamin D status or supplementation affects pharmacological effectiveness or toxicity in people, a comprehensive evaluation of the literature was done. Peer-reviewed papers that were eligible were those that had been published by September 1, 2010, as determined by electronic databases. Study characteristics and results were extracted, and each study's quality was evaluated. The inclusion criteria were satisfied by 109 distinct reports in total [26]. Therefore, this comprehensive evaluation of the literature highlights the need to consider the potential interactions between vitamin D supplementation and pharmacological treatments, as the use of supplements has increased significantly in recent years and may have implications for the effectiveness and toxicity of medications.

Pharmacists should be aware of these potential interactions and must assess the therapeutic relevance of each in order to reduce the number of DDIs and their potential negative effects. By avoiding hazardous DDIs and inappropriate medication use, pharmacists should be

involved in maximizing pharmaceutical treatment. Yet, while using software to find potential DDIs, pharmacists are exposed to a plethora of warnings, including numerous minor and moderate interactions. Hence, significant DDIs may be disregarded. The following statements were provided to DDIs in the clinical decision-making process in order to collect highly qualified information from DDI programs: A new approach should be developed to evaluate evidence regarding DDIs, consistent terminology should be established, the drug interaction probability scale should be used to assess case reports regarding potential DDIs, the FDA documents and drug leaflets should be assessed using the same criteria as the evidence reported, and when evidence is discovered, this potential DDI should be classified according to therapeutic/pharmacology groups [27]. Therefore, DDI and FDA decision programs should be better to re-evaluated based on the findings of this study and other studies in the literature in order to increase concordance between them by evaluating evidence-based outcomes and severity classifications.

### 2.4 Data Mining and Deep Learning Studies

This article describes smart pharmacies, the design, development and study of smart pharmacies. According to this article, the development of big data technology, with the increasing prevalence of artificial intelligence and the widespread use of data mining, traditional pharmacy is now seen as old-fashioned. In order to solve the problem of high cost and low income of traditional pharmacies, it is envisaged that the use of smart pharmacies will provide high efficiency with ease of use by reducing the cost. By using data mining, information such as users' information experiences and drug interactions are collected and this information is used to provide the best performance to the customer. According to some research conducted it shows that by realizing automatic and intelligent management of pharmacies, it effectively improves work efficiency, reduces labor fatigue and distribution errors. The working logic of these outpatient pharmacies is that customers read income prescriptions and take the necessary medications, or in addition, customers report an income complaint and can take medications that they can get without a prescription [28]. Thus, manpower is minimized by means of a machine and the most practical solutions to problems are found. Information about the use of big data, the use of artificial intelligence and data mining, the advantages of smart pharmacies is taken from this text.

In this study, we offer a unique method called MedKGQA, which predicts DDIs from documents in a multi-hop MRC fashion and achieves state-of-the-art performance on the KANGAROO METHOD test set. This method is based on the idea of PPIs. We present a straightforward yet efficient way for adding the natural properties of pharmaceuticals and proteins to our knowledge fusion system. Multi-relation GATs is utilized to model the entities and relationships among the four types of nodes in order to reason the PPIs chains and arrive at the DDIs predictions. In order to better comprehend how the model's predictions are made, we also illustrate the reasoning process. In addition, we hope that this will benefit the fields of medical research. This is a modest attempt to merge NLP and molecular task technology [29]. Overall, the MedKGQA method offers a promising approach for predicting DDIs from documents and could have significant implications for the field of medical research by integrating NLP and molecular task technology.

Since it gives details on the effects that medications co-administered to a patient create during therapy, drug-drug interactions (DDI) comprise significant and valuable information for medical professionals and patients. Several techniques have been used in extraction jobs since DDI are dispersed in a large collection of pharmaceutical documents, including support vector machine (SVM), recurrent neural networks (RNN), and long-short term memory (LSTM) (LSTM). This article provides background information and a systematic review of the literature pertaining to deep learning models of DDI extraction found in recent biomedical literature. It also summarizes the evidence currently available for the most well-known approaches in that field and identifies the current challenges. the potential for examining the development of an alternate model with better performance, opens up [30]. This paper provides a thorough evaluation of deep learning models for DDI extraction and emphasizes the possibility for creating better solutions to the problems posed by DDI information extraction from big collections of biological texts.

Future studies could test the effectiveness of providing a higher level of implementation support for high-need pharmacies and a lower level of implementation support for lower-need pharmacies. For example, high-need pharmacies may need more support to build general implementation capacity as compared with project-specific technical assistance [31]. Therefore, the gatherings of this study can help us in terms of understanding the needs of pharmacies and implementing the most effective strategy related with their needs.

Any new information system that is put into place needs a lot of implementation support so that end users can learn about the capabilities, integrate it into their workflows, and optimize it to provide better patient care. This study can help future studies for providing a thorough explanation of how one statewide network assisted end-users in overcoming implementation-related obstacles. Given that community pharmacists typically lack access to clinical data and use pharmacy management systems built around a dispensing rather than clinical workflow, community pharmacies implementing new medication management applications are likely to encounter similar obstacles and require a similar level of implementation support [32]. Therefore, the gatherings of this study can help us in terms of understanding the importance of feedbacks and capabilities of the software in pharmacy decision systems.

The drug knowledge database, which is included into the program and serves as the foundation for its drug information, may potentially be a source of variation in the performance of the software. There isn't yet a unified system for grading the seriousness of medication interactions. To improve the way pharmaceutical information systems to identify probable DDIs, thorough system upgrades are required. As a result, problems with pharmacy systems' dependability are likely to affect other systems that employ drug-interaction screening algorithms. It’s necessary to conduct more research to enhance pharmacists' capacity to identify DDIs, stop probable adverse events, and safeguard the health and safety of patients [33]. Consequently, previous studies on the precision and dependability of pharmacy software tools have suggested that a contributing factor to their subpar performance is their inability to alert pharmacists about potentially clinically relevant DDIs and FDIs.

# 3. Requirements

In this section of the report, the importance and purpose of the software requirements specification (SRS) will be touched upon and explained in detail. SRS is a detailed document in terms of containing the crucial phases of the project. It describes the product's functionality in terms of fulfilling the needs of all stakeholders. In addition, SRS is one of the most important stages of a project, especially in terms of guiding and informing the developers about the phases of the project. Consequently, SRS studies are an important phase that minimizes the loss of time and money for the project teams.

Therefore, the main purpose of this document is to explain what the system's characteristics are, how it should be built, and how it will respond in various situations along with diagrams related to the system. Moreover, the functional and non-functional requirements of the system will be touched upon and evaluated separately. Consequently, this document is prepared based on the findings of an interview with pharmacists and will be used for stages of the project such as design, testing, and implementation phases.

## 3.1 Scope

The aim of this project is to solve the difficulties in verifying and controlling the suitability of drug-drug (DDI) interactions, and food-drug (FDI) with a systematic decision mechanism. The “Pharmacy Decision Support and Tracking System” is a web-based application to benefit both patients and pharmacists.

The application will identify drug interactions and display a warning to the pharmacist. Furthermore, by considering interactions such as DDI and FDI, the system should be able to forecast which prospective dietary supplements and OTC (over-the-counter) medications could be preventive and protective for each patient's disease. Correspondingly, the rule-based system will make recommendations to pharmacists by predicting and listing the most profitable products according to their ATC (Anatomical Therapeutic Chemical) codes for the product group available to the pharmacist. As a result, the system will be able to safely improve pharmacists' profitability by recommending products to their patients more effectively and precisely. Moreover, patients will be able to use the safest and most effective medications for their diseases.

## 3.2 Overall Description of the Project

The remaining parts of the SRS document include two sections that contain a detailed and comprehensive definition of the requirements for the project. The next section touches upon various crucial topics such as system overview, features, stakeholders, and their relationship with the system. Furthermore, this section also includes a detailed description of the product's assumptions and dependencies and system constraints.

The third section of the document provides technical information in terms of specific requirements and covers the functional and non-functional requirements topics. Moreover, this section also includes detailed information about different system interfaces such as hardware, software, and user interfaces.

## 3.3 Product Perspective

The system aims to determine the drug-drug and drug-nutrient interactions of drugs sold in pharmacies and to recommend food supplements suitable for the patient's disease according to the profit margin of the pharmacy. This feature allows us to determine whether drug-drug interactions reduce the risks associated with these interactions. Also, the system must make predictions accordingly to the patient’s disease and recommended supplements (nutrients). It stores the interaction data of drugs and nutrients on the web server. Accordingly, the data can be accessed from anywhere. The pharmacist accesses the ATC codes in the database and issues an alert for interacting drugs or nutrients. It also gives food supplement information to the patient according to the ATC code. Pharmacists guide the patient by accessing the warnings on the screen by accessing the web interface. Therefore, using the data from the database, the system will suggest the best medications for the patient.

## 3.4 Product Functions

The system shall have the listed features below:

- Login, Register
- Alert Message
- View results
- Create, View, Modify, and Delete Patient

- Insert, Delete, Modify, and View Prescriptions Info
- Allergy Checking
- Drug Interaction Checking
- Medication Reconciliation
- Formulary Management
- Clinical Decision Support

### 3.5 User Characteristics

Admin: The system administrator, known as Admin, has the authority to add, remove, or change the information on patient and pharmacist user accounts. This account has all the same rights as a pharmacist's account. Thus, it may be used for managing and monitoring patients and their interactions.

Admin is the system administrator who is allowed to create/delete/modify user accounts including pharmacists and patients. This account can be used for both managing and keeping track of patients and their interactions as it has all the privileges of a pharmacist’s account.

Pharmacist: Pharmacists are responsible for drug-drug and drug-nutrient interactions of patients. A patient can be added or removed by pharmacists from the list of interactions. Via our web interface, pharmacists may see the outcomes of patient interaction.

Patient: Patients can enter the prescription code into the web-based interface that opens on the pharmacist's screen, namely the medulla. According to the ATC codes in the database, they can learn drug or nutrient recommendations and restrictions from the pharmacist. Patients can also give rights to pharmacists for accessing his/her data.

### 3.6 Constraints

- The pharmacists shall have computers capable of running web-based apps.
- Pharmacists shall be trained on how to use the application.
- Data quality: The accuracy and completeness of data used in PDSS can impact the reliability of recommendations made by the system.

- Integration: PDSS must be integrated with other electronic systems in the pharmacy, such as electronic health records (EHRs), to ensure that patient information is accurate and up-to-date.
- Usability: The user interface of the PDSS must be easy to use and understand to enable pharmacists to quickly and efficiently access information and make informed decisions.
- Customization: PDSS must be customized to meet the specific needs of the pharmacy and its patients, which may vary based on the pharmacy's size, patient population, and other factors.
- Data security: PDSS must comply with applicable privacy and security regulations to protect patient information from unauthorized access or disclosure.
- Cost: PDSS can be expensive to implement and maintain, and the benefits of the system must justify the cost.
- Human factors: The effectiveness of PDSS may be influenced by factors such as the pharmacist's cognitive workload, experience, and training.

### 3.7 Assumptions and Dependencies

- The operation of the system depends on updates being made in the pharmacies' database inventory to update the availability of drugs as the system requests are accepted.
- Data availability: PDSS assumes that the necessary data is available in the pharmacy's electronic systems, such as electronic health records (EHRs), medication history, and laboratory results.
- Data accuracy: PDSS assumes that the data used in the system is accurate and up-to-date. If the data is incomplete or inaccurate, the recommendations made by the system may not be reliable.
- System integration: PDSS is dependent on other electronic systems in the pharmacy, such as EHRs and medication dispensing systems, to ensure that patient information is accurate and up-to-date.
- Clinical guidelines: PDSS is designed to provide recommendations based on established clinical guidelines. Therefore, the system assumes that the clinical guidelines used in the system are up-to-date and evidence-based.

- User interaction: PDSS assumes that the pharmacist will interact with the system appropriately and will use the information provided by the system to make informed decisions about patient care.
- System maintenance: PDSS requires regular maintenance and updates to ensure that it remains up-to-date and effective.
- Regulatory compliance: PDSS must comply with applicable regulatory requirements, such as privacy and security regulations, to protect patient information from unauthorized access or disclosure.

## 3.8 Specific Requirements

### 3.8.1 External Interface Requirements

#### 3.8.1.2 User Interfaces

- The system UI must be simple to use for users.
- The system UI must be responsive to make ease to use for users. (Desktop and mobile layouts must be different)
- The system shall include light/dark mode.
- The system shall display the interactions within a popup to inform the pharmacist.

#### 3.8.1.3 Hardware Interfaces

- Drug-drug, drug-food, and drug-disease interaction information should be kept in a database.
- The model should recommend the best drugs for the patient according to the information that is kept in the database.
- The user Interface should connect to the server to check drug interactions.
- The system must respond to a pharmacist about drug interactions within a popup.

### 3.8.2 Software Interfaces

#### 3.8.2.1 Web server

- The server should keep information about drug interactions.
- The server should identify the type of request. For example, if the request is about getting drug information, the system should identify the request is coming from SGK Medulla Pharmacy Interface and send a response according to the type.
- The system database should be accessible from our model to make decisions and send the “decision results” response to the related UI.

#### 3.8.2.2 Patient Interface

- The web server should be able to fetch patient information and inform the patient about his/her prescription.

#### 3.8.2.3 SGK Medulla Pharmacy Interface

- Pharmacists should be able to fill out the prescription form and submit it.
- The system should get form data from SGK Medulla Pharmacy and analyze it for a recommendation.
- On the same page, a popup should appear to inform the pharmacist about interactions.

### 3.8.3 Communication Interfaces

- The web server should inform pharmacists if there is a risky situation about interactions.

## 3.9 Functional Requirements

Designed to provide comprehensive information and support for both patients and healthcare providers. Pharmacy Decision Support System should be user-friendly, easy to navigate and provide accurate, reliable, and up-to-date information to improve patient safety and quality of care. The functional requirements of the system and the use cases to which the requirements belong are indicated in this section.

- Drug Database: The system should have an extensive database of drugs and their corresponding information such as indications, contraindications, dosages, side effects, and drug interactions.
- The system should have a comprehensive database that includes information on drug-food interactions, including the specific foods that interact with each medication. This database should be regularly updated with the latest information.
- The PDSS should have the capability to provide disease-specific recommendations for medication to ensure that the prescribed medications do not exacerbate the patient's condition or interact negatively with other medications or foods. This feature will help healthcare professionals make informed decisions about medication management and ultimately improve patient outcomes. By taking into account the patient's specific disease or condition, the PDSS can suggest medications that are more likely to be effective and safe for that particular patient.
- Clinical Decision Support: The system should provide real-time clinical decision support for pharmacists based on the patient's information such as age, weight, medical history, allergies, lab results, and current medications.
- The system provides detailed information on drug formulations, dosages, pharmacokinetics, pharmacodynamics, drug-drug, drug-food, and drug-disease interactions, as well as the effects of drugs on different populations such as pregnant or lactating women, and pediatric and geriatric patients.
- Users can search for medications by National Drug Code (NDC) number and access drug monographs with comprehensive information on drug indications, dosages, contraindications, and precautions.
- The system manages patient medication information and provides useful recommendations to prevent harmful interactions and allergies.
- The system alerts users of any possible drug interactions and allergies and provides real-time alerts to avoid harmful combinations.
- The system also allows users to customize drug interaction alerts based on severity, relevance, and preference.

- Drug Interaction Alerts: The system should provide drug interaction alerts when a patient is prescribed a medication that may interact with other medications the patient is taking.
- Adverse Drug Reaction Monitoring: The system should monitor adverse drug reactions and alert the pharmacist if the patient experiences any adverse reactions.
- Patient Education: The system should provide patient education materials such as medication guides, drug information leaflets, and dosage instructions.
- Materials on medication use and side effects, medication administration, and dosing guidelines for healthcare providers are also available, along with information on medication alternatives, including cost, risks, and benefits.
- Prescription Tracking: The system should track prescriptions.
- Electronic Prescription Processing: The system should enable electronic prescribing and processing of prescriptions.
- Reporting and Analytics: The system should generate reports and analytics to track medication usage, patient outcomes, and pharmacy operations.
- The system provides various reports, including drug interaction reports, adverse drug event reports, and medication error reports.
- Users can also view medication history, drug information such as side effects and interactions.
- The system allows users to create and manage patient profiles.
- Integration with EHR: The system should be integrated with the Electronic Health Record (EHR) system used by the healthcare provider to access patient information and update the patient's medication record.
- These features provide healthcare providers with a comprehensive medication management tool to enhance patient care and safety.

This requirement document outlines the need for the system to have medication tracking and inventory management features. Additionally, it should provide medication cost-

effectiveness analysis and allow users to create and manage medication formularies for individual patients.

### 3.10 Non-Functional Requirements

- Security: Only authorized pharmacists should have access to the system, and they must verify the username and password to log in.
- Performance: When pharmacists use the system, the system should be fast and increase the number of procedures performed by keeping the procedure process short.
- Availability: The downtime of the system should be as low as possible, and the maintenance hours of the system should be selected during the hours when the pharmacist is not busy or even not working during the day.
- Compatibility: The application is available on different operating systems (Windows, Linux, macOS, etc.) and must be able to work on and in different browsers (Google Chrome, Mozilla Firefox, Internet Explorer, Safari, etc.) should be able to work.
- Innovation: The system should be innovative and develop itself under the leadership of feedback received from pharmacists.
- Testability: The system should allow a pharmacist to test it to check whether the system is working properly.
- Interoperability: The system should be interoperable with other healthcare systems such as Electronic Health Record (EHR), Health Information Exchange (HIE), and Pharmacy Benefit Management (PBM) systems to share data and improve patient care coordination.
- Usability: The system should be easy to use, intuitive, and require minimal training for pharmacists and other healthcare professionals to use efficiently.
- Compliance: The system should comply with relevant regulatory standards such as HIPAA, FDA, and other state and federal regulations governing healthcare data privacy and security.

- Maintenance: The system should be easy to maintain and support, with regular updates, bug fixes, and enhancements to improve its functionality, usability, and performance.

- Cost: The system should be cost-effective to implement, maintain, and support, with minimal hardware and software requirements, and a low total cost of ownership.

### 3.10.1 OS (operating system) Non-Functional Requirements

- Stability: The system should be clear and understandable, not to make pharmacists hesitate about drug-drug interaction, which can be reliable.

- Resource utilization: Sources should be the most reliable, well-known certified sources in the field of pharmacy.

- Ease of use: The system should be easy to use and clear from the pharmacist's point of view.

### 3.10.2 Database Non-Functional Requirements

- Data consistency: Even if this web application is running on different platforms, it should show the current number of medicines available in the stock of the specified pharmacy.

- Scalability: When new products are added to the pharmacy database, the database should be able to adapt to the changes and the pharmacy database should be minimally affected by system density in terms of performance.

- Backup and recovery: The information should be uploaded to the database version by version and the previous version should be easy to view if a problem is encountered.

### 3.10.3 Programming Environment Non-Functional Requirements

- Support for programming languages and libraries: The system should support languages such as HTML, CSS, and JavaScript at the front end.

# 4. Design

## 4.1 Software Methodology

One of the most crucial steps in the process of managing software quality is reliability evaluation and management. While designing software, certain cost and time restrictions must be taken into account, as well as the product's quality criteria, including its dependability, since program failures can have unexpected effects. In this regard, the evaluation and management of software reliability are especially crucial for the growth and advancement of society and its requirements [34]. Therefore, choosing the right software methodology is vital to the progress of the project.

Agile Software development is a form of a development approach that was created in response to the demand for flexibility. In contrast to conventional techniques, which deliver the full program at the end of the development process, Agile focuses on providing discrete components of the software. The key advantage of Agile Software Development is the ability to assist teams in evolving in a dynamic manner while keeping focused on delivering high product value [35]. Therefore, The Agile software development life cycle is an iterative and incremental method of developing software that stresses flexibility, collaboration, and customer satisfaction. The first step of the Agile software development life cycle is the requirements stage. In this stage, the software requirement specification document is created after determining all of the project's requirements. In the design step, the team defines the software's architecture and develops a thorough plan for each sprint which concludes with designs of the database, interface, architecture, classes, etc. In the development stage, the program is developed according to SRS and design documents in short iterations of 1-4 weeks, with each iteration delivering a potentially shippable product increment. In the testing stage, the team tests the software to ensure that it satisfies the criteria and functions as intended. In the deployment step, the team puts the software into production in accordance with the documents so that end users can utilize it. In the last step which is maintenance, the software project team continues to support and maintain the program, addressing any bugs or problems that appear and adding new features as necessary. Therefore, these steps represent the six stages of the Agile software development life cycle as can be seen in Figure 1.

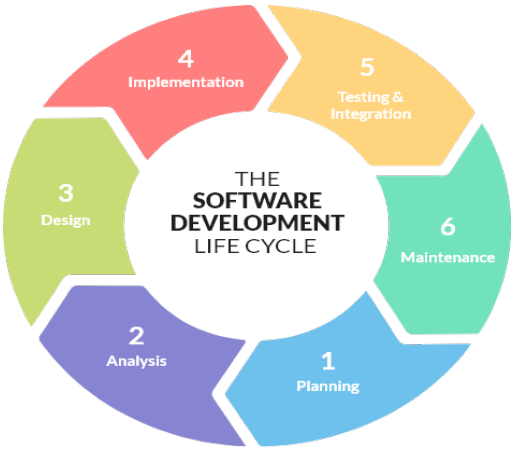


*Figure 1 – Six Stages of the Agile Software Development Life Cycle*

The benefits of the agile methodology such as the interaction with the client being more frequent compared to traditional methods and the continuous development keep the success rate of Agile high. Hence, in the software development life cycle of the Pharmacy Decision Support System, the Agile Scrum methodology was used. The main purpose of using the agile methodology in this project is that the requirements will be determined according to interviews and surveys with pharmacists and there is a possibility of change in the requirements. In addition, compared to traditional methodologies such as waterfall, stages of the project can be revisited and necessary changes can be made according to the needs of the client. Besides, the project team planned to break the project phases into weekly sprints which fits the scrum methodology of Agile. Therefore, in this project, Gantt Chart is used to show the beginning and end dates of the project's development process. Each member of the project team is in charge of informing about what has been done and what is needed in the relevant part of the project in daily short scrum meetings. Moreover, on a certain day of the week, a long meeting compared to daily short meetings is held about each step of the project and what needs to be done in the current stage. In addition, Trello is used for planning each stage of the project in a systematic way and for making the necessary task distribution between the team members and working in weekly sprints.

## 4.2 System Architecture

A pharmacy decision support system with a web-based architecture typically consists of a front-end user interface that can be accessed via a web browser, a back-end database to store information, and a set of decision-making algorithms to assist pharmacists in making informed decisions. The system uses real-time data to provide recommendations, alerts, and reminders based on the patient's medical history, drug interactions, and allergies, among other factors as can be seen in Figure 2.

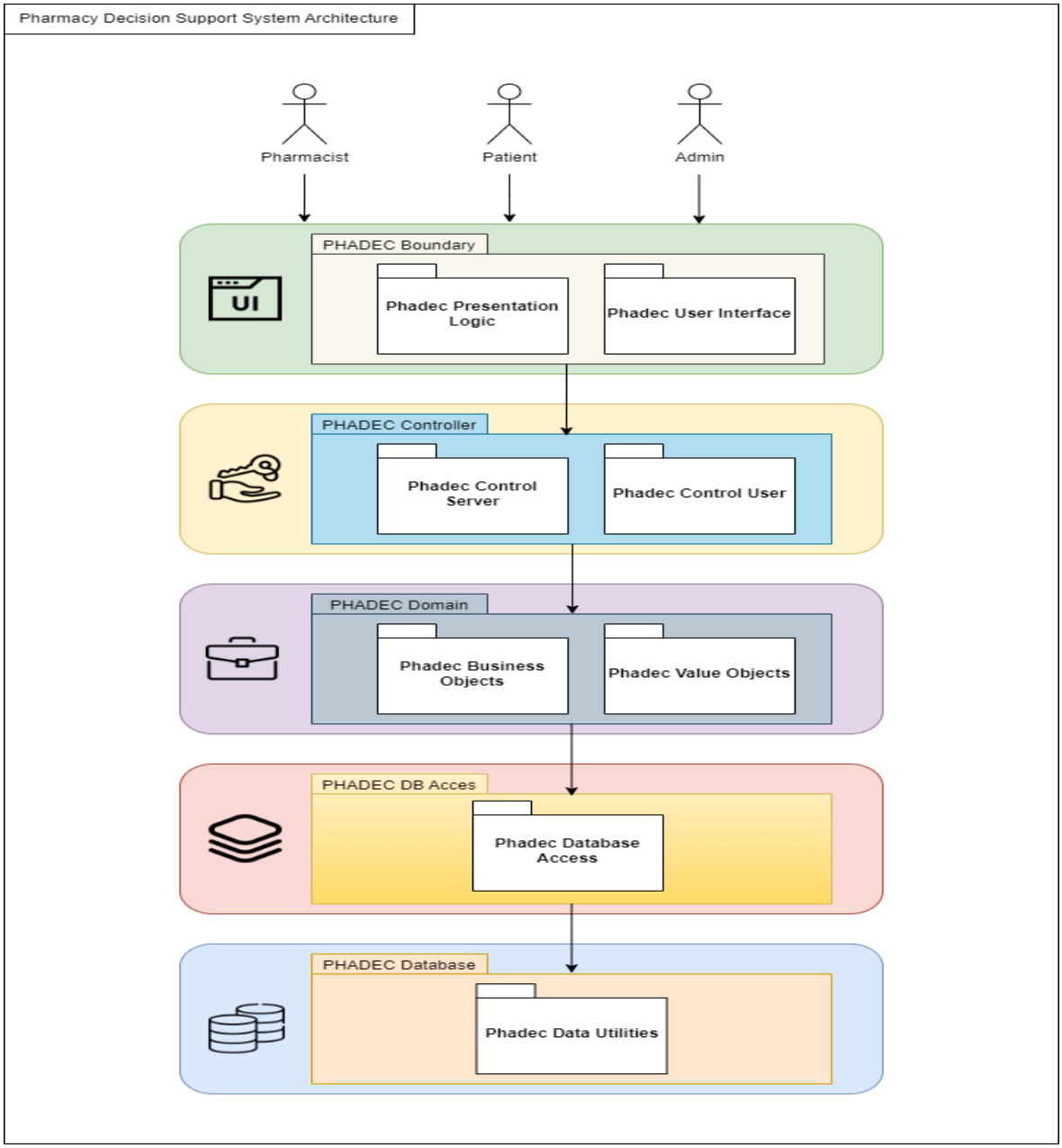


*Figure 2 – Architecture of PDSS*

## 4.3 Use Case Diagram


*Figure 3 – Use Case Diagram of PDSS*

As seen in Figure 3 use case diagram depicts a system involving various actors and their respective responsibilities. The admin, as the central figure, manages the database and user login functionalities. This includes tasks such as maintaining the database by adding, updating, or deleting information, as well as handling user authentication, registration, and account management.

On the other hand, the patient actor has the ability to view documents within the system. These documents could encompass medical records, test results, prescriptions, or other relevant information essential to the patient's healthcare management.

The pharmacist, as another actor, contributes to the system by adding documentation and tracking prescriptions. They can add relevant information, such as prescription details or other essential medical data, to ensure accurate record-keeping. Additionally, the pharmacist can

monitor and track prescriptions, ensuring that the correct medication is dispensed and providing any necessary guidance or follow-up.

The use cases presented in figure 3 provide a comprehensive overview of the system's functionality. They include user login and registration processes, selecting drugs using barcode scanning, searching for drug information based on barcodes, monitoring results, suggesting opinions, viewing documents (for patients), adding documentation (for pharmacists), and tracking prescriptions.

Login/Register: This use case involves the user login and registration process, which typically includes authentication and account creation.

Select drug barcode: This use case refers to the action of selecting a drug using its barcode. It allows for the identification of a specific drug using its unique barcode.

Search drug barcode: This use case involves searching for information about a drug using its barcode. It allows users to retrieve details about the drug, such as its name, dosage, and any relevant warnings or instructions.

Monitor result: This use case focuses on monitoring or tracking the results of a particular process or action. It could relate to tracking the progress or outcome of a medical test, for example.

Suggest opinion: This use case involves the ability to provide opinions or suggestions on a particular matter. It could be related to medical treatment options or other healthcare-related decisions.

View document: This use case allows patients to access and view documents, such as medical records or test results, for their own information.

Add documentation: This use case allows pharmacists to add relevant documentation to the system, such as prescription details or other important information.

Track prescription: This use case involves the pharmacist's ability to monitor and track prescriptions, ensuring accurate dispensing and providing appropriate follow-up.

## 4.4 Use Case Documents

### 4.4.1 Log-In

*Table 1 – Log-In Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-1 | | |
| **Use Case Name:** | Log-In | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Admin | | |
| **Purpose:** | To ensure the security, privacy, and usability of the system by allowing only authorized actors to access its functionality and data. | | |
| **Description:** | This use case contains scenarios and other details for logging into the interface. | | |
| **Prerequisites:** | 1. The user (admin) must beregistered in the system beforehand.<br>2. User has not logged into the system yet.<br>3. User should open the login screen. | | |
| **Main Success Scenario:** | 1. A user logs into the system with their username.<br>2. The user inputs their password onto the computer.<br>3. The system verifies that the user-provided username and password are accurate. | | |
| **Final Conditions:** | 1. The user has logged into the system successfully.<br>2. User is sent to the homepage by the system. | | |
| **Alternative Scenarios:** | 1. The user can change his or her password information whenever they like.<br>2. The system takes the user to the login page if the user provided an unregistered username. If the user enters an incorrect username or password, the system warns the user.<br>3. The system takes the user to the login page if the user provided an | | |

| | |
|---|---|
| | unregistered password and tells the user that they have entered an incorrect username or password. |
| **Actor Description:** | Admin: The admin accesses the login page of the system. The admin enters their login credentials, such as their username and password. The system validates the admin's credentials and authenticates them. If the admin's credentials are valid, the system grants the admin access to the system. If the admin's credentials are invalid, the system displays an error message and denies access. Once the admin is authenticated, they are redirected to the appropriate page or dashboard based on their role and permissions. In summary, the admin initiates the login process by entering their credentials, and the system validates and authenticates them. If successful, the admin gains access to the system. The admin may also be responsible for troubleshooting any issues related to log-in records, providing technical support, and granting or revoking user access to the system as necessary. Additionally, the admin may communicate with other stakeholders, such as the software developers, management, or users, to ensure that the system access control is implemented effectively and efficiently. By searching the log-in records, the admin can ensure the security and privacy of the system and its users, and prevent unauthorized access and data breaches. |

*Table 2 – Log-In Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. Open the login page of the system | 2. Display the login page |
| 3. Enter their username and password | 4. Enter their username and password in the respective input fields |
| 5. Click the “Log-In” button | 6. Validate the username and password entered by the Admin. |
| 7. None | 8. If the username and password are correct, the system logs the Admin in and displays the system dashboard |
| 9. None | 10. If the username and password are incorrect, the system displays an error message and prompts the Admin to enter the correct credentials |

### 4.4.2 Register

*Table 3 – Register Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-2 | | |
| **Use Case Name:** | Register | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Admin, Patient, and Pharmacist | | |
| **Description:** | This use case contains scenarios and other details for user registration into the interface. | | |
| **Purpose:** | To the onboarding process of new actors and to ensure the security, privacy, and usability of the system by providing only authorized access to its functionality and data. | | |
| **Prerequisites:** | 1. Users should not have previously enrolled in the system as administrators, patients, or pharmacists.<br>2. The registration screen should be displayed to the user. | | |
| **Main Success Scenario:** | 1. The user types in a username that is already in the system.<br>2. The system is accessed using the user's password.<br>3. The system determines if the username is present there.<br>4. The new user is added to the system and given a password. | | |
| **Final Conditions:** | 1. The system has received a successful user registration.<br>2. The user is prepared to access the system. | | |
| **Alternative Scenarios:** | 1. The system warns the user and asks them to provide an existing username if they have entered a username that does not already exist in the system. | | |
| **Actor Description:** | Patient: The Patient needs to register with the system or application to access its features and services. The Patient may need to provide personal information, such as name, contact details, and health information, to complete the registration process.<br>Pharmacist: The Pharmacist will provide the required personal | | |

| | |
|---|---|
| | and professional information to create their account, such as name, contact information, professional registration number, and other details. The system will verify the information provided by the Pharmacist and create their account upon successful verification. Once registered, the Pharmacist will be able to log in and access their account to perform various tasks, such as viewing prescription details, adding documentation, and tracking prescription status.<br>Admin: The admin is responsible for initiating the registration process and entering the user's information, while the system performs validation and creates the new user account. |

*Table 4 – Register Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Admin:** Initiates the registration process by providing the necessary details of the new user such as name, email address, password, and any other required information | 2. Verify the provided information and check for any duplicates or errors |
| 3. **Patient:** Provide their personal information such as name, address, contact number, email, and medical history | 4. If the information is valid and complete, the system creates a new user account and sends a confirmation email to the registered email address |
| 5. **Pharmacist:** Provide their personal information, including name, address, contact number, email, and professional qualifications | 6. Log the new user account information in the database for future reference |

### 4.4.3 Suggest Opinion

*Table 5 – Suggest Opinion Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-3 | | |
| **Use Case Name:** | Suggest Opinion | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Patient | | |
| **Purpose:** | To better communication, collaboration, and patient-centered care by empowering patients to play a more active role in their healthcare and by providing healthcare providers with valuable insights and feedback to improve the quality of care they provide. | | |
| **Description:** | This use case allows the patient to provide their opinion or feedback regarding the healthcare services they received. The patient can suggest improvements, share their experience, or provide any other relevant information that can help healthcare providers improve their services. | | |
| **Prerequisites:** | 1. The patient must have accessed the healthcare services provided by the healthcare facility or provider.<br>2. The patient must have a valid username and password to log in to the system or application. | | |
| **Main Success Scenario:** | 1. The patient accesses the "Suggest Opinion" module or feature in the system or application.<br>2. The system or application presents a form or input field for the patient to enter their opinion or feedback.<br>3. The patient enters their opinion or feedback in the form or input field.<br>4. The patient submits the opinion or feedback to the system or application.<br>5. The system or application saves the opinion or feedback in the patient's record or database. | | |

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| | 6. The healthcare facility or provider receives the opinion or feedback and can review and act upon it as needed. |
| **Final Conditions:** | 1. For the healthcare institution or provider to examine and maybe take appropriate action, the patient's opinion or feedback must be effectively saved in the system or application. |
| **Alternative Scenarios:** | • The system or application may provide instructions or troubleshooting tips if the patient encounters any technical issues or has trouble accessing the "Suggest Opinion" module or feature. |
| **Actor Description:** | Patient: The patient initiates the process by suggesting their opinion or providing feedback through the system, and the system validates and confirms receipt. The healthcare providers or administrators may then take action based on the feedback or suggestion provided. |

*Table 6 – Suggest Opinion Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Patient:** Log into the healthcare provider's website | 2. Receive the patient's opinion or feedback |
| 3. Navigates to the "Suggest Opinion" section of the website | 4. Store the opinion or feedback in a database |
| 5. Write their opinion or feedback about the health care services they received | 6. Send a confirmation message to the patient that their opinion or feedback has been received |
| 7. Submit their opinion or feedback | 8. Provider reviews the patient's opinion or feedback and takes appropriate action to address any issues or concerns raised |

### 4.4.4 Search Drug Barcode Number

*Table 7 – Search Drug Barcode Number Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-4 | | |
| **Use Case Name:** | Search Drug Barcode Number | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Patient and Pharmacist | | |
| **Purpose:** | To safer and more efficient medication management by providing quick and easy access to important information about medications and products, and by helping to prevent medication errors or adverse events. | | |
| **Description:** | This use case allows a patient or pharmacist to search for a drug using its barcode number. The patient or pharmacist can use this feature to find detailed information about the drug, including its name, dosage, instructions, and any potential side effects. | | |
| **Prerequisites:** | 1. The patient or pharmacist must have access to the system or application.<br>2. The patient or pharmacist must know the barcode number of the drug they want to search for. | | |
| **Main Success Scenario:** | 1. The patient or pharmacist accesses the "Search Drug Barcode Number" module or feature in the system or application.<br>2. The system or application presents a search field or input box for the barcode number.<br>3. The patient or pharmacist enters the barcode number of the drug they want to search for.<br>4. The system or application searches the database for the barcode number and retrieves information about the drug.<br>5. The system or application displays information about the drug, including its name, dosage, instructions, and any potential side effects. They review the information and decide whether to use the drug or not. | | |

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| **Final Condition:** | 1. Patient and Pharmacist were able to successfully view and verify the drug details such as dosage, route of administration, and warnings for the barcode number entered. |
| **Alternative Scenarios:** | 1. If the system is unable to retrieve the medication information, it will display an error message and prompt patients and pharmacists to check the entered barcode number or contact their healthcare provider.<br>2. The system will prompt the patient and pharmacist to search for the medication by name or another identifier if the medication does not have a unique barcode number assigned to it. |
| **Actor Description:** | Patient: The patient is the individual who has been prescribed medication and is responsible for ensuring that they receive the correct medication. In this use case, the patient may be a primary actor who interacts with various tools and technologies to search for information related to their medication. This may involve using barcode scanning technology to scan the barcode on the medication packaging and access information about the medication, such as its dosage, administration instructions, and potential side effects. Additionally, the patient may use various online resources, such as medication databases or healthcare provider websites, to obtain additional information about their medication and ensure that they understand how to properly take it. The patient may also communicate with their healthcare provider or pharmacist to clarify any questions or concerns related to the medication and ensure that they are receiving the appropriate medication and dosage. By using the barcode scanning technology and other resources available, the patient can take an active role in their healthcare and ensure the safe and effective use of their medication.<br>Pharmacist: The pharmacist is a healthcare professional who is responsible for dispensing medications and ensuring their safe and effective use by patients. In this use case, the pharmacist would be the primary actor responsible for searching the drug barcode number to obtain information about a patient's medication. By using barcode scanning technology and other resources available, the pharmacist can ensure that the patient is receiving safe and effective medication therapy and prevent medication errors. |

*Table 8 – Search Drug Barcode Number Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Patient:** Launche the healthcare provider's website | 2. Receive the barcode number entered by the patient |
| 3. Navigate to the "Search Drug Barcode Number" section of the website | 4. Retrieve the information about the drug from the database |
| 5. Enter the barcode number of the drug they want to search for | 6. Display the information to the patient in a readable format |
| 7. Click the "search" button | 8. None |
| 9. Display information about the drug, such as its name, description, dosage, and possible side effects | 10. None |
| 11. **Pharmacist:** Log into the healthcare provider's system | 12. Receive the barcode number scanned by the pharmacist |
| 13. Navigate to the "Search Drug Barcode Number" section of the system | 14. Retrieve the information about the drug from the database |
| 15. Scan the barcode of the drug using a barcode scanner | 16. Display the information to the pharmacist in a readable format. |
| 17. Display information about the drug, such as its name, description, dosage, and possible side effects | 18. None |

### 4.4.5 Select Drug Barcode Number

*Table 9 – Select Drug Barcode Number Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-5 | | |
| **Use Case Name:** | Select Drug Barcode Number | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Pharmacist and Patient | | |
| **Purpose:** | To enable pharmacists or patients to choose a specific medication or product from a list by scanning or manually entering its barcode number. | | |
| **Description:** | This use case allows the pharmacist or patient to select a specific medication by scanning or entering its unique barcode number. The barcode number is linked to the medication's information and details stored in the system or application. | | |
| **Prerequisites:** | 1. The pharmacist or patient must have logged into the system or application with their username and password.<br>2. The medication must have a unique barcode number assigned to it.<br>3. The system or application must implement a barcode scanner or manual input feature. | | |
| **Main Success Scenario:** | 1. The system or application presents a barcode scanner or manual input field.<br>2. The pharmacist or patient scans or enters the unique barcode number of the medication.<br>3. The system or application retrieves and displays the corresponding medication information.<br>4. The pharmacist or patient can view and verify the medication details, such as dosage, route of administration, and warnings. | | |

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| **Final Conditions:** | 1. Pharmacists and/or patients can view all interactions and information without any problems. |
| **Alternative Scenarios:** | 1. The system will prompt the pharmacist or patient to select the medication from a list or search for it by name if the medication does not have a unique barcode number assigned to it.<br>2. If the system is unable to retrieve the medication information, it will display an error message and prompt the pharmacist or patient to rescan or re-enter the barcode number. |
| **Actor Description:** | Pharmacist: The pharmacist is a healthcare professional who is responsible for dispensing medications and ensuring their safe and effective use by patients. In this use case, the pharmacist would be the primary actor responsible for selecting a drug barcode number to verify the medication being dispensed. This may involve using various tools and technologies, such as barcode scanners or medication management software, to scan the barcode on the medication packaging and verify that it matches the medication that was prescribed to the patient. The pharmacist may also use the barcode number to access additional information about the medication, such as the dosage, expiration date, and storage requirements, to ensure that the medication is safe and appropriate for the patient. Additionally, the pharmacist may communicate with the prescribing healthcare provider to clarify any questions or concerns related to the medication and ensure that the patient is receiving the appropriate medication and dosage.<br><br>Patient: The patient is the individual who has been prescribed medication and is responsible for ensuring that they receive the correct medication. In this use case, the patient may be a secondary actor who interacts with the pharmacist during the medication dispensing process. The patient's role may involve providing the medication prescription to the pharmacist, ensuring that the medication name and dosage on the prescription match the medication being dispensed, and verifying the medication packaging before leaving the pharmacy. The patient may also be required to provide identification or insurance information to the pharmacist to ensure that they are authorized to receive the medication. Additionally, the patient may communicate with the pharmacist to clarify any questions or concerns related to the medication and ensure that they understand how to properly take |

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| | the medication, including dosage and frequency of administration. While the patient is not directly involved in the selection of the drug barcode number, they may observe the pharmacist using barcode scanning technology to verify the medication and ensure its safety and effectiveness. |

*Table 10 – Select Drug Barcode Number Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Patient:** Launch the healthcare provider's website | 2. Receive the search criteria entered by the patient |
| 3. Navigate to the "Select Drug Barcode Number" section of the website | 4. Retrieve the list of drugs that match the search criteria from the database |
| 5. Search for the drug by entering its name, dosage, or other relevant information | 6. Display the list of drugs to the patient |
| 7. Display a list of drugs that match the patient's search criteria | 8. Receive the selection made by the patient |
| 9. Select the desired drug by clicking on it | 10. Retrieve the information about the selected drug from the database |
| 11. Display information about the drug, such as its name, description, dosage, and possible side effects | 12. Display the information to the patient in a readable format |
| 13. **Pharmacist:** Log into the healthcare provider's system | 14. Receive the search criteria entered by the pharmacist |
| 15. Navigate to the "Select Drug Barcode Number" section of the system | 16. Retrieve the list of drugs that match the search criteria from the database |
| 17. Search for the drug by entering its name, dosage, or other relevant information | 18. Display the list of drugs to the pharmacist |
| 19. Display a list of drugs that match the pharmacist's search criteria | 20. Receive the selection made by the pharmacist |
| 21. Select the desired drug by clicking on it | 22. Retrieve the information about the selected drug from the database |
| 23. Display information about the drug, such as its name, description, dosage, and possible side effects | 24. Display the information to the pharmacist in a readable format |

### 4.4.6 Add Documentation

*Table 11 – Add Documentation Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-6 | | |
| **Use Case Name:** | Add Documentation | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Pharmacist | | |
| **Purpose:** | To allow the pharmacist to add new documentation or update existing documentation related to a patient's medical record. | | |
| **Description:** | This use case allows the pharmacist to add new documentation to the system or application. The documentation may include medication guides, drug interaction information, dosing recommendations, or clinical guidelines. | | |
| **Prerequisites:** | 1. The pharmacist must have logged into the system or application with their username and password.<br>2. The system or application must implement a documentation module or feature.<br>3. The pharmacist must have permission to add new documentation. | | |
| **Main Success Scenario:** | 1. The pharmacist accesses the documentation module or feature.<br>2. The system or application presents a form or template for adding new documentation.<br>3. The pharmacist fills in the required fields, such as document title, author, date, and content.<br>4. The pharmacist uploads any relevant files or attachments, such as PDFs or images. She/He submits the new documentation to the system or application.<br>5. The system or application verifies the validity and completeness of the new documentation. | | |
| **Final Conditions:** | 1. The pharmacist can seamlessly add documents containing patient information and drug interactions to the system. | | |

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| **Alternative Scenarios:** | 1. If the system is unable to verify the validity or completeness of the new documentation, it will prompt the pharmacist to review and resubmit the documentation. |
| **Actor Description:** | Pharmacist: The pharmacist is a healthcare professional who is responsible for dispensing medications and ensuring their safe and effective use by patients. In this use case, the pharmacist would be the primary actor responsible for adding documentation related to a patient's health status or medication history. This may involve recording various types of documentation, such as medication allergies, adverse drug reactions, or medication changes, to ensure that the patient's health information is complete and up-to-date. The pharmacist may use various tools and technologies, such as electronic health record systems or medication management software, to add this documentation and ensure that it is easily accessible to other healthcare providers involved in the patient's care. Additionally, the pharmacist may use the information obtained to ensure that the patient is receiving the appropriate medications and dosages based on their health status and medication history. The pharmacist may also communicate with other healthcare providers, such as physicians or nurses, to ensure coordinated and effective care for the patient. |

*Table 12 – Add Documentation Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Pharmacist:** Log into the healthcare provider's system | 2. Receive the selection of the patient made by the pharmacist |
| 3. Navigate to the "Add Documentation" section of the system | 4. Retrieve the patient's medical history or prescription information from the database |
| 5. Select the patient for whom the documentation needs to be added | 6. Display the patient's information to the pharmacist in a readable format |
| 7. display the patient's medical history or prescription information | 8. Receive the documentation or notes added by the pharmacist |
| 9. Add the necessary documentation or notes in the appropriate fields, such as dosage changes, medication interactions, or allergy information | 10. Update the patient's medical history or prescription information in the database |
| 11. Save the documentation | 12. Send a confirmation message to the pharmacist that the documentation has been added successfully |

### 4.7 View Documentation

*Table 13 – View Documentation Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-7 | | |
| **Use Case Name:** | View Documentation | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Pharmacist | | |
| **Purpose:** | To allow the pharmacist to view the documentation related to a patient's medical record. | | |
| **Description:** | This use case allows the pharmacist to view relevant documentation within the system or application. The documentation may include medication guides, drug interaction information, dosing recommendations, or clinical guidelines. | | |
| **Prerequisites:** | 1. The pharmacist must have logged into the system or application with their username and password.<br>2. The system or application must implement a documentation module or feature. | | |
| **Main Success Scenario:** | 1. The pharmacist accesses the documentation module or feature.<br>2. The system or application presents a list of available documentation categories or types.<br>3. The pharmacist selects the desired category or type of documentation.<br>4. The system or application retrieves and displays the relevant documentation.<br>5. The pharmacist can read and refer to the documentation as needed. | | |
| **Final Conditions:** | 1. The pharmacist has successfully identified important drug interactions that should be highlighted during the withdrawal and display all identified interactions from the database and recorded in the system. | | |

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| **Alternative Scenarios:** | There is no alternative scenario for this use case. |
| **Actor Description:** | Pharmacist: The pharmacist is a healthcare professional who is responsible for dispensing medications and ensuring their safe and effective use by patients. In this use case, the pharmacist would be the primary actor responsible for viewing documentation related to a patient's health status or medication history. This may involve accessing various types of documentation, such as electronic health records, medication profiles, lab test results, or physician notes, to obtain a comprehensive view of the patient's health status and medication regimen. The pharmacist may use various tools and technologies, such as electronic health record systems or medication management software, to access and review this documentation. Based on the information obtained, the pharmacist may guide the patient on how to properly manage their medication regimen, identify potential drug interactions or side effects, or communicate with the patient's healthcare provider regarding any concerns or issues related to their care. Additionally, the pharmacist may use the information obtained to ensure that the patient is receiving the appropriate medications and dosages based on their health status and medication history. |

*Table 14 – View Documentation Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Pharmacist:** Log into the healthcare provider's system | 2. Receive the selection of the patient made by the pharmacist |
| 3. Navigate to the "View Documentation" section of the system | 4. Retrieve the patient's medical history or prescription information from the database |
| 5. Select the patient for whom the documentation needs to be viewed | 6. Display the patient's information to the pharmacist in a readable format |
| 7. Display the patient's medical history or prescription information, including any previously added documentation or notes | 8. Sends a confirmation message to the pharmacist that the patient's information has been retrieved successfully |
| 9. Review the information to check for any relevant documentation or notes. interactions, or allergy information | 10. None |

### 4.4.8 Track Prescription

*Table 15 – Track Prescription Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-8 | | |
| **Use Case Name:** | Track Prescription | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Pharmacist and Patient | | |
| **Purpose:** | To allow the pharmacist and the patient to monitor the status of a prescription from the time it is prescribed to the time it is dispensed. | | |
| **Description:** | This use case allows the pharmacist and patient to track the status of a prescription within the system or application. The prescription can be tracked from the time it is initially filled to the time it is refilled or completed. This use case is particularly useful for managing prescription medication orders and ensuring compliance with treatment plans. | | |
| **Prerequisites:** | 1. The pharmacist or patient must have logged into the system or application with their username and password.<br>2. The system or application must implement a prescription tracking module or feature. | | |
| **Main Success Scenario:** | 1. The pharmacist or patient accesses the prescription tracking module or feature.<br>2. The system or application presents a list of available prescriptions to track. They also select the prescription they want to track.<br>3. The system or application displays the status of the selected prescription, such as "filled," "partially filled," "waiting for refill authorization," or "completed."<br>4. The pharmacist or patient can take necessary actions, such as requesting a refill or contacting the healthcare provider, based on the status of the prescription. | | |

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| **Final Conditions:** | 1. Pharmacists and Patients can enter and view interactions information without any problem. |
| **Alternative Scenarios:** | 1. The system will display an error message and prompt the pharmacist or patient to select a different prescription to track. If the selected prescription is not available or has not been filled yet |
| **Actor Description:** | Pharmacist: The pharmacist is a healthcare professional who is responsible for dispensing medications and ensuring their safe and effective use by patients. In this use case, the pharmacist would be the primary actor responsible for tracking the prescription information for a patient. This may involve recording information about the medication, such as the name, dosage, and frequency of administration, as well as the date the prescription was filled and the quantity of medication dispensed. The pharmacist may use various tools and technologies, such as electronic health records or medication management software, to maintain an accurate record of the patient's medication history and track any changes or updates to the prescription over time. The pharmacist may also communicate with the prescribing healthcare provider to clarify any questions or concerns related to the prescription and ensure that the patient is receiving the appropriate medication and dosage. Additionally, the pharmacist may provide the patient with education and guidance on how to properly take the medication and manage any potential side effects or drug interactions.<br><br>Patient: The actor "patient" in the context of the "track prescription" use case could be described as follows:<br>The patient is the individual who has been prescribed medication and is responsible for managing their medication regimen. In this use case, the patient would be the primary actor responsible for tracking their prescription information. This may involve keeping track of the medication name, dosage, and frequency of administration, as well as the date the prescription was filled and the quantity of medication remaining. The patient may use various tools and technologies, such as medication reminder apps or pill organizers, to help them stay on track with their medication regimen. The patient may also communicate with their healthcare provider or pharmacist to clarify any questions or concerns related to their prescription and ensure that they are taking the |

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| | medication as prescribed. Additionally, the patient may report any side effects or adverse reactions to their healthcare provider or pharmacist and work with them to adjust their medication regimen as needed. |

*Table 16 – Track Prescription Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Pharmacist:** Receive the patient's request for information about their prescription | 2. Provide the pharmacist with the necessary information about the prescription, such as the status of the order or the expected delivery date |
| 3. Access the system to retrieve the necessary information | 4. Provide the patient with the requested information |
| 5. None | 6. If there is an issue with the prescription or the order, the pharmacist informs the patient and takes the necessary action to resolve the issue, such as contacting the prescribing physician or the insurance company |
| 7. **Patient:** Request information about their prescription from the pharmacist, such as the status of the prescription or the expected delivery date | 8. Access the system and retrieves the necessary information about the prescription, such as the status of the order or the expected delivery date |
| 9. None | 10. Provide the patient with the requested information |

### 4.4.9 Monitor Result

*Table 17 – Monitor Result Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-9 | | |
| **Use Case Name:** | Monitor Result | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Pharmacist and Patient | | |
| **Purpose:** | To provide a way for actors, such as pharmacists or patients, to monitor and view the results of medical tests, procedures, or treatments that have been performed on the patient. | | |
| **Description:** | This use case allows the pharmacist and patient to monitor the results of medical tests or treatments within the system or application. The results can be viewed as text or graphical representations and may include information such as vital signs, lab test results, or medication efficacy. | | |
| **Prerequisites:** | 1. The pharmacist or patient must have logged into the system or application with their username and password.<br>2. The system or application must implement a monitoring model or feature. | | |
| **Main Success Scenario:** | 1. The pharmacist or patient accesses the monitoring module or feature.<br>2. The system or application presents a list of available tests or treatments to monitor.<br>3. The pharmacist or patient selects the test or treatment they want to monitor.<br>4. The system or application retrieves the latest results for the selected test or treatment and displays them as text or graphical representations. Also, they can view the results and take necessary actions, such as adjusting medication dosages, scheduling follow-up appointments, or consulting with healthcare providers. | | |

| | |
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| **Final Conditions:** | 1. System administrator can view all instructor's course preferences on the screen without any problem. |
| **Alternative Scenarios:** | 1. The system will deny access and display an error message If the pharmacist or patient does not have permission to access the monitoring module or feature. |
| **Actor Description:** | Patient: The patient is the individual who is interested in monitoring their health status, which may involve tracking various types of health measurements such as blood pressure, heart rate, weight, or blood glucose levels. The patient may use various devices, such as a blood glucose meter or a fitness tracker, to collect these measurements and store them for later analysis. In this use case, the patient would be the primary actor responsible for initiating the monitoring process, reviewing the results, and taking any necessary actions based on the information obtained. This may involve sharing the results with a healthcare provider, adjusting medication dosages, or modifying their lifestyle habits to improve their overall health.<br><br>Pharmacist: The pharmacist is a healthcare professional who has expertise in managing medications and helping patients to achieve optimal medication outcomes. In this use case, the pharmacist may be involved in monitoring the results of a patient's medication regimen, which may include tracking various parameters such as blood pressure, blood glucose levels, or other vital signs. The pharmacist may use various tools and technologies, such as electronic health records or medication management software, to access the patient's health information and review the results of their monitoring. Based on the results obtained, the pharmacist may provide the patient with guidance on adjusting their medication regimen, suggest lifestyle changes, or recommend other interventions to improve their overall health outcomes. The pharmacist may also collaborate with other healthcare providers, such as physicians or nurses, to ensure coordinated and effective care for the patient. |

*Table 18 – Monitor Result Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Pharmacist:** Receive the patient's request for information about their lab test results | 2. Provides the pharmacist with the necessary information about the lab tests results, such as the test outcome or the interpretation of the results |
| 3. Access the system to retrieve the necessary information | 4. Provides the patient with the requested information |
| 5. None | 6. If the lab test results are abnormal or require further action, the pharmacist informs the patient and takes the necessary action to follow up with the prescribing physician or the healthcare provider who ordered the test |
| 7. **Patient:** Request information about their lab test results from the pharmacist, such as the test outcome or the interpretation of the results | 8. Access the system and retrieves the necessary information about the lab tests results, such as the test outcome or the interpretation of the results |
| 9. None | 10. Provide the patient with the requested information |

### 4.4.10 Select User Type

*Table 19 – Select User Type Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-10 | | |
| **Use Case Name:** | Select User Type | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Pharmacist and Patient | | |
| **Purpose:** | To provide a way for the system to customize the user's experience based on their role within the system, to improve efficiency and provide a better user experience. | | |
| **Description:** | This use case allows the pharmacist and patient to select their user type in the system or application. Depending on the type of user selected, they may have access to different functions and data within the system or application. | | |
| **Prerequisites:** | 1. The pharmacist or patient must have logged into the system or application with their username and password.<br>2. The system or application must implement a user-type selection module or feature. | | |
| **Main Success Scenario:** | 1. The pharmacist or patient accesses the user type selection module or feature.<br>2. The system or application presents a list of available user types, such as pharmacist, patient, or administrator.<br>3. The pharmacist or patient selects the user type they belong to.<br>4. The system or application updates the user interface to show the relevant functionality and data associated with the selected user type.<br>5. The pharmacist or patient performs the necessary actions, such as accessing their prescription records, managing their medication lists, or scheduling appointments, based on the selected user type. | | |

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| **Final Conditions:** | 1. Pharmacist and Patient have completed all interactions and successfully recorded them in the system. |
| **Alternative Scenarios:** | • The system will display an error message and prompt the pharmacist or patient to select a different user type if the selected user type is not available or has been removed from the system or application. |
| **Actor Description:** | Pharmacist: The pharmacist is a user of the system who has a specialized role within the healthcare organization. When logging into the system, the pharmacist is presented with an option to select their user type. The pharmacist must be able to select the appropriate user type, such as "pharmacist," "pharmacy technician," or "pharmacy manager," depending on their specific role within the organization. This selection determines the features and functionalities that will be available to the pharmacist when using the system. The pharmacist must be able to make this selection quickly and accurately to ensure they have the necessary access and permissions to perform their duties within the system. Additionally, the pharmacist may be responsible for maintaining the security and privacy of patient data within the system, by legal and ethical standards.<br><br>Patient: The patient is a user of the system who has a specific role within the healthcare organization. When logging into the system, the patient is presented with an option to select their user type. The patient must be able to select the appropriate user type, such as "patient," "caregiver," or "family member," depending on their specific role within the organization. This selection determines the features and functionalities that will be available to the patient when using the system. The patient must be able to make this selection quickly and accurately to ensure they have the necessary access and permissions to perform their duties within the system. Additionally, the patient may be responsible for maintaining the security and privacy of their personal health information within the system, by legal and ethical standards. The patient may use the system to schedule appointments, view test results, communicate with their healthcare providers, and manage their health information. |

*Table 20 – Select User Type Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Pharmacist:** Access the system and selects their user type, such as a new pharmacist or an existing pharmacist | 2. Provide the pharmacist with the appropriate options based on their selected user type, such as the registration process for new pharmacists or the login process for existing pharmacists |
| 3. None | 4. Provide the pharmacist with additional options based on their roles, such as the ability to access patient records or the ability to prescribe medications |
| 5. None | 6. If the pharmacist is a new user, the system may prompt them to complete additional steps, such as verifying their credentials or completing training modules before accessing patient records or prescribing medications |
| 7. **Patient:** Visit the system and selects their user type, such as a new patient, an existing patient, or a returning patient | 8. Provide the patient with the appropriate options based on their selected user type, such as the registration process for new patients, the login process for existing patients, or the scheduling process for returning patients |

### 4.4.11 Manage User

*Table 21 – Manage User Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-11 | | |
| **Use Case Name:** | Manage User | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Admin | | |
| **Purpose:** | To provide the actor (usually an administrator) with the ability to manage users within the system. | | |
| **Description:** | This use case contains involves the administration of user accounts and access to a system or application. The actor in this use case is an admin with the necessary permissions and privileges to manage user accounts. | | |
| **Prerequisites:** | 1. The system or application must implement a user management module or feature.<br>2. The system or application must have an existing user database or directory in which user accounts can be created, modified, or deleted. | | |
| **Main Success Scenario:** | 1. The admin logs into the system or application with their username and password. Admin accesses the user management module or feature. Admin selects the action they want to perform, such as creating a new user account, modifying an existing account, or deleting a user account.<br>2. The system or application processes the admin's request and updates the user database or directory accordingly If creating a new user account, the admin enters the required user information, such as username, password, email, and role or group assignment. | | |
| **Final Conditions:** | 1. System admin can view the recorded all drug-drug and drug-nutrient interactions without any problems. | | |
| **Alternative Scenarios:** | 1. If the admin attempts to create a new user account, but the creation fails due to missing or invalid user | | |

| | |
|---|---|
| | information, the system should prompt the admin to correct the errors and try again. |
| **Actor Description:** | Admin: The admin is a privileged user who has access to the system's administrative functions. They are responsible for managing user accounts and performing tasks related to user management, such as creating new user accounts, modifying existing accounts, and deleting user accounts when necessary. The admin also has the authority to assign roles and permissions to users, set user preferences, and monitor user activity. The admin must be able to perform these tasks efficiently and accurately while maintaining the security and integrity of the system. |

*Table 22 – Manage User Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Admin:** Log in to the system with their username and password | 2. Verify the admin's credentials and grant access to the "Manage Users" section |
| 3. Navigate to the "Manage Users" section of the system | 4. Displays a list of users that the admin can manage |
| 5. Select a user from the list of users | 6. Allow the admin to select a user and edit their information |
| 7. Update the user's information (e.g., name, email, password, role) | 8. Save the changes made by the admin and updates the user's information in the system |
| 9. Save the changes | 10. Display a confirmation message to the admin indicating that the changes have been saved |

### 4.4.12 Manage Database

*Table 23 – Manage Database Use Case*

| | | | |
|---|---|---|---|
| **Use Case ID:** | UC-12 | | |
| **Use Case Name:** | Manage Database | | |
| **Created By:** | İsmail Mert Demirok | **Last Updated Person:** | İsmail Mert Demirok |
| **Created Date:** | 03/25/2023 | **Last Updated Date:** | 04/01/2023 |
| **Actor:** | Admin | | |
| **Purpose:** | To describe the functionality for managing a database system, such as creating, modifying, deleting, or backing up databases and their associated data. | | |
| **Description:** | This use case allows an admin to manage the database in the system. The admin can perform tasks such as adding, modifying, or deleting records, creating or modifying tables, and optimizing the database for better performance. | | |
| **Prerequisites:** | 1. The admin must have access to the system or application.<br>2. The admin must have the necessary permissions and privileges to manage the database. | | |
| **Main Success Scenario:** | 1. The admin accesses the "Manage Database" module or feature in the system. It presents the admin with options for managing the database, such as adding, modifying, or deleting records, creating or modifying tables, and optimizing the database.<br>2. The admin selects the desired option and provides the necessary input or information.<br>3. The system performs the requested task and updates the database accordingly. The admin also verifies the results and confirms that the database has been updated correctly. | | |
| **Final Conditions:** | 1. The database has been updated correctly, and the admin has verified the results. The system or application has optimized the database for better performance, and the | | |

| | |
|---|---|
| | admin can continue to use the database without any issues or errors. |
| **Alternative Scenarios:** | • If the admin encounters any technical issues or errors while managing the database, the system or application may provide instructions or troubleshooting tips.<br>• If the admin does not have the necessary permissions or privileges to perform a certain task, the system or application will display an error message and prompt the admin to contact a higher-level administrator for assistance. |
| **Actor Description:** | Admin: The admin is a privileged user who has access to the system's administrative functions. They are responsible for managing the database of the system, including tasks such as creating, modifying, and deleting tables and records. The admin also has the authority to define relationships between tables, set permissions and access controls, optimize the database's performance, and ensure the database's security and integrity. The admin must be able to perform these tasks efficiently and accurately while maintaining the overall health and reliability of the system. Additionally, the admin may be responsible for creating and managing backups and ensuring disaster recovery plans are in place. |

*Table 24 – Manage Database Use Case Actor Action and System Response*

| **Actor Action** | **System Response** |
|---|---|
| 1. **Admin:** Log in to the system with their username and password | 2. Verify the admin's credentials and grant access to the "Manage Database" section |
| 3. Navigate to the "Manage Database" section of the system | 4. Display a list of existing tables and the option to create a new table |
| 5. Select an existing table to modify or deletes or creates a new table | 6. Allow the admin to select a table to modify, delete, or create a new table |
| 7. Add, modify, or delete records in the selected table. | 8. Prompt the admin to enter the details of the new table or modify the existing one. |
| 9. Optimize the database for better performance | 10. Allow the admin to add, modify, or delete records in the selected table |

| | |
|---|---|
| 11. None | 12. Optimize the database for better performance based on the admin's actions |
| 13. None | 14. Confirm to the admin that the changes have been made and saved successfully |

## 4.5 Communication Diagrams

### 4.5.1 Register Pharmacist

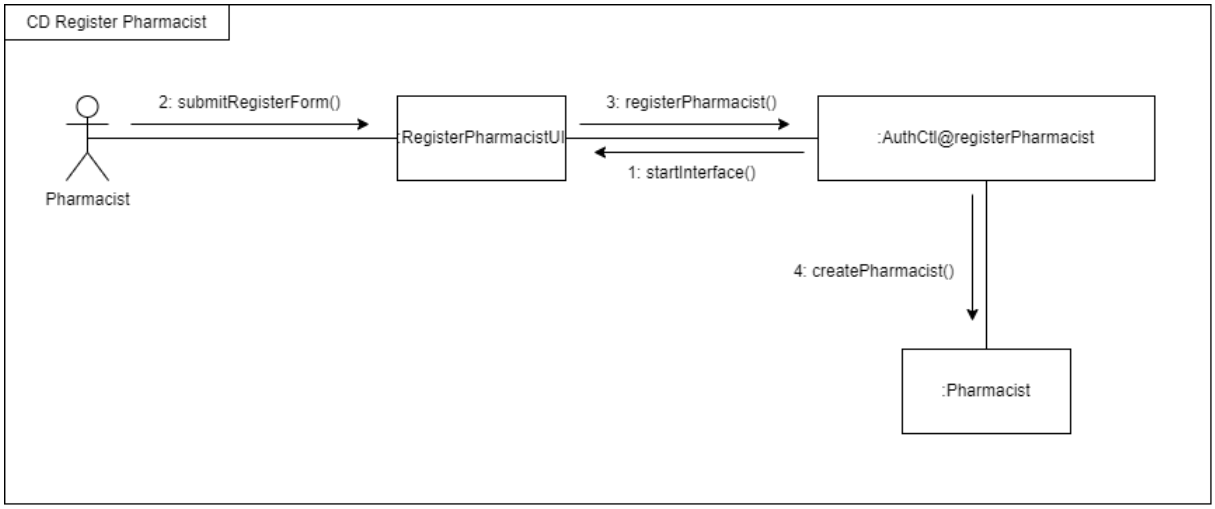



*Figure 4 - Communication Diagram of Register Pharmacist*

### 4.5.2 Login Pharmacist

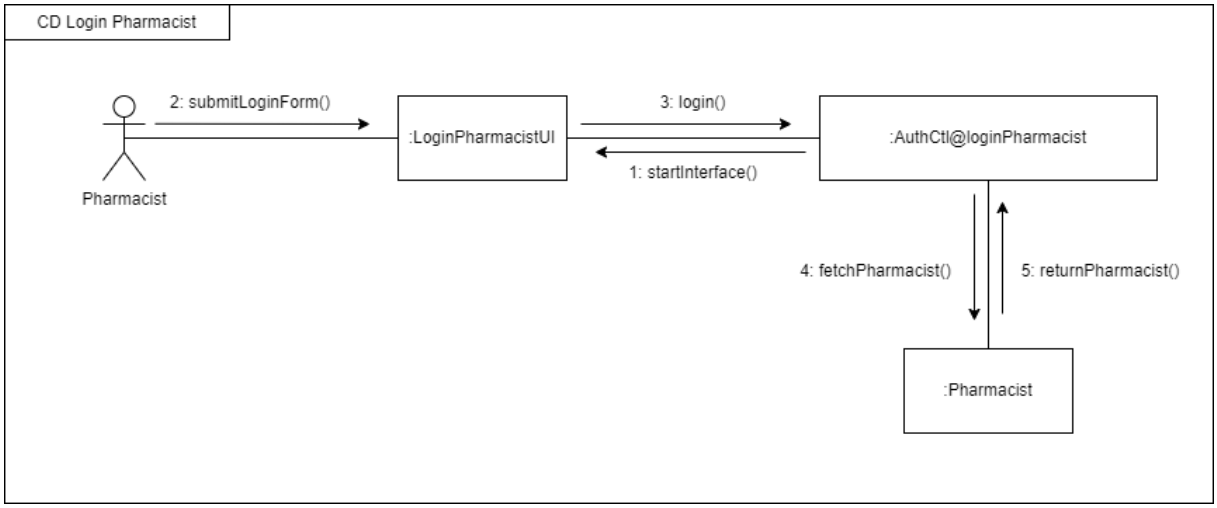



*Figure 5 - Communication Diagram of Login Pharmacist*

### 4.5.3 Register Patient

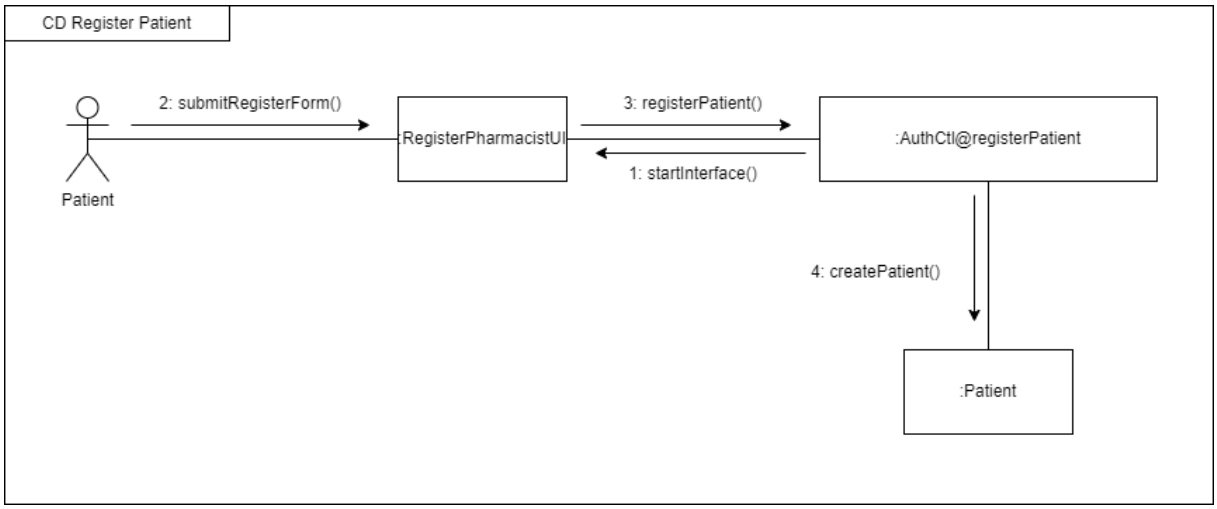



*Figure 6 - Communication Diagram of Register Patient*

### 4.5.4 Login Patient

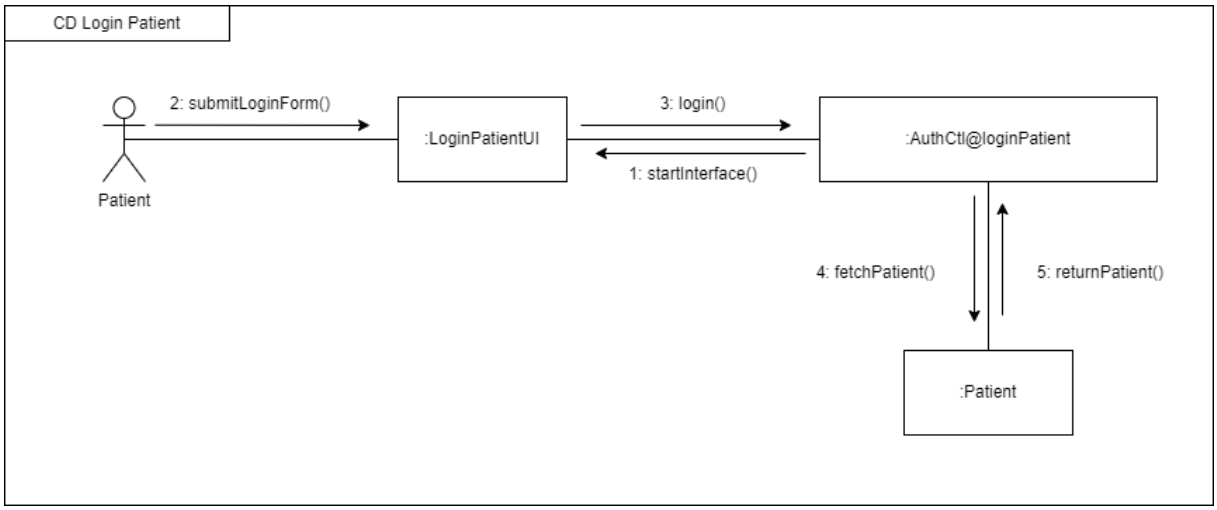



*Figure 7 - Communication Diagram of Login Patient*

### 4.5.5 Patient Opinion

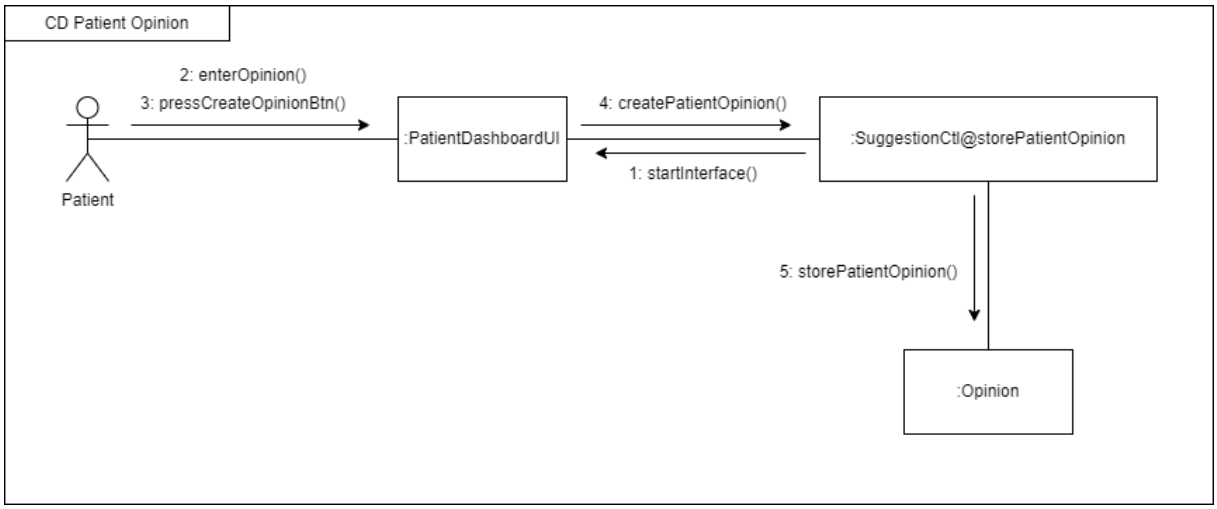



*Figure 8 - Communication Diagram of Patient Opinion*

### 4.5.6 Pharmacist Opinion

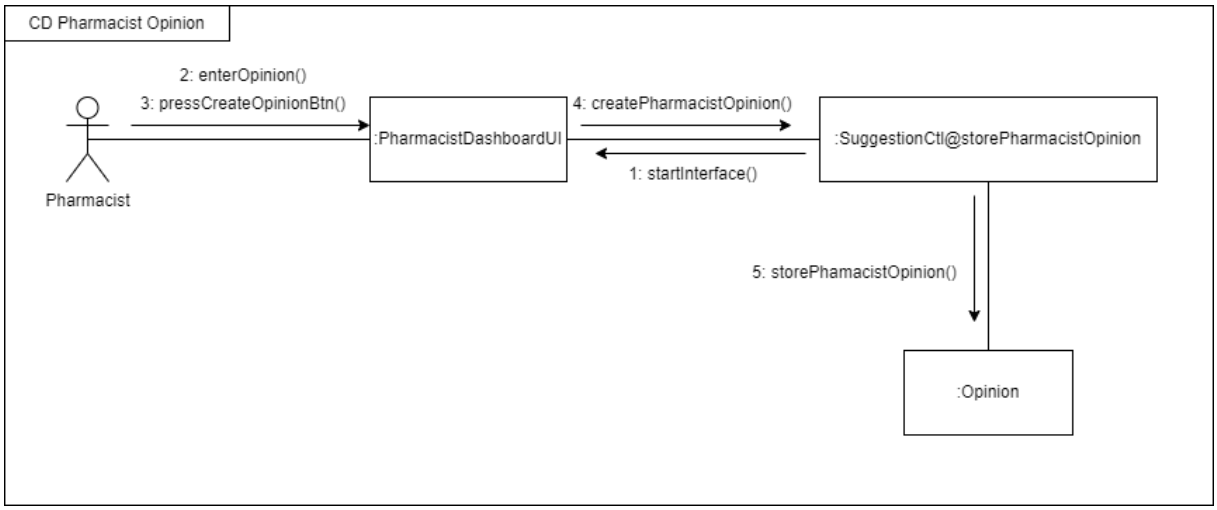



*Figure 9 - Communication Diagram of Pharmacist Opinion*

### 4.5.7 Search Drug by Barcode Number / Patient

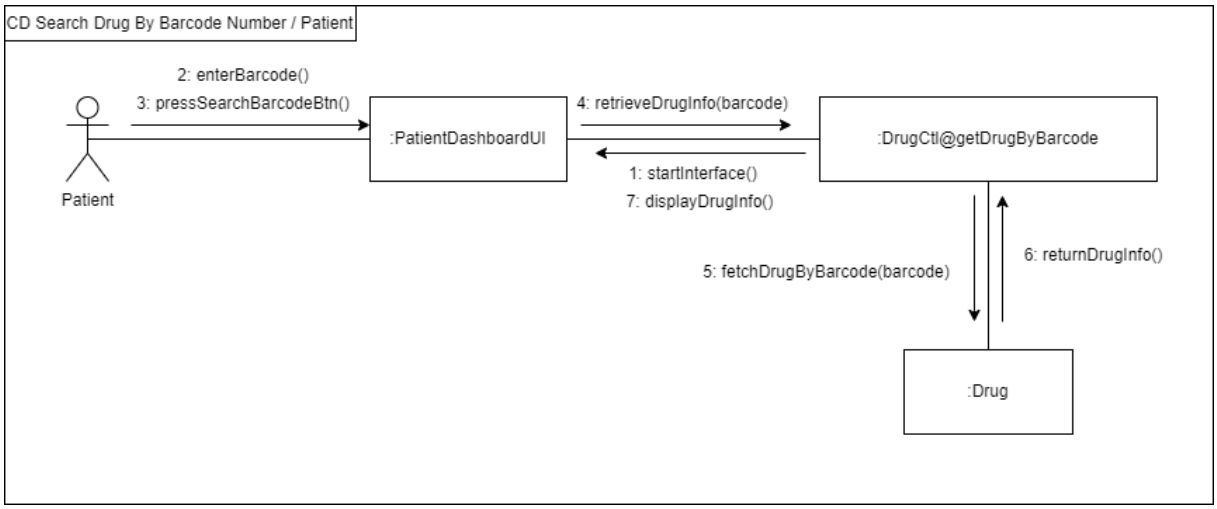



*Figure 10 - Communication Diagram of Search Drug by Barcode Number / Patient*

### 4.5.8 Search Drug by Barcode Number / Pharmacist

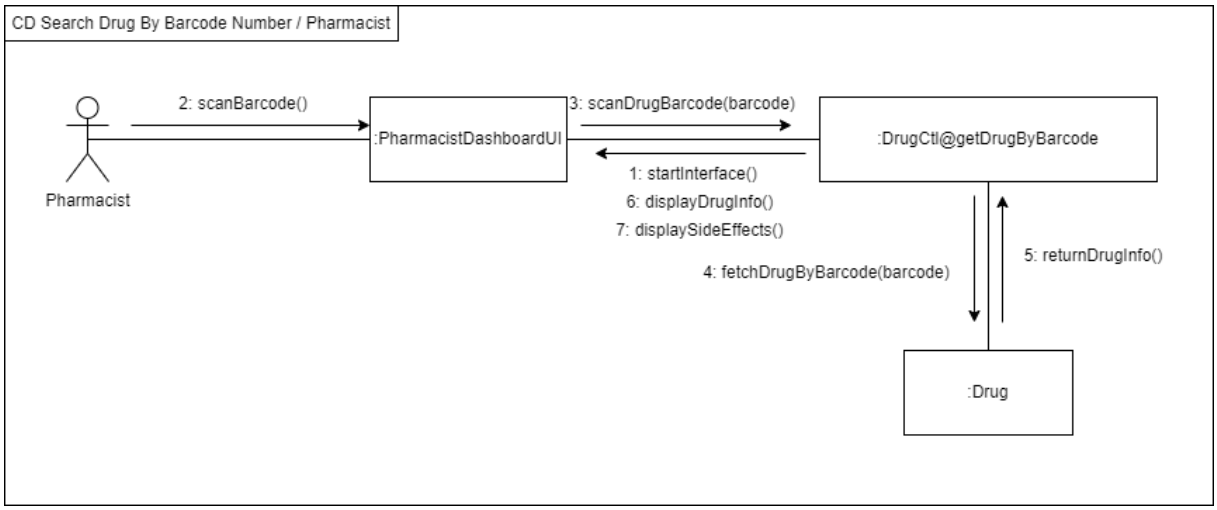



*Figure 11 - Communication Diagram of Search Drug by Barcode Number / Pharmacist*

### 4.5.9 Search Drug by Given Information / Patient

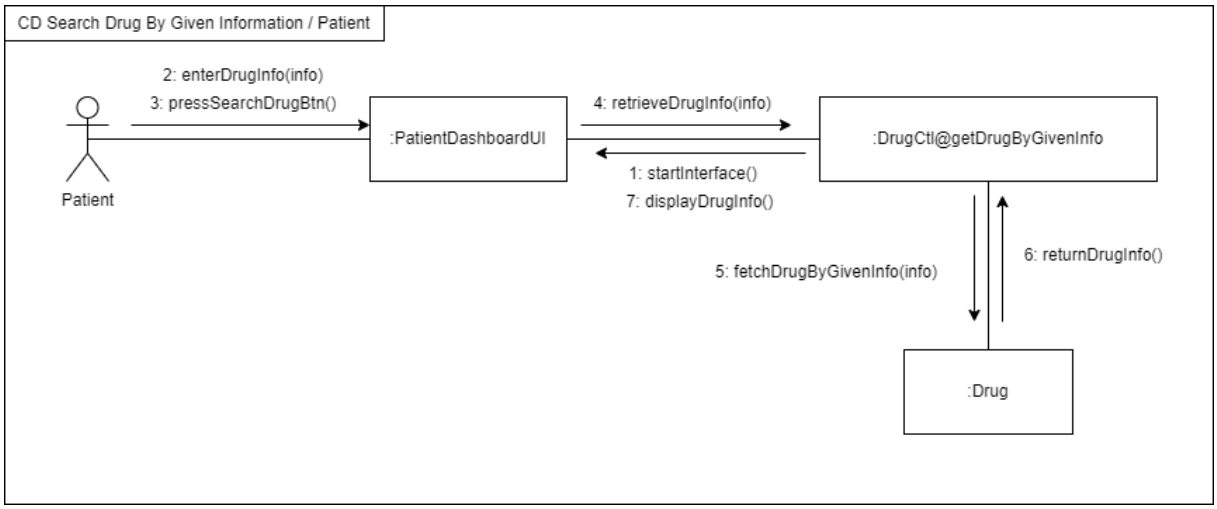



*Figure 12 - Communication Diagram of Search Drug by Given Information / Patient*

### 4.5.10 Search Drug by Given Information / Pharmacist

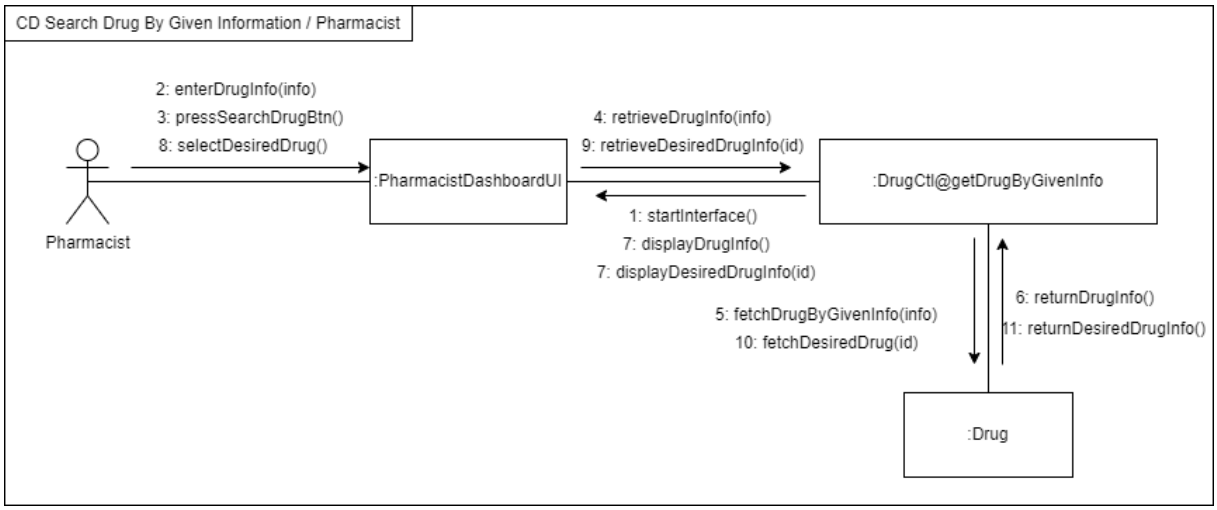



*Figure 13 - Communication Diagram of Search Drug by Given Information / Pharmacist*

### 4.5.11 Add Document

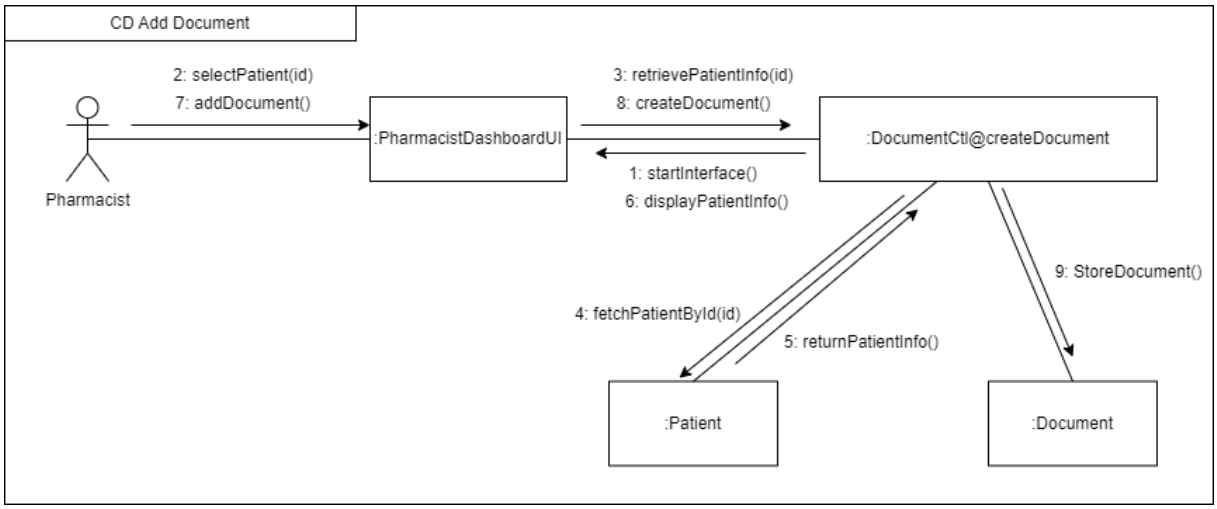



*Figure 14 - Communication Diagram of Add Document*

### 4.5.12 View Document

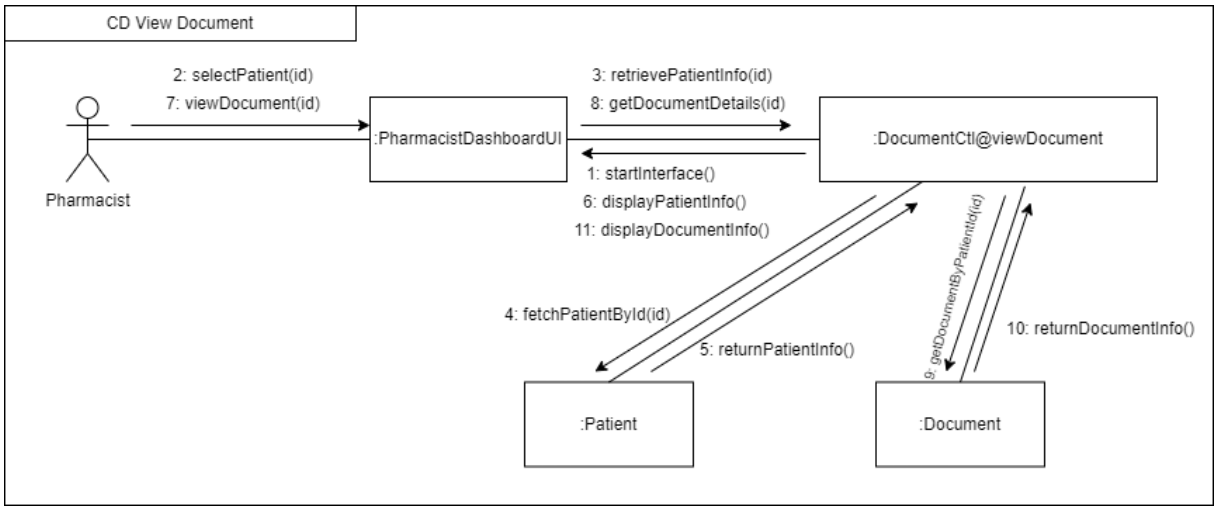



*Figure 15 - Communication Diagram of View Document*

### 4.5.13 Track Prescription / Pharmacist

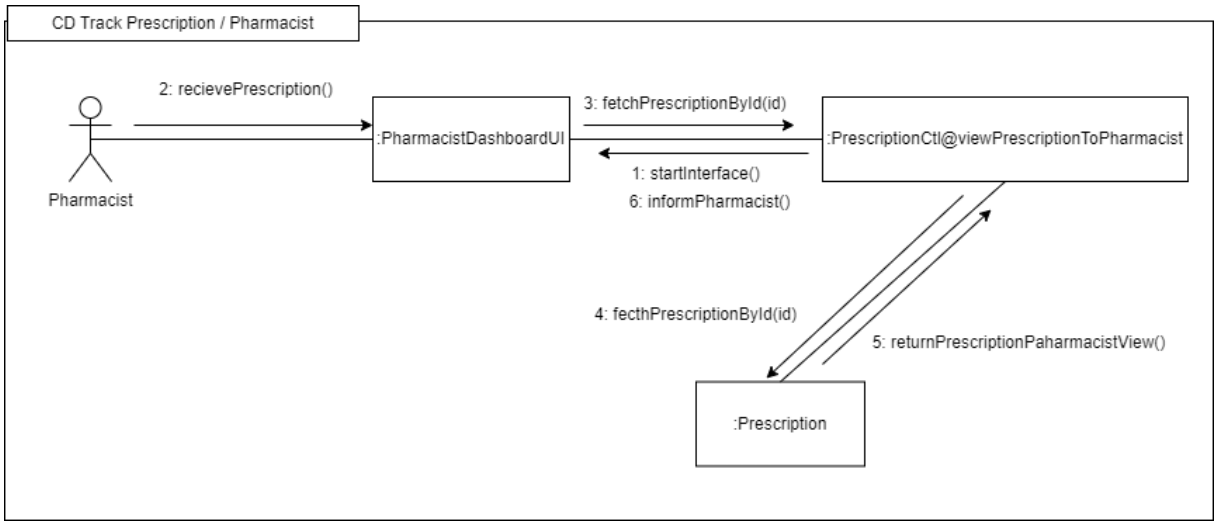



*Figure 16 - Communication Diagram of Track Prescription / Pharmacist*

### 4.5.14 Track Prescription / Patient

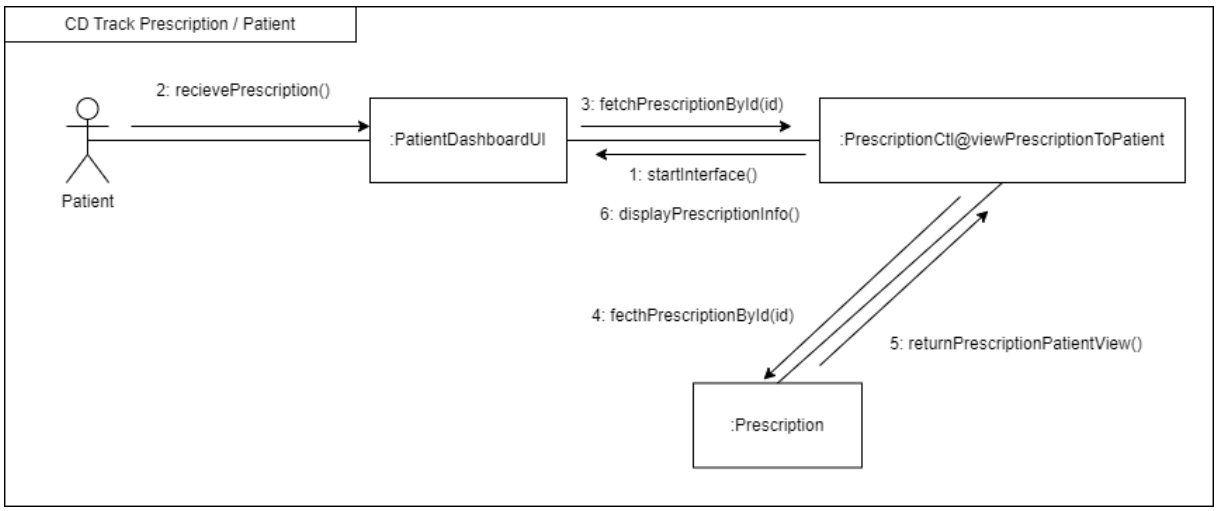



*Figure 17 - Communication Diagram of Track Prescription / Patient*

### 4.5.15 Monitor Result / Pharmacist

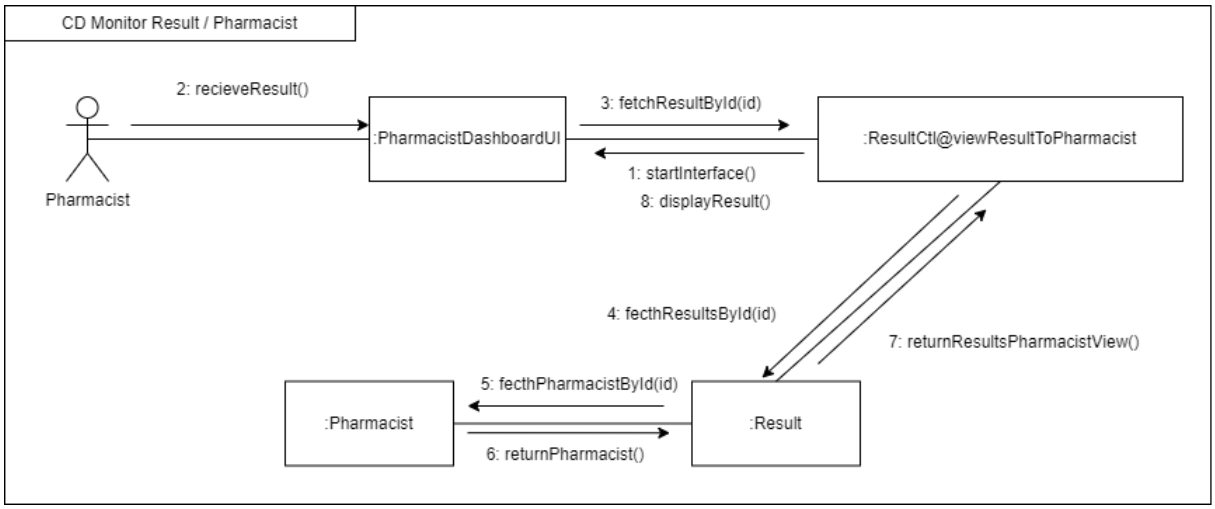



*Figure 18 - Communication Diagram of Monitor Result / Pharmacist*

### 4.5.16 Monitor Result / Patient

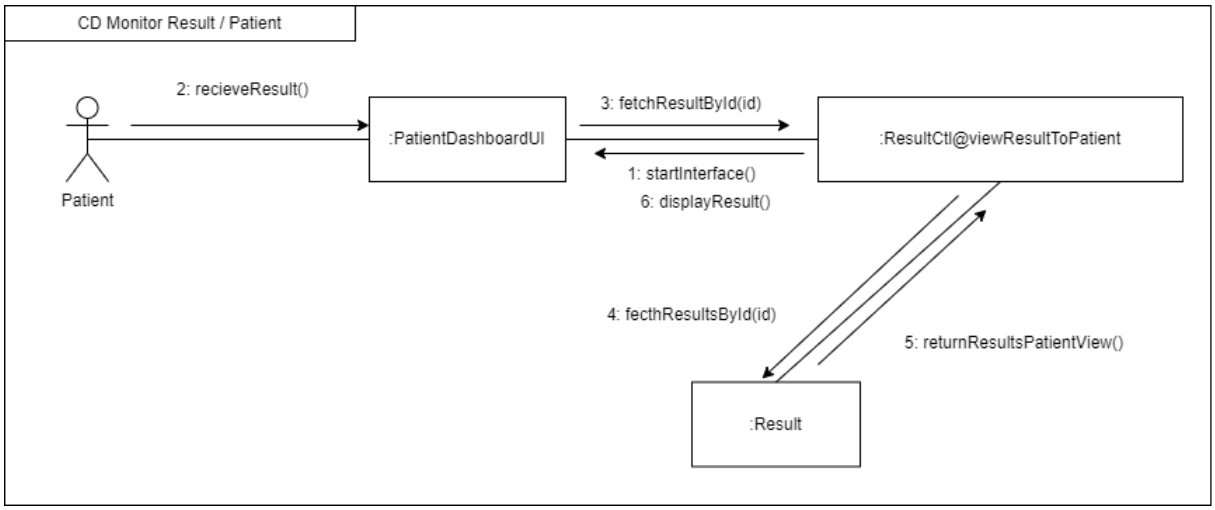



*Figure 19 - Communication Diagram of Monitor Result / Patient*

### 4.5.17 Select User Type / Pharmacist

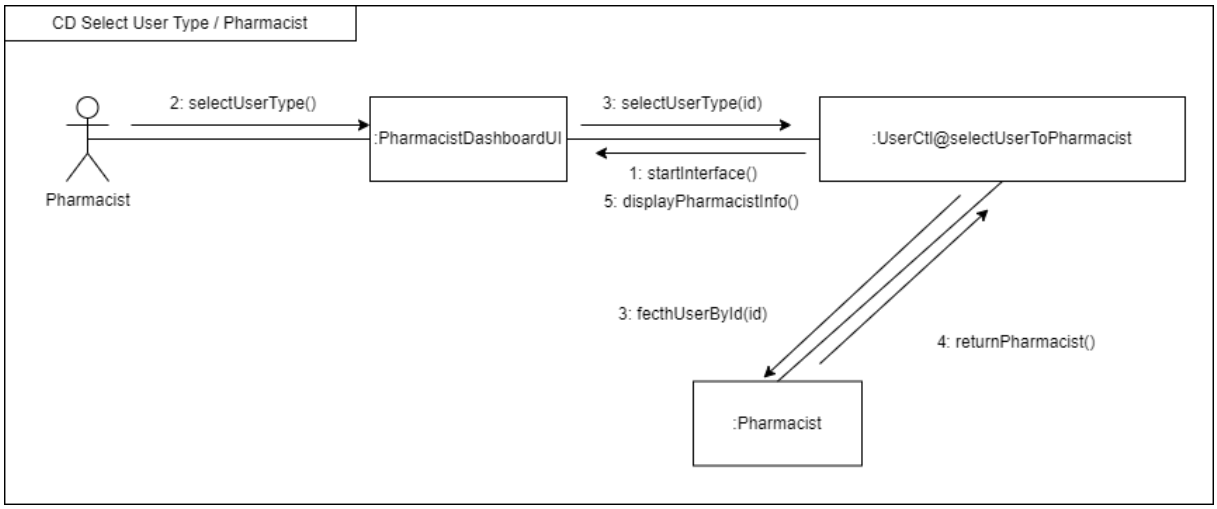



*Figure 20 - Communication Diagram of Select User Type / Pharmacist*

### 4.5.18 Select User Type / Patient

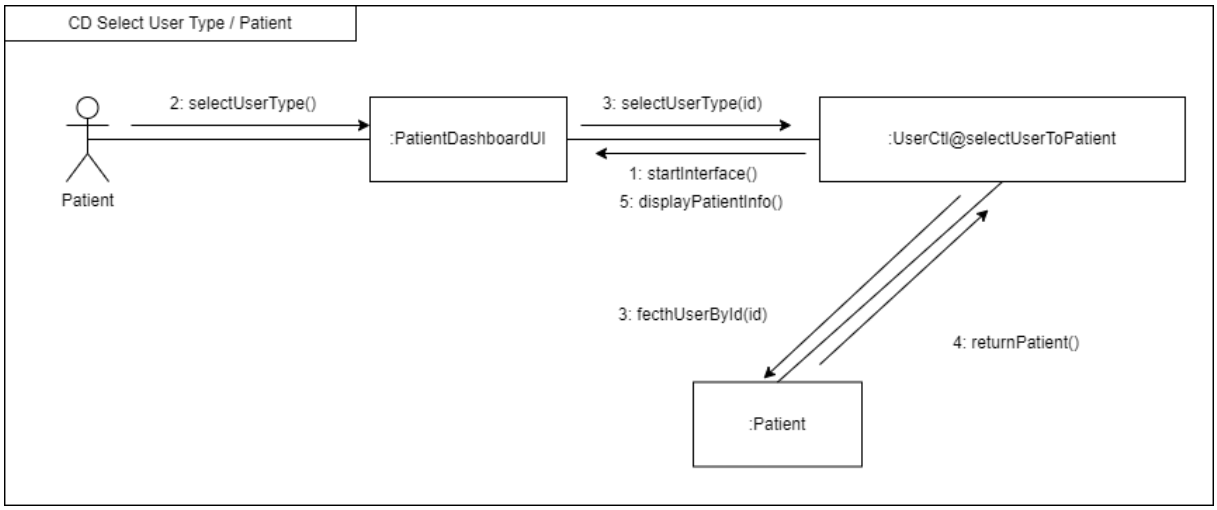



*Figure 21 - Communication Diagram of Select User Type / Patient*

### 4.5.19 Manage User

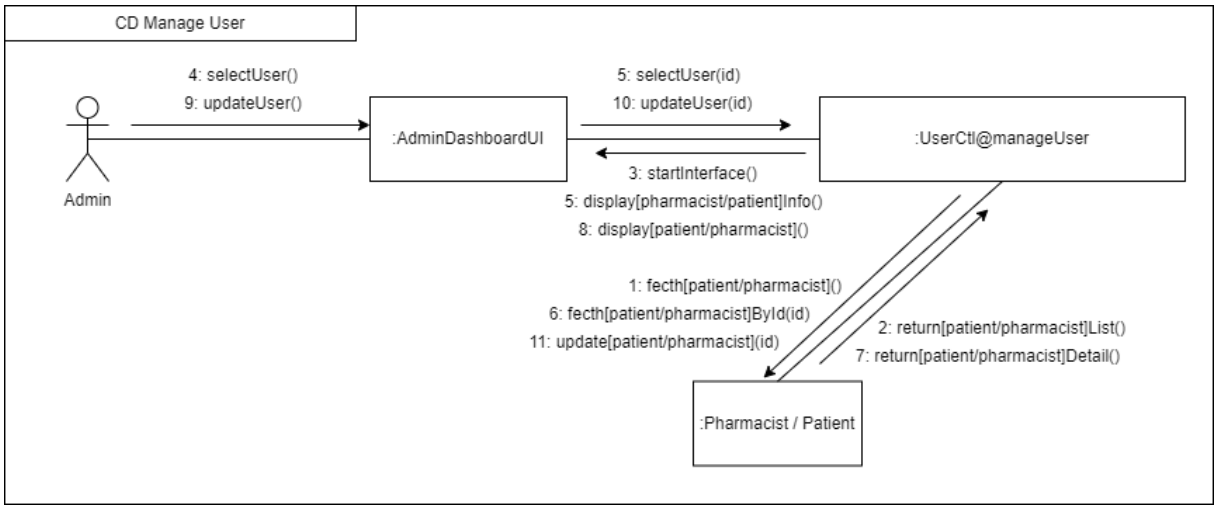



*Figure 22 - Communication Diagram of Manage User*

### 4.5.20 Manage Database

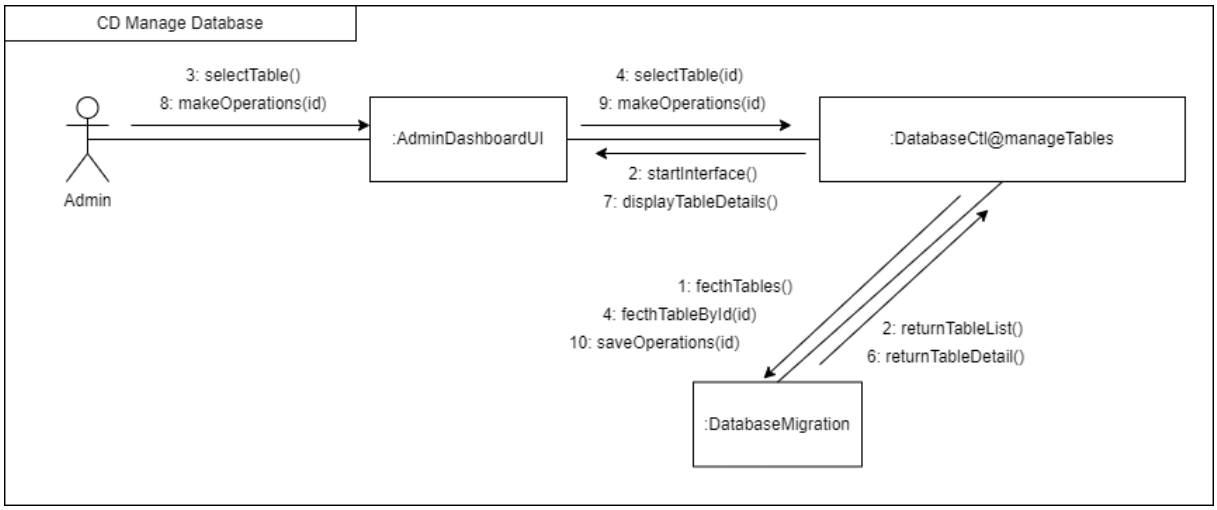



*Figure 23 - Communication Diagram of Manage Database*

## 4.6 Class Diagram

### 4.6.1 Register Pharmacist

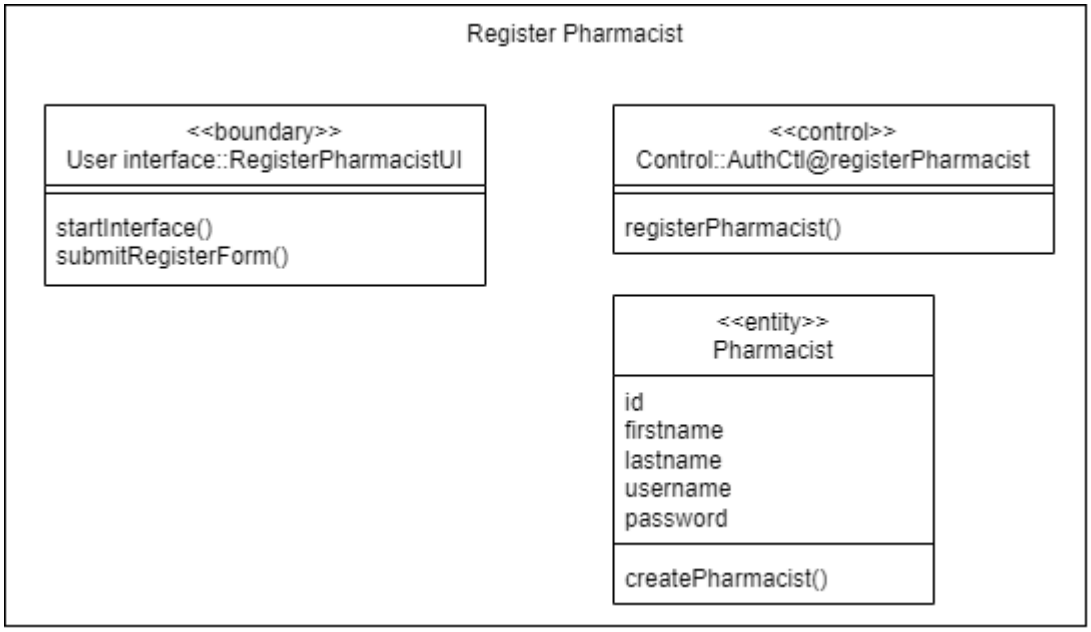



*Figure 24 – Class Diagram of Register Pharmacist*

### 4.6.2 Login Pharmacist

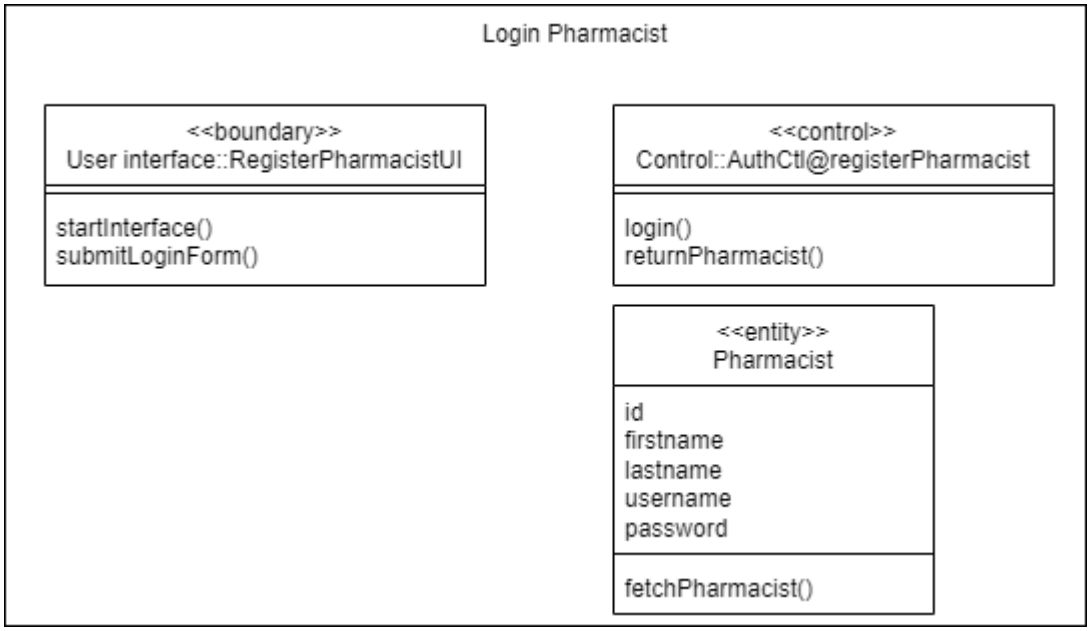



*Figure 25 – Class Diagram of Login Pharmacist*

### 4.6.3 Register Patient

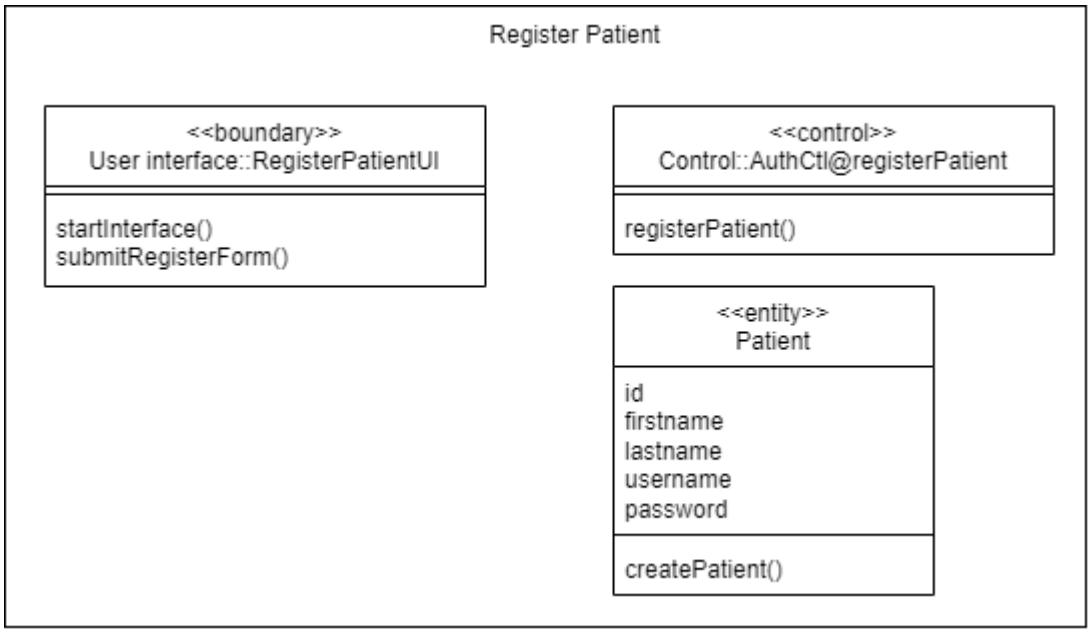



*Figure 26 – Class Diagram of Register Patient*

### 4.6.4 Login Patient

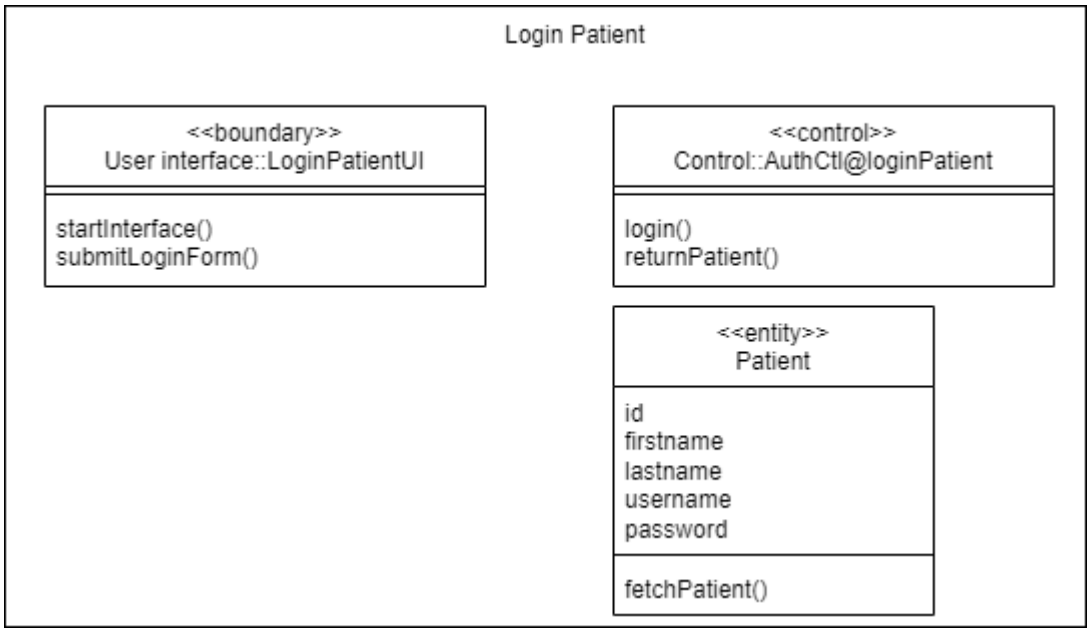



*Figure 27 – Class Diagram of Login Patient*

### 4.6.5 Patient Opinion

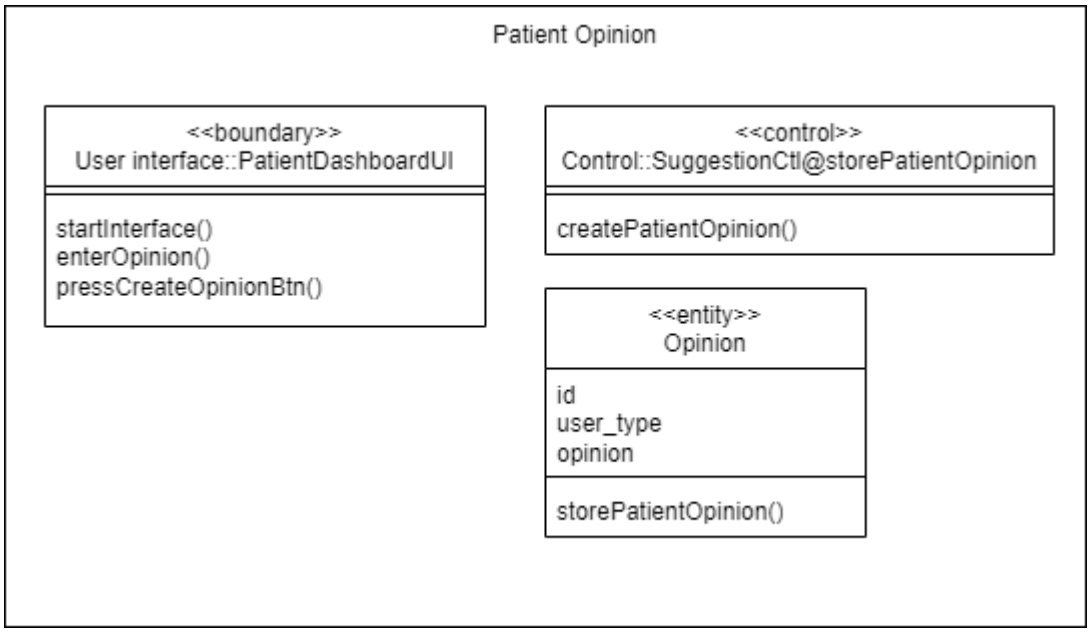



*Figure 28 – Class Diagram of Patient Opinion*

### 4.6.6 Pharmacist Opinion

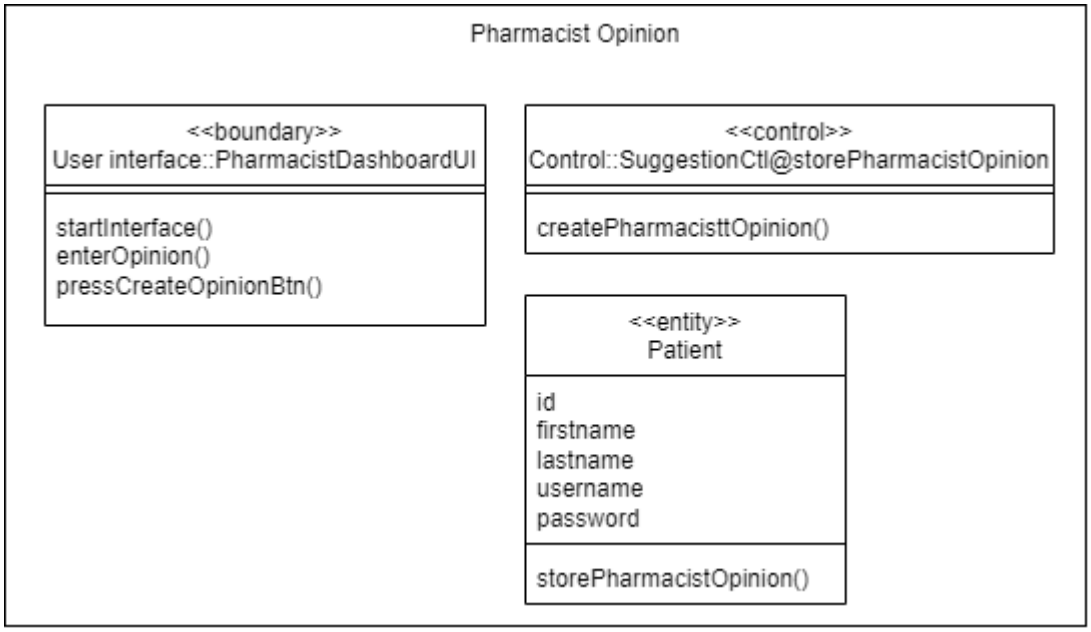



*Figure 29 – Class Diagram of Pharmacist Opinion*

### 4.6.7 Search Drug by Barcode Number / Patient

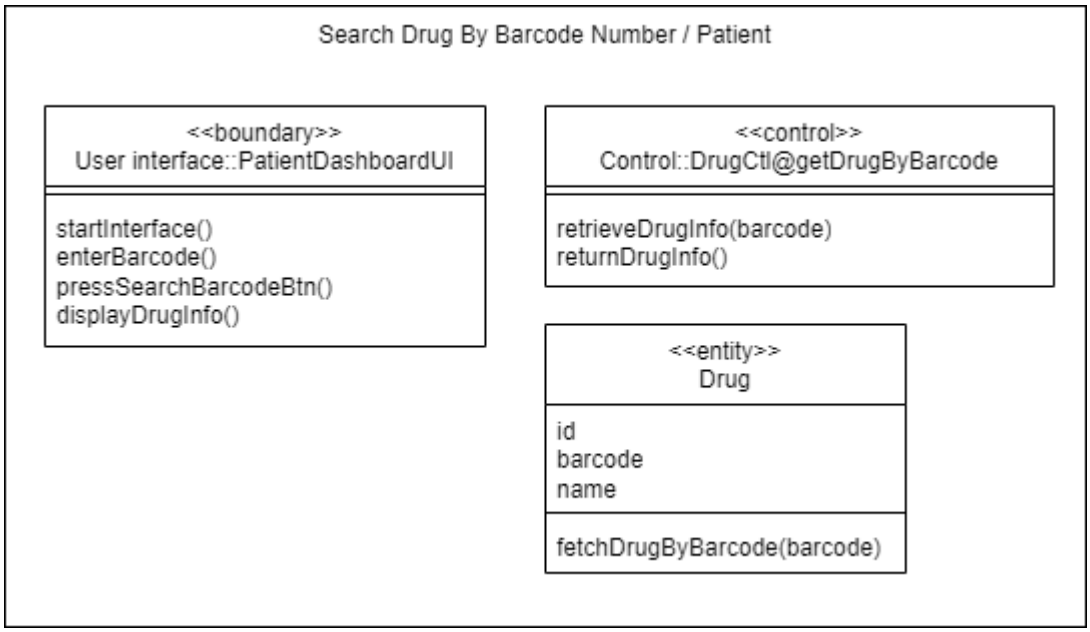



*Figure 30 – Class Diagram of Search Drug by Barcode Number / Patient*

### 4.6.8 Search Drug by Barcode Number / Pharmacist

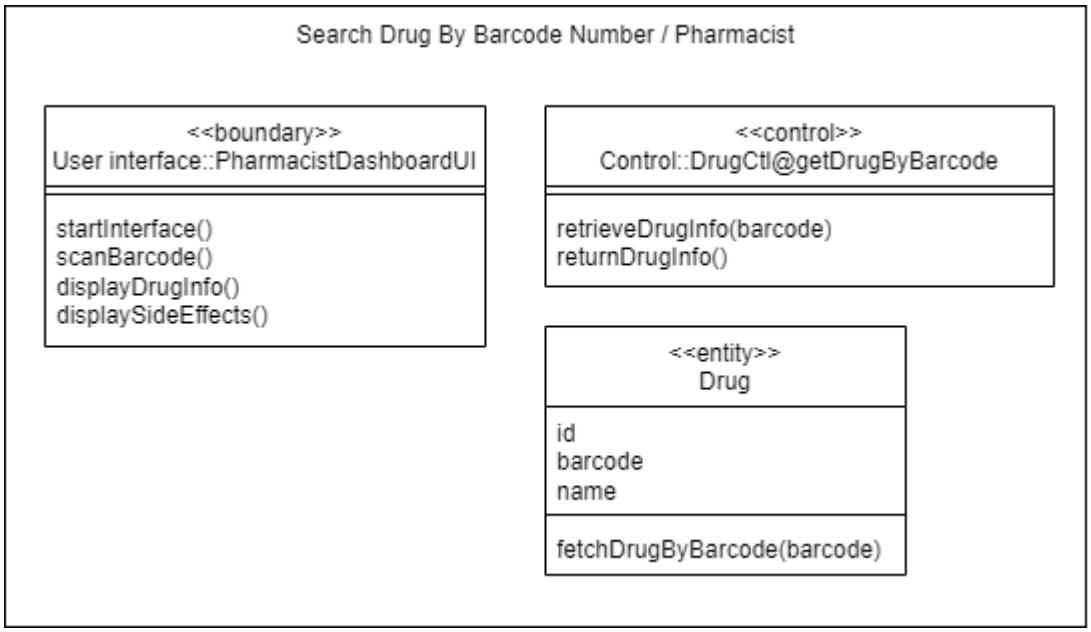



*Figure 31 – Class Diagram of Search Drug by Barcode Number / Pharmacist*

### 4.6.9 Search Drug by Given Information / Patient

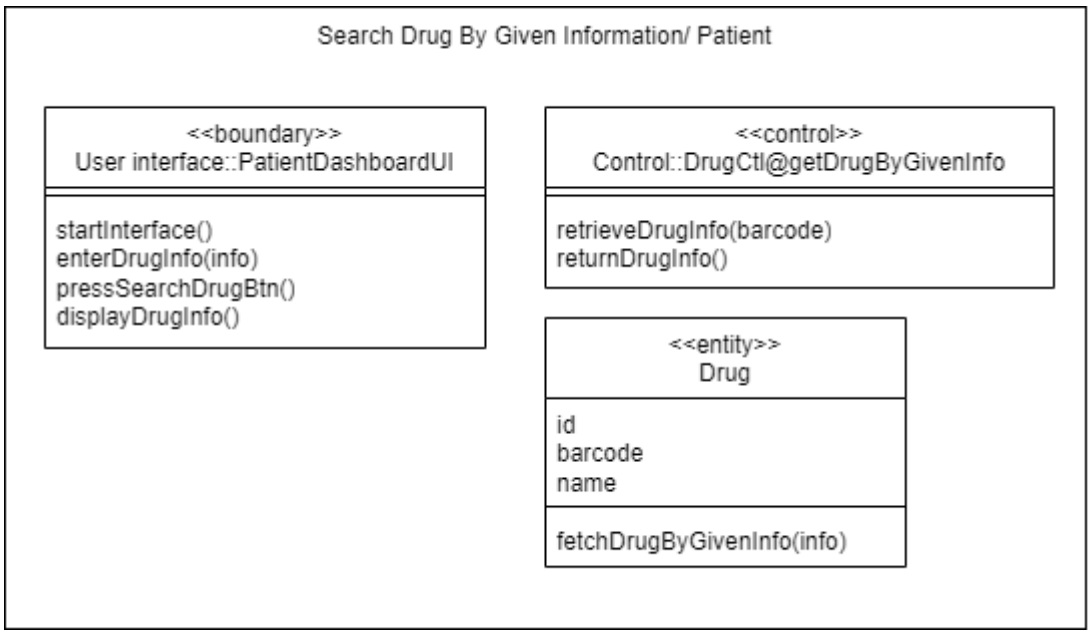



*Figure 32 – Class Diagram of Search Drug by Given Information / Patient*

### 4.6.10 Search Drug by Given Information / Pharmacist

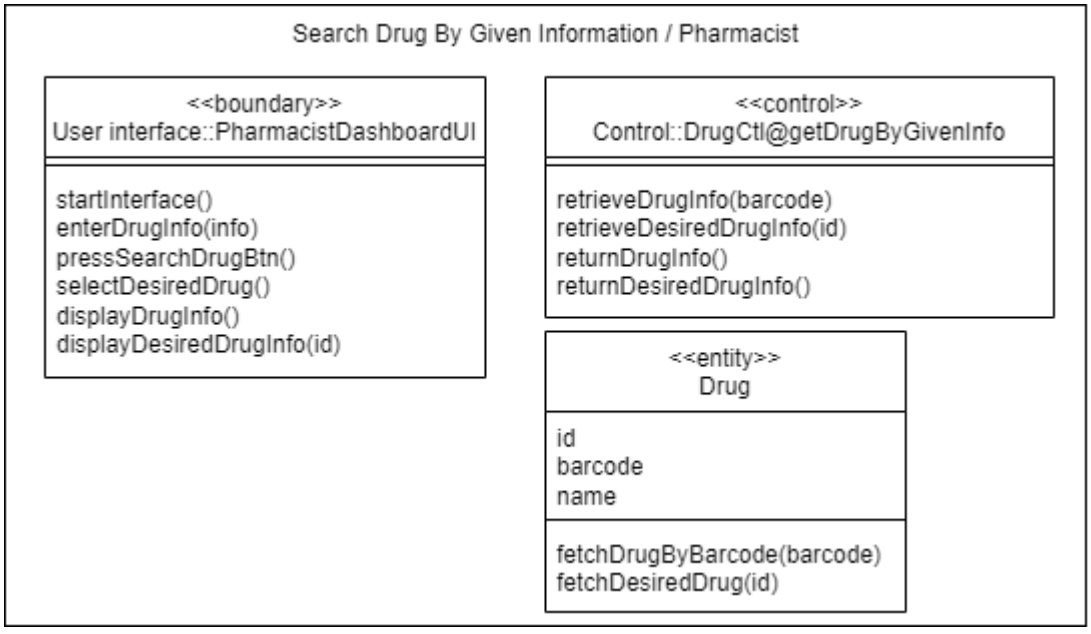



*Figure 33 – Class Diagram of Search Drug by Given Information / Pharmacist*

### 4.6.11 Add Document

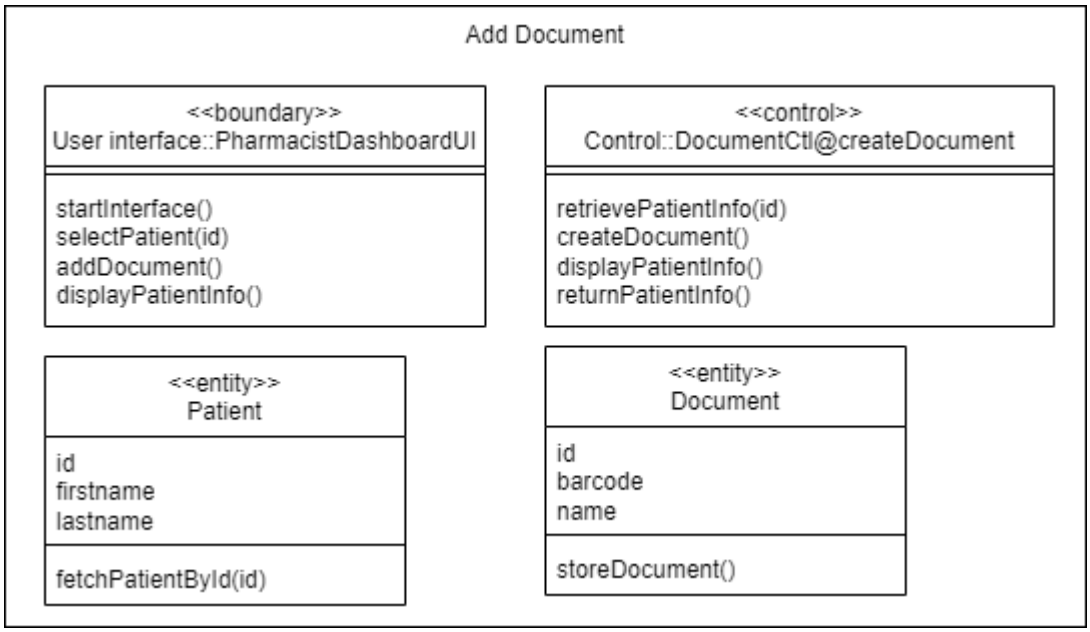



*Figure 34 – Class Diagram of Add Document*

### 4.6.12 View Document

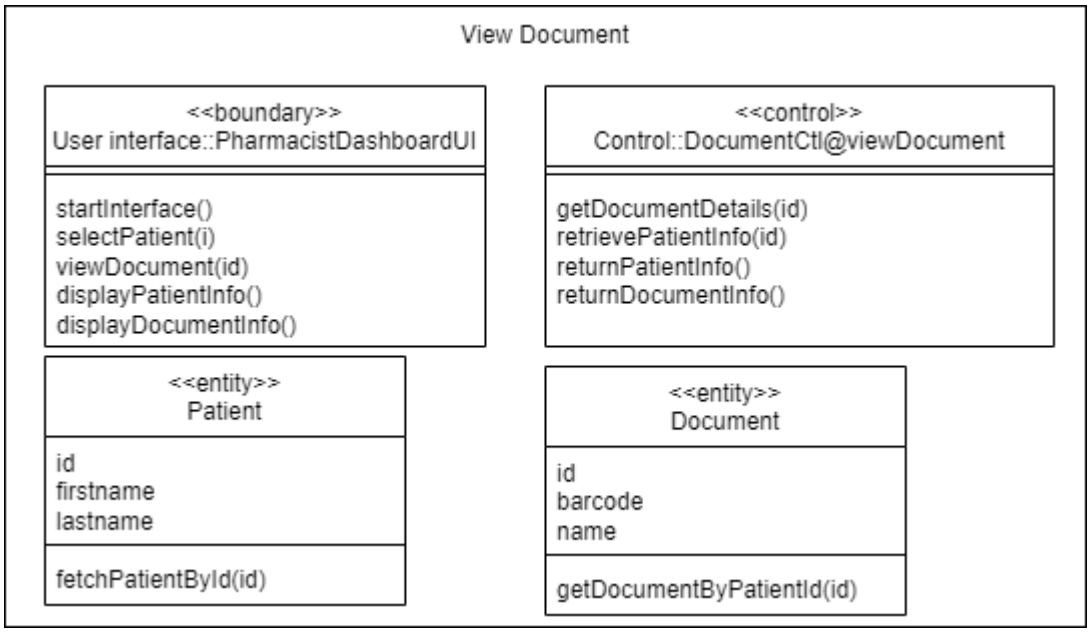



*Figure 35 – Class Diagram of View Document*

### 4.6.13 Track Prescription / Pharmacist

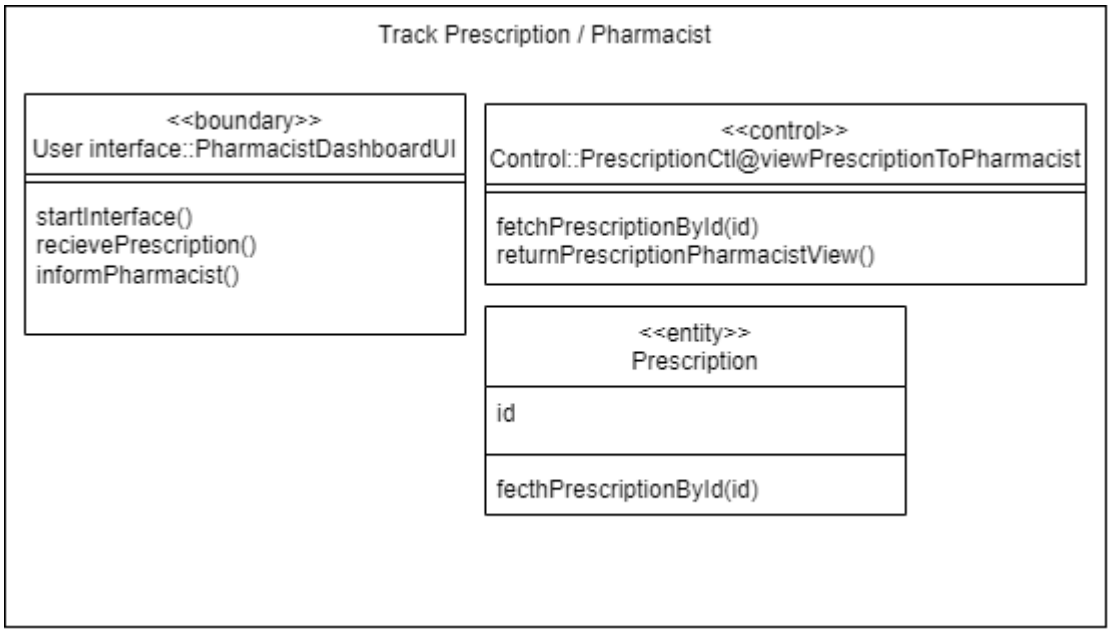



*Figure 36 – Class Diagram of Track Prescription / Pharmacist*

### 4.6.14 Track Prescription / Patient

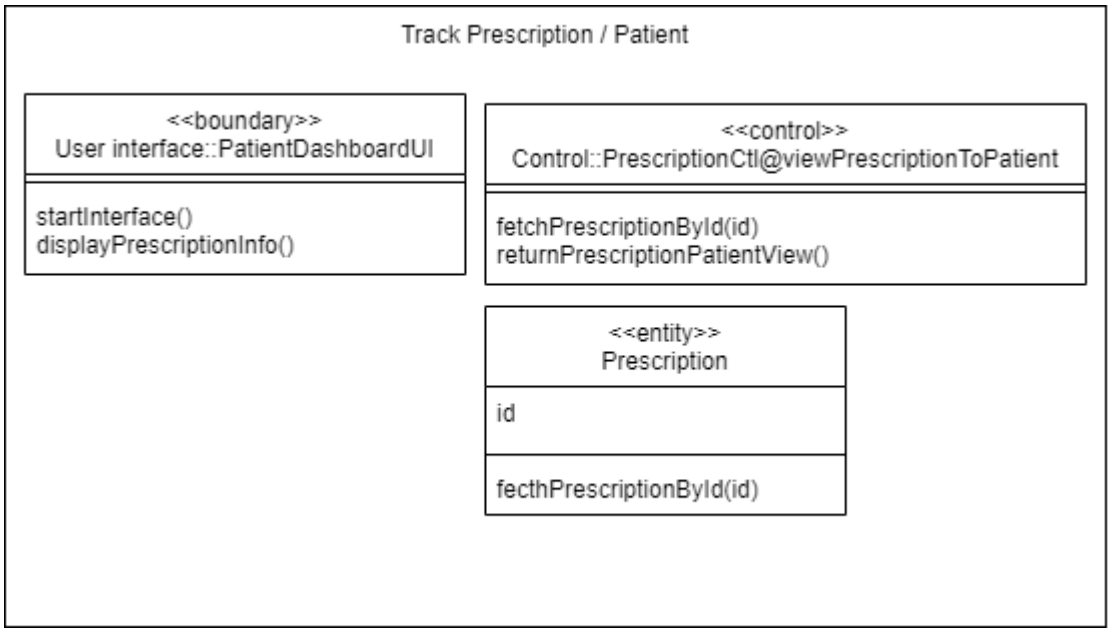



*Figure 37 – Class Diagram of Track Prescription / Patient*

### 4.6.15 Monitor Result / Pharmacist

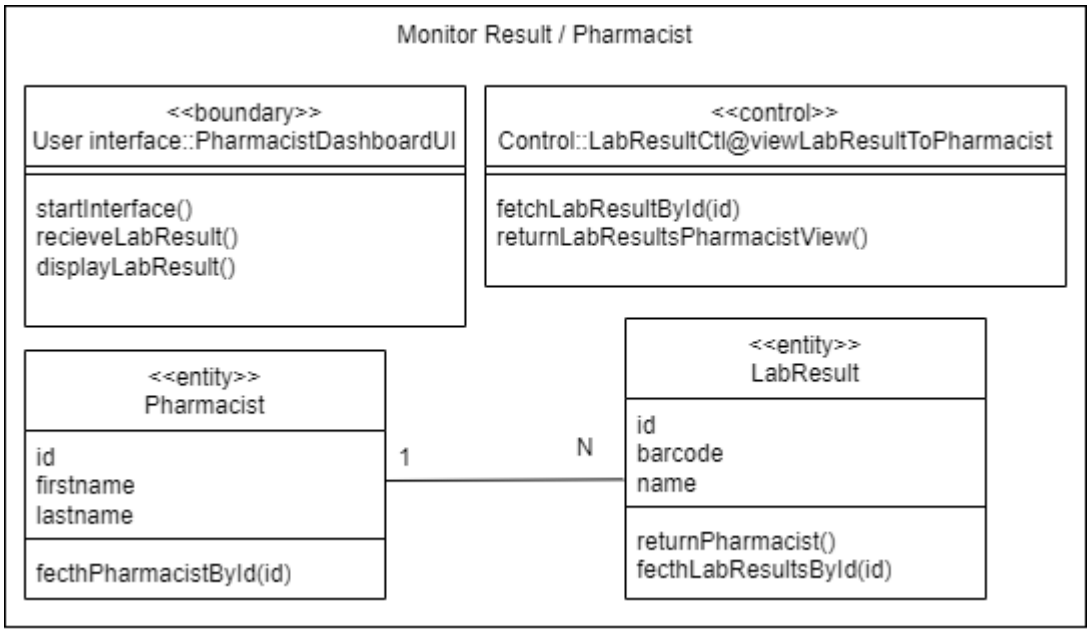



*Figure 38 – Class Diagram of Monitor Result / Pharmacist*

### 4.6.16 Monitor Result / Patient

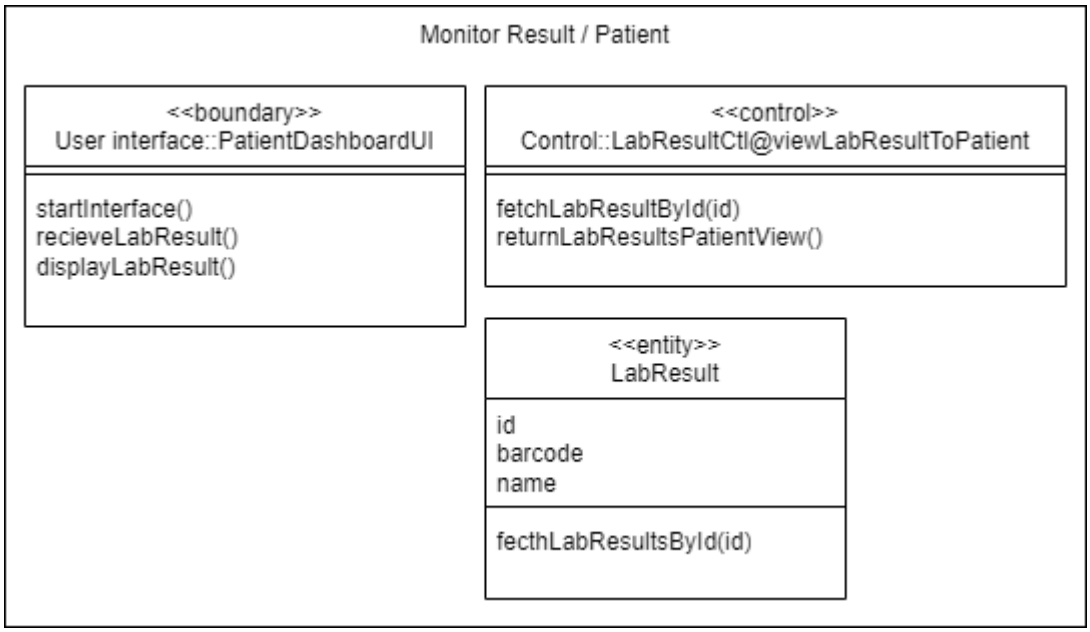



*Figure 39 – Class Diagram of Monitor Result / Patient*

### 4.6.17 Select User Type / Pharmacist

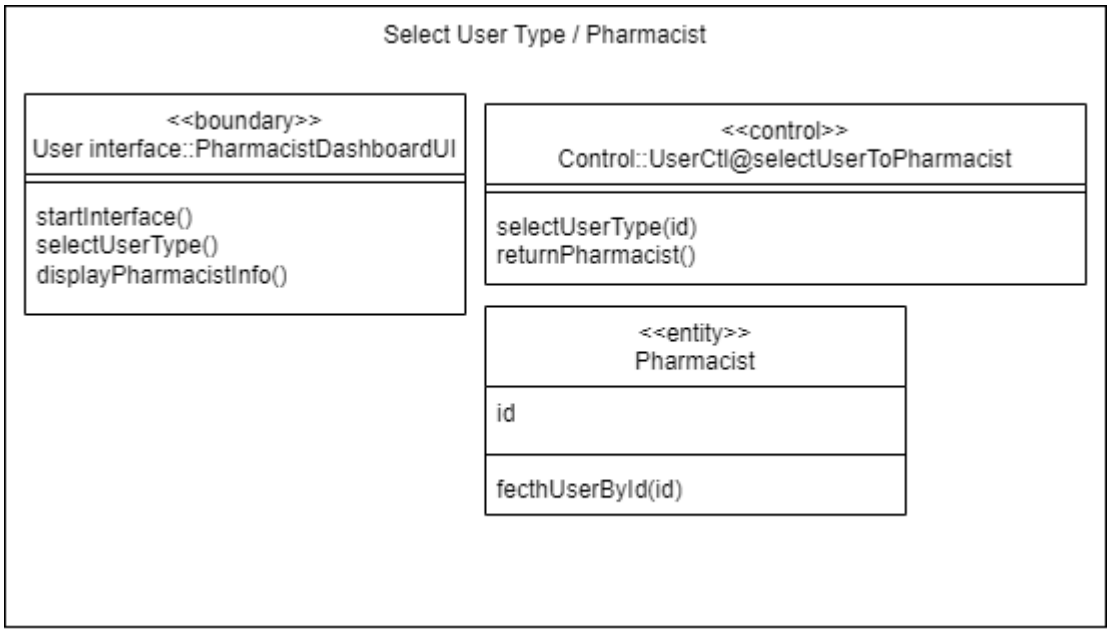



*Figure 40 – Class Diagram of Select User Type / Pharmacist*

### 4.6.18 Select User Type / Patient

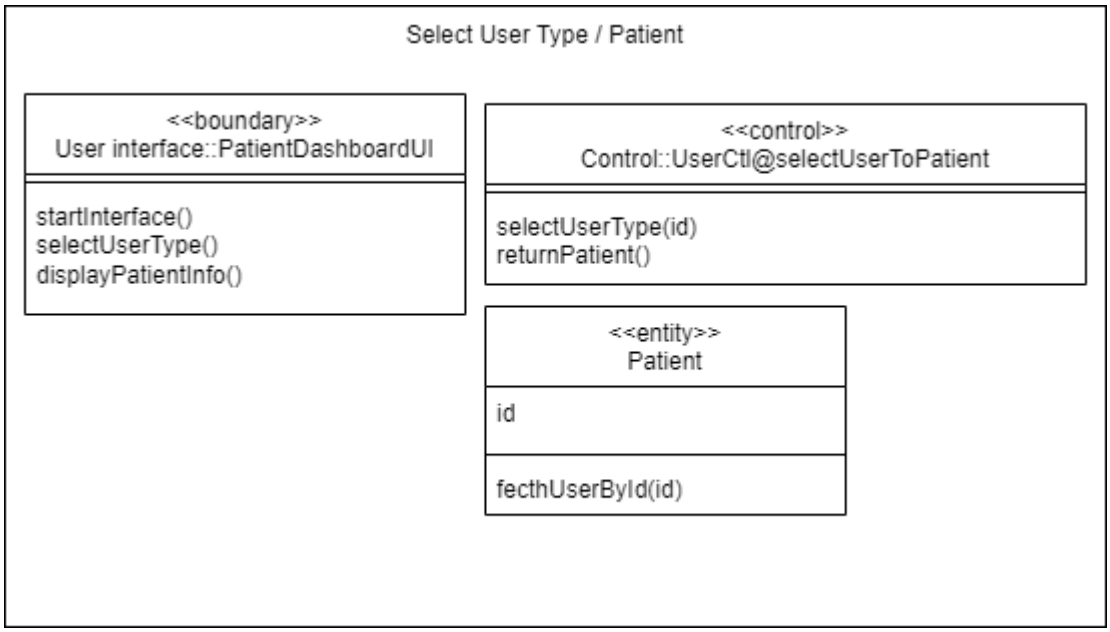



*Figure 41 – Class Diagram of Select User Type / Patient*

### 4.6.19 Manage User

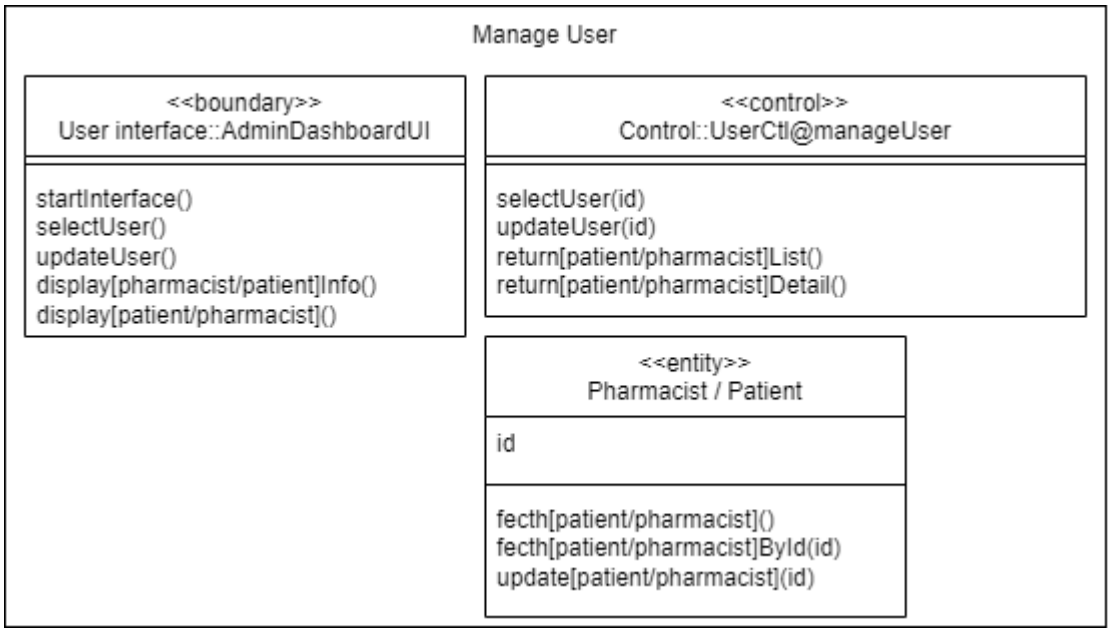



*Figure 42 – Class Diagram Manage User*

### 4.6.20 Manage Database

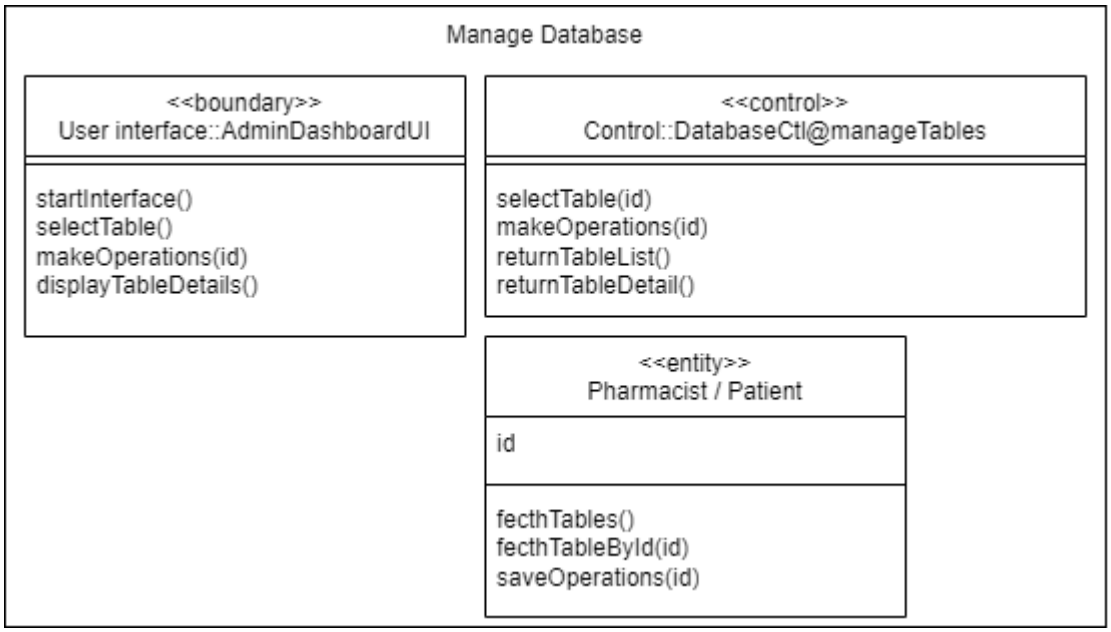



*Figure 43 – Class Diagram of Manage Database*

### 4.6.21 Class Diagram of PDSS

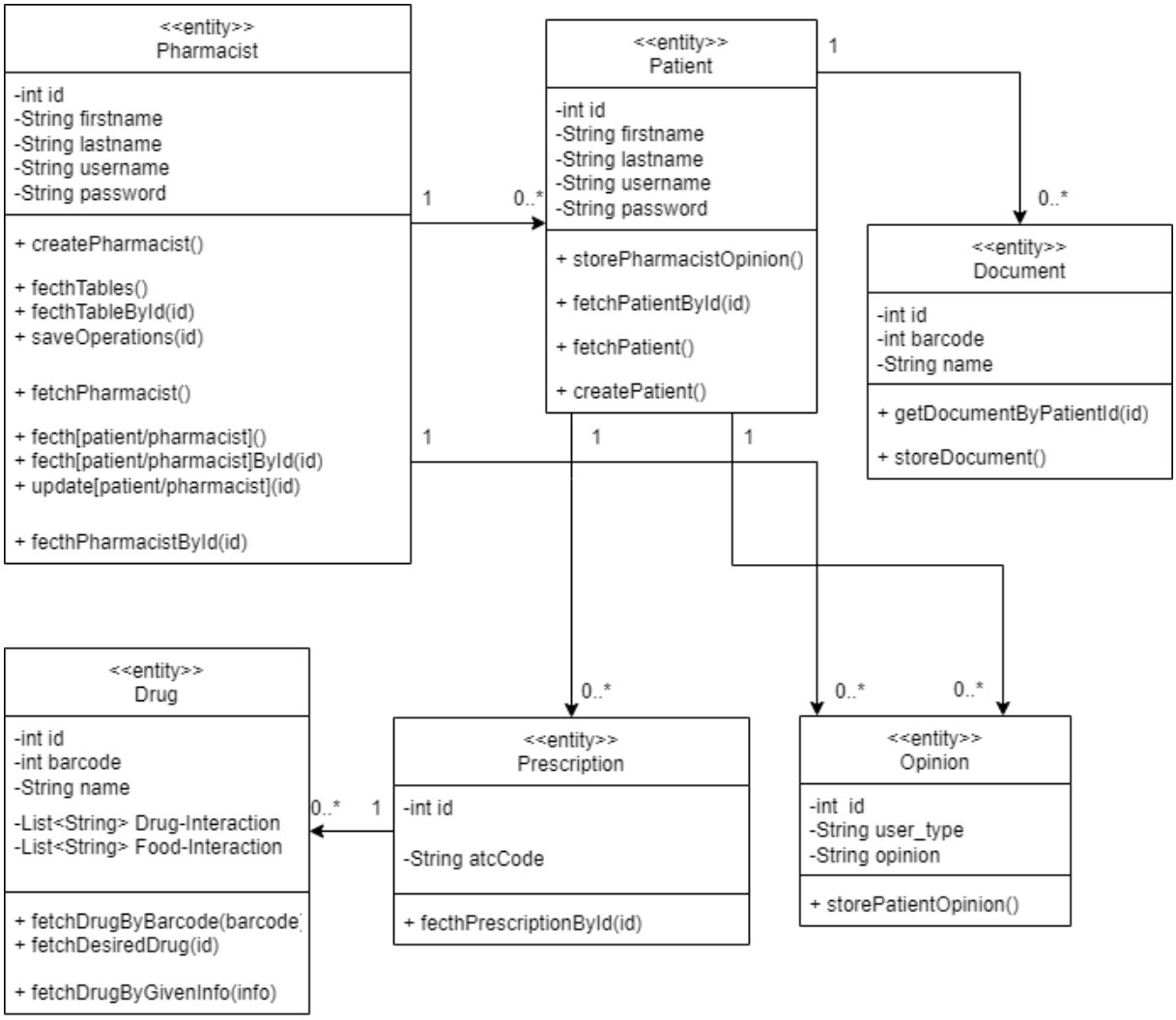



*Figure 44 – Class Diagram of PDSS*

The Pharmacy Decision Support System is a valuable tool for pharmacists to make informed drug prescription decisions by considering patient opinions. As shown in Figure 44 The system consists of several essential classes, including "Pharmacist," "Patient," "Drug," "Opinion," and "Prescription." The "Pharmacist" class represents the users of the system, the pharmacists themselves. It holds relevant information such as the pharmacist's name, ID, and login credentials. The "Patient" class represents individuals for whom the drug prescriptions are intended, storing details such as their name, age, and medical history. The "Drug" class represents the medications being prescribed, containing attributes like the drug's name, dosage,

and indications. The "Opinion" class represents the patient's opinion on a specific drug and includes important attributes such as the rating given by the patient, their review or feedback, and the date the opinion was provided. The "Prescription" class acts as a bridge between the pharmacist, patient, and drug. It represents a prescription made by a pharmacist for a specific patient and associates a particular drug with that patient. This class allows the system to keep track of the prescribed drugs and the patients they are assigned to. As shown in Figure 44 the relationships between these classes. For instance, the "Pharmacist" class has an association with the "Prescription" class, indicating that a pharmacist can create multiple prescriptions. As shown in Figure 44 the "Patient" class also has an association with the "Prescription" class, representing the fact that a patient can have multiple prescriptions. Furthermore, the "Prescription" class has an association with the "Drug" class, signifying that a specific drug is associated with a prescription. The "Opinion" class has associations with both the "Drug" and "Patient" classes, illustrating that a patient's opinion is related to a particular drug.

In summary, the Pharmacy Decision Support System class diagram showcases the relevant classes and their relationships. It provides a concise representation of the entities involved in the system's functionality, allowing pharmacists to leverage patient opinions in their drug prescription decision-making process.

### 4.7 ER Diagram

The database consists of several tables that are interconnected through foreign key references to enable the management of drug-related information and prescriptions. As seen in Figure 44 the Drugs Table contains information about drugs and is linked to the Drug Interactions Table, the Food Interactions Table, and the Recommendations Table through foreign key references. This enables the tracking of drug interactions, food interactions, and recommendations related to specific drugs. The Drug Interactions Table and the Food Interactions Table contain information about drug interactions and food interactions, respectively, and are related to the Drugs Table through foreign key references. This allows for the association of drug interactions and food interactions with specific drugs. The Recommendations Table is related to the Drugs Table and the Products Table through foreign key references. This relationship allows the tracking of drug recommendations and the products associated with them. The Products Table is linked to the Recommendations Table through a foreign key reference, which enables the tracking of product information associated with specific drug recommendations. As seen in Figure 46 the Prescriptions Table is related to the Drugs Table, the Patients Table, and the Doctors Table through foreign key references. This enables the tracking of prescribed drugs for specific patients by doctors. The Patients Table is linked to the Prescriptions Table through a foreign key reference, which allows the tracking of patient information associated with specific prescriptions. The Doctors Table is related to the Prescriptions Table through a foreign key reference, which allows the tracking of doctor information associated with specific prescriptions. As seen in Figure 45 the Users Table is related to the Permissions Table and the User Permissions Table through foreign key references. This enables the management of user accounts and their permissions. Finally, the User Opinions Table is related to the Users Table through a foreign key reference, which allows users to leave their opinions and feedback related to the system or specific drugs.

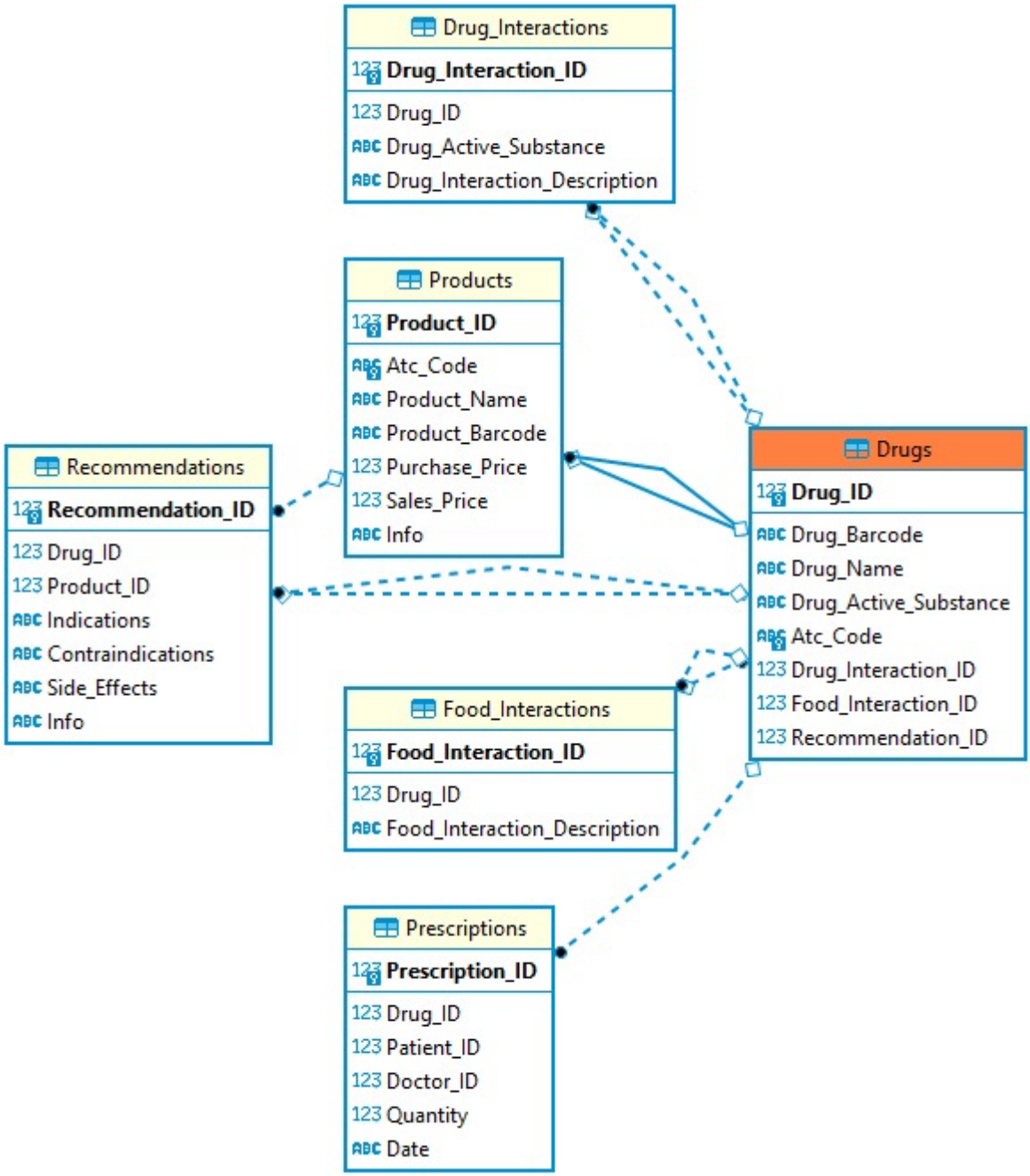



*Figure 45 – ER Diagram of Database PDSS-1*

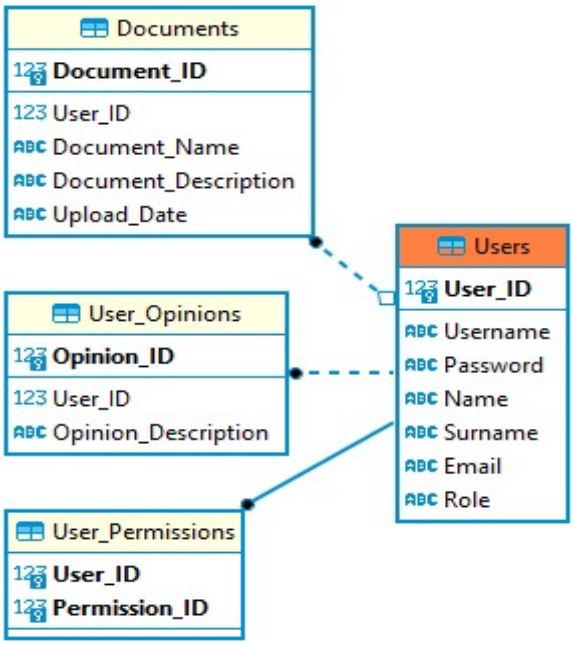



*Figure 46 – ER Diagram of Database PDSS-2*

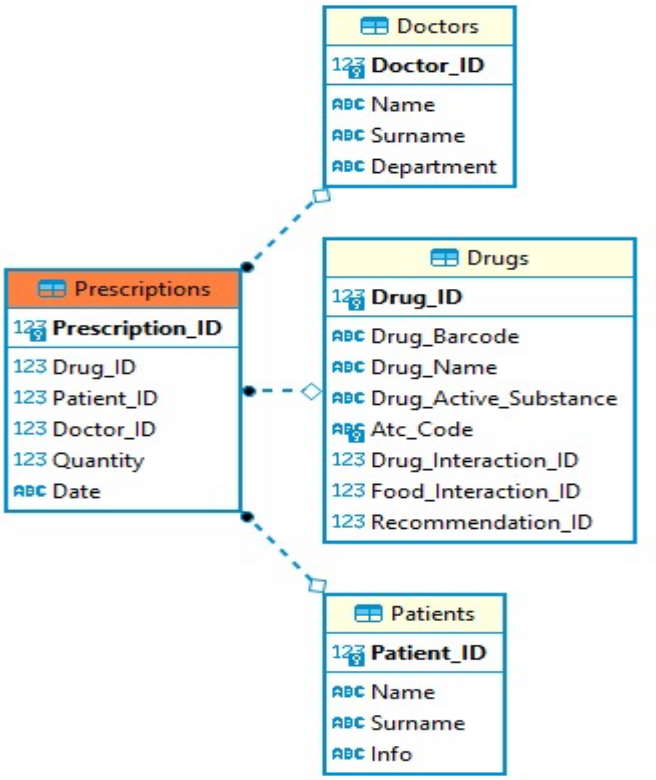



*Figure 47 – ER Diagram of Database PDSS-3*

## 4.8 Activity Diagram

An activity diagram is a graphical representation of a workflow or process, which shows the sequence of activities, decisions, and flows involved in achieving a specific task or goal. In the case of a Pharmacy Decision Support System, the activity diagram can show the steps involved in the various user interactions with the system, such as registering, logging in, searching for drugs by barcode number, adding documentation, suggesting opinions, tracking prescriptions, and monitoring results as can be seen in Figure 48.

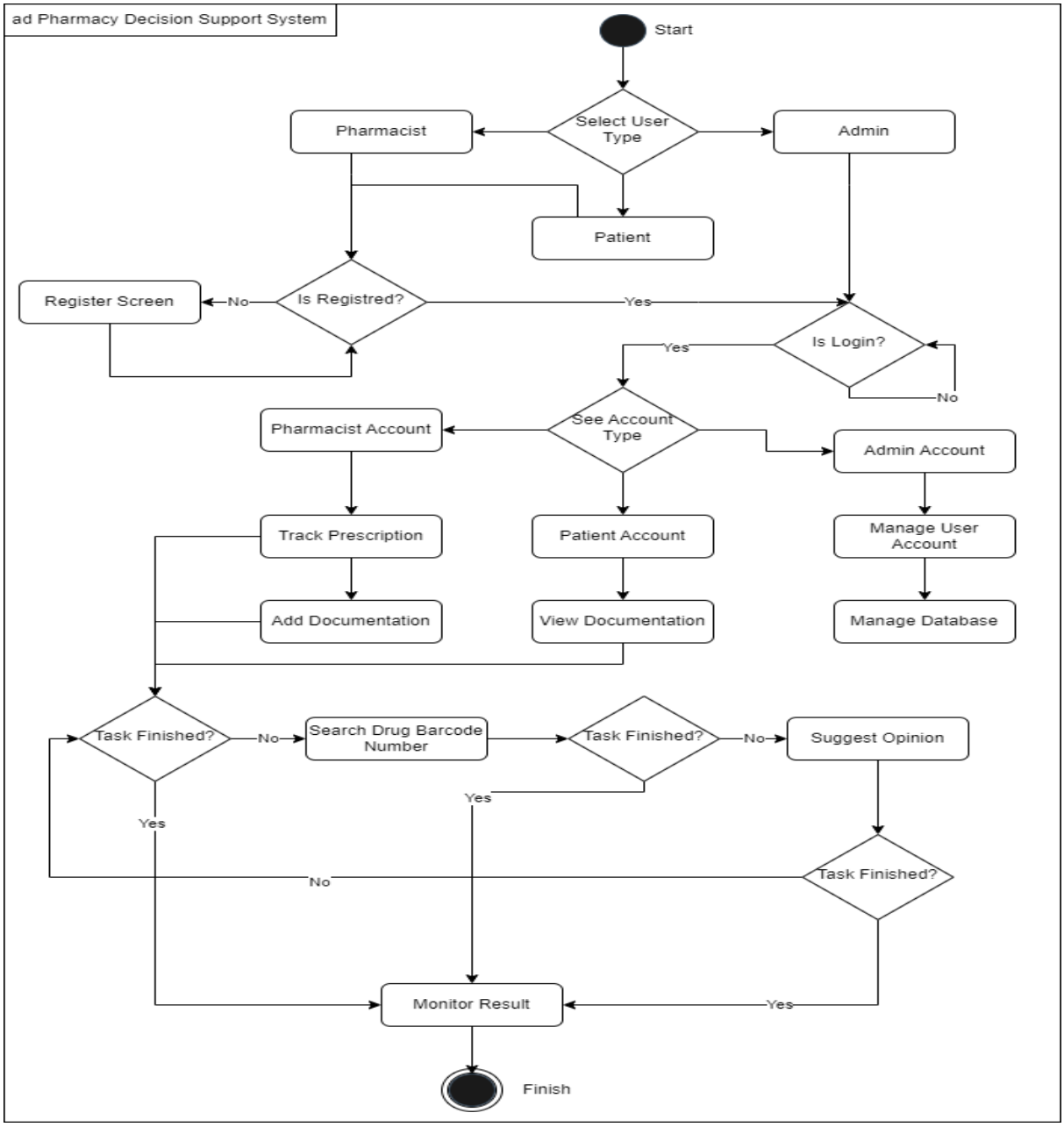



*Figure 48 – Activity Diagram of PDSS*

## 4.9 Sequence Diagram

Sequence diagram displays the sequential interactions between the elements of a system or process. The system consists of a group of horizontal arrows and a collection of vertical lifelines that symbolize the messages or actions that are passed between the objects or components. The following diagram displays each process that flows from pharmacists, patient and admin in the Pharmacy Decision Support System as can be seen in Figure 49.

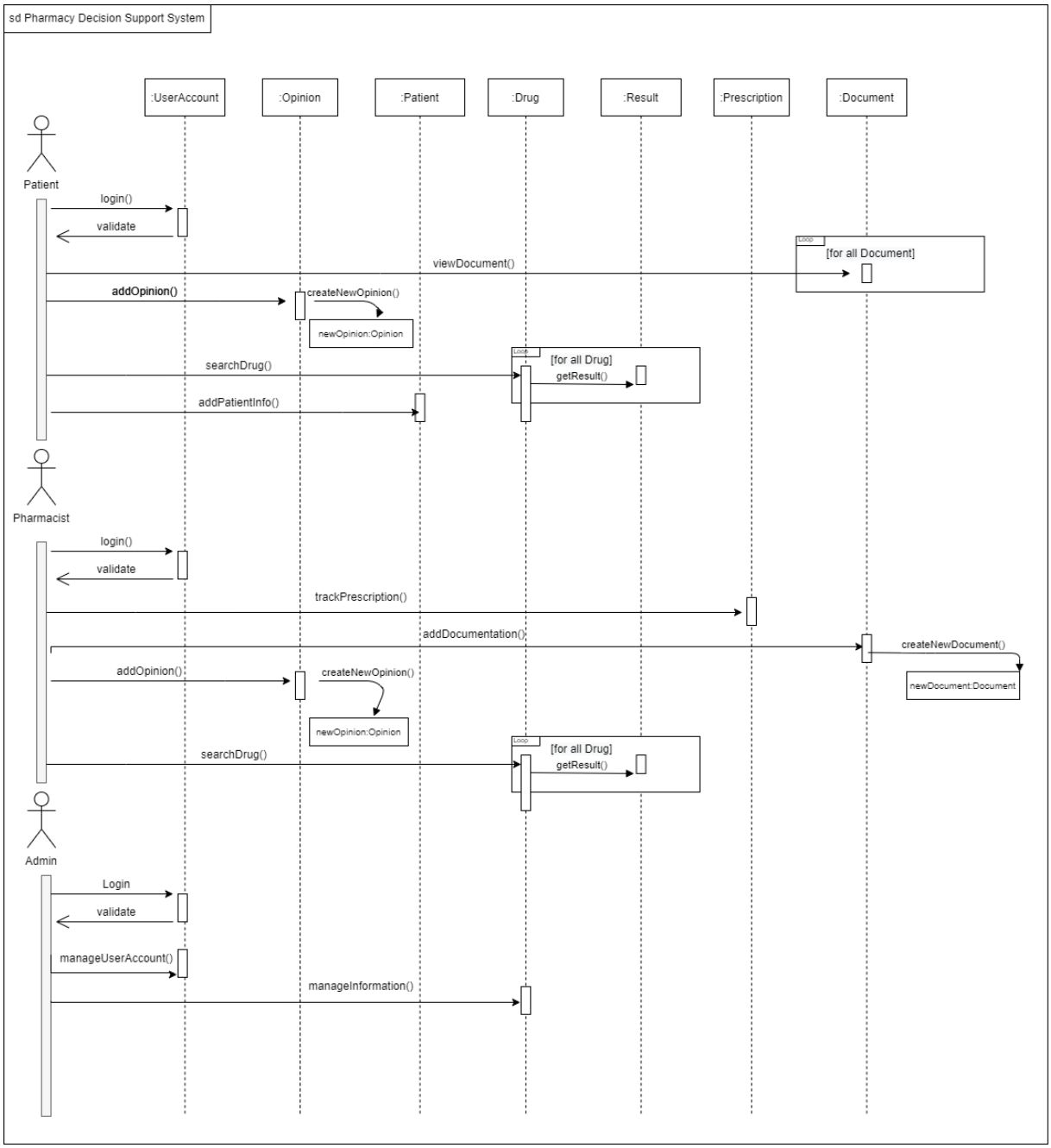



*Figure 49 – Sequence Diagram of PDSS*

## 4.10 Deployment Diagram

The deployment diagram demonstrates the hardware used in the system, the components included in these hardware, and the connections between them. The deployment diagram of the Pharmacist Decision Support System is presented in Figure 50.

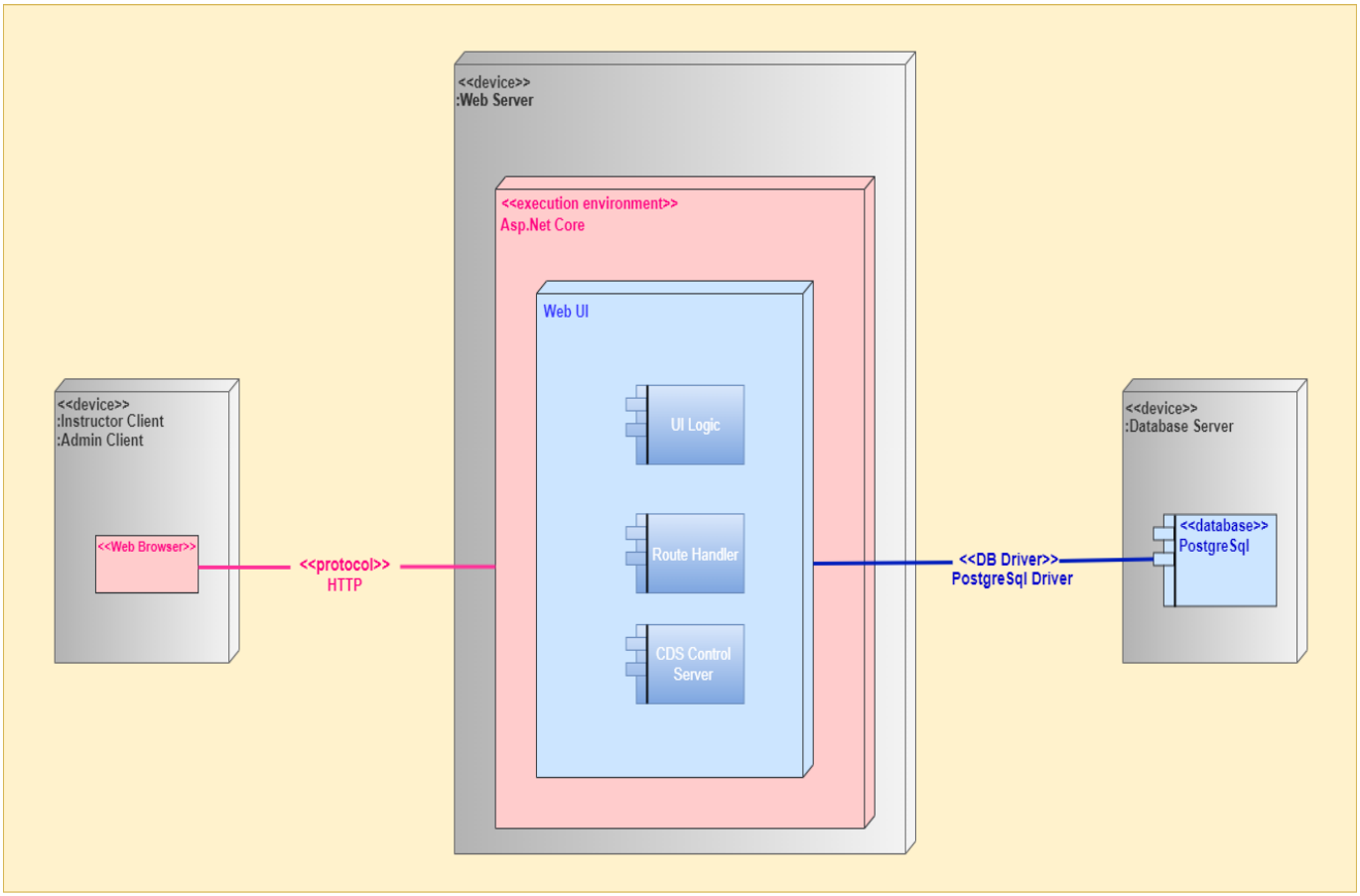



*Figure 50 – PDSS Deployment Diagram*

## 4.11 User Interfaces

### 4.11.1 Admin Home Page

Admin home page displays the system information about amount of data for pharmacist, patient, report, and drug with side menu links that admin has access to the displayed resources as can be seen in Figure 51.

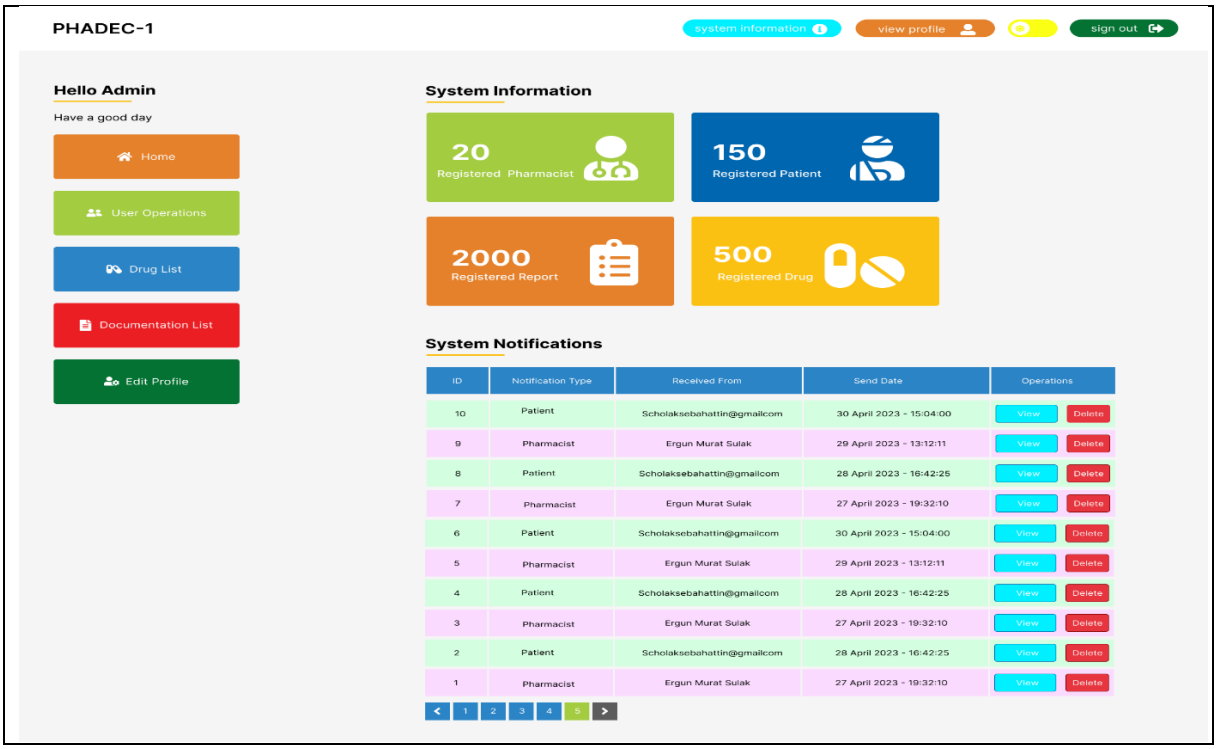



*Figure 51 – Admin Home Page*

### 4.11.2 Admin Manage Documentation Page

Admin manage documentation page is used for making operations such as create, view, or delete about documentations for each patient as can be seen in Figure 52.

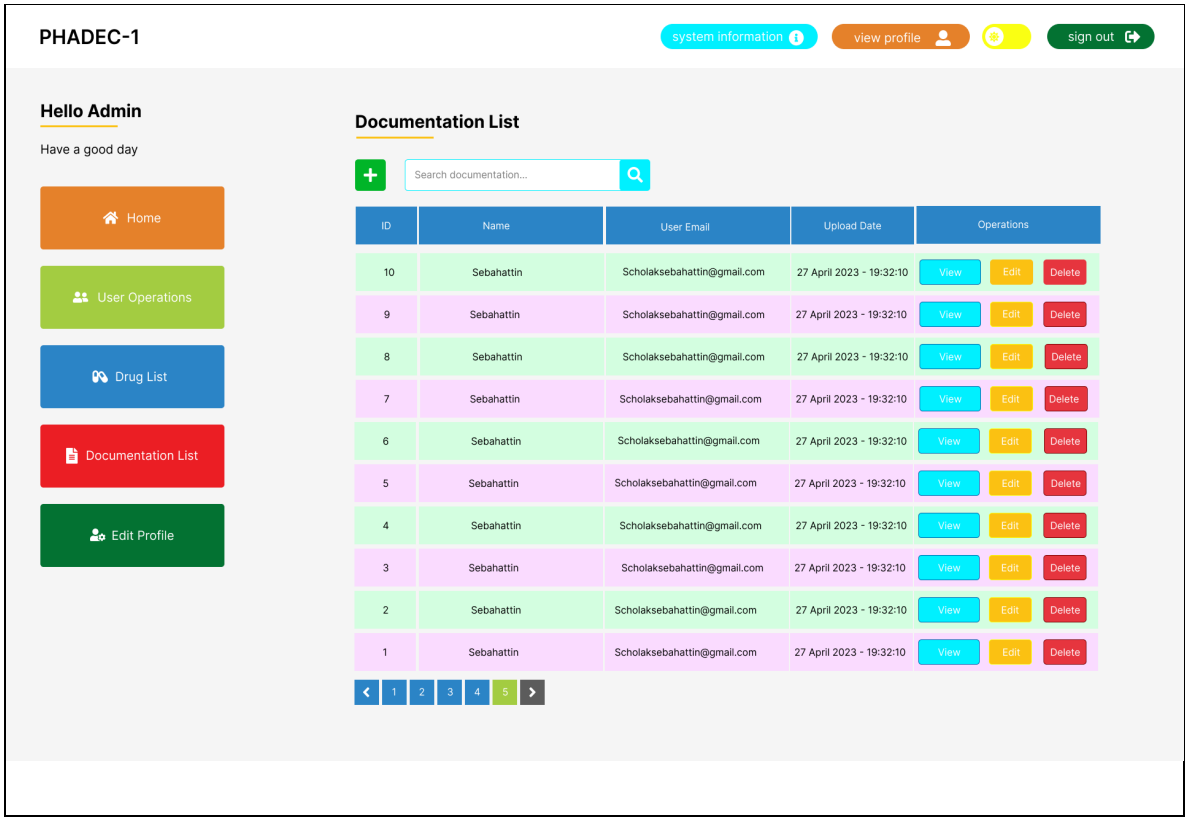



*Figure 52 – Admin Manage Documentation Page*

### 4.11.3 Admin Manage Drug Page

Admin manage drug page is used for making operations such as view about drugs as can be seen in Figure 53.

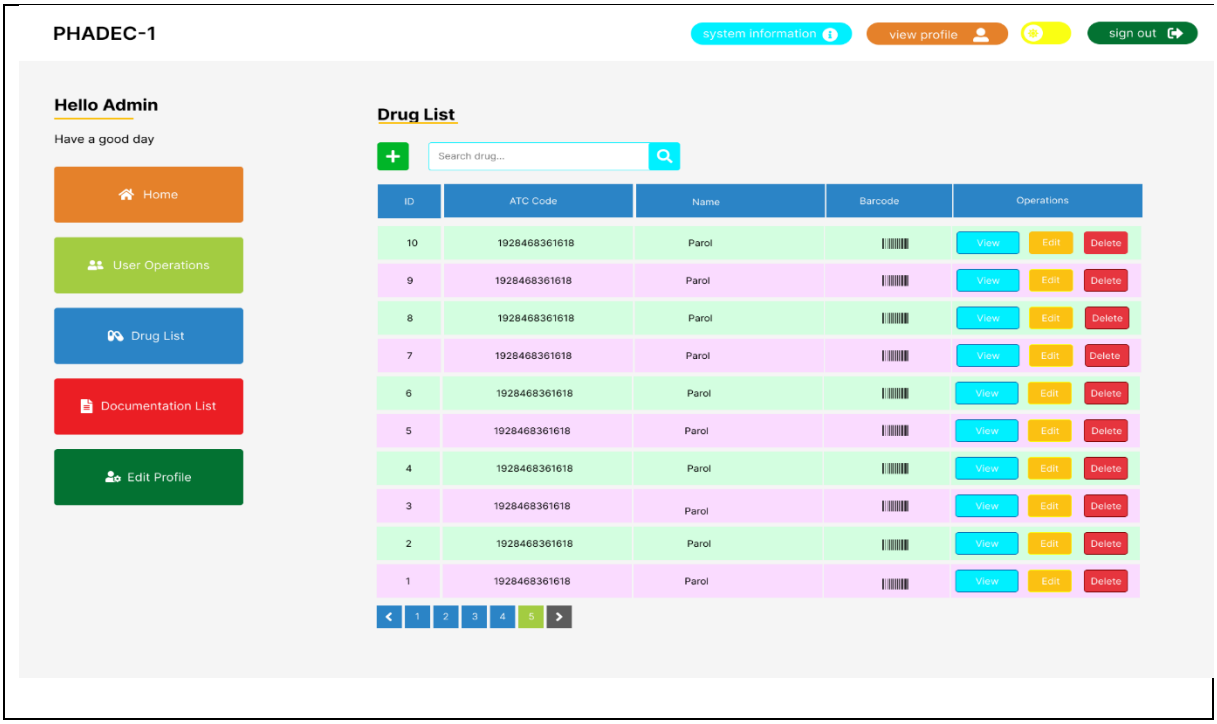



*Figure 53 – Admin Manage Drug Page*

### 4.11.4 Admin Manage Users Page

Admin manage user page is used for making operations such as view, edit and delete users as can be seen in Figure 54.

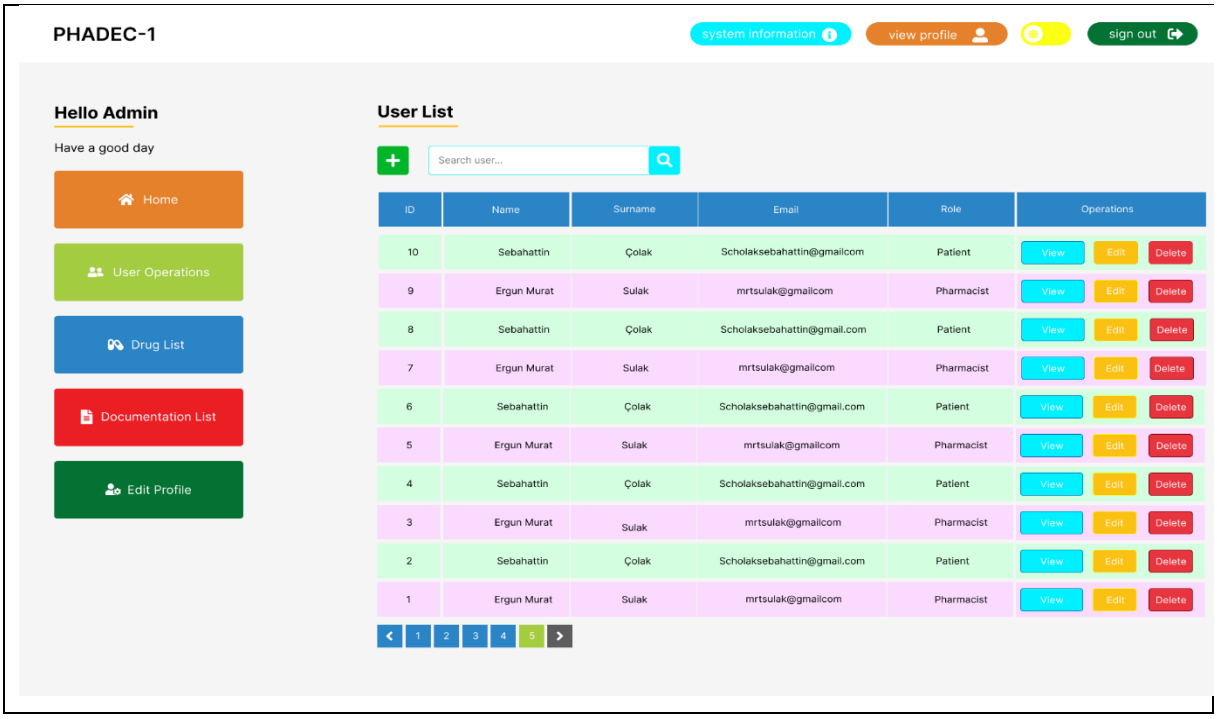



*Figure 54 – Admin Manage Users Page*

### 4.11.5 Example Dark UI

Example dark UI shows how the system would look like when user prefers dark theme as can be seen in Figure 55.

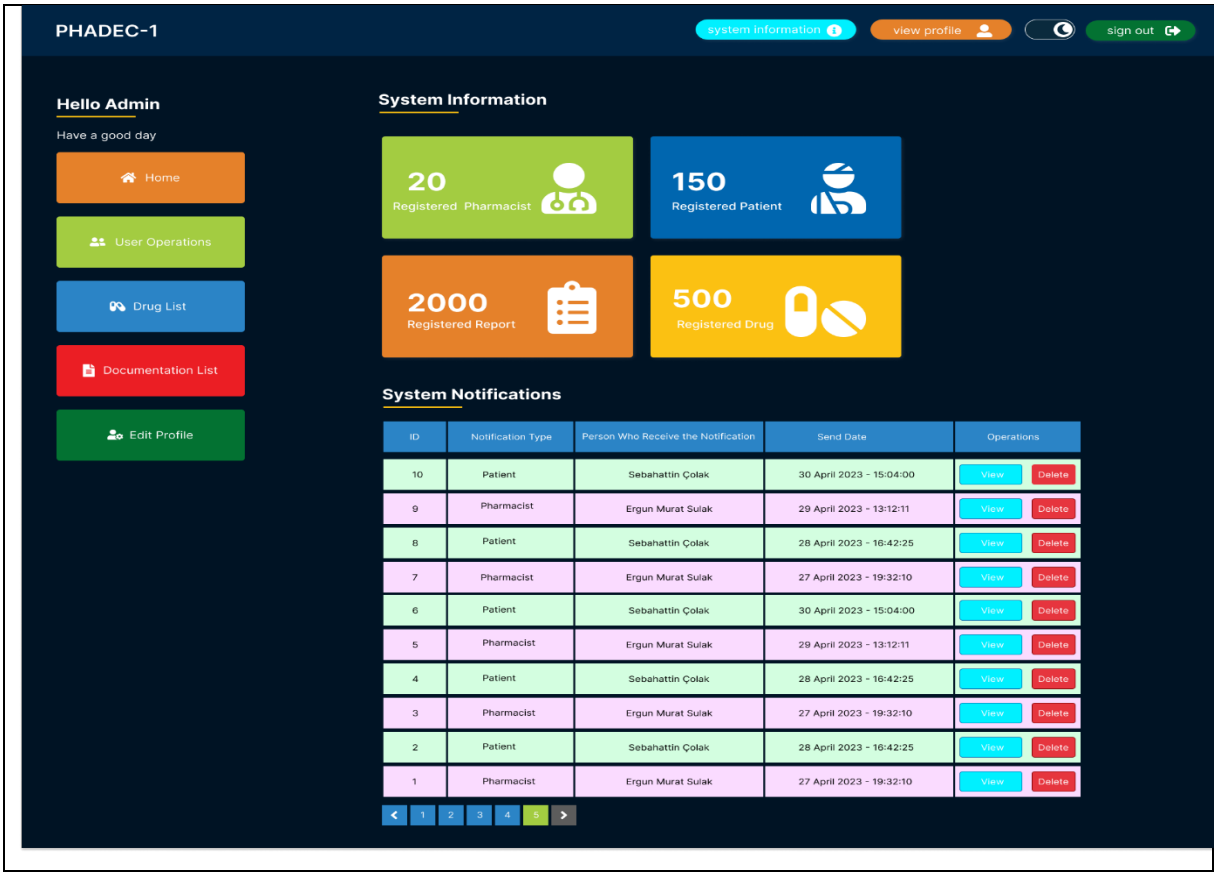



*Figure 55 – Example Dark UI*

### 4.11.6 Patient-Sign in

Patient sign-in page allows patients to sign-in to the system as can be seen in Figure 56.


*Figure 56 – Patient-Sign in*

### 4.11.7 Patient-Signup

Patient sign-up page allows new patients to register to the system as can be seen in Figure 57.


*Figure 57 – Patient-Signup*

### 4.11.8 Patient Home Page

Patient home page displays the system information about amount of data for pharmacist, patient, report, and drug with side menu links that patient has access to the displayed resources as can be seen in Figure 58.

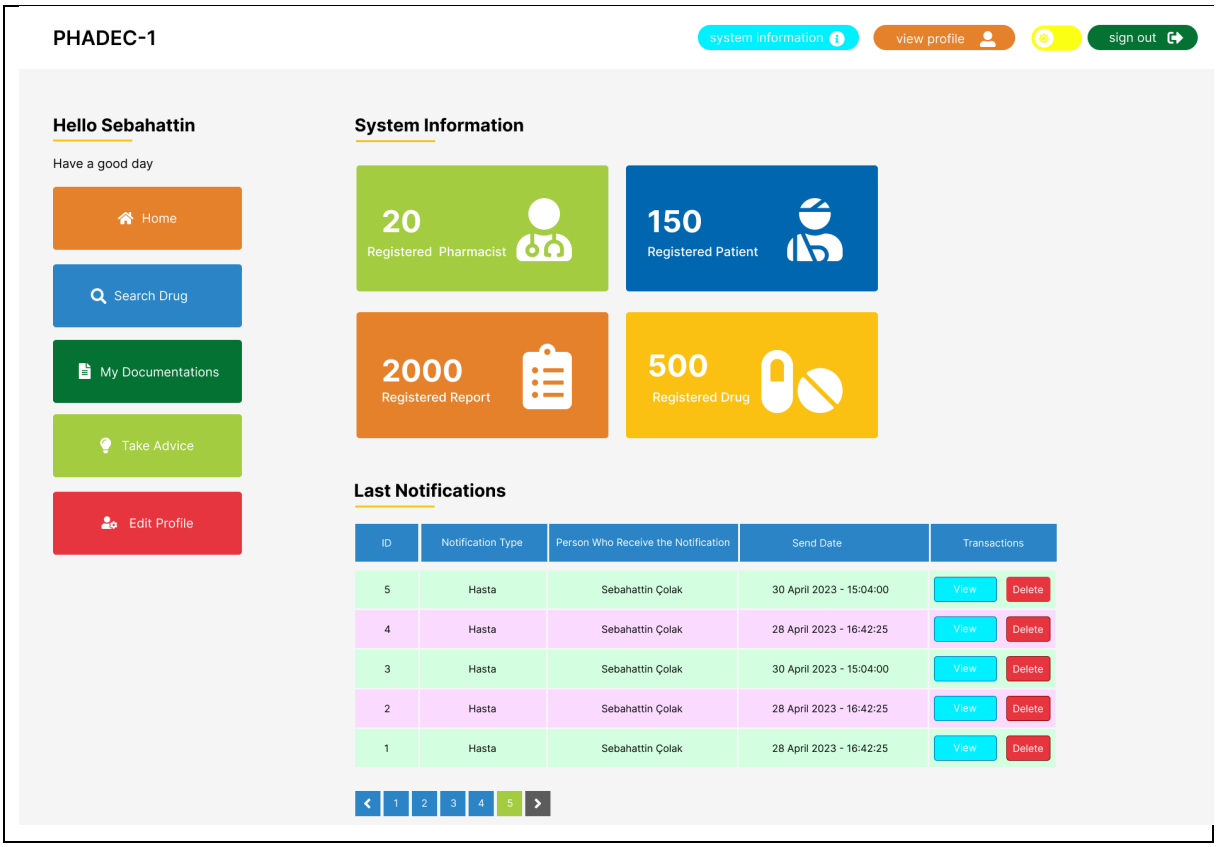



*Figure 58 – Patient Home Page*

### 4.11.9 Patient Search Drug Page

Patient search drug page allows patients to search drugs and check interactions among them as can be seen in Figure 59.

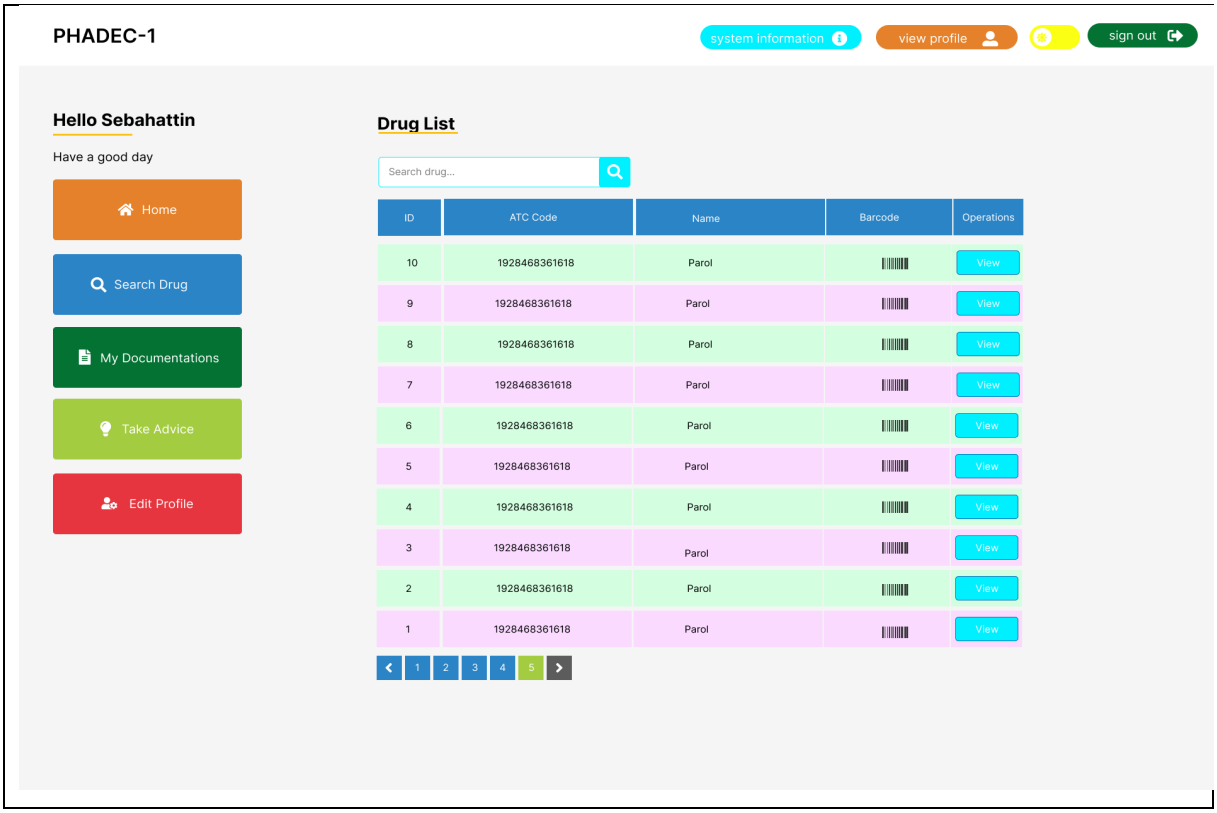



*Figure 59 – Patient Search Drug Page*

### 4.11.10 Pharmacist-Sign in

Pharmacist sign-in page allows pharmacists to sign-in to the system as can be seen in Figure 60.


*Figure 60 – Pharmacist-Sign in*

### 4.11.11 Pharmacist-Signup

Pharmacist sign-up page allows new pharmacists to register to the system as can be seen in Figure 61.


*Figure 61 – Pharmacist-Signup*

### 4.11.12 Pharmacist Home Page

Pharmacist home page displays the system information about amount of data for pharmacist, patient, report, and drug with side menu links that pharmacist has access to the displayed resources as can be seen in Figure 62.

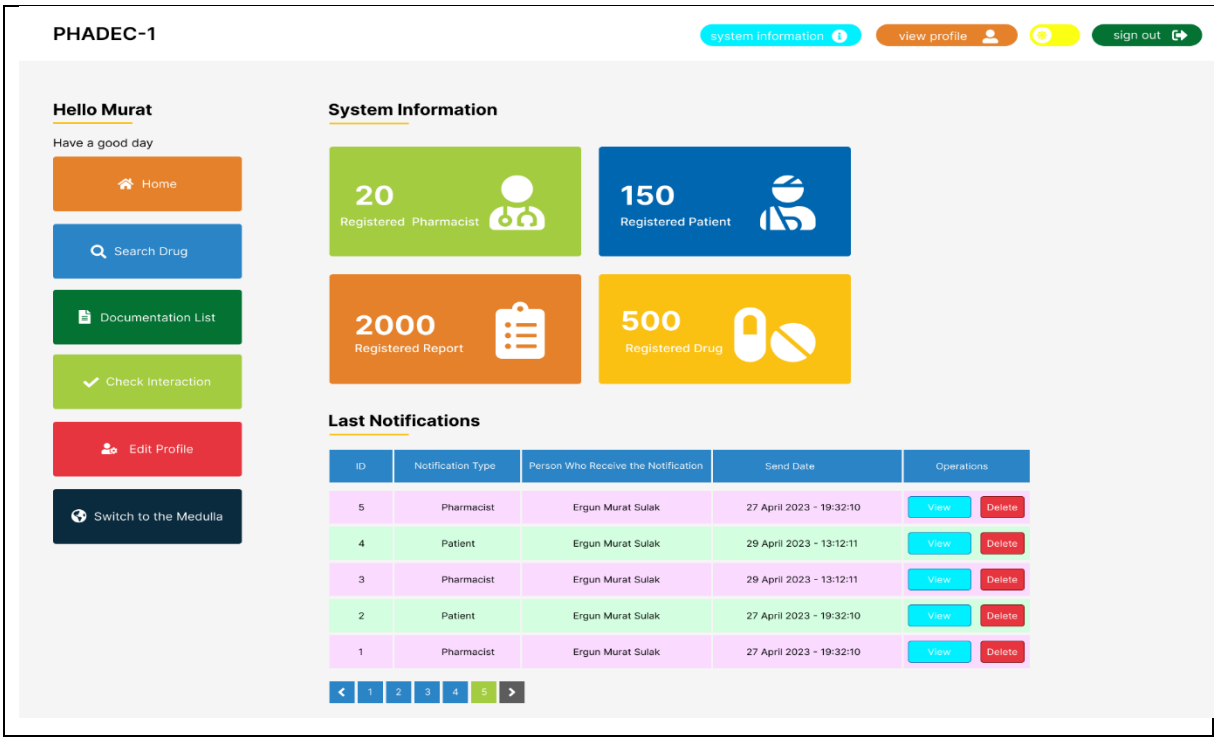



*Figure 62 – Pharmacist Home Page*

### 4.11.13 Pharmacist Documentation page

Pharmacist documentation page displays the documentation table with operations such as create, view, edit and delete as can be seen in Figure 63.

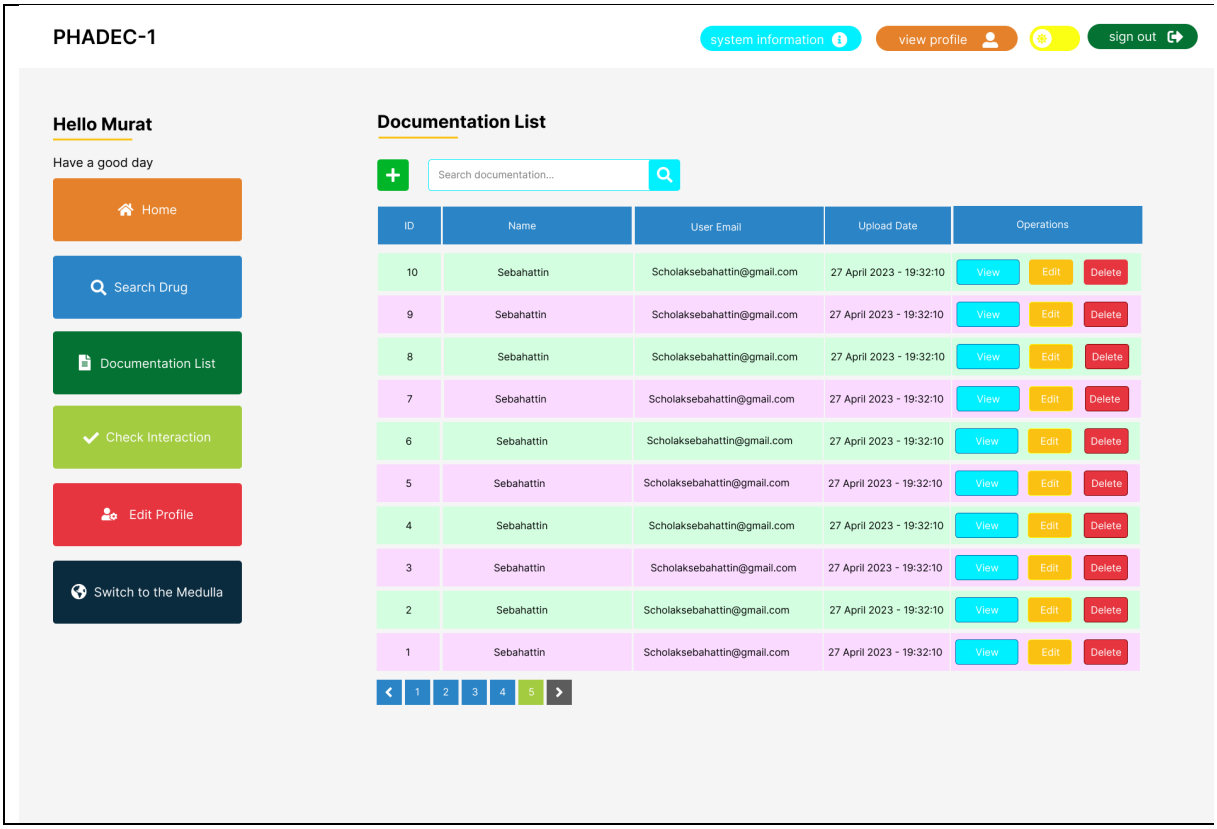



*Figure 63 – Pharmacist Documentation page*

### 4.11.14 Pharmacist Interaction page

Pharmacist interaction page allows pharmacists to select drugs and check interactions among them as can be seen in Figure 64.

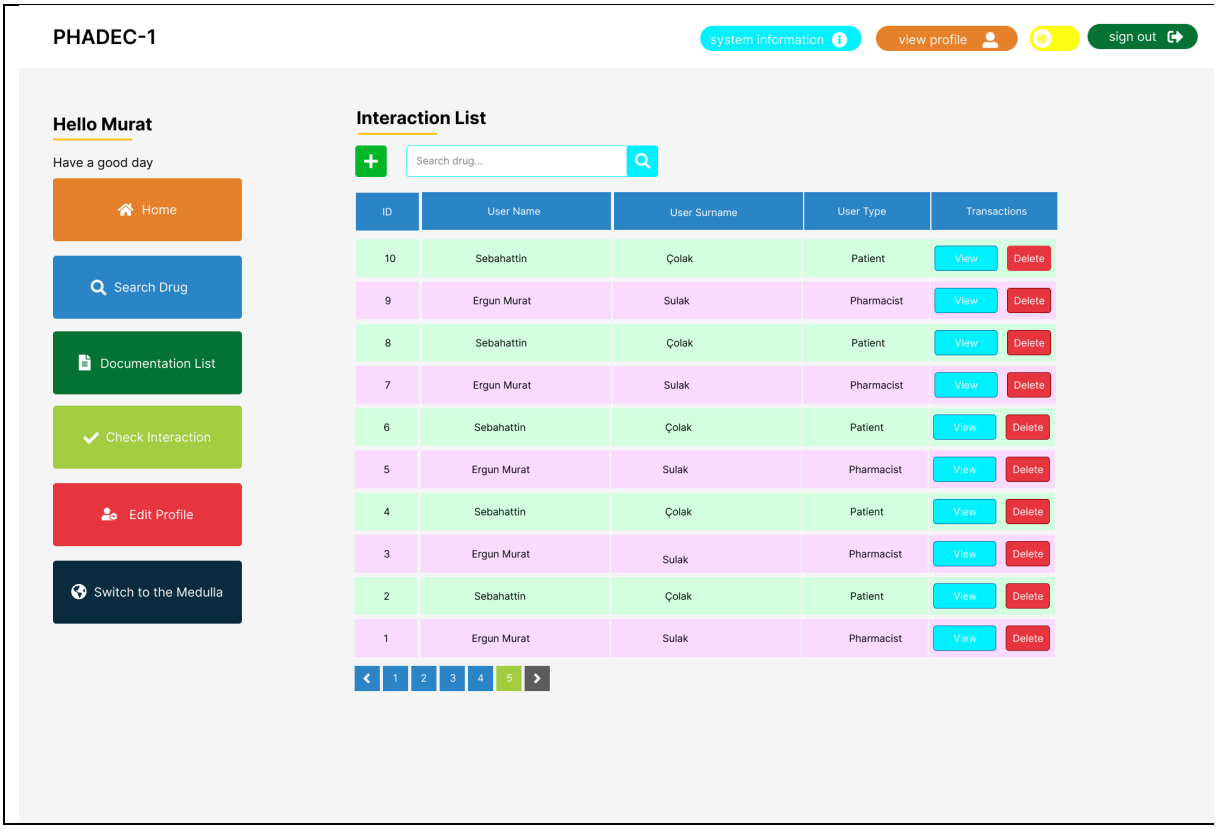



*Figure 64 – Pharmacist Interaction page*

## 4.12 Timetable of PDDS

| ID | Work Breakdown Structure | Start | End | Person | Progress | Dependency | Progress Bar | Days | Work Days |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Contact with preferred supervisors | 27.01.2023 | 03.02.2023 | | 100% | | | 8 | 6 |
| 2 | 1. Submission of project proposals prepared by students and already accepted by their supervisors (e-mail your supervisor) 2. Submission of project preference form including all group members and supervisor (upload from Moodle) | 03.02.2023 | 06.02.2023 | | 100% | | | 4 | 2 |
| 3 | Announcement of project/team allocation results and project kick-offs | 07.02.2023 | 15.02.2023 | | 100% | | | 9 | 7 |
| 4 | Requirements | 16.02.2023 | 17.03.2023 | | 100% | | | 30 | 22 |
| 5 | Intermediate report submission | 16.02.2023 | 19.04.2023 | | 100% | | | 63 | 45 |
| 6 | Code review | 17.03.2023 | 03.05.2023 | | 0% | | | 48 | 34 |
| 7 | Final report submission (for evaluation) | 07.02.2023 | 12.05.2023 | | 0% | | | 95 | 69 |
| 8 | Final report submission (after corrections/modifications) | 13.05.2023 | 29.05.2023 | | 0% | | | 17 | 11 |
| 9 | PROJECT DAY (poster/presentation) | 13.05.2023 | 29.05.2023 | | 0% | | | 17 | 11 |

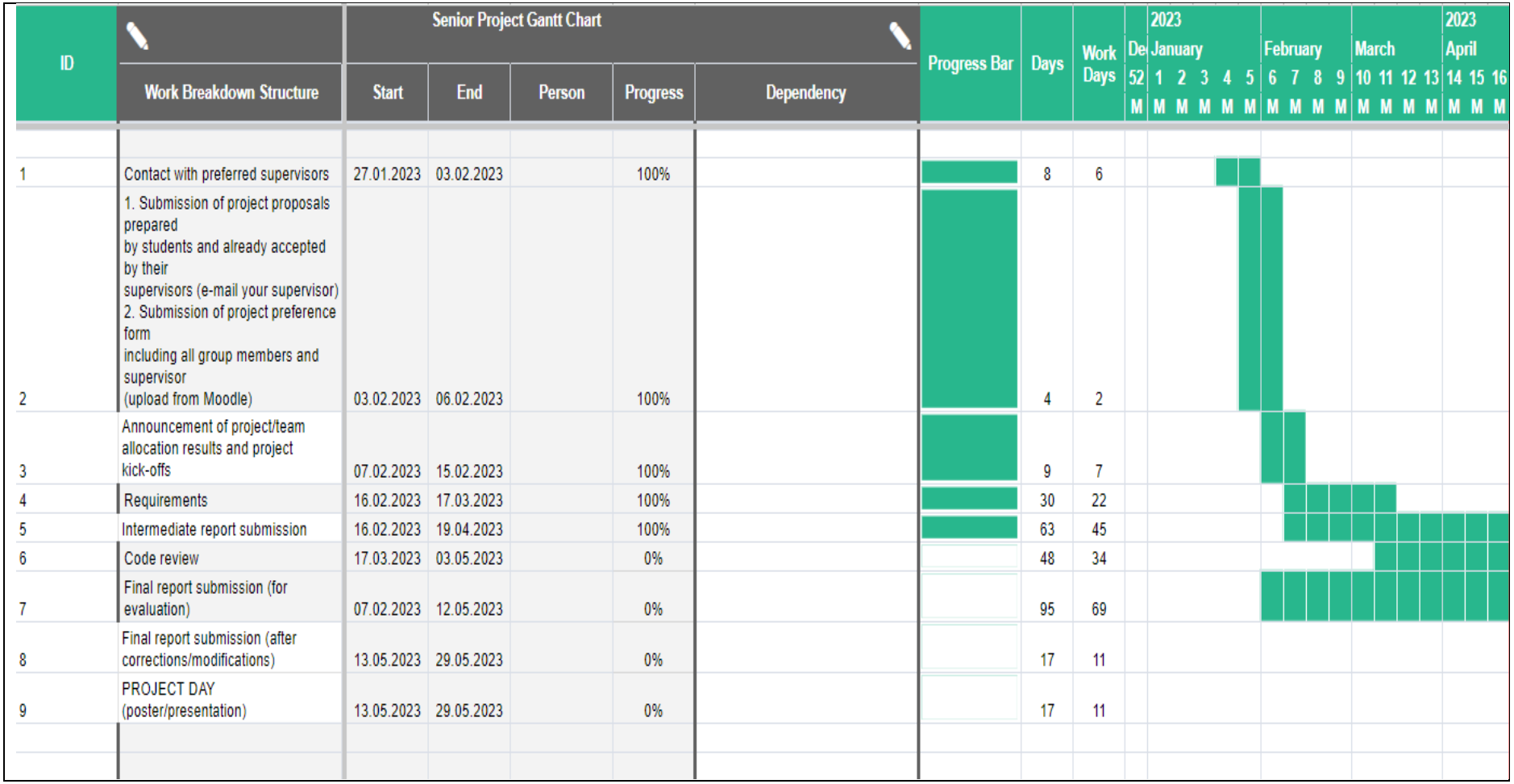



*Figure 65 – Timetable of PDDS*

## 4.13 Task Sharing of PDSS

The responsibilities and methods of collaboration of the members of the project team are crucial for the start, growth, and continuation of software development studies. Each research participant is accountable for completing their tasks on time, making positive contributions to a positive work environment, and sharing information and findings at different phases of the study by showcasing their skills within the parameters of the plan and division of tasks.

The identities of the study participants who will complete each task during the software development study should be established, and all tasks should be organized as distributed tasks. Although all project members are generally responsible for all phases of the project, the responsibilities and duties of each member in the project are given in Table 25.

*Table 25 – Project Members' Tasks & Responsibilities*

| ID | Name and Surname | Tasks and Responsibilities |
|---|---|---|
| 20243510112 | Ali Emre AYGÜN | • Requirement Analysis<br>• System Modeling with UML Diagrams<br>• Entity Relationship Design<br>• Code Development<br>• Testing<br>• Reporting<br>• Documentation<br>• Algorithm Development |
| 20244710105 | Ergun Murat SULAK | • Project Manager<br>• Requirement Analysis<br>• System Modeling with UML Diagrams<br>• Database Implementation<br>• Architecture Design<br>• Testing<br>• Reporting<br>• Documentation<br>• Algorithm Development<br>• Code Development |

| | | |
|---|---|---|
| 18244710058 | Erhan AKTAŞ | • Requirement Analysis<br>• System Modeling with UML Diagrams<br>• User Interface Implementation<br>• User Interface Design<br>• User Interface Implementation<br>• Code Development<br>• Testing<br>• Prototyping |
| 19243510097 | İsmail Mert DEMİROK | • Requirement Analysis<br>• Code Development<br>• System Modeling with UML Diagrams<br>• Entity Relationship Design<br>• Testing<br>• Algorithm Development<br>• Architecture Design |
| 19244710002 | Sebahattin ÇOLAK | • Requirement Analysis<br>• User Interface Implementation<br>• User Interface Design<br>• System Modeling with UML Diagrams<br>• Algorithm Development<br>• Code Development<br>• Testing<br>• Prototyping |

## 4.14 Budget of PDDS

One of the most crucial project processes is budget planning for software development projects. Cost estimation in project management is the process of figuring out how much money will be required to finish the project's activities. Therefore, it is possible to think of software cost estimation as an approach to the financial resources needed to complete the software.

Budget planning for the Pharmacy Decision Support System is presented in Table 26.

*Table 26 – Software License Budget of the Project*

| **Software** | **License fee** | **3- month** |
|---|---|---|
| PostgreSQL | $0 | $0 |
| Microsoft Visual Studio Community Edition | $0 | $0 |
| Visual Studio Code | $0 | $0 |
| Microsoft Windows 10 Pro | $199,00 | $597,00 |
| DBeaver | $0 | $0 |
| | **TOTAL** | **$597,00** |

*Table 27 – Hardware License Budget of the Project*

| **Hardware** | **License fee** | **3- month** |
|---|---|---|
| 5 x Intel Core i7 12$^{th}$ 16GB RAM 1TB SSD | $1.000 | $3.000 |
| Domain (Hostinger.com) | $9,99 | $30,00 |
| Web Hosting | $7,00 | $21,00 |
| | **TOTAL** | **$3.051** |

*Table 28 – Budget Table for Employees of the Project*

| **Employee Role** | **Number of Employees** | **Monthly Fee** | **Working Month** | **Total** |
|---|---|---|---|---|
| **Software Developer** | 2 | $7.600 | 4 | $60.800 |
| **Architecture Designer** | 2 | $4.500 | 1 | $9.000 |
| **Database Designer** | 2 | $3.200 | 3 | $19.200 |
| **Project Manager** | 1 | $9.200 | 4 | $36.800 |
| **User Interface Designer** | 2 | $7.000 | 4 | $56.000 |
| **Software Analyst** | 2 | $2.000 | 3 | $12.000 |
| **Reporting Officer** | 2 | $1.000 | 4 | $8.000 |
| | | | **TOTAL** | **$201.800** |

# 5. Implementation & Test

The Pharmacy Decision Support System (PDSS) is a system that utilizes web browsers. The study's implementation section offers information on the tools used to develop the system. Studies to evaluate the system's accuracy compose the study's test section. The implementation part of the study describes the details of development of the PDSS. The system is implemented in the Visual Studio. ASP.NET CORE MVC and REACT are used as framework for developing the system to run on the web browsers.

## 5.1 Implementation

The implementation part of the study describes the details of development of the PDSS. The system is implemented in the Visual Studio. ASP.NET CORE MVC is used as framework for developing the system to run on the web browsers. REACT is also used as framework. React is a open-source front-end JavaScript library for building user interfaces based on components. JAVASCRIPT, CSS and HTML uses as front end and ASP.NET CORE as backend languages. Database of the PDSS is created through the PostgreSQL.

Pharmacy Decision Support System has three subdomains for both the Pharmacist, the Patient and the Admin. The flow of User Interfaces is depicted in the figure 66.

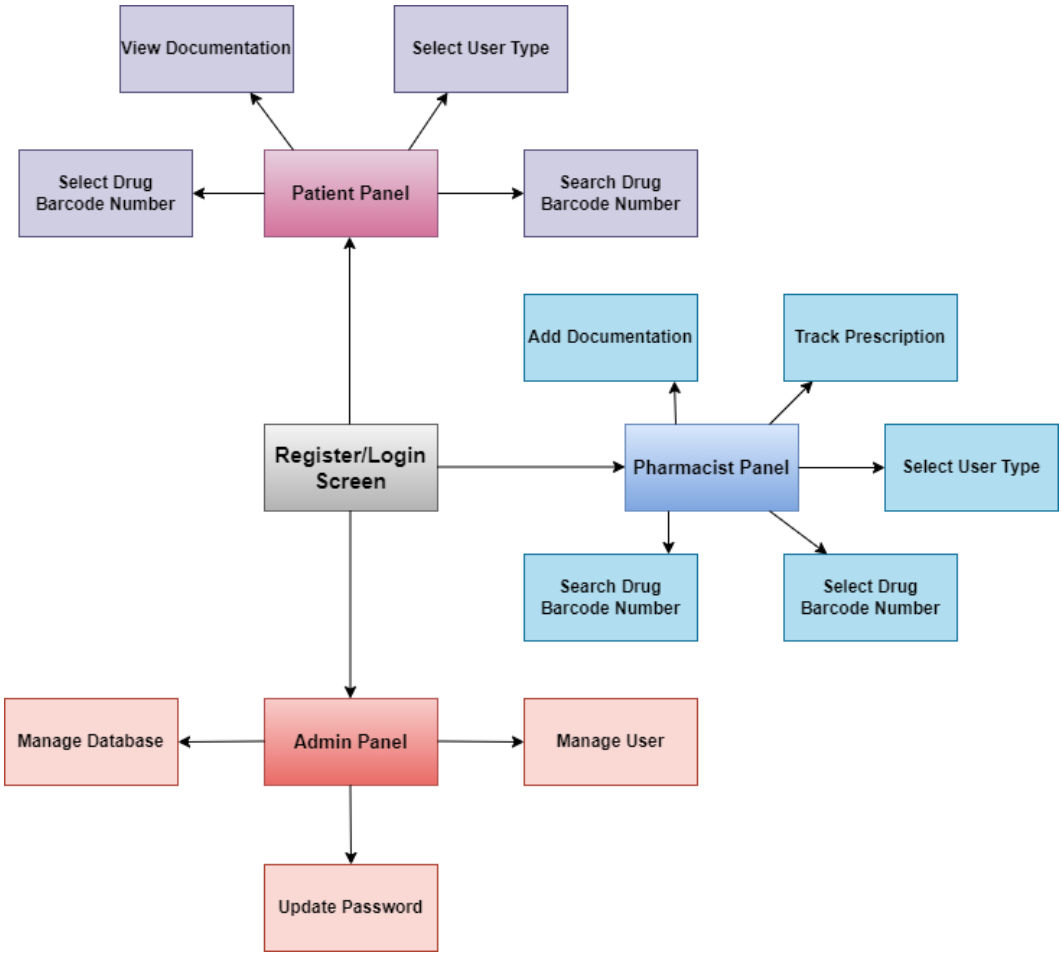



*Figure 66 – UI flow of PDSS*

Pharmacy Decision Support System is developed as layered architecture. It is a structure that enables programmers to create layered architectural projects in accordance with a predetermined standard, improve code readability, tidy up the projects, and simplify error handling. While the developers are required to repeatedly repeat the codes written on the form applications created for the research, the system's structure is fragmented owing to the layered design, increasing the system's durability. PDSS has four different layers. These layers are Presentation Layer, Control Layer, Business Layer and Data Layer.

**Presentation Layer**

The top layer is called Presentation Layer. This layer provides communication with the system's user. The user's requests and data are transmitted to the Data Layer through the intermediary levels from this layer, where the interfaces made using REACT are situated. The answers to the

user's queries are taken out of the Data Layer and conveyed through the intermediary levels to the Presentation Layer. The Presentation Layer shows the user this sent data.

**Control Layer**

The layer after Presentation Layer is the Control Layer. This layer comprises control classes and communicates with the relevant classes in the Business Layer by sending or receiving user requests and data from the Presentation Layer. It establishes the route between the user interface classes and entity classes, to put it briefly.

**Business Layer**

The layer between the Data Layer and the Control Layer is called the Business Layer. In this tier, entity classes are present. The applicable class is used to process and transport the data that was transmitted across the Control Layer to the Data Layer. The data that is transferred through the Data Layer, on the other hand, is processed in the same manner and sent to the user through the intermediary levels. Without the business layer, it is impossible to access the data layer.

**Data Layer**

The bottom layer is called the Data Layer. Data processing, deletion, updating, and withdrawal from the database are all carried out on this layer. Other than the activities listed, this layer cannot be utilized for any other actions.

## 5.2 Testing

In the testing section, detailed information is provided about the test methods employed and the expected and actual results of these tests.

Following the planning phase of the computer program Plan Archive for PDSS, which followed the waterfall strategy, the execution stage began after documenting the requirements and arrangements. As the project progressed, the system became more concrete, making it easier to identify any mistakes that were made. The testing phase is where these errors are fully uncovered. After this final arrangement, a test report was prepared, and any mistakes were rectified by going back to the necessary steps.

The first test strategy used is Unit Testing. It involves checking if the smallest program components, such as individual functions or methods (course behaviors), work

correctly when given specific inputs and produce the expected output. By testing the small units of the program, unit tests ensure that the components function correctly within themselves and contribute to the overall functionality of the program.

The second test method is Alpha Testing. It focuses on evaluating the parts of the program that need to be corrected or modified based on the user-oriented actions that the client will perform. The designers themselves use the program and perform the actions that the users would typically do. Alpha Testing ensures that the program meets the requirements set for it.

White Box Testing is another strategy employed, which involves examining the internal structure of the system or component. In this case, it specifically refers to testing the code itself. The input-output behavior and code design of the PDSS program were checked to ensure that the code is functioning correctly. The expected values from the initial table, the values from manual assignments in the second table, and the results produced by the implemented system in the third table are all presented. A detailed comparison is made between the manual task results and the PDSS task results.

The final test strategy is the Dark Box test. Unlike White Box Testing, this method does not focus on the code and design aspects. Instead, it carries out tests based on the requirements and functionality of the system. Throughout the implementation phase, the system's requirements and its responsiveness to those requirements were continuously emphasized and tested.

*Interaction Detection*

Verify that the system correctly identifies potential drug-drug interactions in a prescription. Input a prescription containing two or more medications known to have a drug-drug interaction. Verify that the system detects and displays the interaction alert or warning. Confirm that the alert provides relevant information about the interaction, such as severity, consequences, and recommended actions.

*Food Interaction Warning*

Validate if the system provides appropriate alerts for drug-food interactions. Input a prescription containing a medication with known food interaction. Verify that the system

detects the presence of a drug-food interaction. Confirm that the system displays a warning or alert indicating the specific food to avoid or precautions to take.

*Allergy and Contraindication Check*

Ensure that the system checks for potential allergies or contraindications before suggesting a medication. Input a prescription with a medication to which the patient is known to be allergic. Verify that the system identifies the allergy and provides an appropriate warning. Confirm that the system suggests an alternative medication that does not pose a risk of allergy or contraindication.

*Disease-Specific Product Recommendation*

Verify that the system suggests appropriate products based on the patient's specific disease. Input a patient's disease information (e.g., diabetes, hypertension, asthma). Verify that the system recognizes the disease and displays relevant product recommendations. Confirm that the recommended products are suitable for managing or treating the specific disease.

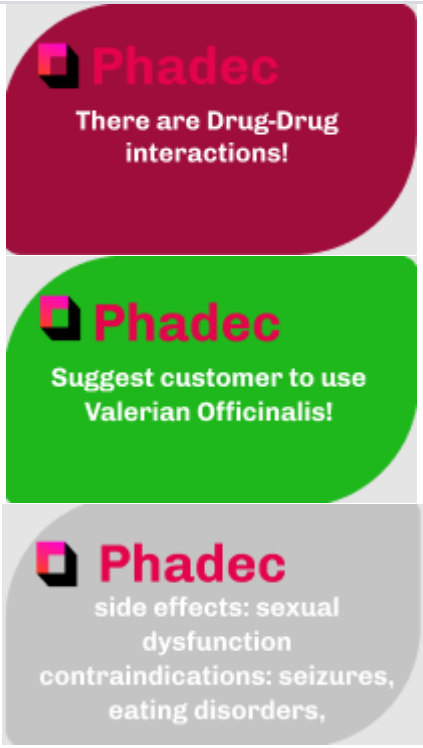
*Table 29 – Testing of Prescription Test Cases*

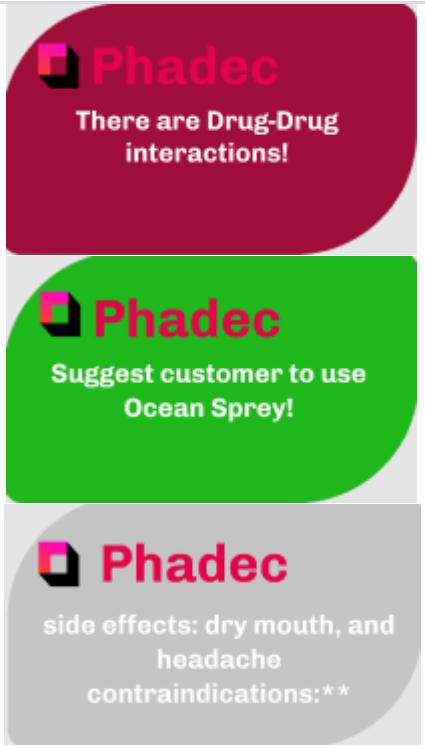
| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 1 | Hypertension | |  |
| | Drug: Amlodipine | | |
| | Drug: Lisinopril | | |
| | Food Interaction: None | | |
| | Drug-Drug Interaction: | - Amlodipine and Lisinopril may cause hypotension (low blood pressure) when taken together. | |
| | | - Monitor for signs of hypotension such as dizziness, lightheadedness, and weakness. | |
| | Suggested Product: | - Suggest a low-sodium diet to complement the medication. | |
| | Side Effects: | - Amlodipine: Common side effects may include edema (swelling), flushing, headache, and dizziness. | |
| | | - Lisinopril: Common side effects may include dizziness, headache, cough, and gastrointestinal issues. | |
| | Contraindications: | - Amlodipine: Contraindicated in patients with known hypersensitivity to dihydropyridine calcium channel blockers. | |
| | | - Lisinopril: Contraindicated in patients with a history of angioedema or hypersensitivity to ACE inhibitors. | |

| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 2 | Diabet | |  |
| | Drug: Metformin | | |
| | Drug: Sitagliptin | | |
| | Food Interaction: | - Avoid consuming excessive alcohol while taking Metformin to prevent a potential increase in the risk of lactic acidosis. | |
| | Drug-Drug | - Metformin may interact with Sitagliptin, leading to an increased risk of hypoglycemia (low blood sugar) | |
| | Interaction: | - Monitor blood glucose levels regularly and adjust dosage as necessary. | |
| | Suggested Product: | - Recommend a balanced diet with controlled carbohydrate intake and regular exercise. | |
| | Side Effects: | - Metformin: Common side effects may include gastrointestinal issues like nausea, diarrhea, and abdominal discomfort. | |
| | | - Sitagliptin: Common side effects may include upper respiratory tract infections, headache, and gastrointestinal upset. | |
| | Contraindications: | - Metformin: Contraindicated in patients with severe kidney disease or renal impairment. | |
| | | - Sitagliptin: Contraindicated in patients with a history of hypersensitivity reactions to the medication. | |

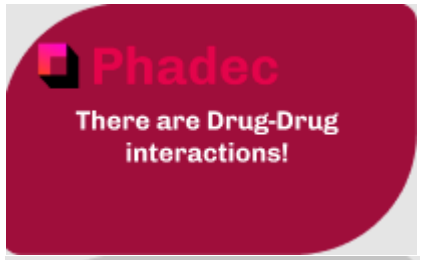
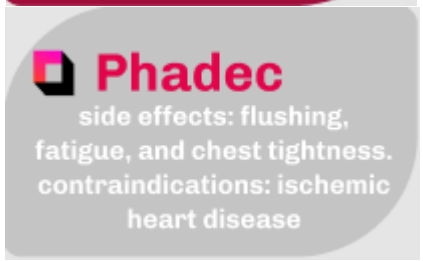
| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 3 | Asthma | |  |
| | Drug: Albuterol | | |
| | Drug: Fluticasone | | |
| | Food Interaction: | - No specific food interactions reported for Albuterol and Fluticasone. | |
| | Drug-Drug | - Albuterol and Fluticasone can be used together to manage asthma symptoms effectively. | |
| | Interaction: | | |
| | Suggested Product: | - Recommend a spacer device for the inhaler to improve drug delivery to the lungs and optimize asthma control. | |
| | Side Effects: | - Albuterol: Common side effects may include tremors, palpitations, increased heart rate, and headache. | |
| | | - Fluticasone: Common side effects may include nasal irritation, sore throat, and fungal infections in the mouth or throat (thrush). | |
| | Contraindications: | - Albuterol: Contraindicated in patients with a history of hypersensitivity to sympathomimetic amines. | |
| | | - Fluticasone: Contraindicated in patients with a known hypersensitivity to corticosteroids or any of the product's ingredients. | |

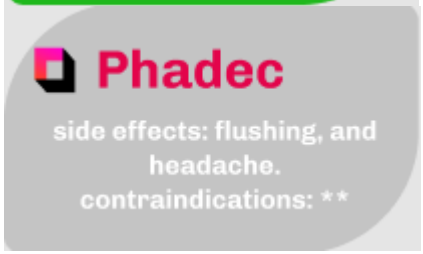
| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 4 | Insomnia | |  |
| | Drug: Zolpidem | | |
| | Food Interaction: | - Avoid consuming high-fat meals before taking Zolpidem as it may delay the onset of action. | |
| | Drug-Drug | - Zolpidem may interact with other central nervous system depressants, such as benzodiazepines or opioids, leading to sedation. | |
| | Interaction: | - Caution should be exercised when combining Zolpidem with other sedative medications. | |
| | Suggested Product: | - Suggest practicing good sleep hygiene, such as maintaining a regular sleep schedule, creating a comfortable sleep environment. | |
| | Side Effects: | - Common side effects of Zolpidem may include drowsiness, dizziness, confusion, and coordination difficulties. | |
| | Contraindications: | - Contraindicated in patients with a known hypersensitivity to Zolpidem or those with a history of sleepwalking or complex sleep behaviors. | |

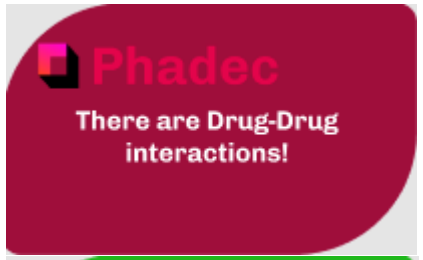
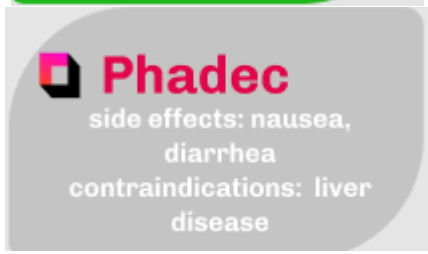
| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 5 | Depression | |  |
| | Drug: Sertraline | | |
| | Drug: Bupropion | | |
| | Food Interaction: | - No significant food interactions reported for Sertraline and Bupropion. | |
| | Drug-Drug | - Sertraline and Bupropion may increase the risk of serotonin syndrome when used together. | |
| | Interaction: | - Careful monitoring is required for symptoms such as agitation, tremors, sweating, and rapid heartbeat. | |
| | Suggested Product: | - Suggest regular therapy sessions and lifestyle modifications to complement medication and manage depression effectively. | |
| | Side Effects: | - Common side effects of Sertraline may include gastrointestinal issues, sexual dysfunction, insomnia, and drowsiness. | |
| | | - Common side effects of Bupropion may include dry mouth, insomnia, headache, and gastrointestinal discomfort. | |
| | Contraindications: | - Sertraline: Contraindicated in patients taking monoamine oxidase inhibitors (MAOIs) or those with a known hypersensitivity to the drug. | |
| | | - Bupropion: Contraindicated in patients with a history of seizures, eating disorders, or abrupt discontinuation of alcohol or sedatives. | |

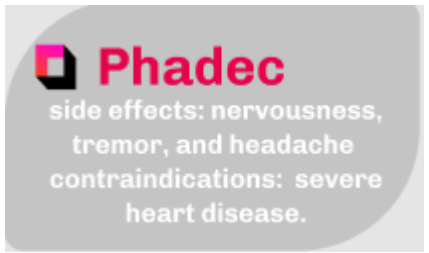
| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 6 | Allergic Rhinitis | |  |
| | Drug: Loratadine | | |
| | Drug: Fluticasone | | |
| | Food Interaction: | - No specific food interactions reported for Loratadine and Fluticasone. | |
| | Drug-Drug | - Loratadine and Fluticasone can be used together to manage allergic rhinitis symptoms effectively. | |
| | Interaction: | | |
| | Suggested Product: | - Recommend avoiding known allergens, implementing environmental control measures, and using saline nasal sprays for symptom relief. | |
| | Side Effects: | - Common side effects of Loratadine may include drowsiness, dry mouth, and headache. | |
| | | - Common side effects of Fluticasone may include nasal irritation, sore throat, and fungal infections in the mouth or throat. | |
| | Contraindications: | - Loratadine: Contraindicated in patients with a known hypersensitivity to the drug or its ingredients. | |
| | | - Fluticasone: Contraindicated in patients with a known hypersensitivity to corticosteroids or any of the product's ingredients. | |

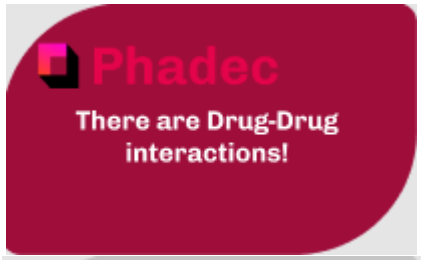
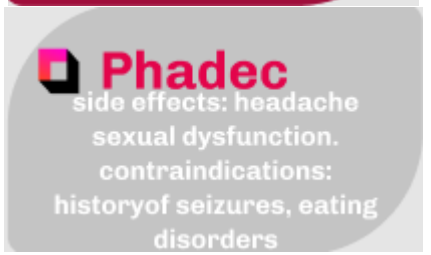
| Test Case No | Prescriptions | Expected Result | Actual result |
|---|---|---|---|
| 7 | GERD | |  |
| | Drug: Omeprazole | | |
| | Drug: Ranitidine | | |
| | Food Interaction: | - No specific food interactions reported for Omeprazole and Ranitidine. | |
| | Drug-Drug | - Omeprazole and Ranitidine should not be used together as they both work to reduce stomach acid, potentially leading to an excess. | |
| | Interaction: | - Recommend discontinuing Ranitidine if switching to Omeprazole for better symptom management. | |
| | Suggested Product: | - Suggest avoiding trigger foods, maintaining an upright posture after meals, and raising the head of the bed for symptom relief. | |
| | Side Effects: | - Common side effects of Omeprazole may include headache, abdominal pain, diarrhea, and nausea. | |
| | | - Common side effects of Ranitidine may include headache, dizziness, diarrhea, and constipation. | |
| | Contraindications: | - Omeprazole: Contraindicated in patients with a known hypersensitivity to the drug or its ingredients. | |
| | | - Ranitidine: Contraindicated in patients with a known hypersensitivity to the drug or any of its ingredients. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

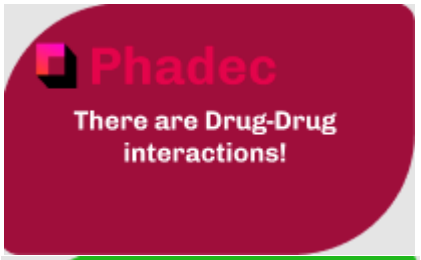
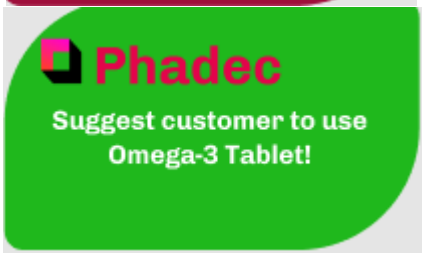
| | | | |
|---|---|---|---|
| 8 | Migraine | |     |
| | Drug: Sumatriptan | | |
| | Drug: Propranolol | | |
| | Food Interaction: | - No specific food interactions reported for Sumatriptan and Propranolol. | |
| | Drug-Drug | - Sumatriptan and Propranolol should not be used together due to the potential for an increased risk of vasoconstriction and reduced therapeutic effect. | |
| | Interaction: | - Recommend using Sumatriptan as an acute treatment for migraines and Propranolol as a preventive measure. | |
| | Suggested Product: | - Suggest implementing lifestyle modifications like stress management techniques and regular sleep patterns to help manage migraines. | |
| | Side Effects: | - Common side effects of Sumatriptan may include dizziness, flushing, fatigue, and chest tightness. | |
| | | - Common side effects of Propranolol may include fatigue, dizziness, gastrointestinal issues, and low blood pressure. | |
| | Contraindications: | - Sumatriptan: Contraindicated in patients with a history of coronary artery disease, ischemic heart disease, or uncontrolled hypertension. | |
| | | - Propranolol: Contraindicated in patients with a history of bronchial asthma, | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

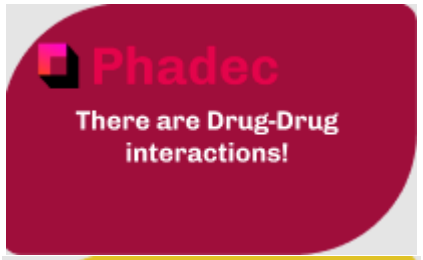
| | | | |
|---|---|---|---|
| 9 | Hypertension | |  <br>  <br>  |
| | Drug: Amlodipine | | |
| | Drug: Lisinopril | | |
| | Food Interaction: | - No specific food interactions reported for Amlodipine and Lisinopril. | |
| | Drug-Drug | - Amlodipine and Lisinopril can be used together as they work through different mechanisms to lower blood pressure. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest maintaining a healthy lifestyle, including regular exercise, a low-sodium diet, and stress management techniques, for blood pressure control. | |
| | Side Effects: | - Common side effects of Amlodipine may include dizziness, edema, flushing, and headache. | |
| | | - Common side effects of Lisinopril may include cough, dizziness, headache, and gastrointestinal issues. | |
| | Contraindications: | - Amlodipine: Contraindicated in patients with a known hypersensitivity to the drug or severe aortic stenosis. | |
| | | - Lisinopril: Contraindicated in patients with a history of angioedema or hypersensitivity to angiotensin-converting enzyme (ACE) inhibitors. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

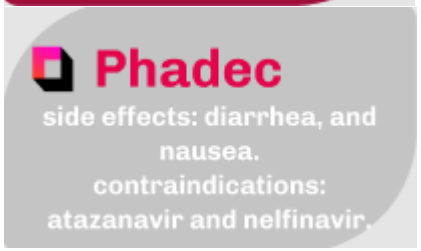
| | | | |
|---|---|---|---|
| 10 | Type 2 Diabetes | |  <br>  <br>  |
| | Drug: Metformin | | |
| | Drug: Sitagliptin | | |
| | Food Interaction: | - No specific food interactions reported for Metformin and Sitagliptin. | |
| | Drug-Drug | - Metformin and Sitagliptin can be used together to manage blood sugar levels in patients with type 2 diabetes. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest maintaining a healthy diet, regular physical activity, and regular monitoring of blood sugar levels. | |
| | Side Effects: | - Common side effects of Metformin may include gastrointestinal issues such as nausea, diarrhea, and stomach upset. | |
| | | - Common side effects of Sitagliptin may include upper respiratory tract infections, headache, and gastrointestinal discomfort. | |
| | Contraindications: | - Metformin: Contraindicated in patients with renal impairment, liver disease, or known hypersensitivity to the drug. | |
| | | - Sitagliptin: Contraindicated in patients with a history of pancreatitis or a known hypersensitivity to the drug. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 11 | Asthma | |  <br>  |
| | Drug: Albuterol | | |
| | Drug: Fluticasone | | |
| | Food Interaction: | - No specific food interactions reported for Albuterol and Fluticasone. | |
| | Drug-Drug | - Albuterol and Fluticasone can be used together as part of an asthma management regimen. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest avoiding triggers that worsen asthma symptoms, having an asthma action plan, and regularly monitoring lung function. | |
| | Side Effects: | - Common side effects of Albuterol may include increased heart rate, nervousness, tremor, and headache. | |
| | | - Common side effects of Fluticasone may include nasal irritation, sore throat, and fungal infections in the mouth or throat. | |
| | Contraindications: | - Albuterol: Contraindicated in patients with a known hypersensitivity to the drug or severe heart disease. | |
| | | - Fluticasone: Contraindicated in patients with a known hypersensitivity to corticosteroids or any of the product's ingredients. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

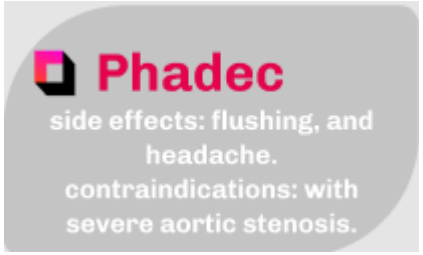
| | | | |
|---|---|---|---|
| 12 | Depression | |     |
| | Drug: Sertraline | | |
| | Drug: Bupropion | | |
| | Food Interaction: | - No specific food interactions reported for Sertraline and Bupropion. | |
| | Drug-Drug | - Sertraline and Bupropion can be used together for the treatment of depression, but caution should be exercised due to the potential for drug-drug interactions. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest engaging in regular exercise, maintaining a supportive social network, and practicing stress reduction techniques for managing depression. | |
| | Side Effects: | - Common side effects of Sertraline may include nausea, insomnia, headache, and sexual dysfunction. | |
| | | - Common side effects of Bupropion may include dry mouth, insomnia, headache, and nausea. | |
| | Contraindications: | - Sertraline: Contraindicated in patients with a known hypersensitivity to the drug or those taking MAO inhibitors. | |
| | | - Bupropion: Contraindicated in patients with a history of seizures, eating disorders, or those undergoing abrupt discontinuation of alcohol or sedatives. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 13 | Insomnia | |  <br>  <br>  |
| | Drug: Zolpidem | | |
| | Drug: Melatonin | | |
| | Food Interaction: | - No specific food interactions reported for Zolpidem and Melatonin. | |
| | Drug-Drug | - Zolpidem and Melatonin can be used together to manage insomnia, but caution should be exercised due to the potential for additive sedative effects. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest maintaining a regular sleep schedule, creating a relaxing bedtime routine, and implementing good sleep hygiene practices for better sleep quality. | |
| | Side Effects: | - Common side effects of Zolpidem may include drowsiness, dizziness, headache, and gastrointestinal issues. | |
| | | - Common side effects of Melatonin may include daytime sleepiness, headache, and dizziness. | |
| | Contraindications: | - Zolpidem: Contraindicated in patients with a known hypersensitivity to the drug or those with respiratory depression. | |
| | | - Melatonin: Contraindicated in patients with a known hypersensitivity to the drug or those with autoimmune diseases or bleeding disorders. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

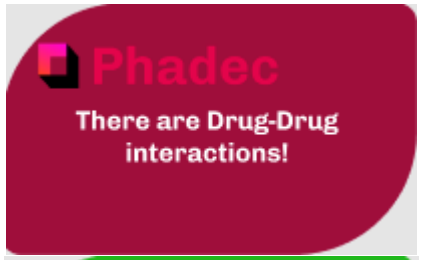
| | | | |
|---|---|---|---|
| 14 | Allergies | |  <br>  |
| | Drug: Loratadine | | |
| | Drug: Fluticasone | | |
| | Food Interaction: | - Do not take with Alcohool | |
| | Drug-Drug | - Loratadine and Fluticasone can be used together to manage allergy symptoms. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest avoiding known allergens, implementing environmental controls, and considering allergen immunotherapy for long-term symptom relief. | |
| | Side Effects: | - Common side effects of Loratadine may include headache, dry mouth, and fatigue. | |
| | | - Common side effects of Fluticasone may include nasal irritation, sore throat, and fungal infections in the mouth or throat. | |
| | Contraindications: | - Loratadine: Contraindicated in patients with a known hypersensitivity to the drug or its ingredients. | |
| | | - Fluticasone: Contraindicated in patients with a known hypersensitivity to corticosteroids or any of the product's ingredients. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 15 | Acid Reflux | |  <br>  |
| | Drug: Omeprazole | | |
| | Drug: Ranitidine | | |
| | Food Interaction: | - No specific food interactions reported for Omeprazole and Ranitidine. | |
| | Drug-Drug | - Omeprazole and Ranitidine can be used together to manage acid reflux symptoms. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest avoiding triggers that worsen acid reflux symptoms, eating smaller meals, and maintaining an upright posture after eating. | |
| | Side Effects: | - Common side effects of Omeprazole may include headache, abdominal pain, diarrhea, and nausea. | |
| | | - Common side effects of Ranitidine may include headache, dizziness, and gastrointestinal discomfort. | |
| | Contraindications: | - Omeprazole: Contraindicated in patients with a known hypersensitivity to the drug or those taking certain medications, such as atazanavir and nelfinavir. | |
| | | - Ranitidine: Contraindicated in patients with a known hypersensitivity to the drug or those with acute porphyria. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 16 | Migraines | | |
| | Drug: Sumatriptan | | |
| | Drug: Propranolol | | |
| | Food Interaction: | - No specific food interactions reported for Sumatriptan and Propranolol. | |
| | Drug-Drug | - No specific food interactions reported for Sumatriptan and Propranolol. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest identifying and avoiding triggers that can provoke migraines, maintaining a regular sleep schedule, and managing stress levels. | |
| | Side Effects: | - Common side effects of Sumatriptan may include tingling, dizziness, and muscle weakness. | |
| | | - Common side effects of Propranolol may include fatigue, dizziness, and gastrointestinal issues. | |
| | Contraindications: | - Sumatriptan: Contraindicated in patients with a known hypersensitivity to the drug or those with severe coronary artery disease. | |
| | | - Propranolol: Contraindicated in patients with a known hypersensitivity to the drug, those with asthma, or those with certain heart conditions. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 17 | Hypertension | |  <br>  |
| | Drug: Amlodipine | | |
| | Drug: Lisinopril | | |
| | Food Interaction: | - No specific food interactions reported for Amlodipine and Lisinopril. | |
| | Drug-Drug | - Amlodipine and Lisinopril can be used together to manage hypertension. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest adopting a healthy lifestyle including a low-sodium diet, regular exercise, and stress reduction techniques to manage hypertension. | |
| | Side Effects: | - Common side effects of Amlodipine may include swelling in the ankles or feet, flushing, and headache. | |
| | | - Common side effects of Lisinopril may include dizziness, cough, and gastrointestinal issues. | |
| | Contraindications: | - Amlodipine: Contraindicated in patients with a known hypersensitivity to the drug or those with severe aortic stenosis. | |
| | | - Lisinopril: Contraindicated in patients with a known hypersensitivity to the drug or those with a history of angioedema. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 18 | Diabetes | |   |
| | Drug: Metformin | | |
| | Drug: Insulin | | |
| | Food Interaction: | - No specific food interactions reported for Metformin and Insulin. | |
| | Drug-Drug | - No specific food interactions reported for Metformin and Insulin. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest following a balanced diet, regular exercise, and monitoring blood sugar levels. | |
| | Side Effects: | - Common side effects of Metformin may include gastrointestinal issues, such as diarrhea and stomach upset. | |
| | | - Common side effects of Insulin may include hypoglycemia (low blood sugar), weight gain, and injection site reactions. | |
| | Contraindications: | - Metformin: Contraindicated in patients with a known hypersensitivity to the drug or those with severe kidney impairment or metabolic acidosis. | |
| | | - Insulin: Contraindicated in patients with a known hypersensitivity to the drug or those with hypoglycemia unawareness or hypersensitivity to any of its components. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | | |
|---|---|---|---|
| 19 | Asthma | |  <br>  |
| | Drug: Albuterol | | |
| | Drug: Fluticasone | | |
| | Food Interaction: | - No specific food interactions reported for Albuterol and Fluticasone. | |
| | Drug-Drug | - Albuterol and Fluticasone can be used together for managing asthma symptoms. | |
| | Interaction: | | |
| | Suggested Product: | - Suggest avoiding triggers that can provoke asthma symptoms, using a peak flow meter to monitor lung function, and having a written asthma action plan. | |
| | Side Effects: | - Common side effects of Albuterol may include tremors, increased heart rate, and headache. | |
| | | - Common side effects of Fluticasone may include nasal irritation, sore throat, and fungal infections in the mouth or throat. | |
| | Contraindications: | - Albuterol: Contraindicated in patients with a known hypersensitivity to the drug or those with severe cardiovascular disorders. | |
| | | - Fluticasone: Contraindicated in patients with a known hypersensitivity to corticosteroids or any of the product's ingredients. | |
| **Test Case No** | **Prescriptions** | **Expected Result** | **Actual result** |

| | | |
|---|---|---|
| 20 | Depression | |
| | Drug: Sertraline | |
| | Drug: Bupropion | |
| | Food Interaction: | - No specific food interactions reported for Sertraline and Bupropion. |
| | Drug-Drug | - Sertraline and Bupropion can be used together for managing depression. |
| | Interaction: | |
| | Suggested Product: | - Suggest engaging in regular physical activity, practicing relaxation techniques, and considering therapy or counseling for comprehensive treatment. |
| | Side Effects: | - Common side effects of Sertraline may include nausea, diarrhea, and sexual dysfunction. |
| | | - Common side effects of Bupropion may include dry mouth, headache, and insomnia. |
| | Contraindications: | - Sertraline: Contraindicated in patients with a known hypersensitivity to the drug or those taking MAO inhibitors. |
| | | - Bupropion: Contraindicated in patients with a known hypersensitivity to the drug or those with a seizure disorder or an eating disorder. |

Based on table 29 test cases the testing results phase of the pharmacy decision support system can be evaluated as follows:

Test coverage: The test cases cover a range of scenarios involving different medical conditions, such as allergies, acid reflux, migraines, hypertension, diabetes, asthma, and depression. This ensures that the system is tested for various scenarios and conditions.

Drug interactions: The expected results include identifying drug interactions between different medications prescribed for specific medical conditions. This shows that the system is capable of detecting potential interactions and providing appropriate recommendations.

Food interactions: The test cases also consider potential food interactions with the prescribed medications. This indicates that the system considers the impact of food on medication effectiveness and safety.

Product suggestions: The expected results provide suggestions for suitable products or management approaches based on the given medical condition. This demonstrates that the system can offer relevant recommendations for addressing specific health concerns.

Side effects: The expected results include potential side effects associated with the prescribed medications. This shows that the system considers and communicates the possible adverse effects of the medications to the users.

Contraindications: The test cases identify contraindications for certain medications based on known allergies or other medical conditions. This highlights the system's ability to recognize situations where certain medications should be avoided.

In the table 29 above several critical test cases should be considered. The first set of test cases focuses on the system's ability to detect drug-drug and drug-food interactions accurately. It involves verifying if the system can correctly identify potential interactions, provide appropriate warnings to users, and maintain an accuracy rate of above 98%. This ensures that the system effectively assists healthcare professionals and patients in avoiding potentially harmful combinations.

The next set of test cases examines how the system handles scenarios where no suggestions are available (Test Cases 16 and 18). It is important to evaluate whether the system appropriately handles these situations without providing misleading or incorrect suggestions. By ensuring the system responds appropriately when suggestions are not available, users can rely on accurate information and avoid potentially harmful decisions.

Additionally, evaluating the system's ability to provide product suggestions for disease protection is crucial. This test case assesses the accuracy of the system's recommendations for specific products that can help prevent or manage diseases. By maintaining an accuracy rate above crical rate, the system can offer valuable guidance to patients and healthcare professionals, facilitating informed decision-making. Considering potential challenges such as value contradictions and missing side effect information is essential. Test cases that intentionally introduce value contradictions and evaluate how the system handles them help ensure that conflicting information is appropriately flagged and addressed. Similarly, test cases involving missing side effect information assess the system's ability to provide relevant warnings and suggestions based on the available data, avoiding false negatives or misleading information.

Overall, based on the test cases, the Pharmacy Decision Support System appears to be providing reliable and valuable information regarding drug interactions, food interactions, suggested products, side effects, and contraindications. However, it is important to note that this evaluation is based on the specific test cases provided, and a comprehensive assessment would require additional testing with a wider range of medications and conditions.

## 6. Evaluation

**Problem**

- The completeness and correctness of the data used by PDSS can affect how reliable the system's recommendations are.
- Since the Agile methodology is used, the system needs to be updated constantly in accordance with the requirements of pharmacists and this might be costly.

**Performance**

- Transition of the system's interface and database processes such as data addition, and data extraction transitions are fast enough and efficient.
- The amount of data being added to the database has a direct correlation with how quickly the system is currently operating. The given speed may not be guaranteed to remain constant as the amount of data used grows.

**Usability**

- User-friendly system interface design is implemented.
- Although it is necessary to read the user manual and directions to use the system most efficiently, all the buttons and tabs in the interface are sufficiently understandable and easy to use with minimal training.
- The headlines, buttons, and error or warning messages used in the interface are compatible and simple to grasp.

**Deployment**

- Internet access is required to access the system.
- Any browser can be used by users to access the system without having to download it on their computer.
- PDDS is compatible with a variety of operating systems such as Windows, Linux, macOS, etc.
- In order for all users to have access to the database, a connection to the service provider must be made available.

**Maintenance**

- Regular maintenance and updates should be changed to make it easily manageable and to ensure that the system remains up-to-date and effective.
- In order for pharmacists to do their job without disruption, new testing methods will be implemented where it can be done more quickly.

**Backup & Recovery**

- The information of the system is uploaded to the database version by version and the previous version is easy to view if a problem is encountered.

**Security**

- At the start of the system, the usernames of users who can register are added to the database; nobody else has access to the system outside of these users.
- The system is only accessible to approved pharmacists, who must validate their login and password before logging in.
- To protect patient privacy, access to the database is restricted to certain individuals and under surveillance.
- An email with a verification number is provided to users who have forgotten their passwords, and a password renewal is carried out.

# 7. Impact of the Project & Compliance with the Constraints

## 7.1 Compliance with the Realistic Constrains

The minimum restrictions required by the system were determined at the beginning of the project, the resources used during the creation of the project is presented in Table 30.

*Table 30 – Realistic Constraints & Conditions*

| **Economic Factors** | |
|---|---|
| | |
| **EXPENDITURES** | |
| Computer | When the system development and preparation report personal computers of team members was used. |
| Other Devices | NA |
| Peripherals | NA |
| Internet Connection | Team member used their own internet connection. |
| Software | Visual Studio Code was used for front-end part, DBeaver was used to back-end part and Trello was used for the business planning part. |
| Textbook/Magazine/Support Material | NA |
| Human Resources | Human resource of our team consists of 5 people |
| Other | NA |
| | |
| **FUNDING Sources** | |
| University Resources | NA |
| Project support (SANTEZ, TÜBİTAK, and so on) | NA |
| Support by the Industry | NA |
| Self-funded | NA |
| Other sources | NA |
| | |
| **OTHER CONSTRAINTS** | |

| | |
|---|---|
| Memory | The system we have created has been designed and coded in such a way that the minimum pharmacist computers meet the requirements of the system. |
| Runtime efficiency | Working time efficiency is met in an appropriate way. |
| | |
| **MANAGERIAL** | |
| Schedule (time) | The project was completed in 16 weeks. |

## 7.2 Impact of the Project

The expected result of this project is to solve the drug-drug interaction in the most detailed way, to ensure that people benefit from drugs in the most efficient way, and to facilitate the work of pharmacists to help with drug selection and drug-drug interaction as can be seen in Table 31.

*Table 31 – Impact Assessment Report*

| **Professional/Ethical Issues** | **Please specify/explain (existence of items, violation of items, awareness about items)** |
|---|---|
| | |
| **ETHICS/IT Law** | |
| Copyright in copying multimedia (sound, video, text) | NA |
| Use of licensed software | Visual Studio Code,DBeaver,Trello |
| Data Privacy | The articles and information used in the system are open to everyone and references are available.No one's personal data and articles have been used, all the resources used are open to everyone. |
| Use of patented products/ideas | NA |
| IT Laws in Turkey (5661 and others) | There are no circumstances that infringe upon any legal regulations. |
| IT Laws - International | There are no circumstances that infringe upon any legal regulations. |

| | |
|---|---|
| Plagiarism | There are no circumstances that infringe upon any legal regulations. |
| | |
| **PROFESSIONAL** | |
| Sustainability (use of Licensed and/or open source code) | All the codes used in the system are written by team members, it is not possible to import and use code from an open source or closed source, the system is encoded as private for data and code security. |
| Maintenance | The system we have designed is designed to be easy to maintain, and care can be provided in future periods for the health of feedback received from pharmacists. |
| Liability | Admin is responsible for the management of the system and users.<br>The pharmacist is responsible for using the system effectively and ensuring that the patient is not affected by the drug-drug interaction.<br>Developers are responsible for ensuring that the system can be operated properly and that there are no errors. |
| Financial impact/Manufacturability | The financial costs of installing and supporting the system have been discussed, determined and added to the report for all users. |
| | |
| **SOCIAL/POLITICAL/ ENVIRONMENTAL** | |
| Political impact | NA |
| Impact on health | It is to ensure that people are affected as little as possible by drug-drug interaction and to ensure that they get the best out of drugs. |
| Gambling | NA |
| Pornography | NA |
| Equal Access/equity | The system gives different access rights to actors these are reserved as patients, pharmacists, admin The access rights granted indicate the responsibility of those who use the system. |

| | |
|---|---|
| Environmental impacts (energy, carbon footprint and so on) | NA |
| Technology acceptance & Human/Business psychology | NA |
| Security issues | NA |
| | |
| **PROFESSIONAL (CODES, STANDARDS, FRAMEWORKS)** | |
| IEEE | NA |
| ISO | NA |
| ANSI | NA |
| TSE | NA |
| ITIL/COBIT | NA |
| OTHER | Report was written with APA style. |

## 8. Conclusion

In conclusion, this study has highlighted the significance of web-based architectures in the pharmacy sector, specifically focusing on the Pharmacy Decision Support System (PDSS). The PDSS aims to revolutionize medication management, enhance patient care, and address challenges related to drug-drug interactions (DDIs) and food-drug interactions (FDIs). By utilizing technology and data-driven approaches, the PDSS offers a user-friendly, comprehensive, and reliable platform that empowers healthcare providers and patients alike.

The PDSS incorporates various functional requirements to provide comprehensive information and support for both patients and healthcare providers. It features an extensive drug database that includes crucial details on indications, contraindications, dosages, side effects, and drug interactions. Additionally, the system includes a comprehensive database of drug-food interactions, enabling healthcare providers to make informed decisions considering specific food interactions. Ensuring optimal patient outcomes, the PDSS provides disease-specific recommendations for medication. It considers the patient's specific condition and suggests effective and safe medications while considering potential negative interactions. Real-time clinical decision support further aids pharmacists by providing instant support based on patient information, such as age, weight, medical history, allergies, lab results, and current medications.

Patient education is another significant aspect of the PDSS, offering comprehensive materials such as medication guides, drug information leaflets, and dosage instructions. These resources empower patients to understand their medications and adhere to proper usage, ultimately improving health outcomes.

The PDSS simplifies prescription management through prescription tracking and electronic prescription processing. It generates reports and analytics to track medication usage, patient outcomes, and pharmacy operations, providing valuable insights to enhance healthcare delivery. Integration with the Electronic Health Record (EHR) system ensures seamless access to patient information and updates to the medication record. This integration improves the efficiency and accuracy of medication management. Food-drug interactions play a crucial role in medication management, and the PDSS recognizes their significance. By including a comprehensive database of food-drug interactions, the system enables pharmacists to consider these factors when recommending medications and educating patients about their usage.

Finally, the Pharmacy Decision Support System integrates various functionalities, user roles, constraints, and assumptions to provide pharmacists with valuable decision support in managing drug interactions, including the critical aspect of food-drug interactions. By leveraging technology and data, pharmacies can enhance their services, improve patient outcomes, and ensure the safe and effective use of medications while considering dietary factors. Continued research and development in this field will further advance the capabilities and impact of pharmacy decision support systems, benefiting both healthcare professionals and patients.

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