DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

LIFESTYLE CHANGE FOR SMOKING CESSATION: TRACKING AND RECOMMENDATION SYSTEM

by
İlay İLTER

June, 2019
İZMİR

LIFESTYLE CHANGE FOR SMOKING CESSATION: TRACKING AND RECOMMENDATION SYSTEM

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by
İlay İLTER

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İZMİR

M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"LIFESTYLE CHANGE FOR SMOKING CESSATION: TRACKING AND RECOMMENDATION SYSTEM"** completed by **İLAY İLTER** under supervision of **PROF. DR. ALP KUT** 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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İlay İLTER

LIFESTYLE CHANGE FOR SMOKING CESSATION: TRACKING AND RECOMMENDATION SYSTEM

ABSTRACT

Today, many diseases are caused by the unhealthy lives of the individuals. One of the important elements of unhealthy life is smoking dependence. Many people are suffering from severe illnesses such as lung cancer and asthma, especially due to smoking. Although these results are known, quitting the cigarette unfortunately is difficult in many ways. With the web and mobile application that will be developed with the aim of solving these problems, it will be possible to change people's lifestyles and become healthier individuals.

The proposed system will be developed under the supervision of a family physician. The developed system consists of two separate modules. The first module is a web-based software that the physician uses. In this software, the physician records the patient's medical information and creates a treatment plan accordingly. The second module is the mobile software used by the patient. The patient follows the treatment plan with this application and records his daily habits. The physician also checks the information received from the mobile application with the web-based application and can update the patient's treatment plan. With this project, it is aimed to help the individuals who will make lifestyle changes, to quit smoking, to exercise and to reach their ideal weight by eating healthy.

Keywords: Smoking cessation, e-health, mHealth, cloud computing, healthy life application

SİGARA BIRAKMA İÇİN YAŞAM TARZI DEĞİŞİKLİĞİ: İZLEME VE TAVSİYE SİSTEMİ

ÖZ

Bugün, birçok hastalığa bireylerin sağlıksız yaşamları neden olmaktadır. Sağlıksız yaşamın önemli unsurlarından biri sigara bağımlılığıdır. Birçok insan, özellikle sigara nedeniyle, akciğer kanseri ve astım gibi ciddi hastalıklar yaşamaktadır. Bu sonuçlar bilinmesine rağmen, ne yazık ki sigarayı bırakmak birçok yönden zor olmaktadır. Bu problemlerin çözümü amacıyla geliştirilecek olan web ve mobil uygulama ile insanların yaşam tarzlarını değiştirerek daha sağlıklı bireyler olmaları amaçlanmaktadır.

Önerilen sistem aile hekimi uzmanının danışmanlığında geliştirilmiştir. Geliştirilen sistem iki ayrı modül içermektedir. İlk modül hekimin kullandığı web tabanlı bir yazılımdır. Bu yazılımda, hekim hastanın tıbbi bilgisini kaydeder ve buna göre bir tedavi planı oluşturur. İkinci modül, hasta tarafından kullanılan mobil yazılımdır. Hasta bu uygulama ile tedavi planını takip eder ve günlük alışkanlıklarını kaydeder. Hekim ayrıca mobil uygulamadan alınan bilgileri web tabanlı uygulama ile kontrol eder ve hastanın tedavi planını güncelleyebilir. Bu proje, yaşam tarzı değişikliği yapacak bireylerin, sigarayı bırakmalarına, egzersiz yapmalarına ve sağlıklı beslenerek ideal kilolarına ulaşmalarına yardımcı olmayı amaçlamaktadır.

Anahtar Kelimeler: Sigara bırakma, e-health, mHealth, bulut bilişim, sağlıklı yaşam uygulaması

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CHAPTER ONE
INTRODUCTION

1.1 General

Smoking is an important public health problem in the world and in our country. It has the potential to be addictive because it contains high levels of nicotine. Every year, 7 million people lose their lives due to smoking. This number means that one person dies in every 10 seconds because of smoking. (Cherukupalli & Perucic, 2018) Many people suffer from severe diseases such as lung cancer and asthma, especially due to their smoking dependence. Although these results are known, unfortunately, smoking cessation may be difficult for many reasons. In order to prevent smoking dependence, it is necessary to make a lifestyle change besides medical treatment. However, lifestyle change treatment requires long-term behavioral change and cannot be applied as desired. Ensuring behavioral change is only possible by providing a physician-controlled continuous counseling and motivation. In the proposed system, the information required to be received in the web-based application will be determined by the help of the family physician. The application will be developed with this information. The physician will determine and apply the treatment plan to the patient using the application. In addition, cloud-based mobile software will be developed and patients will be able to do daily follow-up and be in constant communication with their doctor. With this application, the physician will be able to determine whether his / her patient complies with the treatment and accordingly update the treatment plan and create the right treatment model for the patient.

Thanks to the developing technology and the internet, users are turning to the cloud computing technology which is flexible, economical and accessible everywhere, from the infrastructure of classical information technologies giving local scale and limited service opportunities. Cloud computing provides to access resources independently of the location. (Küçüksille et al., 2013) Cloud computing is a model of getting services by connecting to other servers over the internet without the need of any software or

storage unit via desktop computer, tablet or smart mobile device. (Kavzaoğlu & Şahin, 2012)

In the 21st century intelligent mobile device technology has developed rapidly and has become one of the integral parts of our lives. Daily tasks can be done with mobile technology in more practical, flexible times, in desired environments. Increasing use of mobile technologies in the health field also leads to an increase in the number of mobile health applications. (Eby & Güler, 2015) With the use of cloud computing, systematic and transferable patient records that can be accessed from every point. Patient records, date of examination, time of vaccination, time of drug use, feedback and warning systems related to screening, remote and continuous monitoring of health data, treatment decision-making systems, mobile applications can achieve much faster and more accurate results and the interaction between patients, doctors and hospitals is developing rapidly. (Sağlık alanındaki yeni eğilim bulut bilişim, n.d.)

1.2 Organization of Thesis

This thesis includes six chapters and this thesis is organized as follows.

In Chapter 2, summarizes the related literature and previous studies about smoking cessation mobile and web application, cloud computing, clinical decision support system.

In Chapter 3, the general structure of the proposed system is described.

In Chapter 4, the web based application and technologies used are explained.

In Chapter 5, the mobile based application and technologies used are explained.

Finally, in Chapter 6, the conclusion remarks are given.

CHAPTER TWO
LITERATURE REVIEW

Cloud computing is one of the latest technologies. Cloud computing is also rapidly increasing in everyday life. Today, the application of cloud computing is so common that it is used even in the healthcare industry. When compared to other industries, the health industry has considerable inadequate technology to improve operational efficiency. One of the main reasons for the use of cloud computing in the health sector is increasing population density and cloud computing to provide the infrastructure for the growth and storage of digital data of patients. Cardiovascular disease related death is high due to insufficient follow-up of cardiovascular risk factors such as diabetes, physical inactivity and smoking. Healthy lifestyle choices play an important role in the management of these changeable risk factors. (Rehman et al., 2017) The articles reviewed can be grouped under two main headings. One of them is data security in health systems and the other is similar systems. Table 2.1 shows the articles examined.

Security and privacy concerns still hinder widespread adoption of cloud computing in this area. Hoang and Chen say so far, they have not found a consistent typical security and privacy system requirements framework in this area. They have investigated the security and privacy system requirements for cloud-based medical data sharing scenarios using two strategies. They have applied literature-oriented and scenario-oriented strategies to reveal security and privacy requirements. In literature-oriented strategies, for the use of cloud computing in health, they have done a systematic literature review on security and confidentiality-friendly mechanisms in accordance with the literature review framework using in the EBSCOhost, IEEE Xplore, Emerald, ScienceDirect, AISeL, Springer, ACM Digital Library and Proquest literature databases. In scenario-oriented strategies, they identified stakeholders who were interested in the system and focused on security and confidentiality objectives. They agreed that the common requirements were related to the patient's medical records and identity data, as well as the actions of clinicians in the system, identification data and access privileges. (Ermakova et al., 2013)

Table 2.1 Articles and categories

Name	Author	Year	Category
Security and privacy system requirements for adopting cloud computing in healthcare data sharing scenarios	Ermakova, T., Fabian, B., & Zarnekow, R	2013	Data Security in Health Systems
Privacy-Preserving Public Auditing for Secure Cloud Storage	Cong Wang	2011	
Mobile Phone Apps for Smoking Cessation: Quality and Usability Among Smokers With Psychosis	Ferron, J. C., Brunette, M. F., Geiger, P., Marsch, L. A., Adachi-Mejia, A. M., & Bartels	2017	Similar Systems
Effects of a text message-based motivational interviewing intervention on cigarette smoking in college students	Jorayeva, A.	2016	
Clinical Decision Support Software	Kandula, V. R. & Deodhar S.,	2010	

In the another article, Cloud Computing proposes a public audit system that protects privacy for data storage security. In order to protect data privacy, users who have data and rely only on the third-party auditor for the security of their data do not want this audit process to cause unauthorized information leak security for data security. Wang and others have argued that the use of data encryption prior to outsourcing is a way to reduce this privacy concern but it is only complementary. They used homomorphic linear validators and random masking to ensure that the TPA would not obtain any information about the data content stored in the cloud controller. They also argued that this masking method mitigates users' fear of external data leakage. (Wang et al., 2010)

Along with the developing health systems, how to make the diagnosis of the patients can be done in electronic environment by decision support systems. There are many applications developed for this. An example of this is the eClinician Clinical Decision Support System software. Over the years, this software has been developed by doctors and software developers who successfully integrate standard medical text books and literary information systematically. This system contains notes on a variety of topics including 4500 diseases, more than 1300 lab results, ICD-10 cross references, drug interactions, HIV and AIDS treatment guidelines, clinical examination methods and immunoprophylaxis, vitamin deficiency. eClinician is a logical system developed by taking advantage of thousands of symptoms. There is a differential diagnosis module. This system is able to produce all of the different diagnoses possible from the patient's symptoms; this includes rare and rare possibilities of the disease. 88% of the results from this system are in the first place on the diagnosis list and the other 12% are in the 2nd and 3rd place. This system is designed as a system that can be accessed from any platform, but it is only a one-sided application for doctors. In practice, old data are used or in this system, data will not be refreshed according to changing patient information during the recommendation phase. (Kandula et al., 2010)

Vasa Curcin a, Elliot Fairweather, Roxana Danger and Derek Corrigan conducted a study on the requirements of a Decision Support tool based on the Learning Health System, the introduction of the theoretical model for source templates, and the demonstration of the emerging architecture. The methods have been tested and verified in a diagnostic decision support system. In this study, the reproducibility difficulties encountered by decision support systems under the guidance of the paradigm of the Learning Health System were examined and a solution based on data source technologies and abstract source template structures was proposed. (Curcin et al., 2017)

In the other study, they have reviewed all the original literature to understand the current scope of clinical decision support system for antimicrobial management and to analyze existing methods. Medline, EMBASE, HMIC Health and State and Global Health databases were investigated between January 1, 1980 - October 31, 2015. Fifty-

eight original articles describing 38 independent decision support systems were reviewed. Most of the systems are targeting antimicrobial prescription (76%), with electronic medical records (74%) with integrated platforms and an infrastructure based on rules providing decision support (76%). In the evaluation of the intervention reporting framework, CDSS studies fail to report that the non-specialist, end-user workflow has not been taken into account. They have narrow focuses such as antimicrobial selection and use surrogate outcome measures. The interaction with CDSS by clinicians was poor. (Rawson et al., 2017)

Cigarette addiction is increasing day by day and health problems related to its reach serious dimensions at advanced ages. For this reason, the number of treatments for smoking cessation is increasing. The treatments are provided via web, telephone, text. Recently, treatments with mobile applications are also increasing. This increases access to smoking cessation initiatives. In a study conducted in the United States, it was requested that 100 selected smoking cessation treatments be used to treat two cigarette addicts. Those with psychotic disorders assessed the first nine of these practices according to their usability characteristics. As a result, they analyzed the quantitative results and found that three common usability problems. Some of these have been identified as the intensive text content. Others are small icons on the main page for organizing technical symbols and features. (Ferron et al., 2017)

In another study, the effect of a text message-based motivation on cigarette smoking on university students was examined. In this research, increasingly used motivational interviewing technique was used by clinical therapists and encouraging researchers to quit smoking, and this technique was adapted to the developing mobile phone technology. In this way. This method will reduce number of hospital visits by using the mobile phone, which has already occupied an important place in daily life. Motivational interviewing technique will be applied in a way that makes the person feel more comfortable. This method has yielded successful results. Smoking and health care cost can be reduced. However, because the text messaging method is used, it can increase the GSM costs. (Jorayeva, 2016)

Table 2.2 shows the comparison of other studies with VITAE According to the studies, the main difference is whether the patient-doctor is mutual. In the majority of the investigated practices, the patient follows the daily amount of smoking, diet and exercise independently of the doctor, and receives motivation messages associated with it. However, with the web and mobile application we have developed, the patient applies and follows the treatment model developed by his / her doctor. The doctor decides whether the treatment is working by evaluating the data that the patient has entered during the day. Subsequent treatment is updated as a result of data mining analysis of the patient's data. This increases the success rate of treatment.

In order to live healthy, the applications provide motivation support for the patients to follow their daily movements, to follow their food and reach their goals accordingly. However, it is seen that most of the developed applications are individual and doctors independent applications. Even though the studies are successful, they can not be used if they are used for therapeutic purposes in changing human profiles.

Table 2.2 Comparison of other studies and VITAE (Kandula et al, 2010.; Ferron et al, 2017; Jorayeva, 2016)

	Kandula et al.	Ferron et al.	Jorayeva	VITAE
Daily Tracking	X	✓	✓	✓
Treatment Follow-up	X	X	✓	✓
Motivational Treatment	X	X	✓	✓
Usability without network	✓	✓	✓	✓
Nutrition and exercise tracking	✓	X	X	✓
Smoking cessation treatment	✓	✓	✓	✓
Direct contact with the doctor	X	X	X	✓
Decision Support System	✓	X	X	✓
Cloud computing	X	X	X	✓
Motivation messages	X	✓	✓	✓

CHAPTER THREE
SYSTEM ARCHITECTURE

3.1 Proposed System

The proposed solution is to develop a rule-based proposal system for the treatment of patients who refer family physicians to quit smoking. This system includes a web application that provides treatment advice based on the patient's information. It is also aimed to develop cloud computing based mobile software where patients can make daily follow-ups and constantly communicate with the doctor. Figure 3.1 shows the general structure of a software system that allows lifestyle change for patients who want to quit smoking in order to live healthy.

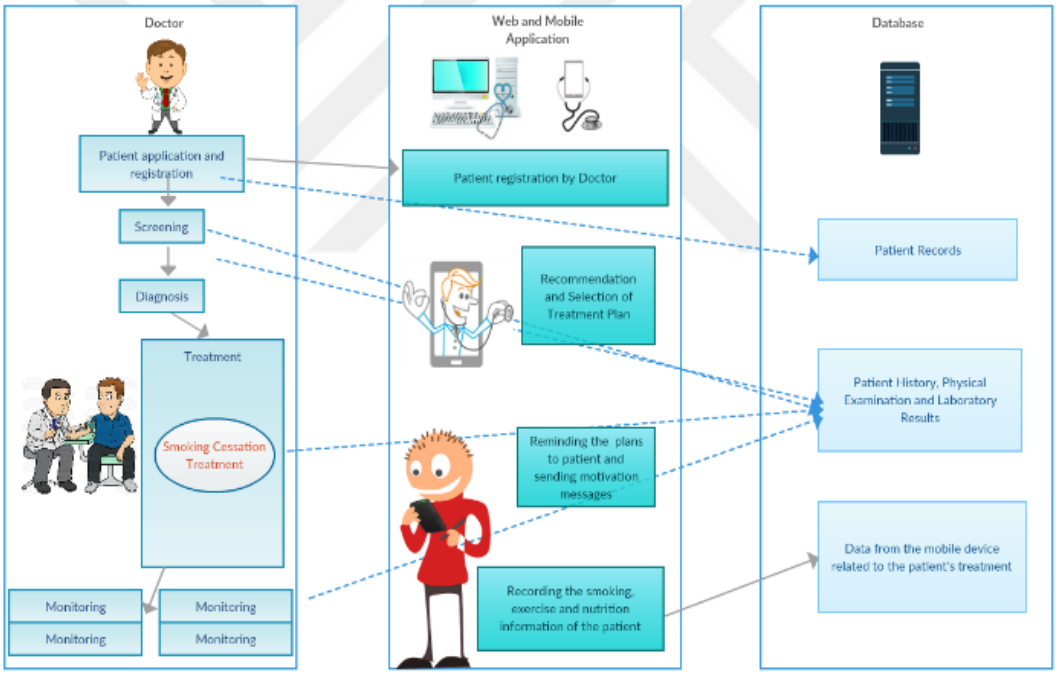

Figure 3.1 The general structure of system to quit smoking

The term context awareness in ubiquitous computing was introduced by Schilit (Schilit, 1994). Context-awareness computing is a kind of computer process that primarily encompasses usage states, or in other words, works with methods customized to the context of user activities. Context-awareness applications promise richer and easier interaction. Context-aware mobile sensors are a best suited

implementing any context-aware applications. In addition, context awareness computing is a research field which is rich in health sector and application area. Figure 3.2 shows the contexts used when developing mobile applications.

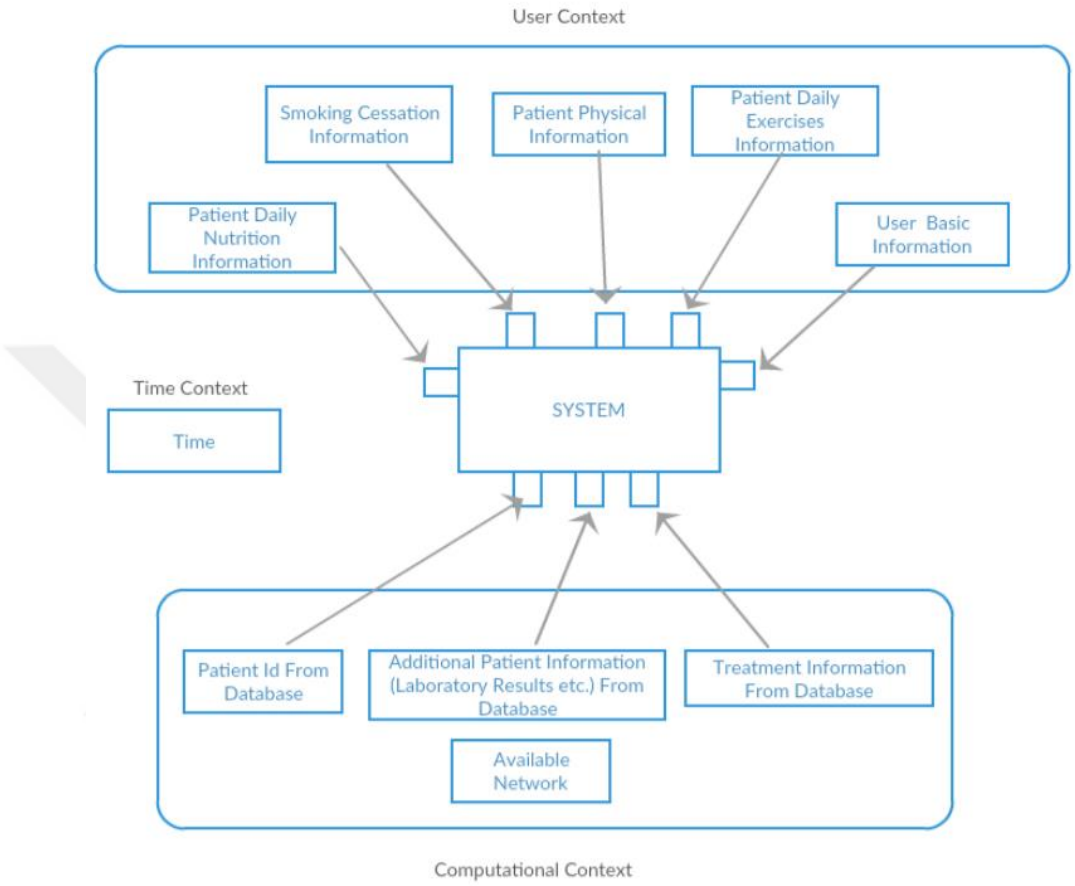

Figure 3.2 Mobile App Contexts

3.2 Proposed System Motivation and Steps

The proposed system mainly consists of two applications, web and mobile. In a web-based application, the patient passes through 3 stages. These;

1. Registration of the patient's general information, recording of the history, physical examination information and laboratory request and completion of the first examination
2. When the patient comes back to the examination together with the laboratory results and the treatment proposal is presented according to the results and the treatment to be applied by the physician is determined

3. Re-examination of the patient for follow-up and continuation, replacement or termination of treatment

The mobile-based application includes three different modules: The Smoking Cessation System, The Exercise System, and The Healthy Nutrition System. These modules include the following items.

- The app will regularly remind the patient of what he needs to do daily (e.g., today's smoking day, a 45-minute fast walk, etc.) and record what he / she has done (e.g., smoking status, exercise period, weight gain etc.).
- As the patient registers what they do, they will tell the difference between what they need to do and send new recommendations and motivation messages. If the patient reaches the targets, it will send messages that will keep the motivation going.
- The application will also remind the patient of the appointment dates.
- Through the application, the physician will be able to adapt his lifestyle modification treatment and monitor his results.
- Through the application, the patient will be able to ask questions and be in constant contact with the doctor.

CHAPTER FOUR
WEB BASED HEALTH SOFTWARE SYSTEM

4.1 Why Do We Need Web-based(e-health) Health Applications?

The impact of rapid developments in communication and information technologies is also evident in the health sector. Therefore, e-health concept has entered our lives. E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. (Eysenbach, 2001)

The introduction of information and communication technologies to health institutions facilitates the work of health care workers and health care providers. In addition, keeping the medical records in digital environment also reduces the follow-up of the treatment and the risk of error.

In the decision-making process, sound, accurate and reliable information is needed. Therefore, Decision Support Systems (DSS) are used. These systems help physicians to make decisions based on specific clinical information of patients. Clinical decision support systems; It can provide great benefits in terms of improving the quality of health care services, early detection of diseases, prevention of medical errors, appropriate treatment for patients and reduction of costs. For this reason, a web-based decision support system has been developed to record the clinical information of smoking cessation patients and to ensure that they achieve the most accurate treatment.

4.2 Data Storage in Smoking Cessation Treatment Web Application

The need for patient data is increasing in order to ensure continuity of treatments with the increase of chronic diseases. It is necessary to ensure the personal data privacy of the patients while they are stored in the digital environment. Data masking algorithms were used in the project we developed in order to ensure this data security.

Microsoft SQL Server is used as database management system while storing the records of data received from web-based application. Data is stored on the local server for data security. After a new patient record is made and the patient's treatment information is generated, the patient's treatment plan record is backed up by the web service to the database which is in private cloud with the patient's id information. This allows people to view treatment information via the mobile application, but sensitive data are only kept in the local server. Figure 4.1 shows the class diagram of the database of the Web-based application.

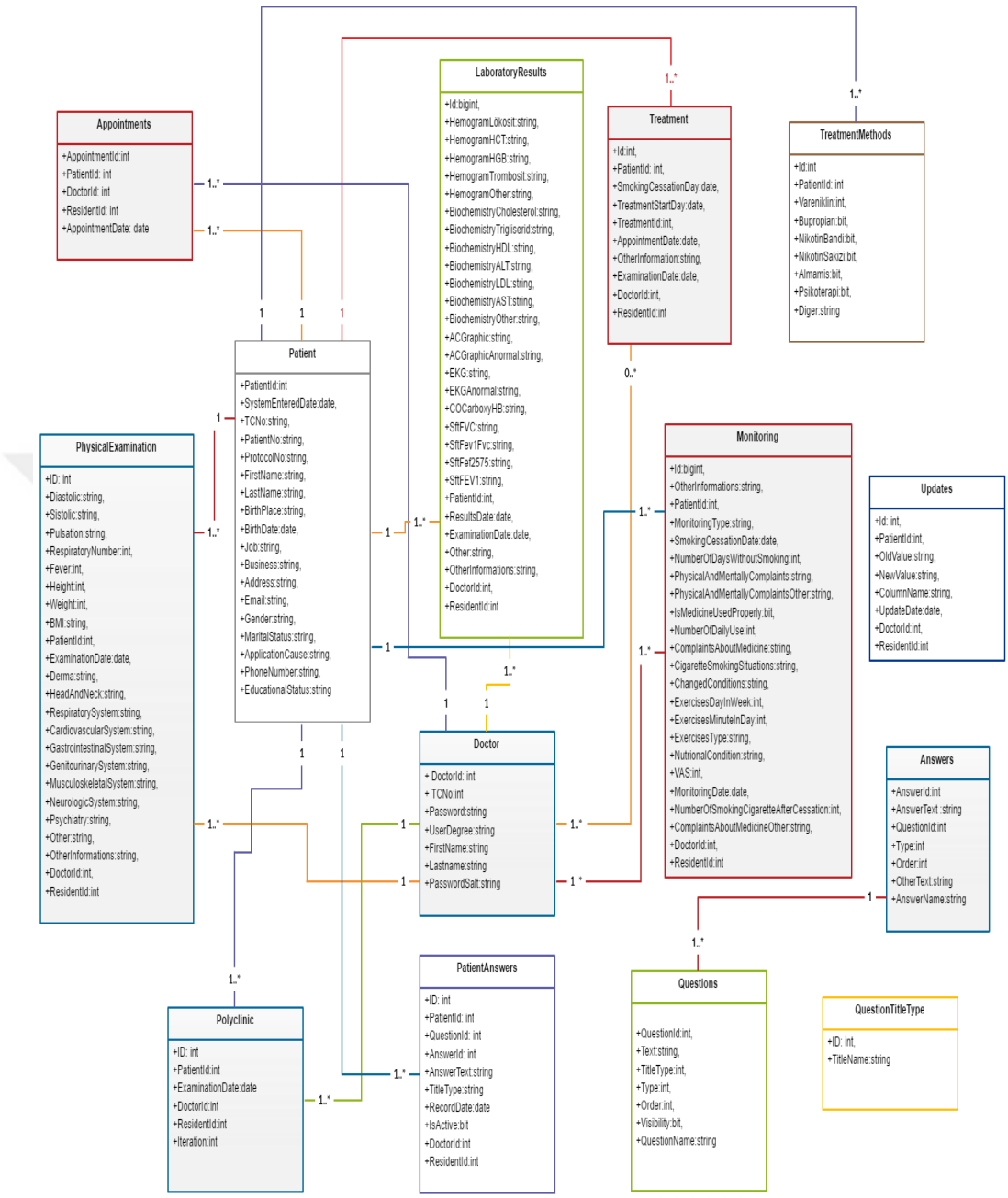

Figure 4.1 Class diagram of the database of the Web-based application

4.2.1 Data Masking Algorithm and Implementation

Data masking is a security method that prevents access to sensitive or confidential data within databases. This method is accomplished by replacing the actual data with unreal but appropriate data. The purpose of using this method is to reduce the risk of leakage and seizure of sensitive information within and outside an organization.

4.2.1.1 What Is Data Masking and Why Is It Important?

In today's data-intensive environments, business and government organizations collect huge amounts of data. Due to the storage and copying of such critical data, it has not been a surprise that data breaches have emerged as a major problem, which poses a huge financial burden on companies. Therefore, data privacy efforts, including data masking, have become more important than ever.

4.2.1.2 Dynamic Data Masking

In our database, the masking feature is the ability to mask other than the information we want to display when scanning the data, we hold in our relational tables. Of course, we mean by the information in the table here are the columns. We are now able to mark which column is hidden by Dynamic Data Masking when a table is created or altered. In other words, the structured restriction against the unauthorized user does not actually mean the absence of relevant data, but they do exist, but they are masked when they are concealed.

Dynamic Data Masking; It works with three functional parameters: default, email, and partial.

Default, the data we want to mask is a textual data, it masks it as XXXX. If the data size is less than 4 characters, less X is used. If the data we want to mask with the Default function is a numeric data, SQL Server will use 0 (Zero) for the masking process. If the data we want to mask together with the Default function is a historical data, a default date of 01.01.2000 00: 00: 00.0000000 will be shown instead of this

data. With the default function, the data we want to mask and the binary data will use the ASCII value of the SQL Server 0 value.

Email, we will mask the data in the format iXXX@XXXX.com using the X character used in the textual data together with the first letter of our data in the format used to mask the email address data we want to mask.

Partial is the function that provides masking process according to the format we determine in the masking process. In the Partial function, which is more flexible than others, we can specify how the data we want to mask will look to the end user, regardless of the type of data we want to mask.

Example:

```
CREATE TABLE [dbo].[Patient]([PatientId] [bigint] IDENTITY(1,1) NOT NULL,
    [TCNo] [nvarchar](50) MASKED WITH (FUNCTION = 'default()') NULL,
    [PatientNo] [nvarchar](50) NULL,
    [ProtocolNo] [nvarchar](50) NULL,
    [FirstName] [nvarchar](50) NULL,
    [LastName] [nvarchar](50) NULL,
    [BirthPlace] [nvarchar](50) NULL,
    [BirthDate] [date] NULL,
    [Job] [nvarchar](50) NULL,
    [Business] [nvarchar](50) NULL,
    [Address] [nvarchar](max) MASKED WITH (FUNCTION = 'default()') NULL,
    [Email] [nvarchar](50) MASKED WITH (FUNCTION = 'default()') NULL,
    [Gender] [nvarchar](50) NULL,
    [MaritalStatus] [nvarchar](50) NULL,
    [ApplicationCause] [nvarchar](50) NULL,
    [PhoneNumber] [nvarchar](20) MASKED WITH (FUNCTION = 'default()') NULL,
    [SocialSecurity] [nvarchar](100) NULL,
    [PersonToBeCalled] [nvarchar](max) NULL,
```

[PatientType] [int] NULL]

We create a table with the above query and data masking. Below is a generic query that shows how to get data from these tables.

```
SELECT c.name, tbl.name as table_name, c.is_masked, c.masking_function
FROM sys.masked_columns AS c
JOIN sys.tables AS tbl
   ON c.[object_id] = tbl.[object_id]
WHERE is_masked = 1;
```

4.3 Used Technologies and Architecture of Web Based Health Application

The system has been developed with three-layer architecture in the visual studio environment with asp.net software language. Three tier architecture means dividing our project into three layers that is Presentation Layer (UI layer), Business Layer (Logic code layer) and Data Layer (Layer which connects to database). The most important reason for choosing this architecture, it makes the logical separation between business layer and presentation layer and database layer. Application layer is between the database layer and presentation layer so the database layer will be more secured, and client will not have direct access to the database. Other reasons, migration to new graphical environments is faster. As each tier is independent it is possible to enable parallel development of each tier by using different sets of developers. Easy to maintain and understand large project and complex project.

In presentation layer, MVC architecture used. The Model-View-Controller (MVC) is an architectural pattern that separates an application into three main logical components: the model, the view, and the controller. (Tutorialspoint, n.d.) Figure 4.2 shows the flow between model, view and presenter. MVC distinguishes the code from different structures that serve different purposes, making the code more comfortable to develop and testable.

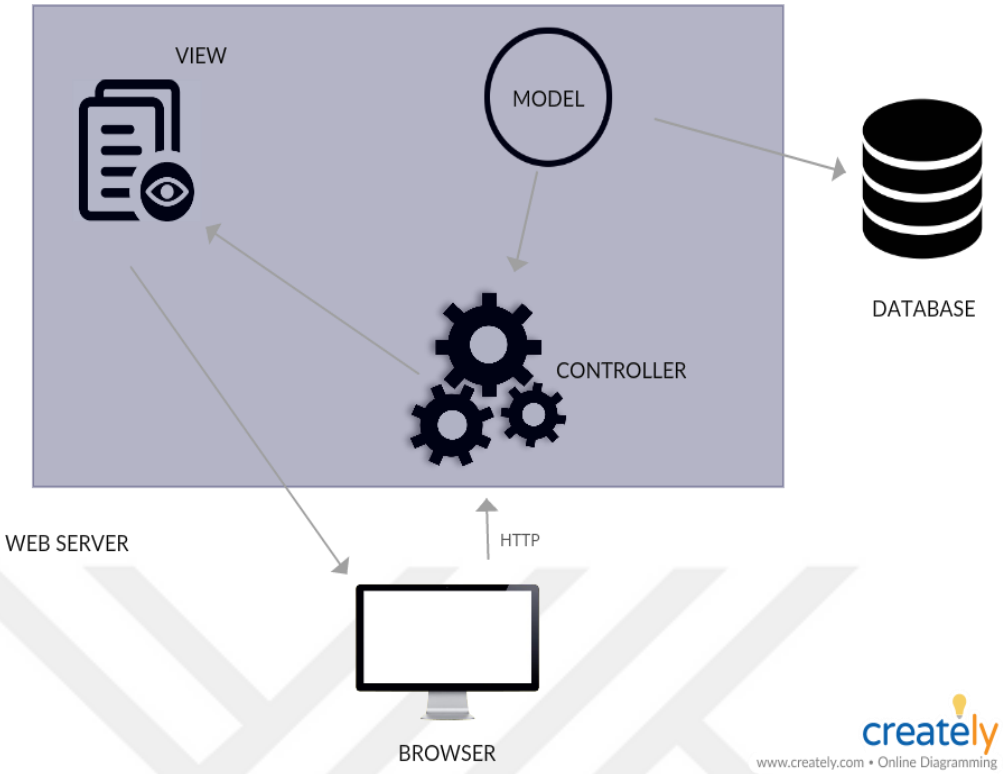

Figure 4.2 MVC Diagram

A dynamic survey screen is created when designing the form screens for which patient information is collected. In this way, when the doctor wants to add a new question or information to the system, there will be no need to develop again within the application. This structure is composed of data from 4 main tables in the database. These are questions, question title type, answers, patients' answers. Figure 4.3 shows that tables.

Using this structure, the following health surveys were applied and the results of these surveys were used in the decision support system.

- Fagerstrom Test for Nicotine Dependence
- PHQ-9 Depression Test Questionnaire
- Hospital Anxiety and Depression Scale(HADS)
- CAGE Questions for Alcohol Use
- Alcohol Use Disorders Identification Test (AUDIT)
- International Physical Activity Questionnaire - Short Form

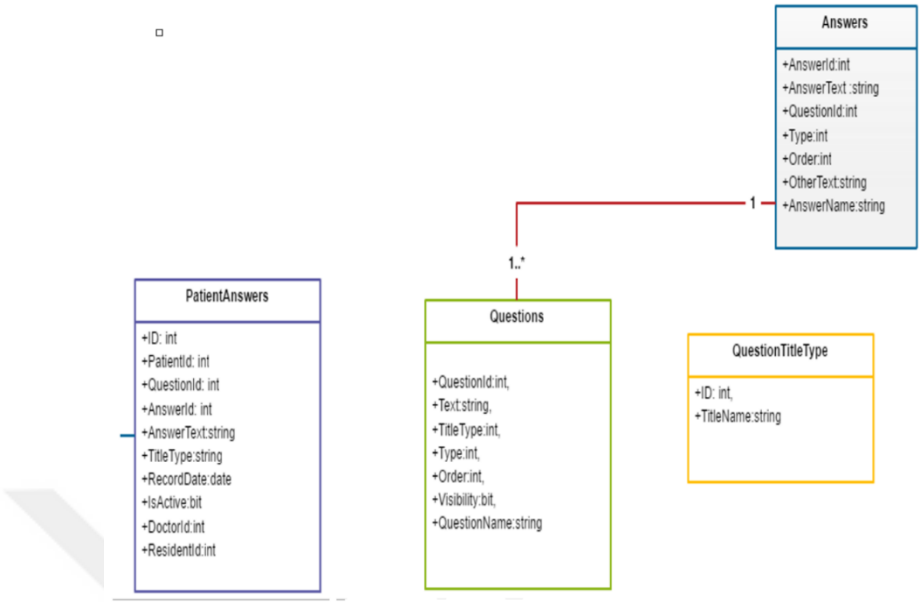

Figure 4.3 Survey class diagram

4.4 Authorization in Application

We store authorization information in the database. In Authorization table, we reserve the authority types, and in the User Authorization table, we have the privileges of the person. The user enters the approval process when it is first registered. Shows figure 4.4.

The approval process is complemented by the fact that the person identified as an administrator has confirmed. The administrator can only approve the application from the page that is accessible. Once the approval process is completed, the user enters the application and starts to use it. The screen created for the administrator is shown on figure 4.5.

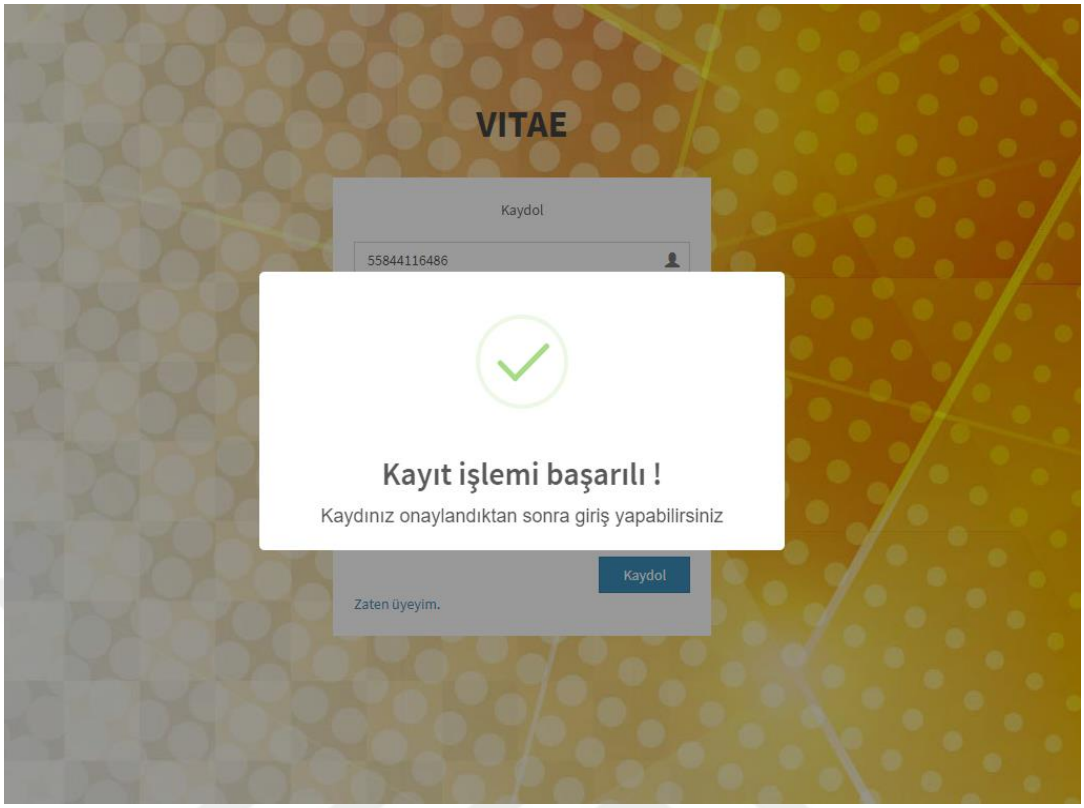

Figure 4.4 Registration complete page

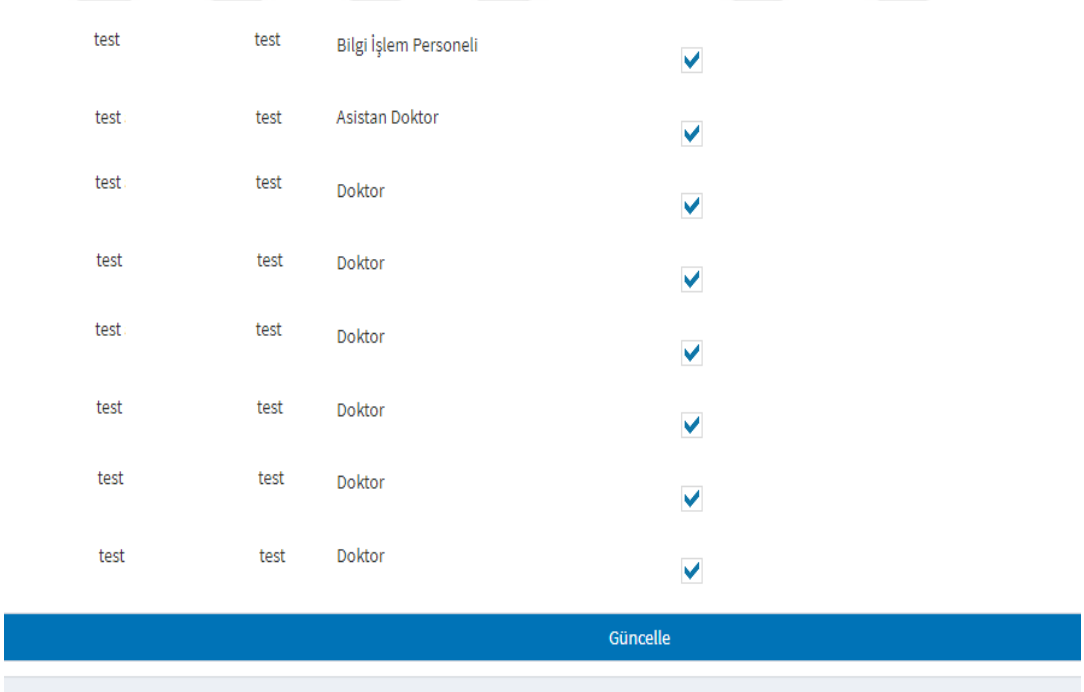

Figure 4.5 Admin screen

4.5 Clinical Decision Support System in Application

Systems that are designed to make decision-making easier, more effective and more accurate, are called Decision Support Systems. Clinical decision support systems also

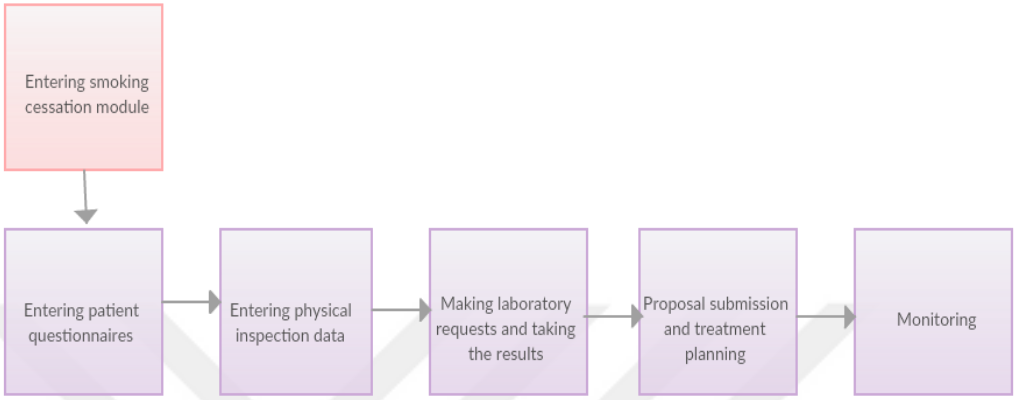

Figure 4.6 Decision support system flow diagram

assist health personnel in the decision-making process. A rule-based decision support system has been developed in the system. The patient is presented with a treatment recommendation using the patient's past medical knowledge and habits. It is aimed to simplify the decisions of the experts on health issues by the procedures made over the collected clinical data. This system is not fully automated, so the decision must eventually be made by a specialist. For this suggestion, the flow indicated in Figure 4.6 is monitored.

After entering the patient smoking cessation module respectively, the person's lifestyle is determined. According to this, healthy nutrition and exercise treatment are decided. Afterwards, questionnaires which determine the tobacco addiction level of the patient are made and a recommendation is given on the treatment process. After the physical examination and laboratory tests of the patient are completed, the physician offers a treatment option with contraindicated, careful use of the medications and the medications that can be used as shown in Figure 4.7.

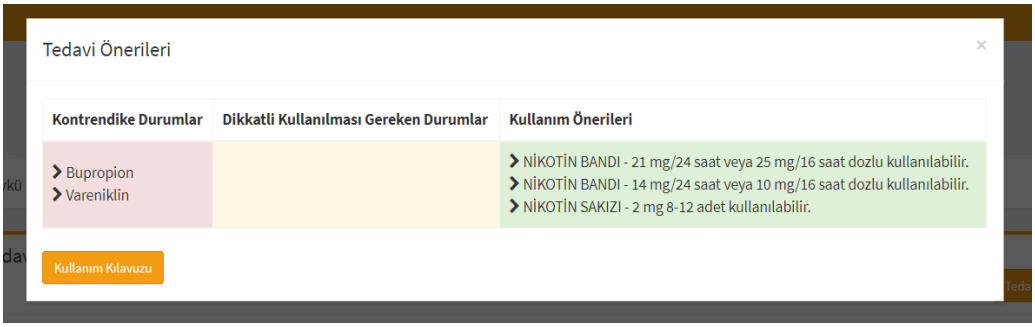

Figure 4.7 Treatment recommendation popup

4.5.1 Used Tests in Clinical Decision Support System in Application

4.5.1.1 Fagerstrom Test for Nicotine Dependence

The Fagerström Test for Nicotine Dependence is a standard instrument for assessing the intensity of physical addiction to nicotine. The test was designed to provide an ordinal measure of nicotine dependence related to cigarette smoking. (Instrument: Fagerstrom Test for Nicotine Dependence (FTND), n.d.) The following Figure 4.8 shows a fagerstorm survey example.

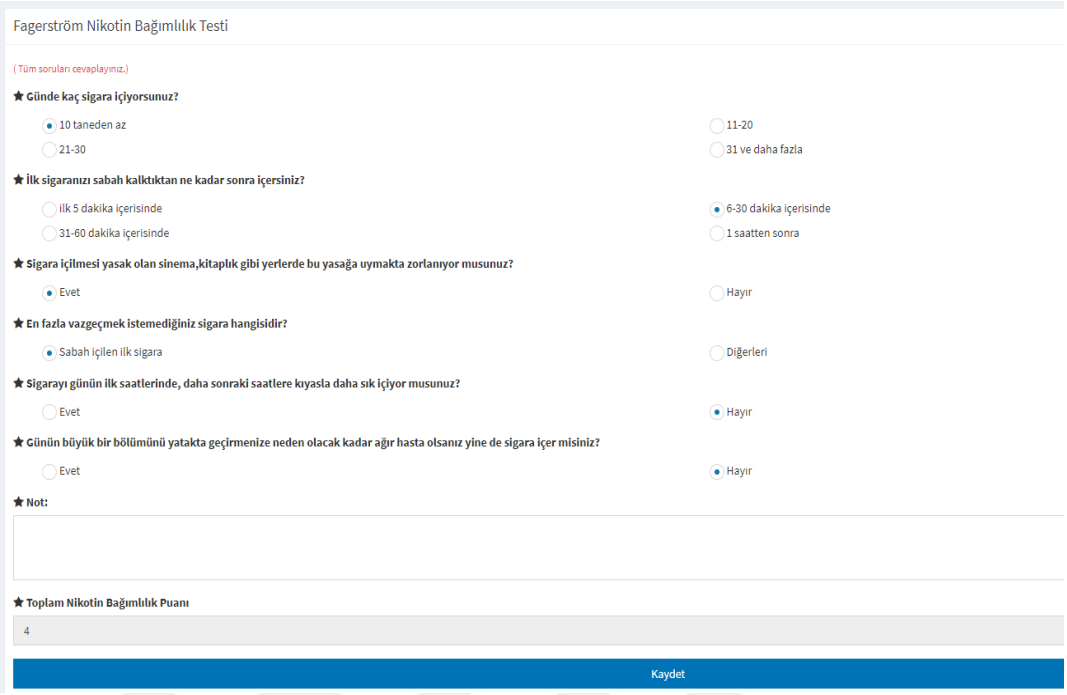

Figure 4.8 Fagerstrom test for nicotine dependence

4.5.1.2 PHQ-9 Depression Test Questionnaire

The PHQ-9 is the depression module, which scores each of the nine DSM-IV criteria as "0" (not at all) to "3" (nearly every day). It has been validated for use in primary care. (Cameron et al., 2008)

4.5.1.3 Hospital Anxiety and Depression Scale (HADS)

The HADS (Hospital Anxiety and Depression Scale) aims to measure symptoms of anxiety (HADS Anxiety) and depression (HADS Depression). (Djukanovic, 2017)

4.5.1.4 CAGE Questions for Alcohol Use

The CAGE questionnaire, the name of which is an acronym of its four questions, is a widely used screening test for problem drinking and potential alcohol problems. (Babor et al., 1992) CAGE, (Cut down, Annoyed, Guilty, Eyeopener) It is a short and simple test consisting of four questions developed to differentiate individuals with

alcohol use disorders (Ewing, 1984). If the physician suspects alcohol use disorder, he / she should perform more detailed tests. For example, AUDIT.

4.5.1.5 Alcohol Use Disorders Identification Test (AUDIT)

The AUDIT was developed as a simple method of screening for excessive drinking and to assist in brief assessment. It can help identify excessive drinking as the cause of the presenting illness. (Babor, Thomas,1992) The AUDIT can also help identify alcohol dependence and some specific consequences of harmful drinking. (Alcohol Use Disorders Identification Test (AUDIT), n.d.) Figure 4.9 shows AUDIT test in application.

4.5.1.6 International Physical Activity Questionnaire - Short Form

IPAQ short form is an instrument designed primarily for population surveillance of physical activity among adults. IPAQ assesses physical activity undertaken across a comprehensive set of domains including (Ara & Ara, n.d.)

- leisure time physical activity
- domestic and gardening (yard) activities
- work-related physical activity
- transport-related physical activity

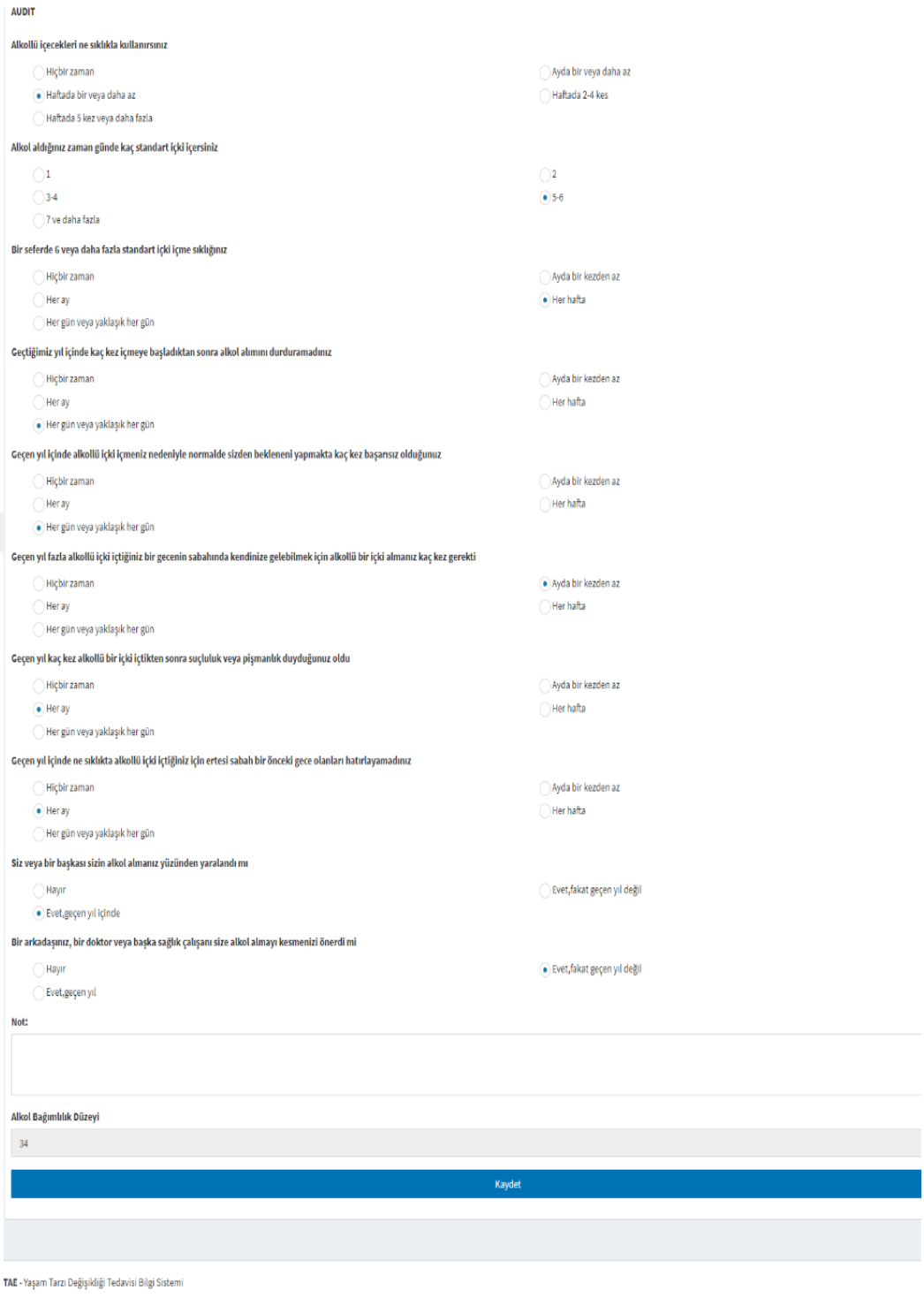

Figure 4.9 Alcohol use disorders identification test

CHAPTER FIVE
WEB SERVICES AND MOBILE BASED HEALTH SOFTWARE SYSTEM

5.1 Why do we need mobile-based health(mHealth) applications?

The health sector, along with technological progress and the increase in the use of smart devices, was introduced to mobile applications. The mobile health or m-health applications that can be installed on smart devices are very effective in creating health awareness in individuals. Mobile applications allow the patient to keep track of the disease and stay in communication with the doctor at any time of the day. In addition, mobile health applications are the applications that are used not only by the patients but also by everyone who wants to keep healthy life among their daily habits.

5.2 Data Storage in Mobile Application

Sqllite is used as database management system while storing the records of data from mobile based application. The data will be stored in the phone's local memory. At the end of the day, the web service will be backed up to the database in private cloud. The reason for monitoring this method is to minimize the use of the person's internet and to minimize the loss of data by using it in times when there is no internet network.

5.2.1 SQLite

SQLite is a database library that is very simple to use and install. As with all relational databases, Sqlite also keeps this data in a table-like structure. Although SQL commands are simpler than complex databases like MySQL, SQLite has the capacity to meet every need in mobile applications. The main reasons for using sqlite in the application are;

- Since SQLite does not need any servers to run, there are no setup or configuration steps.

- There is only one file for each database. This makes it easy to back up and copy the database.
- Platform is independent.

5.3 RESTful Service Architecture

REST (Representational State Transfer) is an architectural style for developing web services. (What is REST (Representational State Transfer)? - Definition from WhatIs.com, n.d.) Rest facilitates the communication between the service systems.

5.3.1 Advantages of using restful service architecture

In the REST architectural style, there are several advantages. These are;

- REST-based interactions can be understood by anyone familiar with using Hypertext Transfer Protocol (HTTP). For example, standard HTTP status codes means
    - 404 requested resource wasn't found
    - 401 requests weren’t authorized
    - 200 everything is OK
    - 500 there was an unrecoverable application error on the server.

- The implementation of the client and the implementation of the server can be done. Client side can be changed at without affecting the operation of the server, and the code on the server side can be changed without affecting the operation of the client.

- REST-based applications can be written using any language, be it Java, Kotlin, .NET, AngularJS or JavaScript.

5.3.2 Endpoints in Web Service

Web APIs are becoming a very important issue. Therefore, the importance of developing clean api is also increasing. There are some things to consider when developing a clean api. These are;

- HTTP has verbs: GET, POST, PUT, PATCH and DELETE are the most common. verbs map to CRUD operations: GET means Read, POST means Create, PUT and PATCH mean Update, and DELETE means, Delete. (RESTful API Design: 13 Best Practices to Make Your Users Happy, n.d.) Therefore, the endpoint should also be used with nouns not verb.

- REST architectural style, most REST APIs use JSON as a data format. t is not enough to return a body containing a JSON-formatted string. You need to specify the Content-Type must be set application/json.

- Use plural resource nouns. Should you use /article/:id/ (singular) or /articles/:id/ (plural)

Endpoints were created by using the following pattern in our project. "api/{controller}/{action}/{id}".

5.3.3 Service-Oriented Architecture (SOA) and Cloud Computing

Service-oriented architecture (SOA) is a software development model for distributed application components that incorporates discovery, access control, data mapping and security features. (What is service-oriented architecture (SOA)? - Definition from WhatIs.com, n.d.) The cloud service will be used by the mobile application and will be used by the web application to display the data received from the mobile to the health personnel. A service provider will be in the cloud and communicate with a provider that is not in the cloud. That is, a service-oriented

architecture (SAO) may include any cloud and cloudless combination as shown in Figure 5.1 below.

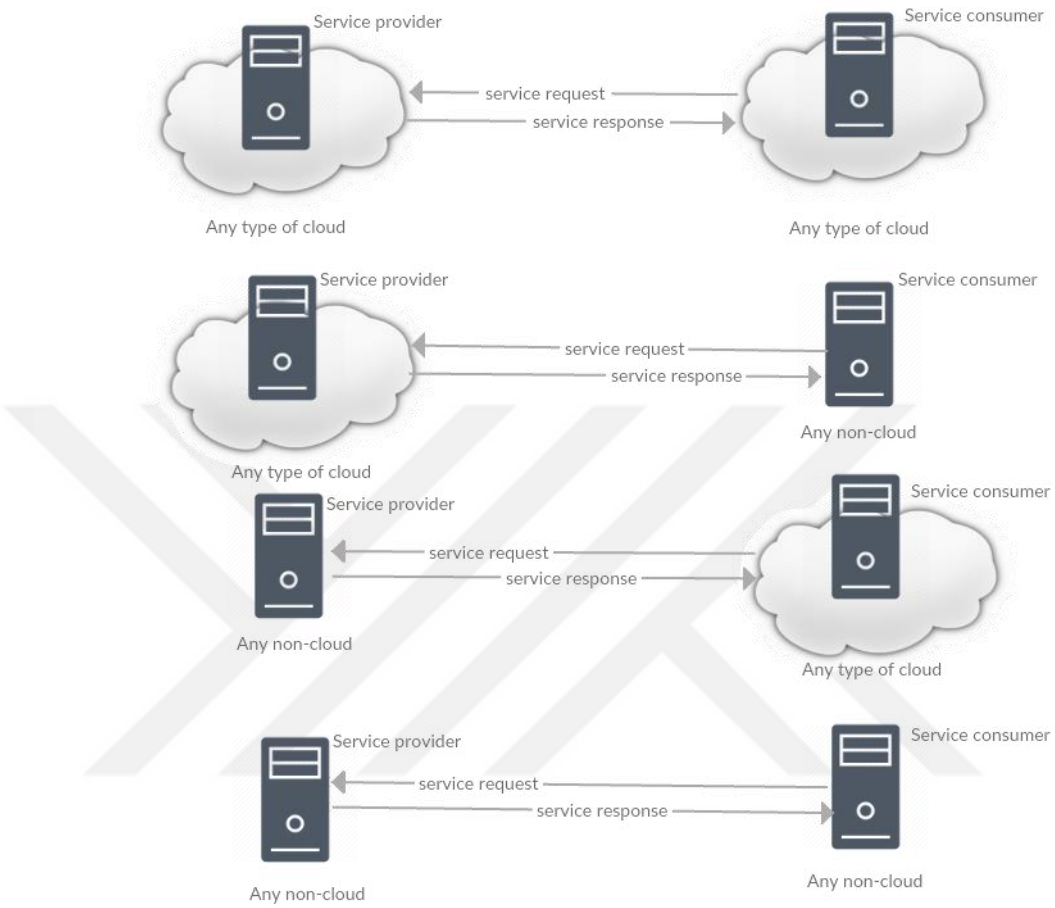

Figure 5.1 SOA cloud and cloudless combination

5.4 Mobile Based Health Application

5.4.1 Development Tools

We used the android studio tool while developing the application. Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development.

5.4.2 Operating System

We have developed a mobile health application that can be used in phones with Android operating system.

5.4.3 Used Libraries

Android Studio provides great convenience to the developers in the library. The only thing you need to do to include the library in Android Studio is to add the gradle code of the library to the build.gradle file.

5.4.3.1 Android Asynchronous Http Client (LoopJ)

Android Asynchronous Http Client is a popular third-party library. It helps handle the entire process of sending and parsing network requests. You can use the library by adding dependency: *compile 'com.loopj.android:android-async-http:1.4.9'*

We used this library to transfer data from the forms to the local database and to transfer it to the cloud.

5.4.3.2 Android Volley

The Volley library allows us to briefly communicate with our database and to exchange json, xml data. You can use the library by adding dependency: *compile 'com.mcxiaoke.volley:library:1.0.6@aar'*

This library allows us to do the following.

- You can download your pictures via HTTP. You can even cache pictures you have downloaded in memory or on disk
- You can connect to your REST services and automatically convert JSON or XML responses to your desired class with the translators you will write yourself.

- It performs its operations in a specific order and works in a multithread structure.
- It keeps requests in the queue structure and automatically cancels the request if the request is no longer needed.

5.4.3.3 GSON

GSON is a library developed by Google. It is the most important library used by most of you in project development. GSON is open source and standalone library which is used to convert JSON data into java objects and vice versa. (Sinhal, 2017) You can use the library by adding dependency: *compile 'com.google.code.gson:gson:2.7'*

5.4.3.4 MPAndroidChart

MPAndroidChart is a beautiful and useful library that can be used for graphical operations in Android projects. You can draw LineChart, BarChart, ScatterChart, CandleStickChart, PieChart, BubbleChart or RadarChart using this library. We used this library to visualize smoking, weight and exercise. Figure 5.2 shows the sample graphics drawn using this library. You can use the library by adding dependency: *compile 'com.github.PhilJay:MPAndroidChart:v3.2.0'*

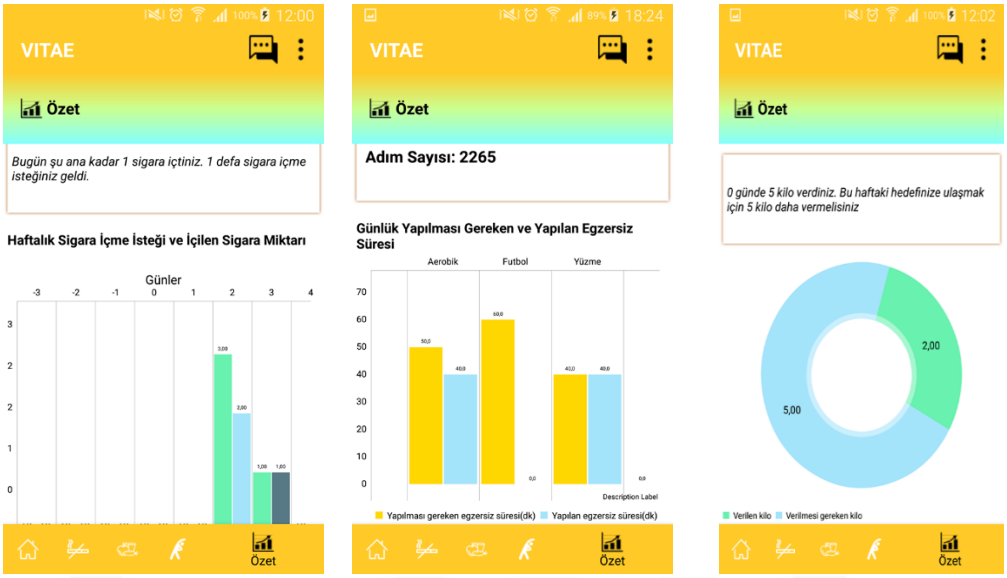

Figure 5.2 Sample graphics for mpandroidchart

5.4.4 Architecture

Figure 5.3 shows the stage in which the mobile software is to be used. Figure 2 shows the architecture of the mobile software system. The mobile software system is classified under three headings. The first title is smoking cessation treatment, the second title is follow-up nutrition, and the third title is follow-up exercise.

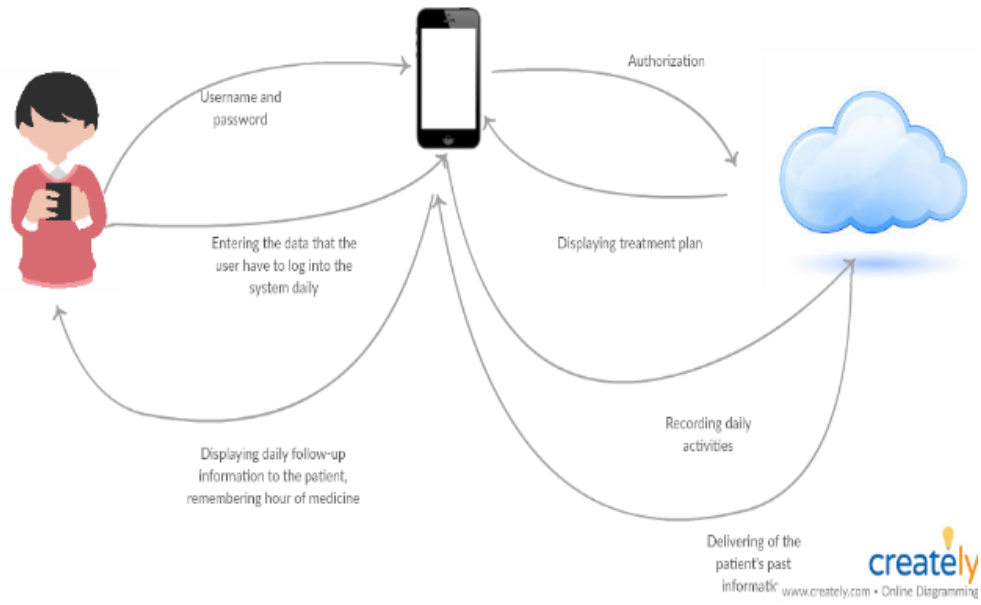

Figure 5.3 Architecture of Mobile Software

5.4.5 Implementation

The patient logs in to the system with his / her username and password if it is registered. If not registered, the user sings in and logs in later. The first time the patient logs in, patient records the sleep and wake time and turns on or off notifications to receive motivation messages. Figure 5.4 shows the homepage when the patient enters the mobile application.

Patient then clicks on the segment he is being treated for. Later, if the doctor has entered a treatment plan in the database, the current treatment plan will be displayed. If not, the plan will be entered. It records daily information in accordance with this plan. The patient can perform daily follow-ups quickly and at any time. In accordance with the information entered by the patient and the follow-up information entered by the doctor, the treatment plan is updated as a result of data analysis methods at specific time intervals. It is aimed to improve patient compliance and success rate of treatment applied in this way. In smoking cessation treatment, the number of cigarettes the patient smokes during the day, the factors causing smoking and the behaviors he / she makes when he / she wants to smoke are followed.

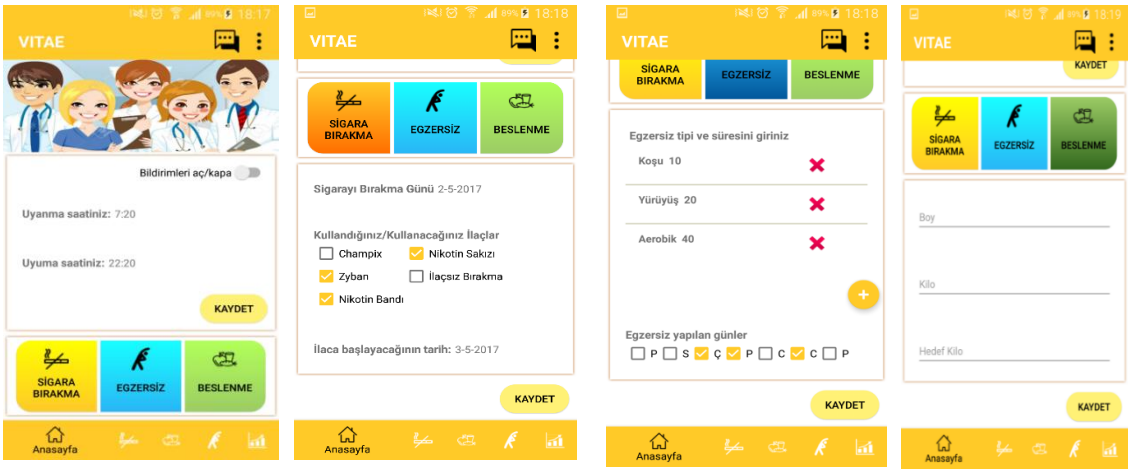

Figure 5.4 Mobile application main page

Motivation messages are sent to the patient in the direction of this data. These collected data are stored in the database that the cloud computing platform has

provided, and the doctor can follow the data from anywhere and at any time to provide follow-up treatment of the patient, and as a result, update the treatment form of the patient.

The web and mobile application are communicated. While the content of the treatment provided by the physician is transmitted to the mobile application used by the patient, the activities that the patient performs within the scope of the treatment on a daily basis and entered the system via mobile application have been made traceable by the physician. Figure 5.5 shows the page where the data entered by the patient via the mobile application is viewed by the doctor.

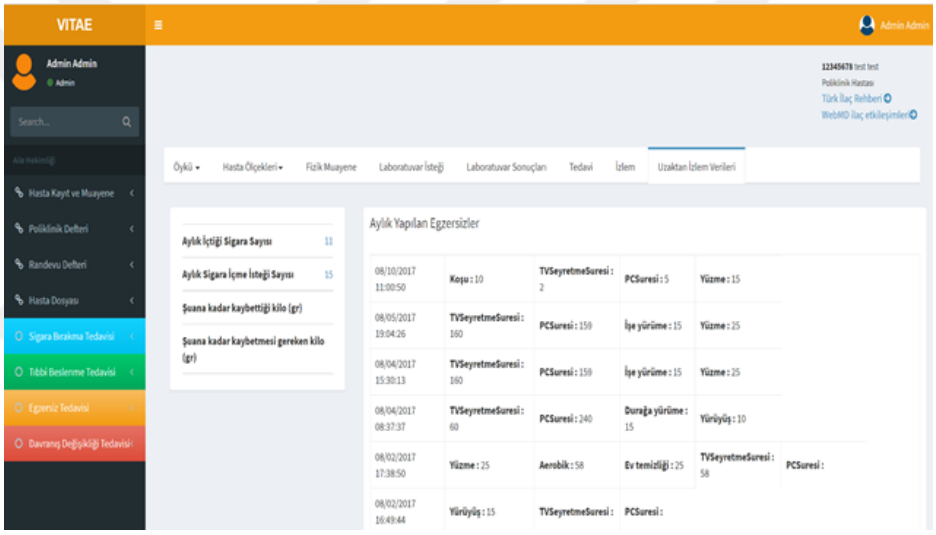

Figure 5.5 Patient tracking page for doctor

5.4.5.1 Smoking Cessation Treatment

In smoking cessation treatment, how many cigarettes the patient smokes during the day, the factors that cause smoking and the behaviors of the patients when they want to drink are followed up. In accordance with these data, motivation messages are sent to the patient. This collected data is stored in the database provided by the cloud computing platform. The physician achieves the follow-up of this data from anywhere and at any time to monitor the patient's treatment and, as a result, updates the patient's treatment.

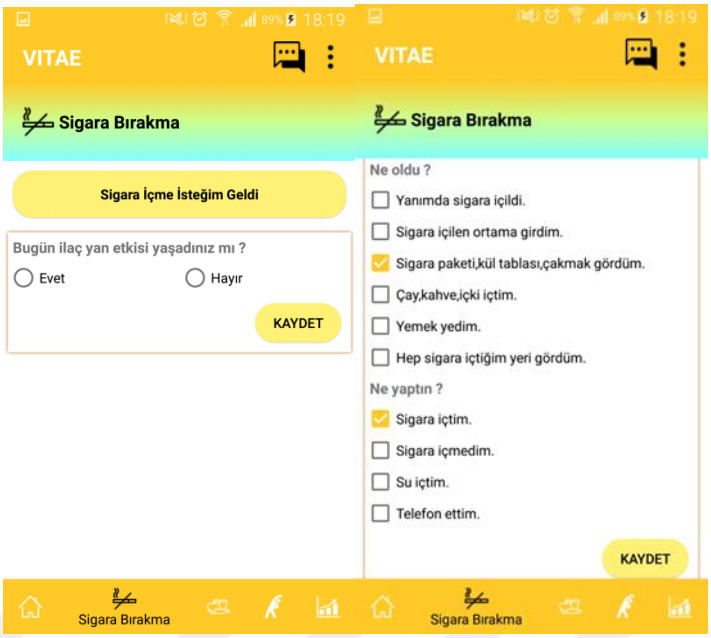

Figure 5.6 Smoking cessation treatment page in mobile app

When the patient wants to smoke during the day, he presses the "I want cigarette" button in figure 5.6. It then selects the factor (s) and consequently what it does. At the end of the day, if the patient is taking medication, he / she is experiencing the side effects of drug-induced side effects during the day. This information can be viewed by the patient's family physician through the web portal and thus can change the patient's treatment. In other words, patient-specific individualized treatment model is created and thus the success of the treatment is increased.

5.4.5.2 Nutrition Therapy

In the treatment of nutrition, follow-up of the patient's daily weight and diet plan is followed. The motivation messages are sent to the patient according to these data. The notification will be sent 10 minutes to patient after the wake-up time and you will be asked to fill out the form. The doctor follows the patient's diet and monitors the weight loss in this way and updates the patient's diet according to this data. In addition, the patient was given a graph to determine how much weight she lost today, and how much weight she lost in a week for motivating yourself.

5.4.5.3 Exercise Tracking

In exercise follow-up, the patient should follow daily exercises and follow the daily calories. According to the results of the exercise follow-up, motivational messages are sent, and the patient is provided to lose weight in a healthy way. The exercise information that the patient has exercised is stored in the cloud-based database so that his doctor can follow up on all platforms. The patient can track how much he / she is exercising through graphics.

CHAPTER SIX
CONCLUSION AND FUTURE WORK

With developing information technology and the increasing use of smartphones, tablets, the number of web and mobile applications that are being developed in the healthcare sector is increasing day by day. Thanks to web based clinical decision support systems and electronic recording systems, accurate data in the electronic environment provides a high level of benefit to follow the patient's treatment and to find the right treatment. Mobile applications are also rapidly developing in the health sector. Using mobile and web applications together more effective and more efficient it is ensured.

Mobile applications are available for many things such as monitoring the health of people, controlling heart rate and blood pressure, calculating calorie intake daily, controlling medication dose and timing, and monitoring the pregnancy process. A web-based system has been developed in which the proposed software system can provide follow-up advice and follow-up of treatment. The patient can communicate directly with the family physician from anywhere and at any time with the possibilities provided by cloud technology and can follow up at the same time in reaching and practicing the treatment given by the family physician. In this study, lifestyle modification therapy was applied by mobile application to smoking cessation and achieve a healthier life. The proposed solution continues to be applied to family physicians and continues to work for worldwide use.

In future, the accuracy and success rates of the proposal presented on the model will be followed and the data bank will provide resources for the development of new interventions and algorithms in the next stage. In this model, a large number of data will be collected in the database as patients will have continuous data flow. Hidden patterns can be discovered among the collected data. It is a fact that many medical lines have not been identified since it is not possible to collect the data of the patients at this level. This system will provide new medical information.

REFERENCES

Ara, A., & Ara, A. (n.d.). *Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms Contents*. Retrieved April 01, 2019, from https://www.academia.edu/5346814/Guidelines_for_Data_Processing_and_Analysis_of_the_International_Physical_Activity_Questionnaire_IPAQ_Short_and_Long_Forms_Contents

Cameron, I. M., Crawford, J. R., Lawton, K., & Reid, I. C. (2008). Psychometric comparison of PHQ-9 and HADS for measuring depression severity in primary care. *British Journal of General Practice*, *58*(546), 32-36.

Cherukupalli, R., & Perucic, A. (2018). Affordability of cigarettes products in the World Health Organization Report on the Global Tobacco Epidemic, 2017. *Tobacco Induced Diseases, 16*(1), 696.

Curcin, V., Fairweather, E., Danger, R., & Corrigan, D. (2017). Templates as a method for implementing data provenance in decision support systems. *Journal of Biomedical Informatics, 65*, 1-21.

Diagram Maker | Online Diagram Software. (n.d.). Retrieved April 01, 2019, from https://creately.com/

Djukanovic, I., Carlsson, J., & Årestedt, K. (2017). Is the hospital anxiety and depression scale (HADS) a valid measure in a general population 65–80 years old? A psychometric evaluation study. *Health and Quality of Life Outcomes*, *15*(1), 193.

Ermakova, T., Fabian, B., & Zarnekow, R. (2013). Security and privacy system requirements for adopting cloud computing in healthcare data sharing scenarios. *Proceedings of the Nineteenth Americas Conference on Information Systems*. Retrieved April 01, 2019, from

https://pdfs.semanticscholar.org/4d58/98c4e864c1df1682fd1f4af094d7116a40ed.pdf

Eysenbach, G. (2001). What is e-health? *Journal of Medical Internet Research, 3*(2), 20.

Ferron, J. C., Brunette, M. F., Geiger, P., Marsch, L. A., Adachi-Mejia, A. M., & Bartels, S. J. (2017). Mobile phone apps for smoking cessation: quality and usability among smokers with psychosis. *Journal of Medical Internet Research Human Factors*, *4*(1), 7.

Güler, Ö. G. E., & Eby, G. (2015). *Akıllı Ekranlarda Mobil Sağlık Uygulamaları. Instrument: Fagerstrom Test for Nicotine Dependence (FTND*). (n.d.). Retrieved April 01, 2019, from https://cde.drugabuse.gov/instrument/d7c0b0f5-b865-e4de-e040-bb89ad43202b

İlter, I., Kut, A., Mevsim, V., & Utku, S., (2018) Lifestyle Change Treatment with Cloud Based Mobile Tracking Application: VITAE. *International Conference on Advanced Technologies, Computer Engineering and Science*, 96-99.

Jorayeva, A. (2016). *Effects of a text message-based motivational interviewing intervention on cigarette smoking in college students*, Phd. Thesis, University of Louisville, Louisville

Kandula, V. R. & Deodhar S., (2010). Clinical Decision Support Software, *International Telecomunication Union QUESTION 14-2/2*, 6-8.

Kavzoğlu, T., & Şahin, E. K. (2012). Bulut Bilişim Teknolojisi ve Bulut CBS Uygulamalari*, IV. Uzaktan Algılama ve Coğrafi Bilgi Sistemleri Sempozyumu.* Retrieved April 01, 2019, from http://uzalcbs.org/wp-content/uploads/2016/11/2012_047.pdf

Küçüksille, E., Özger, F., & Genç, S. (2013). Mobil bulut bilişim ve geleceği. *Akademik Bilişim Konferansı Bildirileri*, 23-25.

Nigam, V. K., & Bhatia, S. (2016). Impact of cloud computing on health care. *International Research Journal of Engineering and Technology*, *3*(5), 2804-10.

Rawson, T. M., Moore, L. S. P., Hernandez, B., Charani, E., Castro-Sanchez, E., Herrero, P., ... & Holmes, A. H. (2017). A systematic review of clinical decision support systems for antimicrobial management: are we failing to investigate these interventions appropriately?. *Clinical Microbiology and Infection*, *23*(8), 524-532.

Rehman, H., Kamal, A. K., Sayani, S., Morris, P. B., Merchant, A. T., & Virani, S. S. (2017). Using mobile health (mHealth) technology in the management of diabetes mellitus, physical inactivity, and smoking. *Current Atherosclerosis Reports*, *19*(4), 16.

RESTful API Design: 13 Best Practices to Make Your Users Happy. (n.d.). Retrieved May 13, 2019, from https://blog.florimond.dev/restful-api-design-13-best-practices-to-make-your-users-happy

Sağlık alanındaki yeni eğilim bulut bilişim. (n.d.). Retrieved from April 10, 2019, https://www.bthaber.com/saglik-alanindaki-yeni-egilim-bulut-bilisim/

Saunders, J. B., Aasland, O. G., Babor, T. F., De la Fuente, J. R., & Grant, M. (1993). Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction*, *88*(6), 791-804.

Schilit, B. N., Adams, N., & Want, R. (1994). Context-aware computing applications, *IEEE Workshop on Mobile Computing Systems and Applications*, 85-90.

Tutorialspoint (n.d.). *MVC Framework Introduction*. Retrieved April 10, 2019, from https://www.tutorialspoint.com/mvc_framework/mvc_framework_introduction.htm

Wang, C., Chow, S. S., Wang, Q., Ren, K., & Lou, W. (2011). Privacy-preserving public auditing for secure cloud storage. *IEEE transactions on computers*, *62*(2), 362-375.

What is REST (REpresentational State Transfer)? - Definition from WhatIs.com. (n.d.). Retrieved April 10, 2019, from, https://searchmicroservices.techtarget.com/definition/REST-representational-state-transfer

What is service-oriented architecture (SOA)? - Definition from WhatIs.com. (n.d.). Retrieved April 10, 2019, from https://searchmicroservices.techtarget.com/definition/service-oriented-architecture-SOA