DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DEVELOPMENT OF CHEMOTHERAPY PLAN GENERATION TOOL

by

Mert GÜLÇİN

February, 2020

İZMİR

DEVELOPMENT OF CHEMOTHERAPY PLAN GENERATION TOOL

A Thesis Submitted to the
Graduate School of Natural and Applied Sciences of Dokuz Eylül University
In Partial Fulfillment of the Requirements for the Degree of Master of Sciences
in Computer Engineering, Applied Computer Engineering

by

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February, 2020
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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled "**DEVELOPMENT OF CHEMOTHERAPY PLAN GENERATION TOOL**" completed by **MERT GÜLÇİN** under supervision of **PROF. DR. YALÇIN ÇEBİ** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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DEVELOPMENT OF CHEMOTHERAPY PLAN GENERATION TOOL

ABSTRACT

Cancer which caused by the irregular division and proliferation of cells is becoming increasingly common today. Chemotherapy is a treatment based on the use of drugs. The forms in which the treatment processes are defined according to the type of cancer are called “plan”.

The plans specify the drugs, active substances, supplements, application steps and other issues to be used in the treatment. The treatment process and health status can be monitored by using chemotherapy plans. Nowadays, it is seen that the plans used in chemotherapy applications consist of written documents and are stored in electronic format only in PDF or MS-Word formats. To the best of our knowledge, there is no software for direct use of these documents in information systems in treatment centers and matching and monitoring of treatment processes and plans in electronic environment.

In this study, a software has been developed which can enable the generate of chemotherapy plans jointly with the various software which used in treatment centers. This software also facilitates the rearrangement of the plans according to the patients and their treatment processes. In this software, the common and different aspects of the existing plans were taken into consideration and a user-friendly interface was designed for the plan makers. This software will make it easier for clinical managers to apply their existing chemotherapy plans, as well as making changes in plans and creating new plans for them. C # .NET, .NET MVC, .NET Entity Framework and MS-SQL were used in the development of the software.

Keywords: Cancer, chemotherapy plan, content management system

KEMOTERAPİ PLAN ÜRETME ARACI GELİŞTİRİLMESİ

ÖZ

Hücrelerin düzensiz bölünüp çoğalmasıyla oluşan kanser, günümüzde giderek yaygınlaşmaktadır. Kemoterapi kanser tedavisinde ilaçların kullanılmasına dayanan bir tedavi şeklidir. Kanser türüne göre tedavi süreçlerinin tanımlandığı formlar, "plan" olarak adlandırılmaktadır.

Planlarda tedavide kullanılacak ilaçlar, etken maddeler, yardımcı maddeler, uygulama aşamaları ve diğer hususlar belirtilmektedir. Kemoterapi planlarının kullanılmasıyla tedavi süreci ve sağlık durumu gözlemlenebilmektedir. Günümüzde kemoterapi uygulamalarında kullanılan planların yazılı dokümanlardan oluştuğu ve elektronik ortamda yalnızca PDF veya MS-Word biçemlerinde saklandığı görülmektedir. Bilindiği kadarıyla, bu dokümanların tedavi merkezlerindeki bilişim sistemlerinde doğrudan kullanımı ve tedavi süreçleri ile planların elektronik ortamda eşleştirilmesi ve takibinin yapıldığı bir yazılım bulunmamaktadır.

Bu çalışmada, kemoterapi planlarının tedavi merkezlerinde kullanılan muhtelif yazılımlarla ortak olarak kullanılmasını sağlayabilecek, tedavi süreçleri ile birlikte hastalara göre planların yeniden düzenlenmelerini kolaylaştıracak bir yazılım geliştirilmiştir. Bu yazılımda mevcut planların içerikleri, ortak ve farklı yönleri dikkate alınmış plan hazırlayıcıları için kullanıcı dostu bir ara yüz tasarlanmasına çalışılmıştır. Bu yazılım ile klinik yöneticilerinin mevcut kemoterapi planlarını uygulamaları kolaylaşacak, planlarda değişiklikler yapmaları yanında kendilerine göre yeni planlar oluşturmaları da sağlanacaktır. Yazılımın geliştirilmesinde C#.NET, .NET MVC, .NET Entity Framework ve MS-SQL kullanılmıştır.

Anahtar Kelimeler: Kanser, kemoterapi planı, içerik yönetim sistemi

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CHAPTER ONE
INTRODUCTION

1.1 General Overview

Cancer is defined cells that appear when cells in an organ or tissue are irregularly divided and multiplied. Although there are a wide variety of cancer types, all types of cancer occur as a result of uncontrolled proliferation of abnormal cells. If cancer cells are separated from the tissue from which they are formed, they can spread to the body through blood or lymph circulation. Cancer must be treated, if left untreated, it can cause serious illnesses and even death (Understanding Cancer, 2019).

Chemotherapy is one of the treatment methods used to treat cancer. Chemotherapy treatment targets and stops all cells that proliferate rapidly in the human body. Unfortunately, many side effects occur in the result of chemotherapy treatment. The aim of chemotherapy treatment is to stop and slow the progression of the disease (How Is Chemotherapy Used to Treat Cancer, 2019).

Chemotherapy plans (also called chemotherapy protocols) are created by clinic chefs and applied by doctors and cancer organizations to manage patients' treatment process (CPS, 2019). The duration of chemotherapy is usually more than one day. A separate treatment protocol is prepared to control treatments. These protocols include medicines, active substances and supplementary substances to be used in the patient's treatment plan (CPS, 2019). These protocols are made by clinic chefs according to the type of cancer, the age of the patient, patient’s general condition and other diseases that patient have (e.g., heart disease, hypertension, diabetes, kidney disease). In addition, doctors decide the doses and frequency of application of the selected drugs according to chemotherapy protocols made by clinic chefs.

Chemotherapy protocols are prepared by health institutes, oncology department of hospitals or clinic chefs. It was seen that prepared chemotherapy plans were created on computer (using Microsoft Word or PDF format) or hard copy (Yilmaz, 2010).

According to the research conducted so far, there is no software for the preparation of chemotherapy protocols and control of treatment and drug process. Since such software cannot be found, the current chemotherapy protocols cannot interact with the hospital information management software and pharmacy drug management software for this reason chemotherapy protocols cannot be updated. The current list of drugs used in chemotherapy protocols and the active substances are constantly changing, so chemotherapy protocols should stay up to date. In addition, the patient's disease history is also taken into consideration when preparing chemotherapy protocols. As there is no such software and no interact with Hospital Information Management Systems, the patient's disease history cannot be displayed. Therefore, there is a strong need for a software which interacts with the hospital information management systems and drug management systems and helps to create a chemotherapy protocols more flex and creative way.

1.2 Aim of Thesis

Chemotherapy protocols should remain up-to-date for better chemotherapy treatment and integrated with other hospital information management and pharmacy software. Also, chemotherapy treatment is a sensitive and challenging process and patients should be monitored quickly and easily. For all these reasons, it is aimed to review the chemotherapy protocols and transfer them to the web project. For this purpose, all the chemotherapy protocols that have been made so far will be examined. Information about the drugs used in chemotherapy protocols and the active and supplementary substances related to the drugs will be examined. Finally, the software and frameworks that necessary to transfer the chemotherapy protocols to the web environment will be searched and project coding will be started with the appropriate ones.

1.3 Statement of Thesis

In this thesis, brief information about cancer, chemotherapy and chemotherapy protocols are given in first chapter. Related works and previous studies for chemotherapy protocols is explained in the second (Chemotherapy Protocols and Related Works) chapter. In the third chapter (Database and Project Structure) the infrastructure of the project, selected software language and frameworks are explained. In chapter four (CHEPSYS: Chemotherapy Plan Tool), what the project is and how the project works are encapsulated. Finally, the general conclusion and future studies of the thesis are presented.

CHAPTER TWO
CHEMOTHERAPY PROTOCOLS AND RELATED WORKS

Chemotherapy is one of the most important treatment methods used in cancer treatment (How Is Chemotherapy Used to Treat Cancer, 2019). Today, health institutions and oncology departments of hospitals are striving to be able to treat cancer diagnosed patients more quickly and more effectively. Most studies are performed for emerging cancer types. As a result of these studies, chemotherapy plans (also called chemotherapy protocol) ensue. Nowadays, chemotherapy protocols are used in the treatment of cancer patients for check and control treatment plan.

2.1 Definition of Chemotherapy

Cancer is the second leading cause of death in the world after cardiovascular diseases. “Cancer” is a term used to describe a group of diseases that exhibit uncontrolled growth and abnormal cell spread. Commonly used cancer treatment methods are surgery, radiotherapy, immunotherapy and chemotherapy (Understanding Cancer, 2019).

Chemotherapy is a drug treatment of cancer; is one of the important treatment methods and is used to slow down, regress or stop the process of cancer treatment. Cancer cells are generally fast and uncontrolled proliferating cells. The target of chemotherapy drugs is these rapidly proliferating cells. Some of the healthy cells in human body reproduce rapidly. The main examples of these healthy cells are hair, skin and mouth cells. Chemotherapy targets cancer cells as well as rapidly reproducing cells in our body. Side effects such as hair loss, mouth sores and diarrhea are seen after chemotherapy. The type and rate of disease are also important in the choice of chemotherapy. As chemotherapy can be used alone, in some cases chemotherapy can also be used combination with surgery and/ or radiotherapy (How Is Chemotherapy Used to Treat Cancer, 2019).

2.1.1 Chemotherapy Drugs

Various drugs are used in chemotherapy. Some of the drugs are chemotherapeutic drugs and hormones that act directly on the tumor and biological agents that strengthen the immune system. Some drugs are used to increase the effect of drugs directly acting on the tumor, or to reduce or eliminate side effects. The side effects of these drugs are different. Drugs are distributed throughout the body through the blood. Chemotherapy drugs that act directly on the tumor affect the tumor cells. It prevents the growth and reproduce of cells and destroys the tumor.

Table 2.1 Drug table of chemotherapy schemas (Eren, Ata, & Arıcan, 2012)

Alkylating agents	**Antimetabolites**	**Antibiotics**	**Mitotic Inhibitors**	**Others**
Busulfan	Azotioprim	Adriamisin	Etoposid	Aldeslökin
Dakarbazin	Fludarabin	Bleomisin	Vinkristin	Amifostin
Estramustinfosfat sodyum	Fluorourasil	Daktinomisin	Vinblastin	Aminoglutetimid
Fotemustine	Merkaptopürin	Daunorubisin	Vinerolbin	Asparaginaz
İfosfamid	Metotreksat	Epirubisin		Dietilstilbestrol
Karboplatin	Procarbazin	İdarubisin		Doksetaksel
Karmustin	Sitosin arabinoside	Mitomisin C		Etinil Estradiol
Klorambusil	Tioguanin			Gemsitabin
Klornafazin				Hidroksiüre
Lomustin (CCNU)				İnterferon alfa
Mekloretamin hidroklorür				İrinotekan HCl trihidrat
Melfalan				Medroksiprogesteron
Mileran				Megestrol
Siklofosfamid				Mitoksantron
Sisplatin				Paklitaksel
Streptozosin				Tamoksifen
Teosulfan				Topotekan
Tiotepa				Tretinoin
Urasil Hardalı				

2.2 Definition of Chemotherapy Protocols

Chemotherapy protocols are prepared by health professionals (usually clinic chefs) or health institutions and published as forms. According to these protocols, patient's chemotherapy application is planned. The amount of each chemotherapy, how many days to be given, the duration of administration are determined by clinical studies and applied in the chemotherapy protocol. There are many sources in which the chemotherapy protocol is prepared and shared with the community (CPS, 2019).

Chemotherapy is chosen depends on the type of cancer, extent of the cancer, the purpose of the chemotherapy, the general condition of the patient, the comorbidities of the cancer and the patient's preference. The overall objective is to achieve the highest effect with the lowest side effect. Chemotherapy is usually given in cures. Cure refers to the frequency and scheme of chemotherapy. It is usually consists of a period of chemotherapy followed by a period of rest. The frequency and scheme of administration of each chemotherapy protocol are determined after clinical studies and they are very diverse. There may be one, two, three or four applications per week, as well as more sustained use in certain medications, particularly oral chemotherapy (CPS, 2019).

Research shows that most health institutions and hospitals' oncology departments write their chemotherapy protocols in various applications (Word or PDF) on computer or create hard copy records (Yilmaz, 2010). These methods are useful but have been observed to be sufficiently challenging for both the institution and clinic chefs that preparing the chemotherapy protocols and the physicians applying the chemotherapy protocols. As mentioned above, chemotherapy protocols are varying greatly, and the treatment process takes long time. At the same time, it is necessary to re-establish the protocol again and again to create a similar chemotherapy protocol. Also, chemotherapy protocols were created using hard copy and programs as word or excel, it was observed that chemotherapy protocols did not interact with hospital information management systems and pharmacy drug information systems. When all these situations were taken into consideration, it was decided to pass the chemotherapy

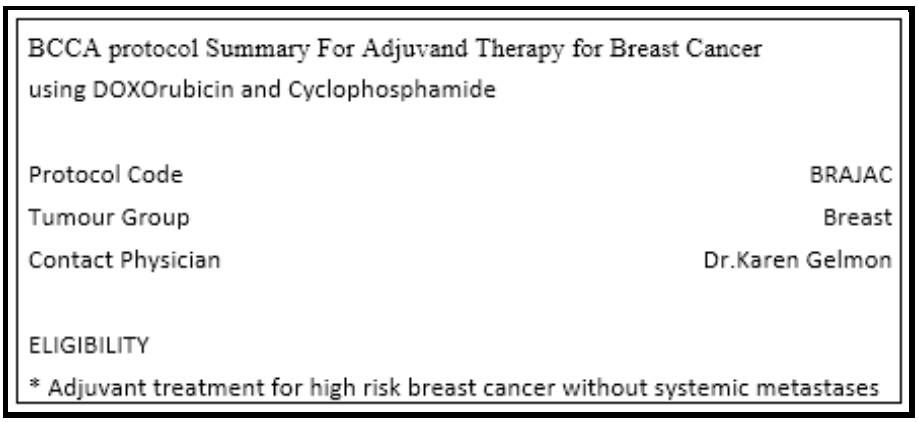
protocols on the web environment to make the creating chemotherapy process shorter and more efficient.

2.2.1 British Columbia Cancer

BC Cancer deals with cancer patients and strives to improve the quality of live for cancer patients. It provides low-cost healthcare services with healthcare professionals at the service, and also prepares patients' cancer treatment plan (Chemotherapy Protocols, 2019).

BC Cancer has several chemotherapy protocol summaries and these protocol summaries for sixteen different types of cancer protocol summaries. There are several chemotherapy protocols for each type of cancer. These protocols are used by health professionals in many cancer treatment centers (Chemotherapy Protocols, 2019).

BC Cancer plans usually consist of four different types which are eligibility, tests, treatment, dose modification and precautions. Eligibility indicates cancer type, protocol name, protocol code, tumor group and physician name of the chemotherapy protocol (Chemotherapy Protocols, 2019).


BCCA protocol Summary For Adjuvand Therapy for Breast Cancer
using DOXOrubicin and Cyclophosphamide

Protocol Code	BRAJAC
Tumour Group	Breast
Contact Physician	Dr.Karen Gelmon

ELIGIBILITY

* Adjuvant treatment for high risk breast cancer without systemic metastases

Figure 2.1 Eligibility example of breast cancer (Chemotherapy Protocols, 2019)

Test section specifies the test items of chemotherapy protocol that must be performed before and during the implementation of the chemotherapy protocol. These test items did not have a specific standard that varies with the type of cancer.

TESTS:

* Baseline: CBC & diff, platelets, bilirubin
* Before each treatment: CBC & diff, platelets
* If clinically indicated: bilirubin, creatinine

Figure 2.2 Test example for breast cancer (Chemotherapy Protocols, 2019)

In treatment section, there is a table showing which drugs the patient is used, the doses of these drugs and how these doses will be used. Further, this part includes days and frequency of drugs and finally if necessary, there is an explanation for all treatments.

TREATMENT:

Drug	Dose	BCCA Administration Guideline
DOXOrubicin (ADRIAMYCIN®)	60 mg/m^2	IV push
cyclophosphamide	600 mg/m^2	IV in NS or D5W 100 to 250 ml over 20 min to 1 hour

* Repeat every 21 days x 4 cycles
* If radiation therapy is required, it is given following completion of chemotherapy (BCCA Cancer Management Manual).

Figure 2.3 Treatment example for breast cancer (Chemotherapy Protocols, 2019)

There may be some changes in the height and weight of the patient during treatment. According to these changes, the doses of the drugs are changed. In dose modifications table contains drug names and information that when drug dosage must be changed. Also, there are necessary explanations for other dosage changes.

DOSE MODIFICATIONS:

1.Hematological:

ANC (x 10^9/L)	Platelets (x 10^9/L)	Dose (both drugs)
Greater than or equal to 1.5	Greater than or equal to 90	100%
1 to 1.49	70 to 89	75%
Less than 1	Less than 70	delay

Figure 2.4 Dose modification example of breast cancer (Chemotherapy Protocols, 2019)

Because of the usage of strong and effective medications in chemotherapy treatment, this can lead to several side effects in the patient. Precautions part writes what to look for when applying the treatment protocol. This section usually mentions side effects of drugs.

PRECAUTIONS

1. **Cardiac Toxicity :** DOXOrubicin is cardiotoxic and must be used with caution, if at all, in patients with severe hypertension or cardiac dysfunction. Cardiac assessment recommended if lifelong of 400 mg/m^2 to be exceeded (see BCCA Cancer Drug Manual)
2. **Extravasation :** DOXOrubicin causes pain and tissue necrosis if extravasated. Refer to BBCA Extravasation Guidelines.
3. **Neutropenia :** Fever or other evidence of infection must be assessed promptly and treated aggressively.

Figure 2.5 Precaution part example of breast cancer (Chemotherapy Protocols, 2019)

2.2.2 American Joint Committee on Cancer

The American Joint Committee on Cancer (AJCC) is an active group since the cancer has been identified. They have the widest anatomic staging data, the Cancer Staging Manual and Cancer Staging Atlas. For that reason, clinicians and the surveillance communities rely on the ASCC for years (AJCC - American Joint Committee on Cancer, 2019).

These AJCC publications are readjust as the authoritative guides for cancer staging information and are used by many medical professionals every day. AJCC is committed to the treatment of cancer, and it is striving to develop, treat and categorize cancer and still try developing systems for cancer treatment.

The AJCC is committed to achieving five key goals;

- By facilitating a timely and rigorous, evidence-based process, they want to support a biologically relevant system for classification and outcome

prediction of cancer that can work with systems of cancer population surveillance.

- With the development and delivery of effective programs and products to guide patient care, they want to educate the oncology community.
- Enlarging collaborative relationships with AJCC member organizations and organizations with mutual goals in support of systems to diagnose and treat cancer.
- To improve care and predict outcome for cancer patients, they want to support and be responsive to public and private efforts (AJCC - American Joint Committee on Cancer, 2019).

The AJCC has created a set of reference resource materials for clinic chefs, doctors, other healthcare professionals and the cancer registrars abstracting cancer cases to ensure them has no difficulty to access the information. In short, The AJCC Cancer Staging Manual is the highest standard and the best choice to help the cancer patient management team determine the correct stage for patients, allowing for the most appropriate care plan (AJCC - American Joint Committee on Cancer, 2019).

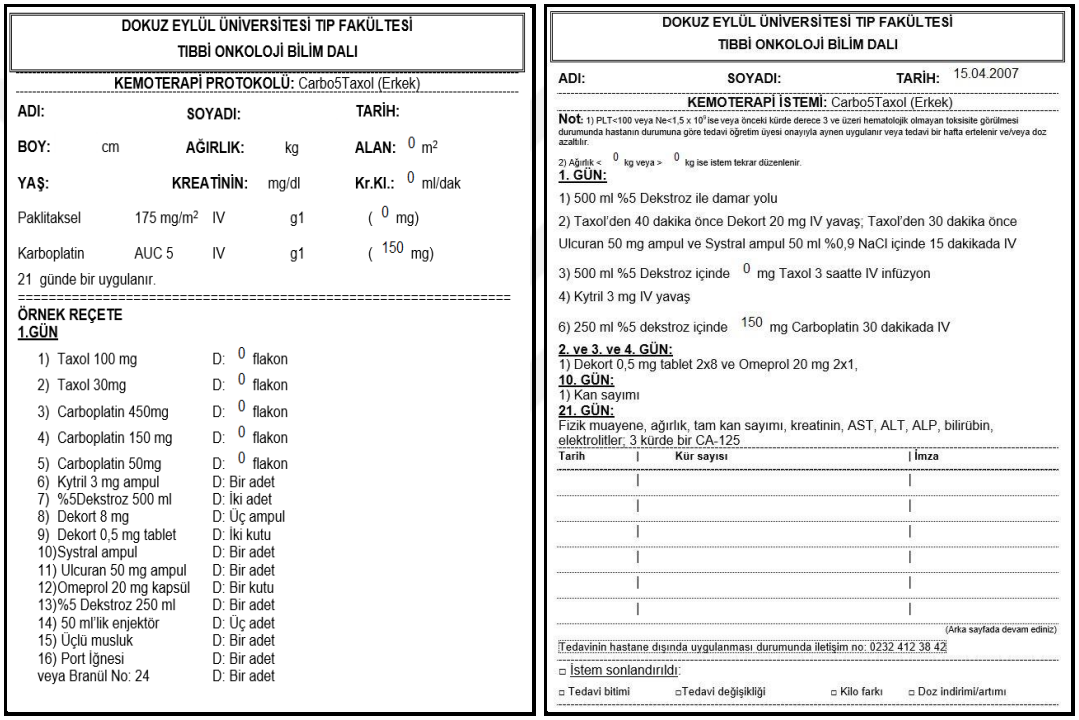
2.2.3 Dokuz Eylul University Research and Application Hospital Oncology Department

In Dokuz Eylul University Faculty of Medicine Research and Application Hospital, chemotherapy protocols have prepared for patients in their computers as a word format file. All these chemotherapy protocols have been examined. From this examination, it can be seen that each file separates at least two parts and each protocol include patient's name, surname, age height and weight and duration of the treatment, application of the medicine, active substances, supplementary substances, in these specific treatment days (Yilmaz, 2010).

In these files the macro feature of Microsoft Word was used. By entering the name, physical properties (height, weight) the body area was calculated. By using the body

area value and in some cases creatinine value, the required amounts of medical substances were determined. Thus, a separate chemotherapy scheme is obtained for each patient.

All protocols used in the oncology department of hospital are prepared with reference to British Columbia Cancer (BC Cancer) and American Joint Committee on Cancer (AJCC) by Prof. Dr. A. Uğur Yılmaz who was the head of the medical oncology clinic (Yilmaz, 2010).



DOKUZ EYLÜL ÜNİVERSİTESİ TIP FAKÜLTESİ
TIBBİ ONKOLOJİ BİLİM DALI

KEMOTERAPİ PROTOKOLÜ: Carbo5Taxol (Erkek)

ADI: **SOYADI:** **TARİH:**

BOY: cm **AĞIRLIK:** kg **ALAN:** 0 m²

YAŞ: **KREATİNİN:** mg/dl **Kr.Kl.:** 0 ml/dak

Paklitaksel 175 mg/m² IV g1 (0 mg)

Karboplatin AUC 5 IV g1 (150 mg)

21 günde bir uygulanır.

==========

ÖRNEK REÇETE
1.GÜN

1) Taxol 100 mg D: 0 flakon
2) Taxol 30mg D: 0 flakon
3) Carboplatin 450mg D: 0 flakon
4) Carboplatin 150 mg D: 0 flakon
5) Carboplatin 50mg D: 0 flakon
6) Kytril 3 mg ampul D: Bir adet
7) %5Dekstroz 500 ml D: İki adet
8) Dekort 8 mg D: Üç ampul
9) Dekort 0,5 mg tablet D: İki kutu
10)Systral ampul D: Bir adet
11) Ulcuran 50 mg ampul D: Bir adet
12)Omeprol 20 mg kapsül D: Bir kutu
13)%5 Dekstroz 250 ml D: Bir adet
14) 50 ml'lik enjektör D: Üç adet
15) Üçlü musluk D: Bir adet
16) Port İğnesi D: Bir adet
veya Branül No: 24 D: Bir adet

DOKUZ EYLÜL ÜNİVERSİTESİ TIP FAKÜLTESİ
TIBBİ ONKOLOJİ BİLİM DALI

ADI: **SOYADI:** **TARİH:** 15.04.2007

KEMOTERAPİ İSTEMİ: Carbo5Taxol (Erkek)

Not: 1) PLT<100 veya Ne<1,5 x 10^3ise veya önceki kürde derece 3 ve üzeri hematolojik olmayan toksisite görülmesi durumunda hastanın durumuna göre tedavi öğretim üyesi onayıyla aynen uygulanır veya tedavi bir hafta ertelenir ve/veya doz azaltılır.

2) Ağırlık < 0 kg veya > 0 kg ise istem tekrar düzenlenir.

1. GÜN:

1) 500 ml %5 Dekstroz ile damar yolu
2) Taxol'den 40 dakika önce Dekort 20 mg IV yavaş; Taxol'den 30 dakika önce Ulcuran 50 mg ampul ve Systral ampul 50 ml %0,9 NaCl içinde 15 dakikada IV
3) 500 ml %5 Dekstroz içinde 0 mg Taxol 3 saatte IV infüzyon
4) Kytril 3 mg IV yavaş
6) 250 ml %5 dekstroz içinde 150 mg Carboplatin 30 dakikada IV

2. ve 3. ve 4. GÜN:
1) Dekort 0,5 mg tablet 2x8 ve Omeprol 20 mg 2x1,

10. GÜN:
1) Kan sayımı

21. GÜN:
Fizik muayene, ağırlık, tam kan sayımı, kreatinin, AST, ALT, ALP, bilirübin, elektrolitler; 3 kürde bir CA-125

Tarih	Kür sayısı	İmza

(Arka sayfada devam ediniz)

Tedavinin hastane dışında uygulanması durumunda iletişim no: 0232 412 38 42

□ İstem sonlandırıldı:

□ Tedavi bitimi □Tedavi değişikliği □ Kilo farkı □ Doz indirimi/artımı

Figure 2.6 Oncology department chemotherapy plan (Yilmaz, 2010)

2.3 Hospital Information Management System

The main objective of the sector managers providing health services, such as hospitals, is to improve service quality while reducing costs. Therefore, in addition to medical studies such as diagnosis and treatment, useful and meaningful information is needed for decision making in administrative issues such as patient satisfaction and institution's income and expenses. In order to meet this need, different methods and

ancillary software are used to make the data meaningful and usable, especially in institutions with intensive information flow such as hospitals (HBYS, 2019).

This ancillary software supports the management of the hospital in Appointment, Patient Referral, Patient Acceptance, Patient Hospitalization, Collection, Service, Invoicing, Personnel Brevity, Laboratory, Screening, Operating Room, Pharmacy Transactions, Drug Tracking System, Inventory Management, Purchasing Management, Device Maintenance and Repair (HBYS, 2019).

The chemotherapy treatment process is not just about creating a treatment protocols and applying it. There are many patients who apply to oncology departments of hospitals or other health institutions. Appointments and health records of these patients are kept in hospital management system software. When chemotherapy protocols are being prepared or when a chemotherapy protocol is to be applied to a patient, practitioners receive patient information from the hospital management system software. If the software in which the chemotherapy protocols are prepared and the software in the hospital information management system work in an integrated way, the chemotherapy protocol will be prepared more easily.

2.4 Pharmacy Management System

Pharmacy management system aims to make the sales and inventory analysis of the pharmacy as the fastest and most efficient way. Generates numerous reports and analyzes on the basis on category, subcategory, brand and product by automatically decomposing the products available in the pharmacy (EYS, 2019).

By means of Pharmacy Management Software,

- Drug Entry / Exit operations are performed.
- Basic and detailed information about drugs is obtained.
- Drug lists are created.

- The drug treatment profile is displayed.
- Drug dose calculations are made.
- Pharmaceutical, sanitary material stock status and movements are displayed.
- Stock critical and average levels of drugs are calculated.
- Explanation and warnings are made in drug movements (outpatient, inpatient, all treatments).
- Drug prices are updated automatically.
- User-defined custom reports, graphs and rich statistics are created.
- Pharmacological information is generated.
- Signage lists are imported.
- Service signage requests are issued.
- Outer sign items are arranged.
- Invoice Lists are edited.
- Daily, monthly and quarterly concepts of movements are taken.
- Ensures the production of magisterial drugs.
- Drugs and materials used are automatically reflected in the patient's financial records.
- Individual and batch notifications are received for each box of medication.
- Orders are tracked with a single number according to the company.
- Prescription request is made, and the request letter is issued.

Chemotherapy protocols contain many active substances, drugs and supplementary substances. The clinic chef who prepares the chemotherapy protocols will keep the chemotherapy protocols up-to-date by accessing the current list of drugs and drug-related active substances while preparing the chemotherapy plan. At the same time,

during the preparation of chemotherapy protocols integrated with pharmacy management software, it is aimed not to waste the drugs used during chemotherapy.

2.5 Related Works

According to research conducted so far, in order to improve the appointment system for oncology departments of hospitals and patients receiving chemotherapy treatment, different software packages are in use.

MOSAIQ Medical Oncology Program (Elekta, "MOSAIQ® Medical Oncology", 2019) is an integrated information system. With this program, cancer treatment can be diagnosed, and chemotherapy program can be followed. A single database is used in the software, the patient's drug and disease information is collected in database. It also simplifies the management of all-round chemotherapy programs, manages a patient record for multiple treatment types, improves the quality and steady of chemotherapy care and connect with pharmacies and healthcare facilities.

ARIA OIS oncology software (ARIA® OIS for Medical Oncology, 2019) that helps manage oncology department operations. ARIA helps to diagnose and treat cancer. It provides access to close to 300 chemotherapy protocols for cancer treatment. Automates cancer staging and allows custom cancer staging, allowing the display of laboratory results for patients. Finally, automates cancer staging and allows custom cancer staging, allowing the display of laboratory results for patients and patient's treatment process can be monitored.

In the study carried out by (Fishbein, et al., 2017) a software was developed in which the patients treated with chemotherapy and their treatment and chemotherapy schemes were evaluated. The aim of that study is to provide management of oral chemotherapy in patients receiving cancer treatment and to receive various feedbacks. In addition to the research team; patients, families and health professionals were included in the study. The study included the compliance of drugs used in oral chemotherapy, a training library showing the nutritional list of chemotherapy patients

and a questionnaire system where chemotherapy patients and their family could receive feedback. With the help of these data, it was aimed to improve the treatment quality of the patients receiving chemotherapy and to prepare proper chemotherapy protocols.

Another study carried out by (Gandhi, Tyono, Pasetka, & Trudeau, 2014) was conducted to minimize complexity and errors in chemotherapy treatment. To get information, in city of Ontario located in Canada, High percentage of the patients diagnosed with cancer and they received chemotherapy treatment are used. These treatments could be oral or infuser pump format which they can apply in their home. For preventing any errors which occurred during the treatments this CPOE become important tool in Canada. Cancer Care Ontario (CCO) which is the main counselor in there developed its own CPOE which is introduced as Oncology Patient Information System (OPIS).

In addition, during the chemotherapy treatment period, the study, carried out by (Sevinc, Sanli, & Goker, 2013) was conducted to ensure that patients can make appointments in treatment centers in the most efficient way. During chemotherapy, patients must receive support from treatment centers or laboratories in hospitals for their treatment. Therefore, each patient is given an appointment, however this leads to serious complexity. There is no efficient appointment system and patients are waiting longer than necessary to receive treatment. The study (Sevinc, Sanli, & Goker, 2013) has identified three main objectives for this subject. These are allowing the oncologist to prepare chemotherapy plans, reduce patient waiting time and optimize resource usage.

CHAPTER THREE
DATABASE AND PROJECT STRUCTURE

Chemotherapy plan tool which we called CHEPSYS, has been prepared to be web based. By the reason of CHEPSYS is web-based and should be integrated with all other hospital and pharmacy management systems, a comprehensive technology solution was sought.

3.1 Used Technologies

Chemotherapy plan tool was prepared using the C# .NET MVC 4.5.2 framework. MS-SQL database was used to keep the project information. Entity Framework 6.2.0, published by Microsoft, was used to bridge the table objects in the database and the models in the project (Divega, 2019).

ASP.NET MVC is the framework developed by Microsoft to add the MVC pattern to ASP.NET. The MVC consists of the initials of the words Model, View and Controller and each word represents a different layer of MVC. With using MVC Pattern, by separating the codes to be presented to the user (HTML, CSS, etc.), the logical codes that make the system work, makes it easier to write clean and tidy code. Also, allows easier optimization, expansion and reuse of code. Lastly, it makes debugging and testing code easier (ASP.NET MVC Pattern: .NET, 2019).

Framework means semi-generated code, so that the chemotherapy plan tool has ready-generated code by Entity Framework. By means of Entity framework, the database is easily mapped to objects and no complex query writing is required LINQ Lambda expression support by using its feature. There are 3 different methods used in Entity framework which are Database First, Code First and Model First approaches. By means of the Database First approach, an existing database can be use and database table relationships can be established in database. Since manual changes to the database are requested, the Code First approach is not used (Divega, 2019).

MS-SQL has rich database management system features for websites and desktop applications that constantly process data. MS-SQL is preferred because it is compatible with C# software language and works faster with C# (Sql Server, 2019).

The Entity framework acts as a bridge between the database objects and the model objects. This task provides a class called DB Context. Repository patterns can be added to this layer. Repository basically ensures that database query operations are performed from a central location, preventing the transmission of these jobs to the job layer, thus preventing query and code repetition. In other words, the main purpose is transferring data processing and query operations to a central structure. In this way, database operations do not have to repeatedly write in the business layer. For these reasons, repository pattern was preferred (Kudchikar, 2019).

Nowadays, tablets and phones are also widely used in addition to computers and each phone and tablet device have a different resolution. This has led to the need to make different designs for each display. To solve this situation, Bootstrap 4 was used in the project. Bootstrap contains all the HTML, CSS and jQuery components necessary for a website, thus ensuring design for all devices (What is Bootstrap? 2019).

3.2 Database Structure

In the database design stage, all tables are created in the SQL Management Studio. Generally, user information, schema information and drug and active substance information are kept in the tables. Database tables will be explained according to these 3 sections. These are user information, schema information and supplementary and auxiliary information.

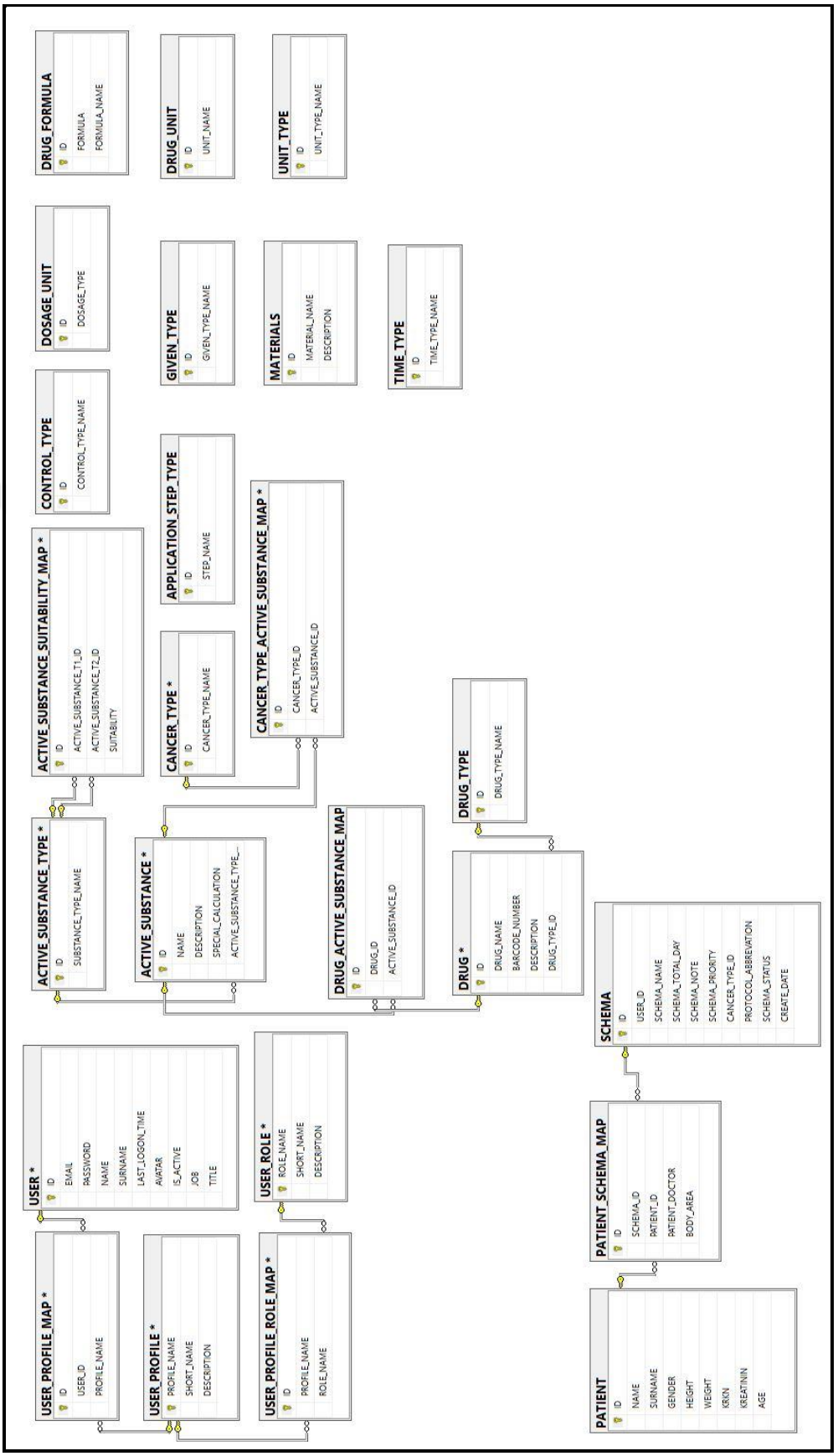


Figure 3.1 Database structure

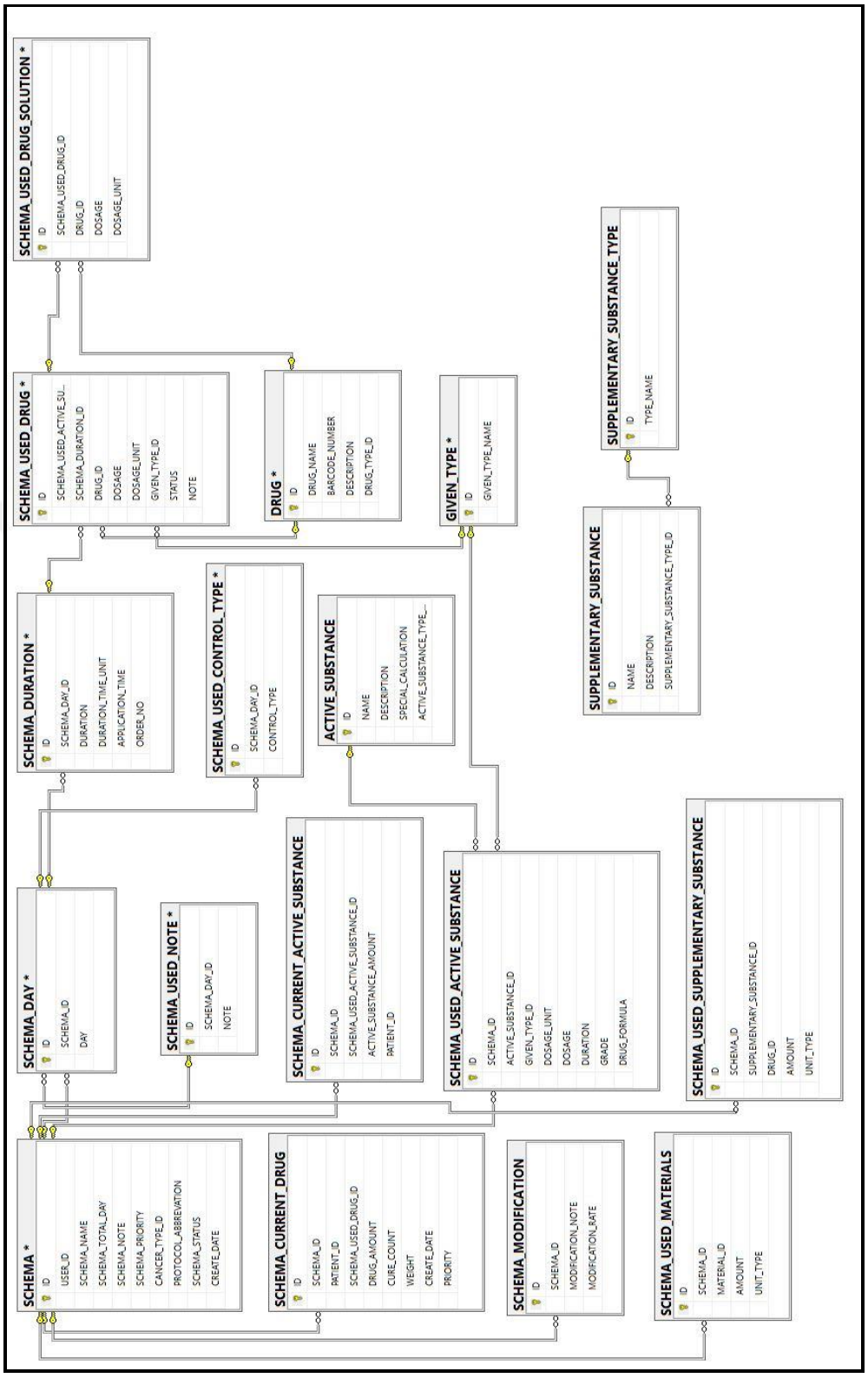


Figure 3.1 Database structure (cont'd)

3.2.1 User Management Tables

In order to keep user information and system security, five tables were used. These tables contain the user's personal information, the user's roles, and the user's profiles. A user has multiple profiles and each profile has multiple roles.

The “User” table consists of ten fields (Figure 3.2). ID field is auto increment, which means that the number increases as the users are added. EMAIL field contains the user's email address. In the password field, the user's password is kept as hashed. The name and surname of the user are kept in the NAME and SURNAME fields. LAST_LOGON_TIME field keeps track of when the user last logged in. AVATAR field contains the user's picture information. User can be set as active and passive and that information is kept IS_ACTIVE field. JOB field keep user’s job information. Finally, TITLE field is kept for the information of the user's title (doctor, nurse, etc.).

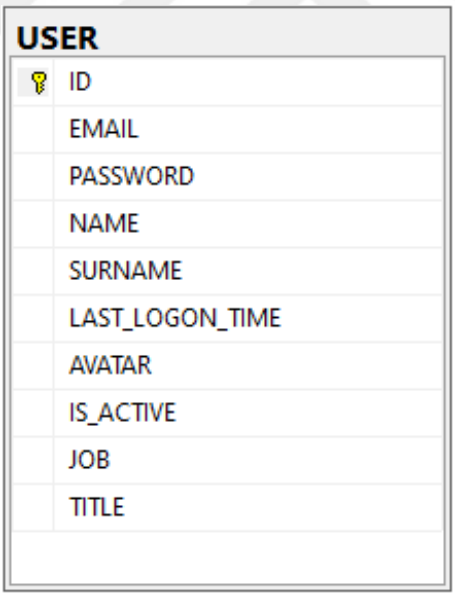


Figure 3.2 “User” table

The “User Profile” table is used to store the complete list of profiles in the system. PROFILE_NAME field holds the full name of the profile and it is also the primary key for this table. SHORT_NAME field holds the shortened profile name. DESCRIPTION field is required for the description of the profile (Figure 3.3).

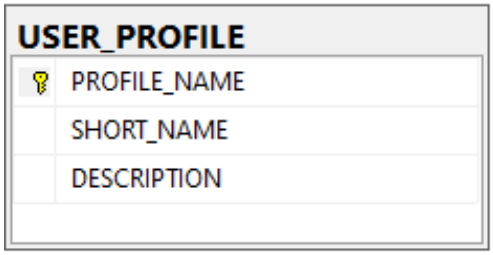


Figure 3.3 “User Profile” table

The “User Role” table is used to keep the list of roles for the project. ROLE_NAME field holds the full name of the role and it is also the primary key for this table. SHORT_NAME field holds the shortened role name. DESCRIPTION field is required for the description of the role (Figure 3.4).

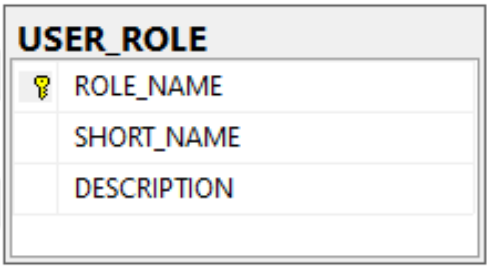


Figure 3.4 “User Role” table

The “User Profile Map” table is used to access which profiles that the users have. ID field is used as primary key and has auto increment feature. USER_ID field holds users' id. PROFILE_NAME field comes from the profile table and the information of the profile name is kept in this field (Figure 3.5).

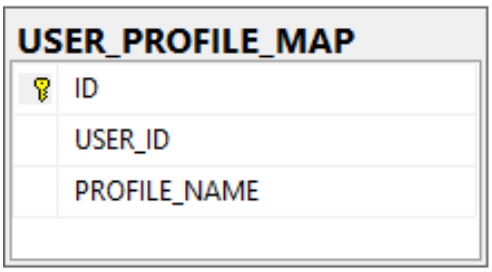


Figure 3.5 “User Profile Map” table

The “User Profile Role Map” table is required to keep the information of which roles that the profiles have. ID field is used as primary key and has auto increment feature. PROFILE_NAME holds the profile name and ROLE_NAME holds the name of the role (Figure 3.6).

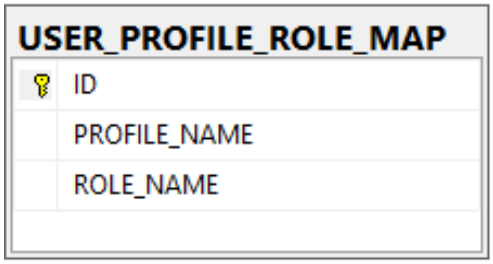


Figure 3.6 “User Profile Role Map” table

3.2.2 Chemotherapy Schema Tables

In order to keep general protocol information, protocol days, protocol notes and priorities if any, active and supplementary substances of protocol, fifteen tables were used.

The “Schema” table is the table where general information of chemotherapy plans is kept. ID field is used as primary key and has auto increment feature. USER_ID field holds the creator user of the chemotherapy plans. SCHEMA_NAME field holds the name of the chemotherapy plan. SCHEMA_TOTAL_DAY field holds the total number of days the chemotherapy plan lasts. SCHEMA_NOTE field holds any information of the schema and SCHEMA_PRIORITY field keeps any priority information about that schema. CANCER_TYPE_ID field holds information of which cancer type the chemotherapy plan belongs to. PROTOCOL_ABBREVATION field is for keep schema name abbreviation. SCHEMA_STATUS field keep schema publish status which are active, passive and published (Figure 3.7).

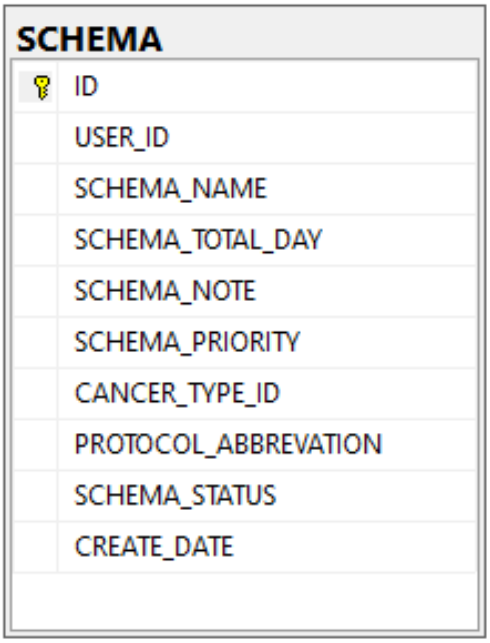


Figure 3.7 “Schema” table

The “Schema Day” table was created to keep the implementation days of the schema. ID field is used as the primary key and has auto increment feature. SCHEMA_ID field is added to known which schema belongs to the specified day. DAY field is represented for schema day (Figure 3.8).

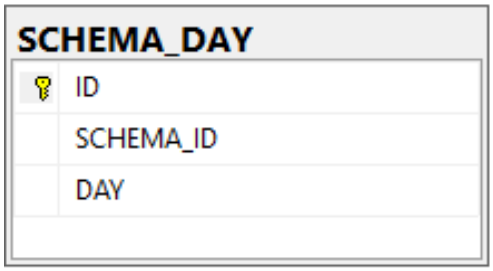


Figure 3.8 “Schema Day” table

The “Schema Duration” table is the table where the application information of the drugs is kept for the specified application day of the schema. DURATION and DURATION_TIME_UNIT fields contain information on how long the drug will be used. APPLICATION_TIME field specifies the time zone in which the drug will be used within the selected day. ORDER_NO field determines the order of use of drugs (Figure 3.9).

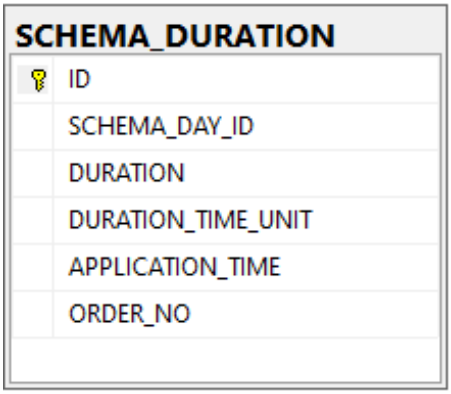


Figure 3.9 “Schema Duration” table

The “Schema Modification” table contains the modification information of the schema. If there is a change in the physical characteristics of the patient (e.g. weight), these changes are calculated by means of the ratios in the chemotherapy schema. ID field is used as primary key and has auto increment feature. MODIFICATION_NOTE field includes modification information and MODIFICATION_RATE field keeps the change rate of modification (Figure 3.10).

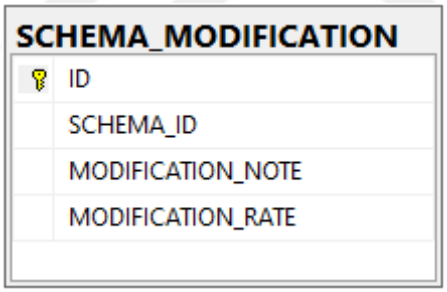


Figure 3.10 “Schema Modification” table

There are many active substances in chemotherapy schemas. Schema used active substance table is used to store the active substances of schemas. ID field is used as primary key and has auto increment feature. ACTIVE_SUBSTANCE_ID indicates which active substance is used in the schema. GIVEN_TYPE_ID specify which given type is used in the schema. DOSAGE and DOSAGE_UNIT fields indicate the dosage of the active substance. DURATION field specifies the total time that the active substance will be used. GRADE field indicates cancer staging status. Lastly, while some active substances are calculated with a specific formula, DRUG_FORMULA field indicates the choice of formula (Figure 3.11).

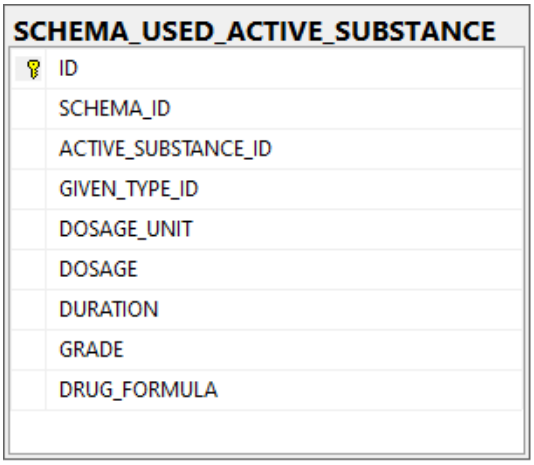


Figure 3.11 “Schema Used Active Substance” table

The treatment of chemotherapy is a long process and occasionally patient’s health status should be checked. Health checks are performed on certain days and for that reason the “Schema Used Control Type” table is needed. ID field is used as primary key and has auto increment. SCHEMA_DAY_ID represents specific schema day and CONTROL_TYPE field hold information of which control types should made to patient (Figure 3.12).

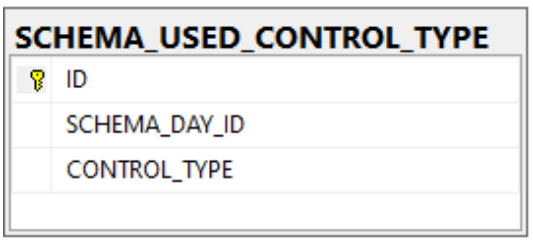


Figure 3.12 “Schema Used Control Type” table

The “Schema Used Drug” table holds drug information of the schema. ID field is used as primary key and has auto increment. SCHEMA_USED_ACTIVE_ SUBSTANCE_ID holds the active substance information of the drug used in the schema. SCHEMA_DURATION_ID field holds the drug’s usage time and order number information. DOSAGE and DOSAGE_UNIT fields indicate the dosage of the used drug. GIVEN_TYPE_ID specify which drug given type is used the schema. STATUS field holds whether the drug used in the schema is standard type or optional type. NOTE field is keeps the information of drug if needed (Figure 3.13).

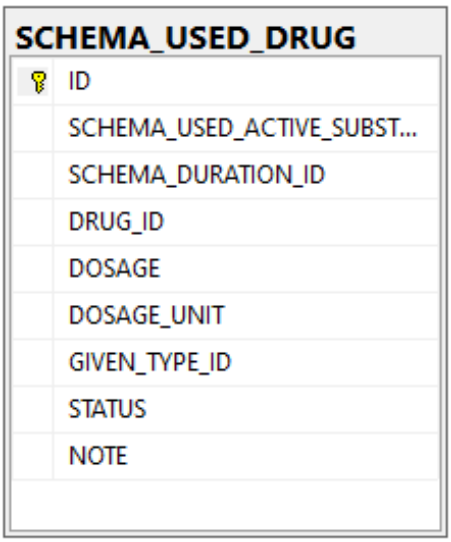


Figure 3.13 “Schema Used Drug” table

The “Schema Used Drug” table was needed because some drugs are used in some solutions. ID field is used as primary key and has auto increment feature. SCHEMA_USED_DRUG_ID field connects drug table and drug solution table. DRUG_ID field indicates solution drug. DOSAGE and DOSAGE_UNIT fields indicate the dosage of the used drug (Figure 3.14).

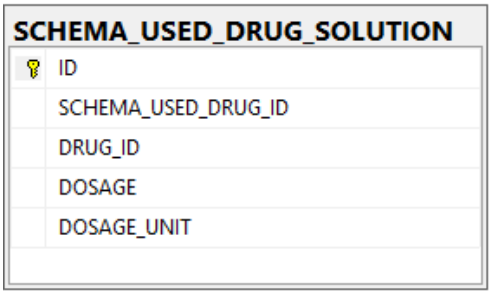


Figure 3.14 “Schema Used Drug Solution” table

In some cases, some products such as bandages or injectors are used in chemotherapy schema, and this information holds the “Schema Used Materials” table. ID field is used as primary key and has auto increment feature. SCHEMA_ID indicates which material belongs to specific schema. MATERIAL_ID field keeps the material information. AMOUNT field indicates how many materials are used and UNIT_TYPE specify the material unit (Figure 3.15).

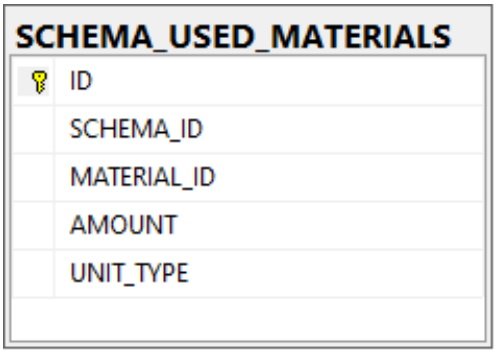


Figure 3.15 “Schema Used Materials” table

In some cases, it is possible to enter notes instead of entering drug on specific schema day. For this reason, the “Schema Used Note” table is used for schema day notes. SCHEMA_DAY_ID field indicates which day has schema note and NOTE field holds day note (Figure 3.16).

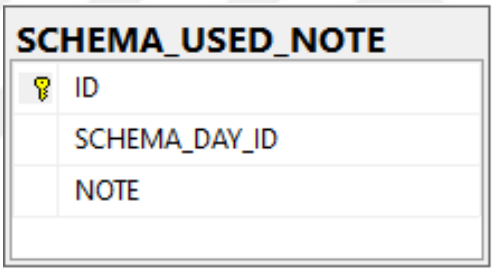


Figure 3.16 “Schema Used Note” table

In consequence of chemotherapy treatment is a difficult treatment, some chemotherapy patients may need supplementary substances like antibiotics or sleeping pills. The “Schema Used Supplementary Substance” table holds that supplementary substance information. ID field is used as primary key and has auto increment feature. SCHEMA_ID field indicates which supplementary substance belongs to specific schema. SUPPLEMENTARY_SUBSTANCE field keeps the supplementary substance information. AMOUNT field indicates how many supplementary substances are used and UNIT_TYPE specify the substance unit (Figure 3.17).

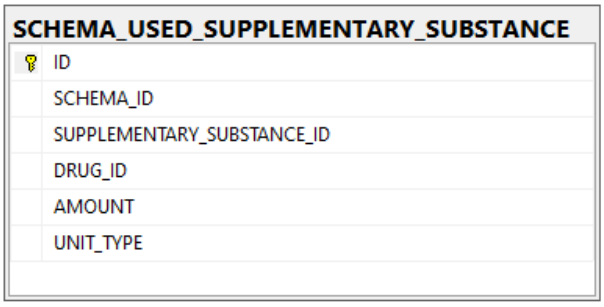


Figure 3.17 “Schema Used Supplementary Substance” table

The doses of the active substance in the chemotherapy schema are prepared using patient’s personal information and drug formulas. These prepared active substance dosages are kept in the “Schema Current Active Substance” table. ID field is used as primary key and has auto increment feature. SCHEMA_ID field indicates which active substance and specific amount calculation belongs to specific schema. SCHEMA_USED_ACTIVE_SUBSTANCE_ID field points to active substance that selected for schema. ACTIVE_SUBSTANCE_AMOUNT holds calculated amount of active substance. Finally, PATIENT_ID field reference to which patient information used that amount calculation (Figure 3.18).

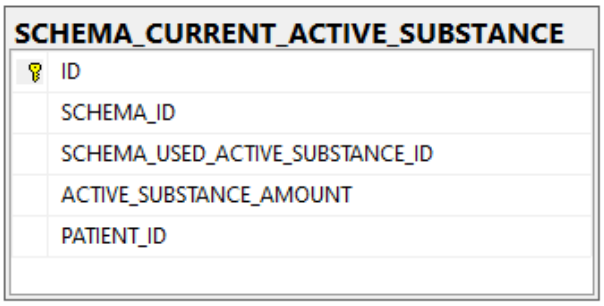


Figure 3.18 “Schema Current Active Substance” table

The doses of the drugs in the chemotherapy schema are prepared using patient’s personal information, drug formulas and calculated active substance amount. These prepared drug dosages are kept in the “Schema Current Drug” table. ID field is used as primary key and has auto increment feature. SCHEMA_ID field indicates which active substance and specific amount calculation belongs to specific schema. PATIENT_ID field reference to which patient information used that amount calculation. SCHEMA_USED_DRUG_ID field points to drug that selected for

schema. DRUG_AMOUNT field holds calculated amount of drug. CURE_COUNT field shows the number of times the schema assigned to the patient is repeated. WEIGHT field shows the patient's current weight at the time the schema is applied. Finally, PRIORITY field determines which schema takes precedence if more than one schema is assigned to a patient (Figure 3.19).

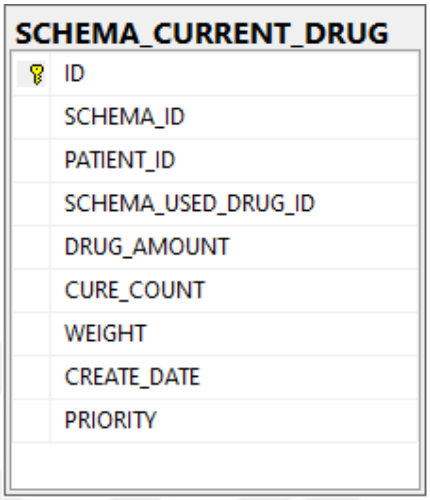


Figure 3.19 "Schema Current Drug" table

The "Patient" table is the table where the general information of the patient is kept. ID field is used as primary key and has auto increment feature. KREATININ, KRKN, AGE, WEIGHT and HEIGHT fields are used to calculate active substance and drug amounts (Figure 3.20).

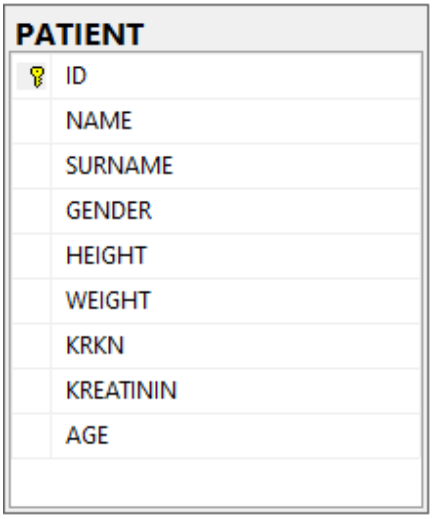


Figure 3.20 "Patient" table

The “Patient Schema Map” table was created due to a table was needed to match schemas with patients. ID field is used as primary key and has auto increment feature. SCHEMA_ID field represents schema information and PATIENT_ID represents patient information. PATIENT_DOCTOR field holds information that current doctor of a patient. Finally, BODY_AREA field indicates patient’s body surface area value and that value is used for calculation of drugs and active substance amount (Figure 3.21).

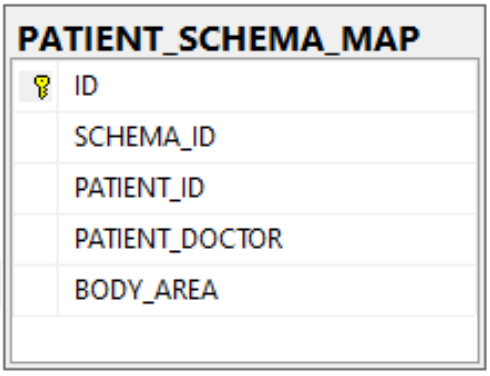


Figure 3.21 “Patient Schema Map” table

3.2.3 Supplementary and Auxiliary Tables

During the chemotherapy application process, additional materials and substances are required. Active substances and types of active substances are required to select the drugs to be used in the chemotherapy plan. The active substances may be incompatible with each other, in which a table is required to get information about suitability between active substances. The types of cancer are required to show in the chemotherapy plan and to list the active substances by type of cancer. It can be use substances such as injector, sleeping pills in the chemotherapy plan, so there are database tables for hold that data.

Active substance table holds information of all active substances. ID field is used as primary key and has auto increment feature. NAME field is necessary to hold the name of the active substance. DESCRIPTION field keeps the necessary explanation of the active substance. Dosage calculations of some active substance can be made

with different formulas hence SPECIAL_CALCULATION field is added to table. Lastly, ACTIVE_SUBSTANCE_TYPE_ID field specifies the type of active substance (Figure 3.22).

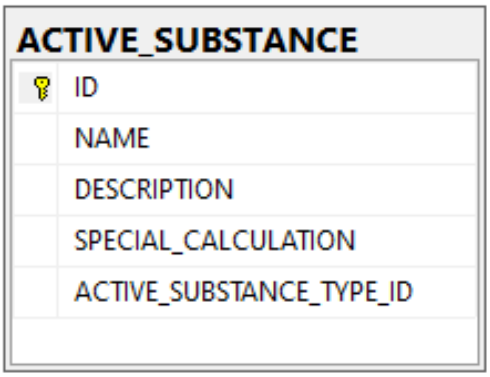


Figure 3.22 “Active Substance” table

The “Active Substance Type” table is used to specify the types of active substances. ID field is used as primary key and has auto increment feature. SUBSTANCE_TYPE_NAME field is the name of the type of active substances (Figure 3.23).

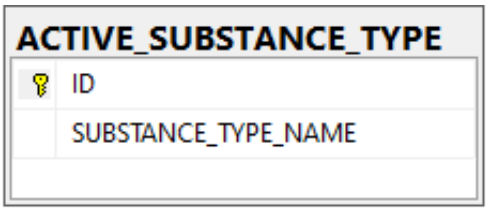


Figure 3.23 “Active Substance Type” table

This table shows the compatibility between the two active substances. ID field is used as primary key and has auto increment feature. ACTIVE_SUBSTANCE_T1_ID field shows the active substance id and ACTIVE_SUBSTANCE_T2_ID field shows another active substance id. SUITABLILITY field shows compatibility between two active substances (Figure 3.24).

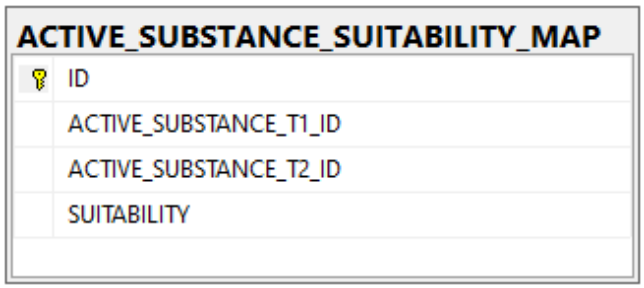


Figure 3.24 “Active Substance Suitability Map” table

When creating a chemotherapy schema, both drug, grade and control types can be added to the treatment days. The “Application Step Type” table was created to store these options. ID field is used as primary key and has auto increment feature. STEP_NAME field holds the option step name (Figure 3.25).

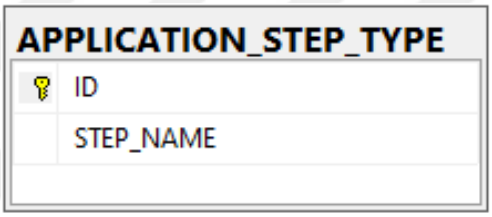


Figure 3.25 “Application Step Type” table

The “Cancer Type” table where cancer types are kept. ID field is used as primary key and has auto increment feature. CANCER_TYPE_NAME field is the name of the type of cancers (Figure 3.26).

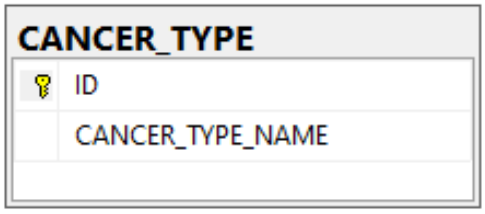


Figure 3.26 “Cancer Type” table

The “Cancer Type Active Substance Map” table shows the active substances that can be used for a cancer type. CANCER_TYPE_ID field indicates the cancer type and ACTIVE_SUBSTANCE_ID field indicates the active substance (Figure 3.27).

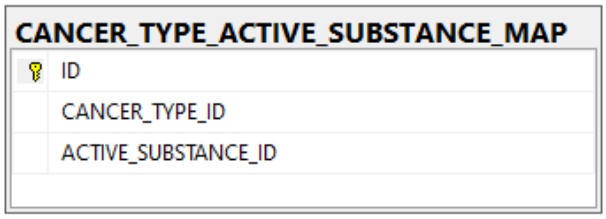


Figure 3.27 “Cancer Type Active Substance Map” table

The “Control Type” table is a table that keeping patient’s treatment control types. ID field is used as primary key and has auto increment feature. CONTROL_TYPE_ NAME field specifies the name of the control type (Figure 3.28).

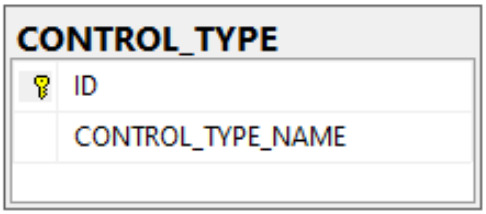


Figure 3.28 “Control Type” table

The “Dosage Unit” table is the table where all units are kept for selecting the dosage unit of drugs and active substances. ID field is used as primary key and has auto increment feature. DOSAGE_TYPE field indicates dosage type name (Figure 3.29).

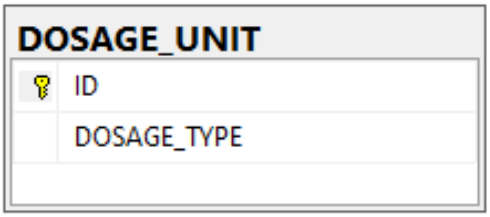


Figure 3.29 “Dosage Unit” table

The “Drug” table is the database table where the drug information is kept. ID field is used as primary key and has auto increment feature. BARCODE_NUMBER field shows the barcode number of the drug. DESCRIPTION field provides information about the drug. DRUG_TYPE_ID is required for the drug type (Figure 3.30).

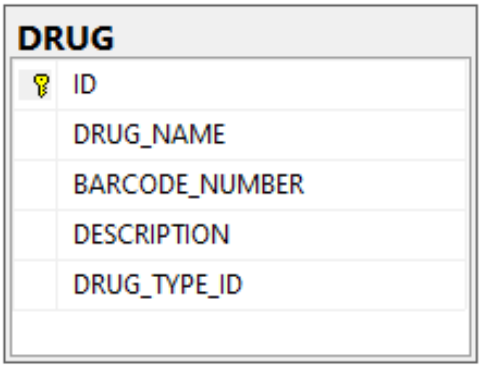


Figure 3.30 “Drug” table

The “Drug Formula” table is a table containing formulas used to calculate the amount of active substances and drugs in some special cases. ID field is used as primary key and has auto increment feature. FORMULA field is the field where the formula types are specified. FORMULA_NAME field indicates formula types of active substances or drugs (Figure 3.31).

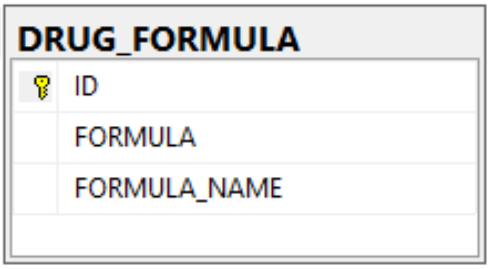


Figure 3.31 “Drug Formula” table

The “Drug Type” table is a database table for hosting drug types. ID field is used as primary key and has auto increment feature. DRUG_TYPE_NAME field contains the names of the drug types (Figure 3.32).

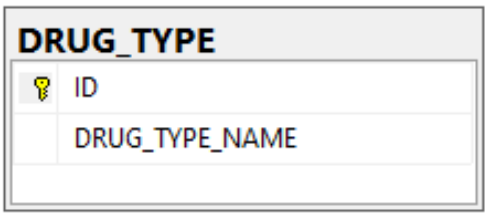


Figure 3.32 “Drug Type” table

The “Drug Unit” table is the table where the units of drugs are kept. ID field is used as primary key and has auto increment feature. UNIT_NAME field contains the names of the drug units (Figure 3.33).

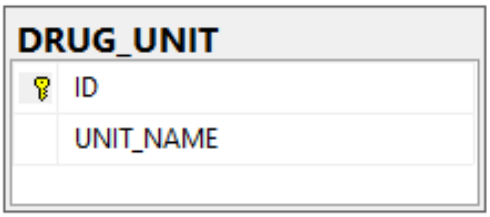


Figure 3.33 “Drug Unit” table

The “Drug Active Substance Map” is a table that shows which drugs belongs to which active substances. ID field is used as primary key and has auto increment feature. DRUG_ID field shows the drug information. ACTIVE_SUBSTANCE_ID field shows the active substance information (Figure 3.34).

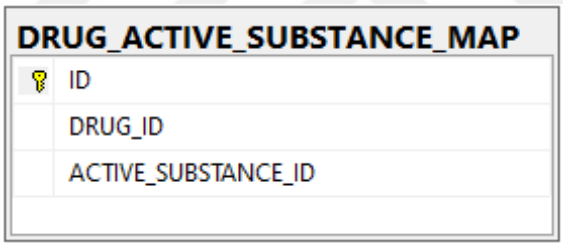


Figure 3.34 “Drug Active Substance Map” table

The “Given Type” table holds the given type of drugs or substances. ID field is used as primary key and has auto increment feature. GIVEN_TYPE_NAME field is the field that holds the information about the given type of drug to the patient (Figure 3.35).

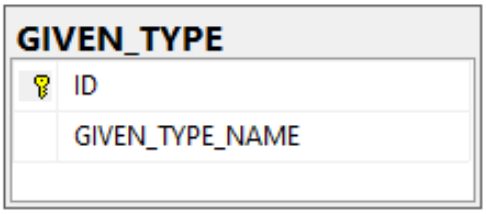


Figure 3.35 “Given Type” table

The “Materials” table contains the materials used in the treatment of chemotherapy. ID field is used as primary key and has auto increment feature. MATERIAL_NAME field holds the name of material and DESCRIPTION field indicates information about that material (Figure 3.36).

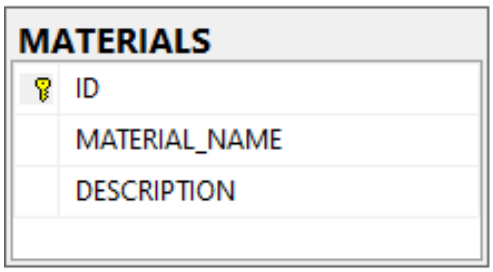


Figure 3.36 “Materials” table

The “Supplementary Substance” database table shows the supplementary substances to be used in the chemotherapy plan. ID field is used as primary key and has auto increment feature. NAME field shows the name of the supplementary substance, DESCRIPTION field shows the explanation of the supplementary substance, and the SUPPLEMENTARY_SUBSTANCE_TYPE_ID field shows the type of the supplementary substance (Figure 3.37).

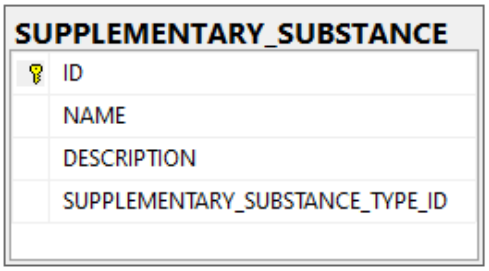


Figure 3.37 “Supplementary Substance” table

The “Supplementary Substance Type” table is prepared to hold supplementary substance types. ID field is used as primary key and has auto increment feature. TYPE_NAME field contains the type of supplementary substance (Figure 3.38).

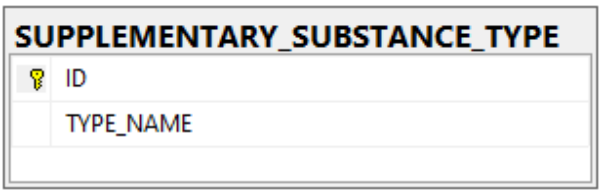


Figure 3.38 “Supplementary Substance Type” table

The “Time Type” table is the table where the time unit information is kept. ID field is used as primary key and has auto increment feature. TIME_TYPE_NAME field holds the names of the time units (Figure 3.39).

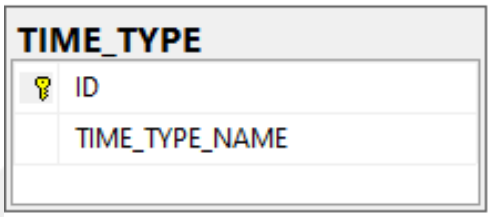


Figure 3.39 “Time Type” table

The “Unit Type” table is that table that where supplementary substance’s and material’s unit information is kept. ID field is used as primary key and has auto increment feature. UNIT_TYPE_NAME field holds the names of the time units (Figure 3.40).

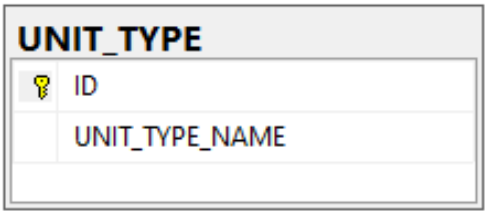


Figure 3.40 “Unit Type” table

3.3 Project Structure

Chemotherapy Plan Tool project consist of four sections which are Database, Service, Test and Web sections (Figure 3.41).

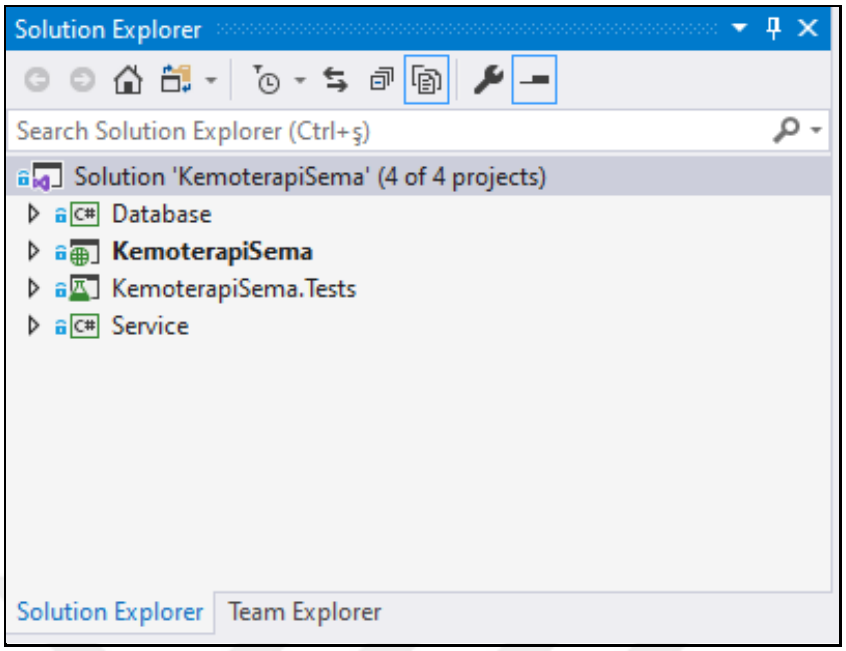


Figure 3.41 Project general structure

In database project; models, model maps and context are kept. Models are same as database objects. Model maps indicate the relationship between model and database objects. Context is the bridge between database project and database. Repository pattern and database context classes are located in this section and data exchange is provided from this field (Figure 3.42).

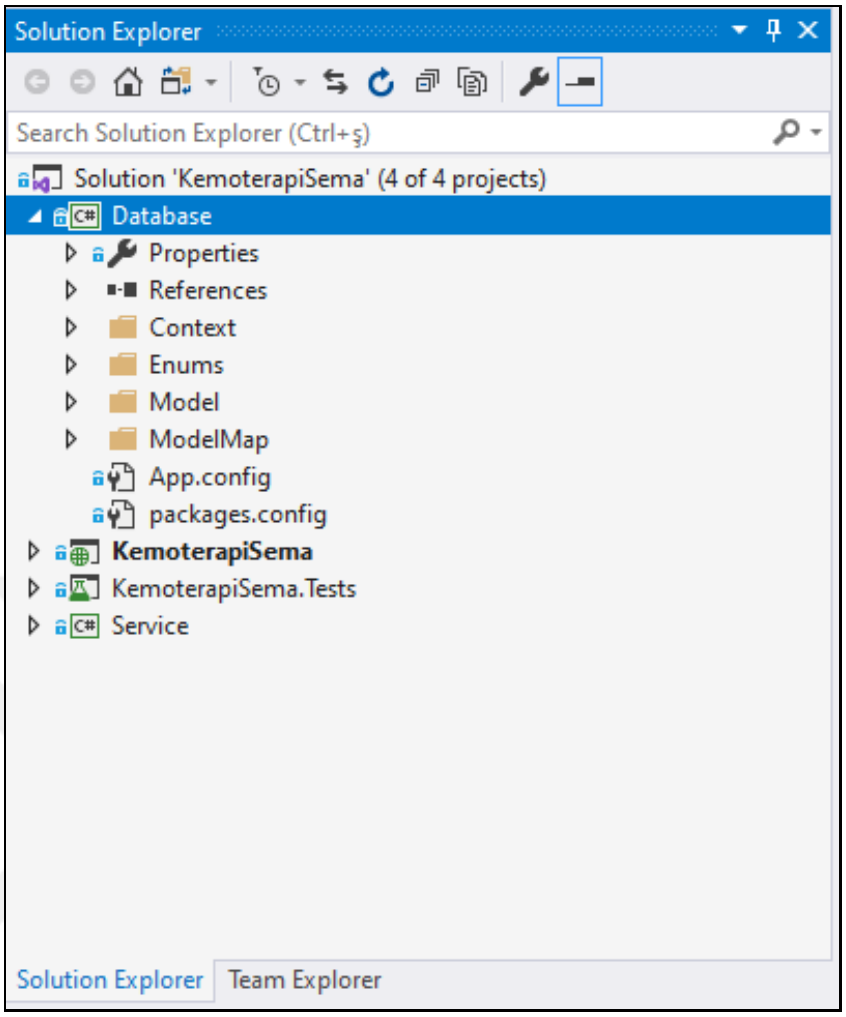


Figure 3.42 Database project general structure

In the service project, it is referenced from the database project and a separate service class is created for each database object. In the generated service class, the model object is called using a repository pattern. The service classes contain database queries and methods. Lastly, the service classes are written into the controller classes (Figure 3.43).

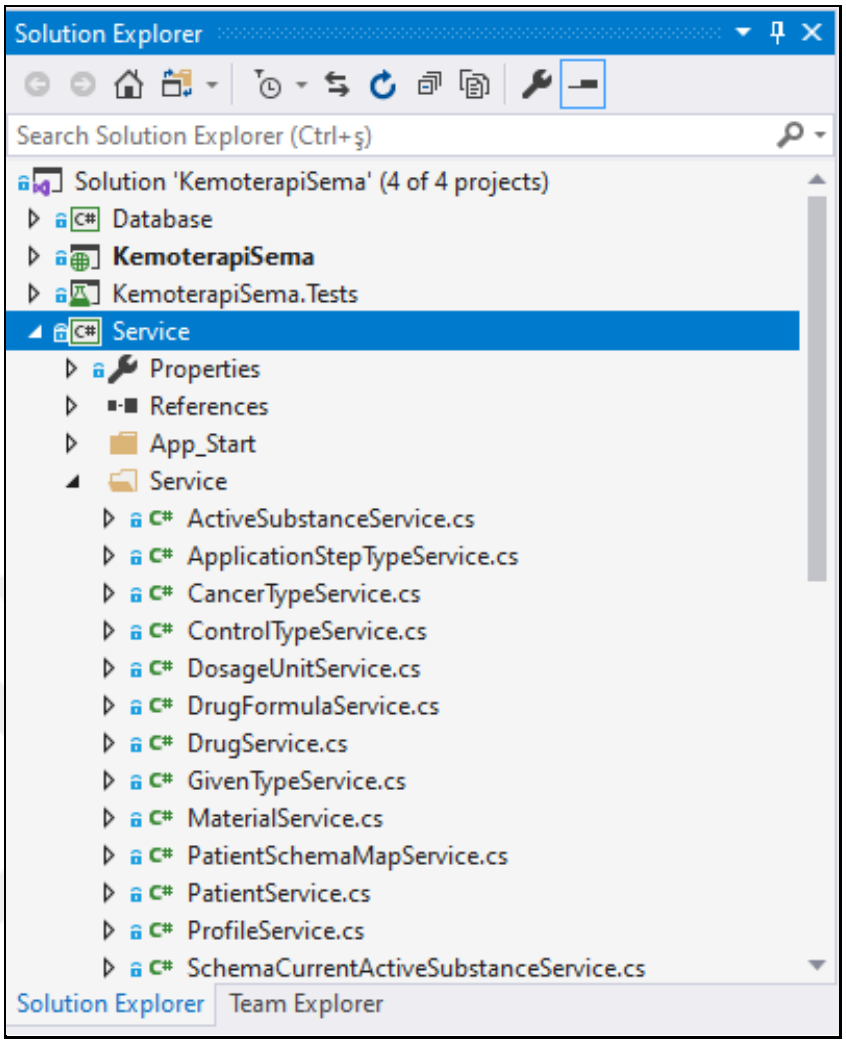


Figure 3.43 Service project general structure

In the web project, there is MVC pattern. In the model folder, there are classes that carry data to the controller and view layers. View files contain html pages. In the Controller class, there are service classes and functions for each page (Figure 3.44).

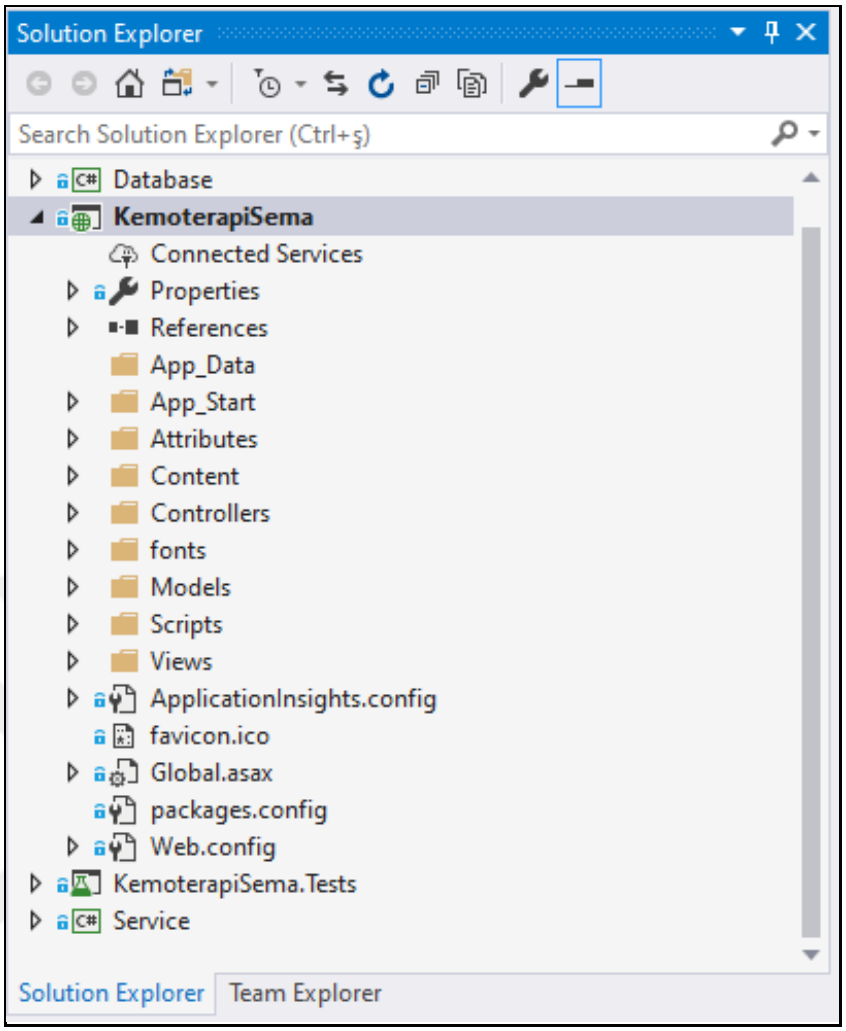


Figure 3.44 Web project structure

CHAPTER FOUR
CHEPSYS: CHEMOTHERAPY PLAN TOOL

Chemotherapy Plan Tool (CHEPSYS) is a web-based project and has been designed with many hospital and healthcare facilities in mind. Most hospitals or healthcare facilities have clinic chefs, doctors, nurses and healthcare professionals. According to the observed hospitals and healthcare facilities, the clinical chefs are responsible for preparing the chemotherapy protocols. While doctors take a copy of chemotherapy protocols and apply them to patients, nurses follow up chemotherapy plans and look after patient. Health professionals are responsible for the drugs given to the patient. In some cases, doctors can look after patient and responsible for the given drugs instead of nurses. When all these situations are taken into consideration, it is revealed that there is an authorization system in hospitals and healthcare facilities.

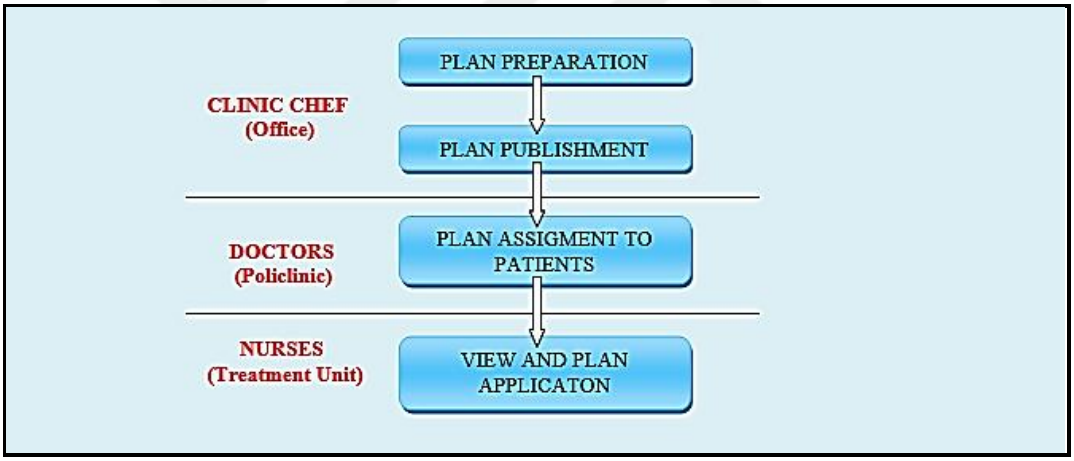


Figure 4.1 Authority system in hospitals and clinics

Therefore, a similar authorization system has been implemented in the CHEPSYS project. With that authorization system; separate profiles are defined for each user and different roles are defined for each profile. Thus, each page in the project are protected by roles, in this way users who don't have the required role are not able to view the pages that are not authorized. Thus, only the clinical chefs are displayed the pages for which the chemotherapy protocol has been created or updated, and doctors will be able to view the list of chemotherapy protocols created and view the pages where they can

copy the chemotherapy protocol of their choice. In addition, roles and profiles have been made flexible which makes allow adding and removing profiles on users.

Login is the screen that where users can log in with their email and password (Figure 4.2). If any error occurs during the login process, the system displays an error message. If the session information is correct, the user's roles are added to the user object. Profiles and roles information come from profile and role tables. Their authority over the system will be given according to their roles. Each page protected by controller's attribute class. Attribute class shows the pages to the users according to their roles. In this way, pages are protected by roles.

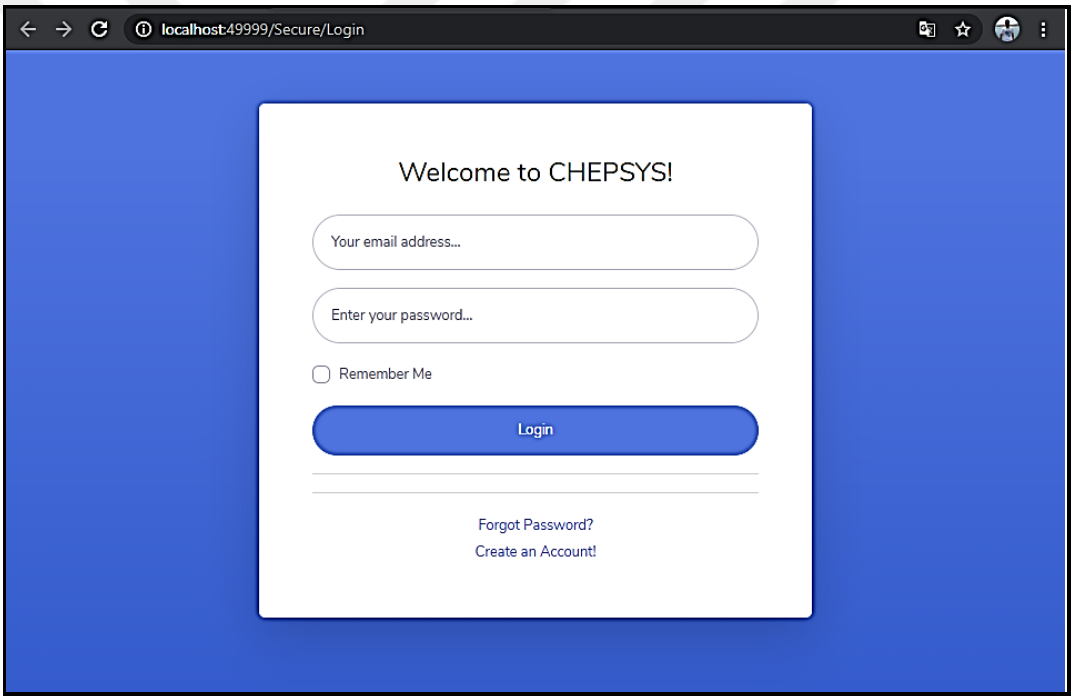


Figure 4.2 Login screen

A basic user interface and main page are shown for this project. In the middle of the page it shows the numbers of the protocols that has been created. Next to this field, the total number of users on the website is displayed. On the left side of the menu, user can view his own protocols, make a new protocol or manage system users (Figure 4.3).

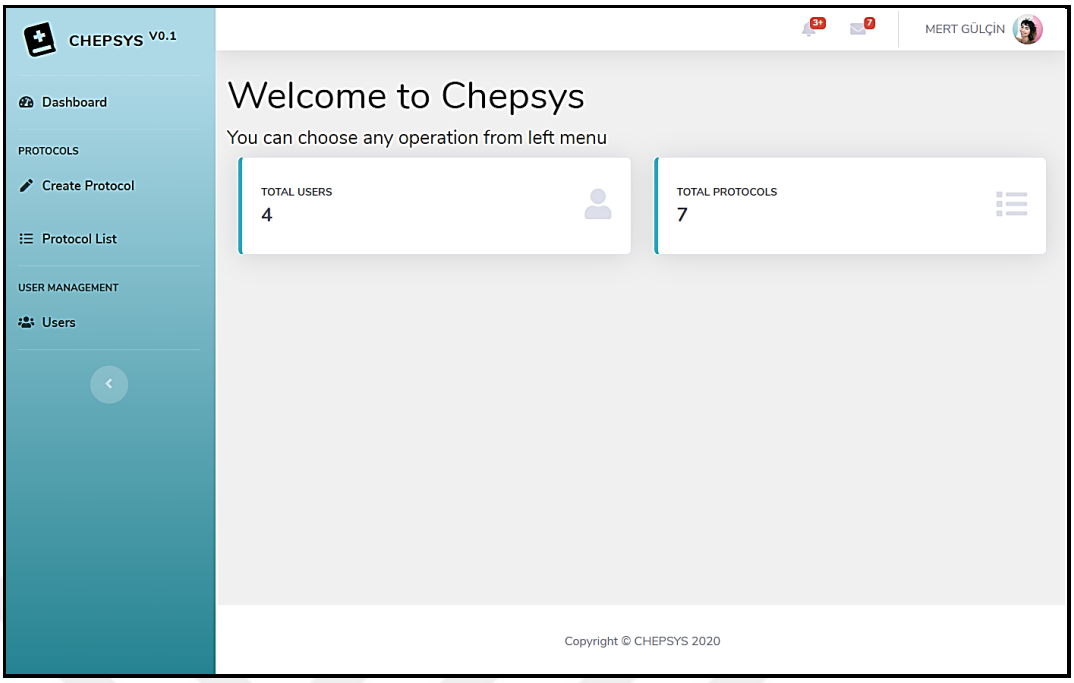


Figure 4.3 Dashboard screen

If the user clicks the ‘Create a new Protocol’ button in the menu on the left (Figure 4.3), a new protocol creation step is begun. This creation process consists of five steps. In the first step, user is asked about the schema name, type of cancer, total therapy days, repetition of treatment, protocol abbreviation, protocol note and protocol priority which are the required data for a protocol. Each protocol also includes notes or important situations that should be made before starting treatment however these notes are optional. After the required fields are filled, the user can click the ‘Next Step (Active Substance)’ button (Figure 4.4).

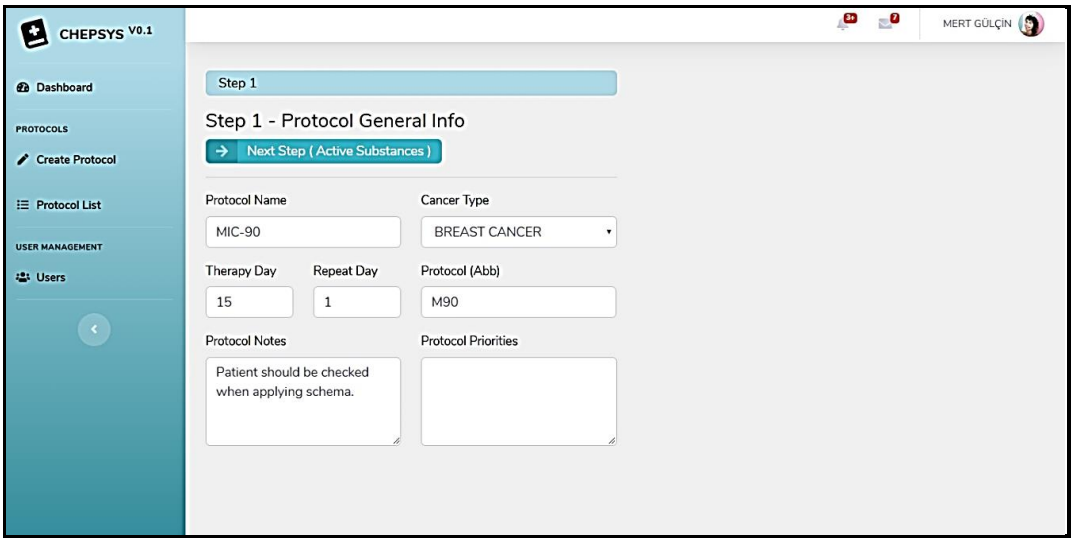


Figure 4.4 Step one: Protocol general information

In the second step, the user is asked for the active substances to be entered for the chemotherapy plan. Active substance, dosage, given type, duration and grade fields are required fields. Special formulas are used to calculate the dosages of some active substances. If an active substance that has a special formula is selected, the formula options are presented to the user (Figure 4.5).

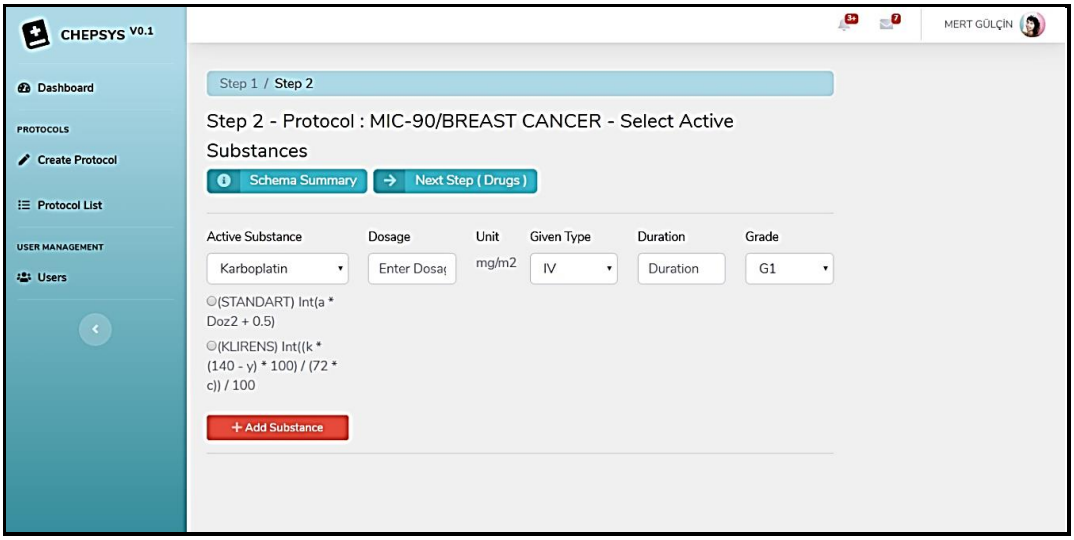


Figure 4.5 Step two: Select active substances

After the required fields are filled, “Add Substance” button is clicked. Added active substances are listed at the bottom of the page. The user can also view the schema summary and added active substances by clicking the “Schema Summary” button.

When the necessary active substances are added, “Next Step (Drugs)” button is pressed (Figure 4.6). At least one active substance is required to proceed to the next step.

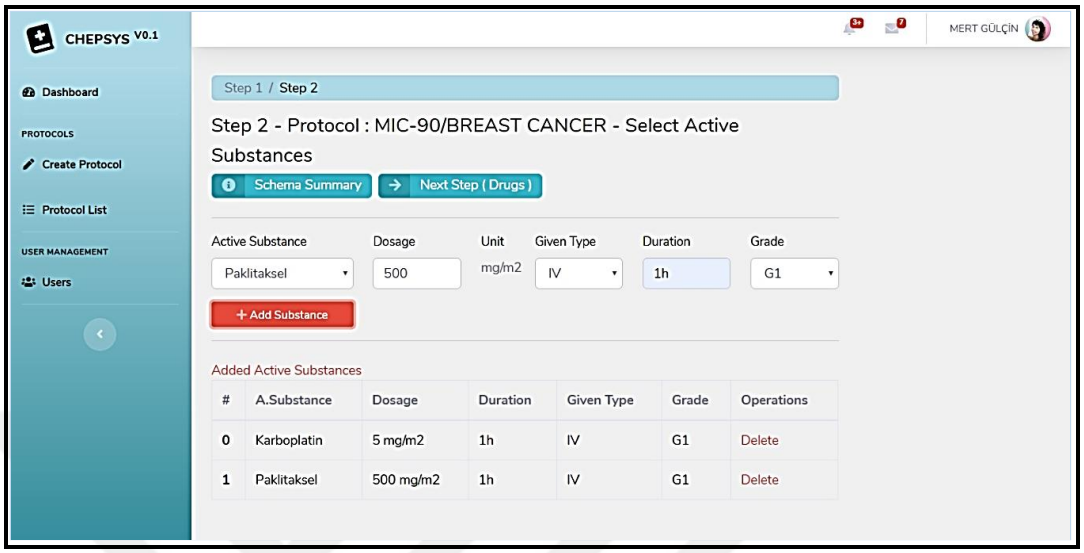


Figure 4.6 Step two: Adding active substance

In the third step, the user can add drug, note or control type to the chemotherapy schema. User can switch between steps by using the step list at the top of the page. “Schema Summary” button shows the user all the features added to schema so far. “Clone Specific Day” button is used to clone all drugs, notes and control types added to a day to another day. In the day selection field below, the user can select the day that wants to add the item. In the application type field, the user made choice between the drug, note or control type to add (Figure 4.7).

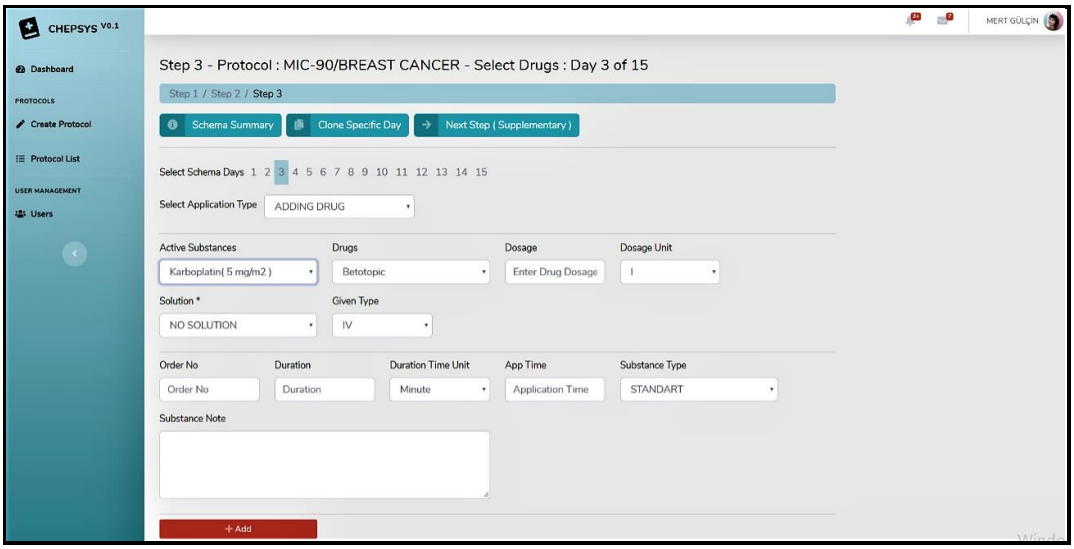


Figure 4.7 Step three: Adding drug to schema

First, on the left, the active substances selected in the second step are listed along with their dosages. In addition, the list of drugs and the solution list change depending on active substance change. To add the drug, first the active substance is selected then the drug is selected from the list of drugs that are bound to the active substance. The dosage of the drug to a patient is given in two different ways. If the dosage of a drug is to be calculated by a formula based on the physical characteristics of the patient, dosage field is left blank or zero number is entered in the dosage field. Then, the dosage unit is selected for the drug dosage. In some cases, chemotherapy solutions may be used in drugs. The user can select a solution for the drug if user wants to use a solution (Figure 4.7).

Order number field must be entered in the sequence number field due to more than one drug can be added to the selected treatment day. Duration field determines how long a drug is to be used and it is not a required field. While sometimes drugs are used at certain hours and minutes, for that reason app time field has been added. Lastly, substance type field is used to specify whether the drug is necessary or optional (Figure 4.7).

If user wants to add notes to the selected treatment day, user selects adding note using the select application type section. Henceforth, user enters the note that considers necessary and then press the “Add” button (Figure 4.8).

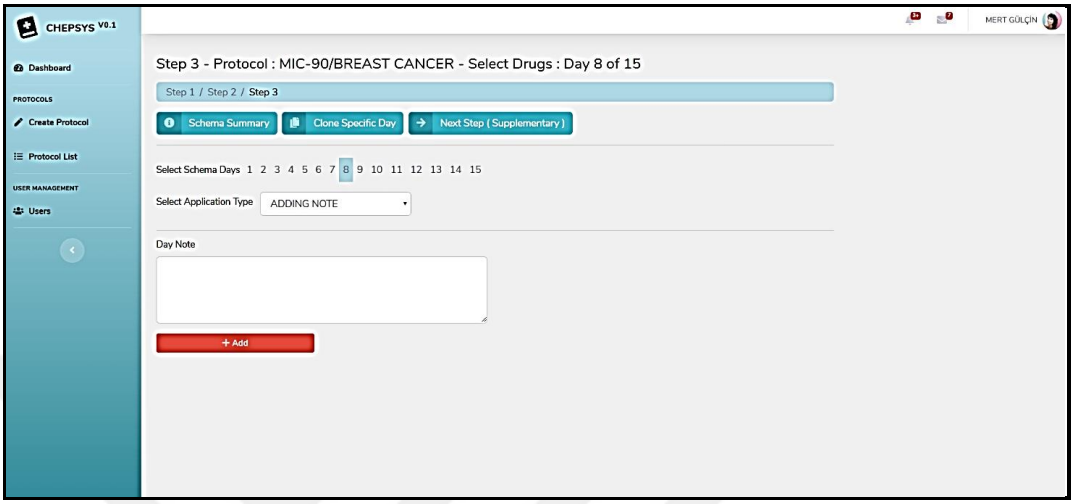


Figure 4.8 Step three: Adding note to schema

Users can also add control type to the treatment days of the schema. The control type represents the control that patients must undergo during the treatment process. First, the adding control type tab is selected from the select box menu. Then, control types are selected using the check boxes and multiple selections can be made if necessary. After the required fields are selected, “Add” button is pressed. “Next Step (Supplementary)” button is pressed after making necessary additions to treatment days (Figure 4.9).

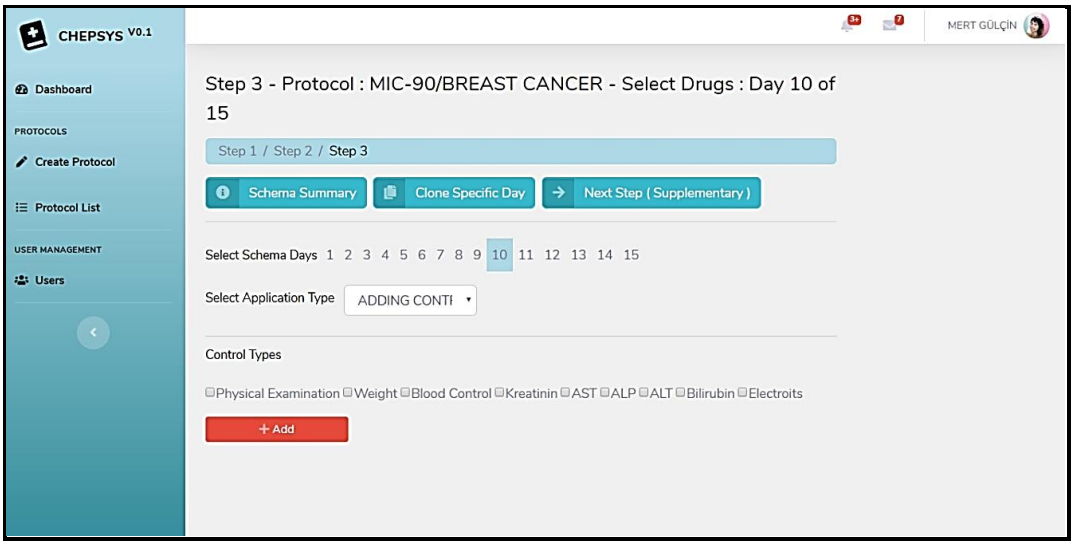


Figure 4.9 Step three: Adding control types to schema

Hence chemotherapy treatment has serious ailment, cancer patients can be given extra supplementary substances. For this reason, in the fourth step, the user is optionally provided with supplementary substance options. At the top of the page choices given to user such as (antibiotics, sleeping pills, etc.). Below that area there is a material (syringe, bandage, etc.) insertion section. This is not a required, the user can pass this step blank if user wishes (Figure 4.10).

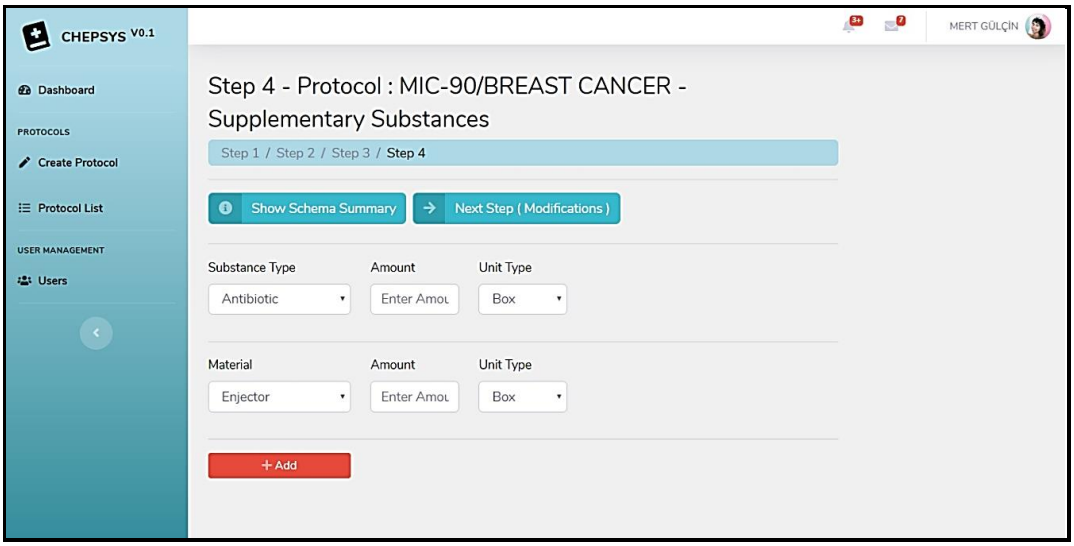


Figure 4.10 Step four: Adding supplementary substances

In the last step of creating schema, the modification notes and modification rate is entered for the chemotherapy schema. Modification notes of the chemotherapy schema area written in the modification note section. The modification rate section indicates the patient's weight change rate. Patient's minimum and maximum weight is calculated according to the entered modification rate. If the current weight of the patient is outside the boundaries calculated, then depending on the doctor's decision the treatment is canceled, or another schema is selected to be applied to the patient (Figure 4.11).

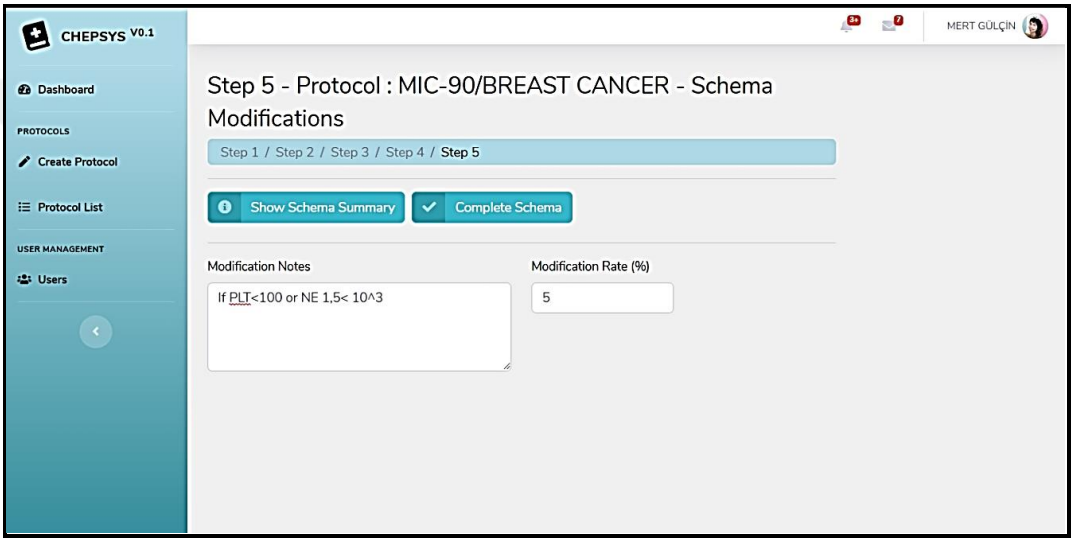


Figure 4.11 Step five: Completing schema

After a new chemotherapy schema is created, the user is redirected to the dashboard screen. Then the user can view the list of chemotherapy schemas created so far using the protocol list link to the left of the page. If the logged in user has the role of clinical chief; then user can view the entire schema list, view schemas, edit schemas, delete schemas or approve the schemas (Figure 4.12).

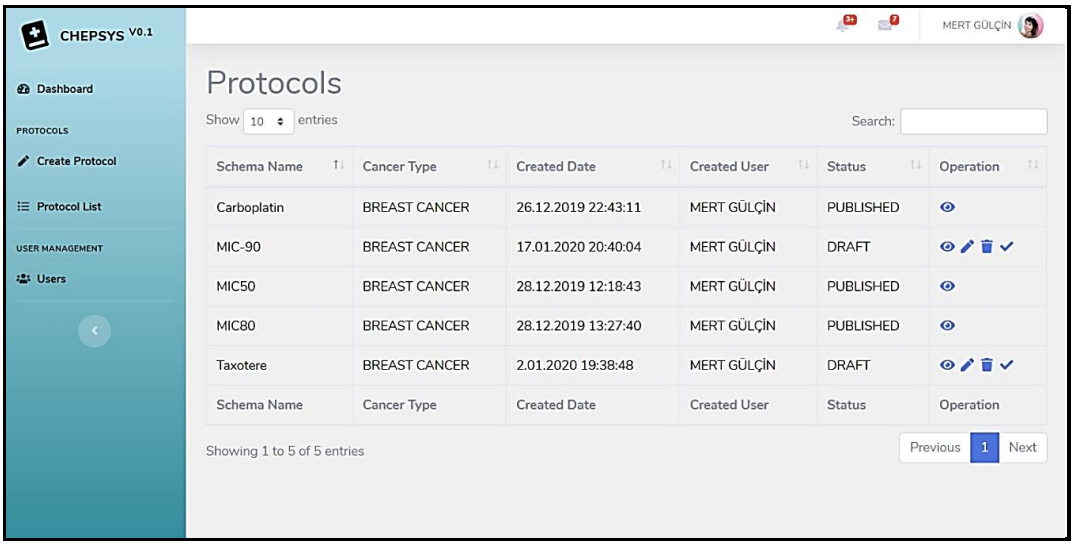


Figure 4.12 List of schema page (Clinic chef view)

If the user has a doctor or nurse role, then cannot make any changes to the schema list, only displays the chemotherapy schemas that was created before (Figure 4.13).

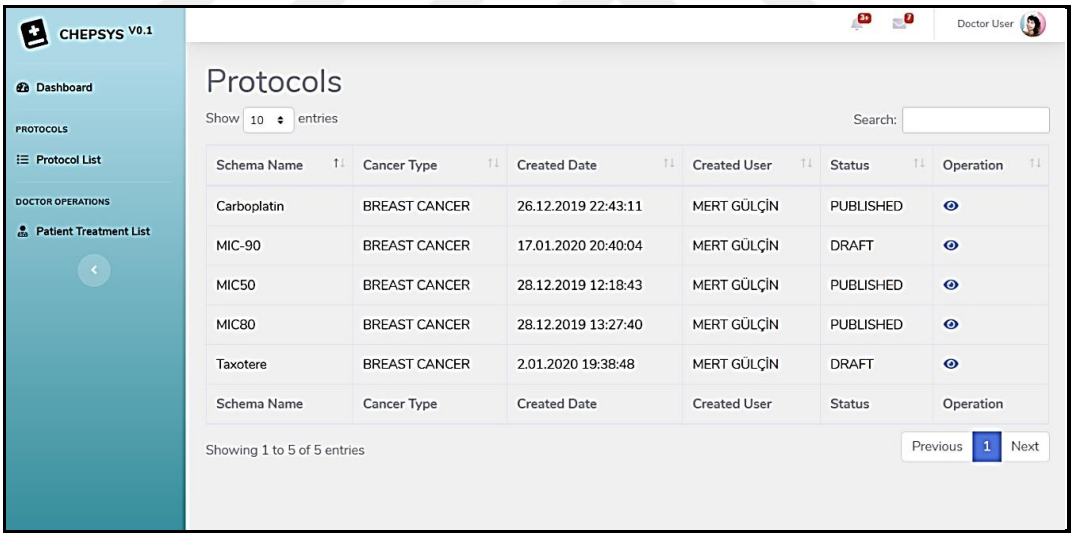


Figure 4.13 List of schema page (Doctor user view)

The schema that was created is displayed on the schema detail page (Figure 4.14). This page can be classified into three sections. In the first section, at the top of the page is the schema general information field. This field contains the schema name, type of cancer, total days, repetition days, schema name, abbreviation, schema notes, schema priority notes, schema modification notes and modification rate.

Second section is the selected active substances section that contains the active substances selected for the schema, dosages of the active substances, and duration of the active substance (Figure 4.14).

In the third section, the drugs selected for the schema, the notes selected for the schema and the control types are shown. In addition, the supplementary substances are also displayed in this section, if they are added to schema. All medications are displayed sorted by day and by order number. The fields shown in red indicate that the drug dosage will be calculated with the patient after being assigned to the patient. Fields shown in green indicate that the drug will be used with a drug-dependent solution.

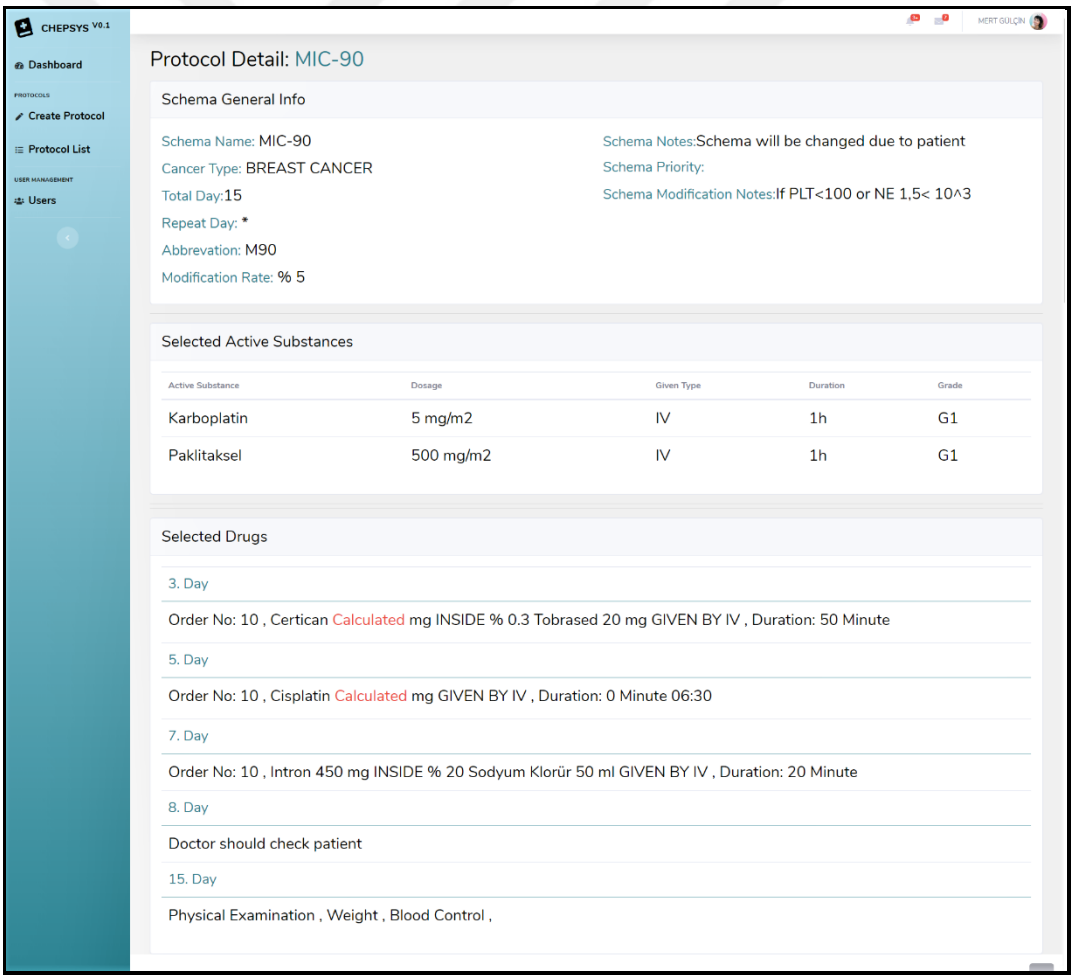


Figure 4.14 Schema detail page

After all these schema creation and display operations, if the user has a doctor profile then user can click on the patient treatment list link to the left of the dashboard screen to view the chemotherapy schemas assigned to the patients. The opened page there is a list of schemas assigned to patients so far. At the top of the page, there is a button for assigning schema to patients (Figure 4.15).

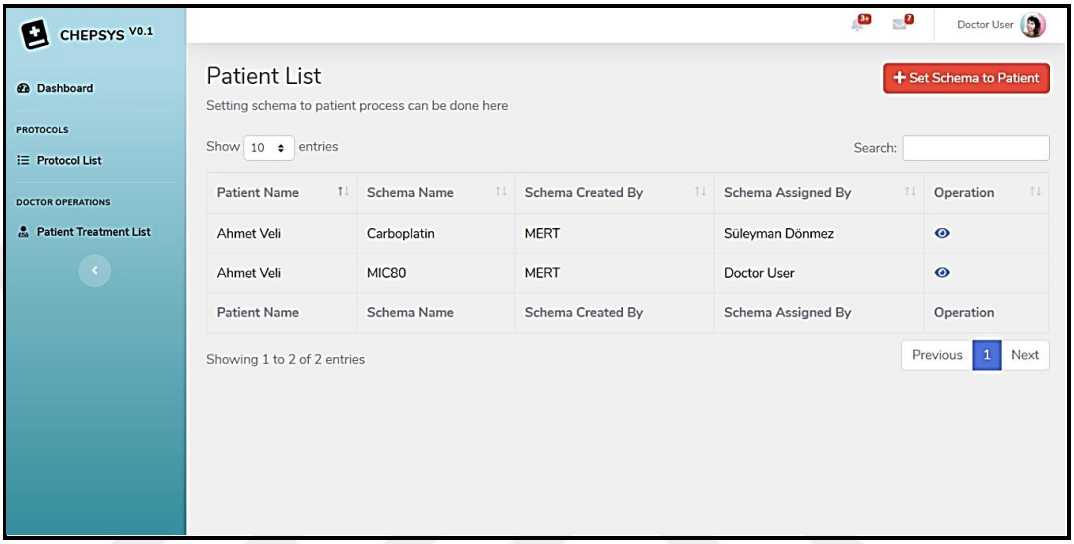


Figure 4.15 Patient list page

In the patient list page; the name of the patient, the name of the schema, the name of the user that creator of the schema, the name of the user that assign schema to patient are shown to the current user. If the current user clicks the “Set Schema to Patient” button at the top right of the page, a pop-up is displayed. This screen will display schemas approved by the clinical chef and patient list. The current doctor user assigns schema to the desired patient and during this assignment, the dosages to be calculated according to schema drugs and patient physical information then schema assigning operation is completed (Figure 4.16).

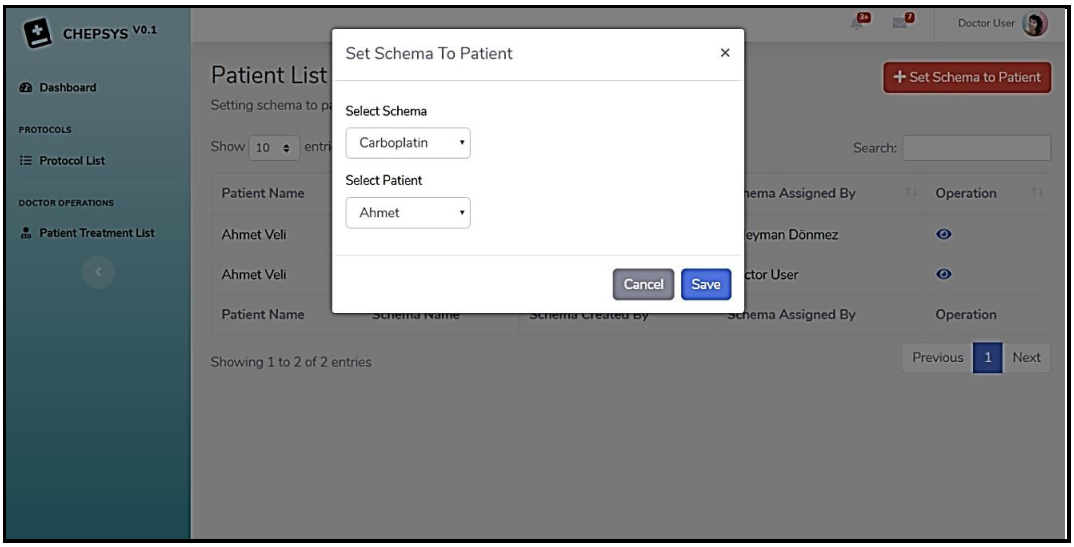


Figure 4.16 Set schema to patient screen

After the patient is assigned the schema, this list screen is displayed on the list. The opened detail page consists of three parts which are “Schema General Info”, “Schema Notes and Modifications” and “Schema Drug Information”. First part is gives user to patient general information, creatinine and clearance values. Moreover, active substance information and their calculated dosage values in this section. In the second part; notes, priorities and change information of schema are given. In the third section, the user is shown the notes and control types of drugs assigned to the schema. In addition, dosages of drugs are shown which are calculated by using patient’s information and specific formulas are shown in this section. The user can view which drugs will be used on treatment days by referring to this section (Figure 4.17).

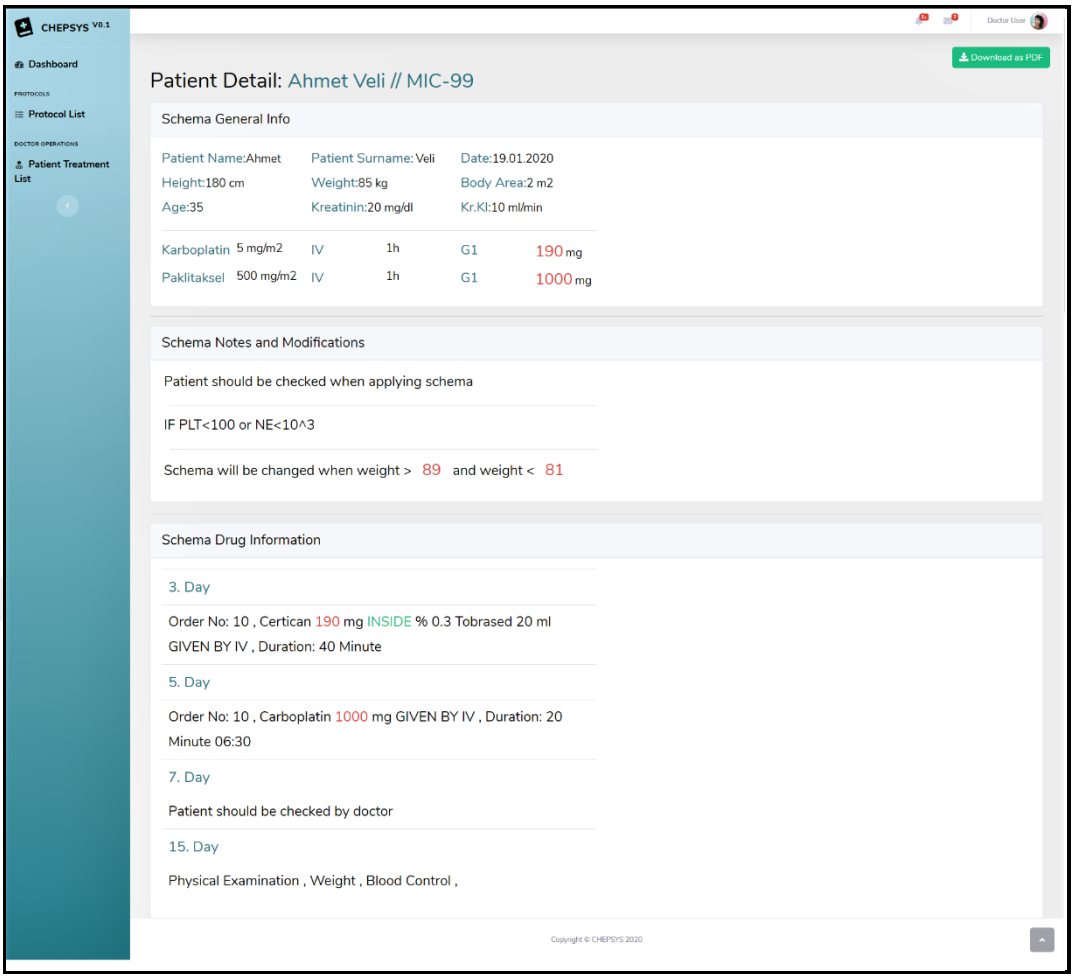


Figure 4.17 Assigned schema detail page

CHAPTER FIVE
CONCLUSION AND FUTURE WORK

Chemotherapy is one of the most important treatment methods in cancer treatment. Creating treatment plans according to cancer types is called chemotherapy protocols. Chemotherapy protocols include many conditions as active substances, supplementary substances, treatment duration, given drugs and duration of drugs. All chemotherapy protocols prepared according to the studies conducted so far have been prepared by a health institutions or clinic chefs in the oncology departments in hospitals. The prepared chemotherapy protocols are prepared by a computer program (Word or PDF) format or as hard copy. Due to the inability of existing software to interact with hospital information management systems and pharmacy drug management systems, there was a need for software that creates easier more convenient and faster chemotherapy protocols and interacts with hospital information management systems and pharmacy drug information management systems (Understanding Cancer, 2019).

With the use of the information technologies in the field of health, there is clear evidence that health science has evolved, and that health-related research is more useful. It appears that health informatics leads to effective and efficient use of information in the field of health. With the help of technological developments, many applications can be transferred to the electronic environment and all information about a patient's health is recorded in the database and this information can be accessed quickly.

In this study, chemotherapy schemas which are a part of chemotherapy treatment are transferred to electronic environment and it is aimed to create chemotherapy schemas faster and more easily. Thus, it was aimed to reach the previously chemotherapy treatments applied to patients and the drugs used to patient by the doctors.

Using the data obtained from the study, a variety of statistical data such as the most commonly used drugs, the most common cancer types, or the most commonly used

chemotherapy schema can be obtained. In addition, these statistical data pave the way for new scientific researches.

When all these conditions were taken into consideration, it was decided to transfer the chemotherapy protocols to the web site so that the treatment follow-up of cancer patients could be improved more quickly and easily. Firstly, chemotherapy protocols were investigated, and cancer treatment centers and hospitals were examined. It was learned that what chemotherapy drugs, active substances and their side substances are and how they are used. Then the technological infrastructure required for the project began to be researched (CPS, 2019).

CHEPSYS provides a planning environment for those who will prepare a chemotherapy protocol using a simple interface. Hence clinic chefs, doctors, nurses and health professionals in hospitals and healthcare facilities have different authority; CHEPSYS provides support for multiple users, differentiating between those who prepare chemotherapy plan and those who view chemotherapy treatment. Authorized users can log on the CHEPSYS, update their profile information, create a new chemotherapy protocol, view all chemotherapy protocols, see details of any chemotherapy protocol if they have required profile, set any confirmed schema to any patient and view the schema that assigned to the patient.

No similar study has been found based on the research done so far. Observed programs are desktop based, even if CHEPSYS is created by web based.

Table 5.1 Project comparison table

FEATURES	**CHEPSYS**	**PDF or WORD DOCUMENTS**
List of Chemotherapy Schemas	Available	Not Available
Create of Schema	Available	Available
Integration with other Software	Available	Not Available
User Authorization System	Available	Not Available
Support Multiple Users	Available	Not Available
Display of All Schemas Assigned to Patients	Available	Not Available
Statistical Data Retention	Available	Not Available
Assignment of a Chemotherapy Schema to Multiple Patients	Available	Not Available

For the project to work in all environments, the project can be upgraded to the .NET Core framework provided by Microsoft. Sometimes patients receiving chemotherapy treatment have to go to many other hospital units in the hospital environment during chemotherapy treatment. Hospital units usually work by appointment system. The project can be integrated with an appointment system that has been or will be made and a more efficient patient monitoring system can be realized.

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APPENDICES

Appendix-1 List of Abbreviations

AJCC	American Joint Committee on Cancer
APP	Application
BC	British Columbia
CCO	Cancer Care Ontario
CSS	Cascading Style Sheets
HTML	Hyper Text Markup Language
ID	Identification Number
LINQ	Language Integrated Query
MS-SQL	Microsoft Structured Query Language
MVC	Model View Controller
OPIS	Oncology Patient Information System
ORM	Object Relation Mapping
PDF	Portable Document Format
SQL	Structured Query Language