Rule Based Diet Planning Mobile Application

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A dissertation submitted for the Degree of Master of Information Technology

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ABSTRACT

The imbalance food intakes and unhealthy eating habits have contributed to the overweight and obesity conditions in human lives. Even for individuals at a healthy weight, a poor diet is related with most of the health risks that can originate for sickness and even death. Therefore, human death due to heart diseases and high blood pressure are increasing rapidly. The people can protect themselves from those health issues by following a proper diet plan. The dietician consultation is required to find a proper diet menu based on everyone's health conditions. Finding free time for consulting a dietician is the next challenge in human busy lives. The appropriate diet application can assist people to go along with a proper diet plan. Currently, there are many mobile health applications associated with diet plans and tracking health status of people. The lack of simplicity and poor user experience can be considered as limitations in most of those existing applications. Therefore, the aim is to develop a simple mobile application to seek a proper diet menu based on a created diet plan, facilitate a way to regularly check the plan progress and develop a web-based data analytics dashboard based on application data. Once completed the system development, the system had been evaluated by selected potential users and analysed the results to find out benefits and limitations. The future enhancements are identified based on the system evaluation feedback and 78.6% of participants were agreeing that they would be able to reach the target weight goal using this application. Furthermore, the web-based data analytics dashboard has been verified by the experts and they have claimed that it will be a value addition for a dietician to make their daily job easy.

***Keywords**: Diet Planning, Diet Apps, Mobile Application, Mobile Phone, Mobile Technology, Rule-based Approach, Data Analytics Dashboard, Human Health*

Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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Signature: Date: 11/19/2020

This is to certify that this thesis is based on the work of Mrs. K.A.N. Maduwanthi under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor Name: **Dr. G.D.S.P. Wimalaratne**

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Signature: Date: 11/19/2020

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I would also like to thank the experts and participants who were involved in providing required information for system implementation and evaluation. Without their passionate participation and input, the feedback survey could not have been successfully conducted. I would also like to thank all colleagues who helped me in this work.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
BMI	Body Mass Index
UML	Unified Modelling Language
ER	Entity Relationship
MVP	Model-View-Presenter
API	Application Program Interface
IDE	Integrated Development Environment
JSON	JavaScript Object Notation
HTTP	HyperText Transfer Protocol
RESTful	Representational State Transfer
SQL	Structured Query Language
USB	Universal Serial Bus
ADB	Android Debug Bridge
APK	Android Package Kit

1. INTRODUCTION

1.1. Motivation

A balanced diet plays a major part of leading a healthy lifestyle. Furthermore, the combination of proper diet and enough physical activities can help anyone to maintain a healthy weight. Unfortunately, today people are losing control in their overall health and risk of chronic diseases are increasing rapidly. According to the recent studies, around 30% of world's population is overweight or obese [1]. Furthermore, the World Health Organization was revealed that more than 1.9 billion adults, 18 years and older, were overweight in 2016 and of these over 650 million were obese [2]. Therefore, people should pay more attention to their health especially in terms of balanced food intake.

Furthermore, it all starts with a proper healthy diet plan. It is recommended that any individual should consult a nutritionist or a dietician before deciding what type of diet is the right choice. It will help individuals to organize their diet correctly. Unfortunately, finding free time to consult a dietician or go to the gym is another challenge in human busy lives. Additionally, smartphones, mobile devices and mobile applications become essential parts of human's life. Interconnecting people with a diet application through a mobile phone will be a topical solution for healthy issues related with diet.

The appropriate diet application can assist people to go along with a proper diet plan. Therefore, the main idea is to develop a mobile application to create a quick diet plan, find the best diet menu based on a selected diet plan and facilitate a way to regularly check the health progress with a given diet plan. Additionally, a data analytics dashboard with progress of each diet plan can be used as a value addition for a dietician to make their daily job.

1.2. Aims and Objectives

This project aims to develop a mobile application to seek a proper diet menu based on selected diet plan, facilitate a way to regularly check the plan progress and develop a web-based data analytics dashboard based on application data.

There are a set of general objectives of this project as defined below.

- Study and understand similar systems and solutions of the same problem domain in detail by interacting with the Domain Experts and referring the web materials.
- Study of methods such as rule-based approach and other mobile application development platforms.
- Develop a mobile application to seek a quick diet plan and facilitate a way to regularly check the health progress with a given diet plan.
- Develop a web application with a data analytics dashboard for real dieticians or admin users to quickly view the overall picture of diet plan progress.
- Assist users to live a healthy life by minimizing the difficulties associated with finding a better diet plan.
- Minimize the cost and time in channelling dieticians continuously for better diet plans and motivate people to use mobile applications for planning diet easily.
- Testing and Evaluation of the proposed solution.

1.3. Scope of the Project

This project is to develop a mobile application to assist users to plan their diets and obtain better diet meal recommendations. The scope of the project can be divided into main two categories as functional scope and the non-functional scope.

1.3.1. Functional Scope

The functional scope expresses the desired behaviour of the system based on functional requirements. The functional scope can be listed as below.

- Simple user registration with credentials.
- Facility to update the user's health profile with basic information such as weight, height, age, etc.
- Assist users to create different diet plans.
- Generate diet menu based on active diet plan.

- Web-based data analytics dashboard with different diet plan progress of all available users for real dieticians to analyse diet progress.
- Facility to regularly check user progress for the active diet plan.
- Present the updated diet plan based on the latest health profile data such as weight, age, etc.
- Generate individual user progress charts based on daily progress.
- Provide a web-based data analytics dashboard based on all active diet plan progress and details.

1.3.2. Non-Functional Scope

The Non-functional scope is not directly affected with the basic functionality of the system. It can be derived based on non-functional requirements which describe critical operational qualities of the final system. List of non-functional scope is listed as below.

- The system should be reusable and maintainable. Therefore, future enhancements should be able to easily integrate with the current application.
- The caching data for optimizing the application performance in offline mode will be implemented.
- The system should be designed and developed in a very simple and attractive way. Therefore, the end user will take less time to become familiar with the application functionalities.
- The system should be able to handle typical security issues in the authentication and authorization process.

Any pricing models will not be included in the scope of this project. Basic user authentication will be included in this project, but not highly focusing on authentication/authorization.

1.4. Structure of the Dissertation

The remaining chapters of this dissertation are organized as follows. An analysis of the requirements, a review of similar systems and a comparison of alternative design strategies are discussed in detail in chapter 2. Chapter 3 examines the analysis and design of the system which includes database structure, solution architecture, etc. Chapter 4 describes implementation of the application with the detailed explanation of methodologies and techniques. A critical evaluation of the system is presented in Chapter 5 through how the project objectives were satisfied and lessons learnt during the project. In the Chapter 6, the dissertation concludes the work indicating a summary of the results of the project and highlights how improvements could be made through future work.

2. REVIEW OF SIMILAR SYSTEMS AND TECHNOLOGIES

2.1. Introduction

Providing healthcare services via mobile technology would be advantageous in many aspects. Currently, there are many mobile health projects related to diet plans for tracking health status of people. It can be used for different features, evaluation, and analysing techniques from related works in proposed system development. The aim is to represent the review and analysis of similar approaches with the proposed system.

2.2. Diet Considerations

The connection between diet and blood types are discussed deeply by Dr.Peter J.D'Adamo [3]. Dr. Peter D'Adamo's Blood Type Diet is mentioned as the most popular personalized diet system in the world [4]. Dr. Peter D'Adamo launched The Blood Type Diet in 1996 with the publication of *Eat Right 4 Your Type* [5] [3]. His work has since changed the lives of over ten million followers of The Blood Type Diet [5]. Most of the studies and blogs explain his theories related to diet considerations. Some preliminary work was carried out by Drake Puryear in 2017 to explore the set of claims in study of Dr. Peter J.D'Adamo [3] who studied regarding best foods for an individual based upon their blood type [6]. Personal experiences of Drake were mainly motivated by the study in "The Right Type of Diet" in which clearly represented the potential relations between human blood types and the way they ingest [6]. The process of digestion with blood type inheritance is examined deeply in this paper. Furthermore, this paper addresses the need for selecting a proper blood type diet. A set of factors believed to be associated with successful maintenance of a healthy diet were investigated by Tiril C. Borge through initiation of weight reduction program participation [7]. A set of questionnaires and different data analysis methods were used in this study to measure participant's self-perceived maintenance degree of a healthy diet [7]. More key factors in eating behaviour and characteristics of healthy foods were presented in the study of Sangmook Lee, M.S. Different research questions and questionnaires were used by Lee to identify the features of healthy foods, eating behaviours and healthy knowledge and concern of college students [8].

A balanced diet is important to provide proper intake of energy and nutrients to maintain good health. A proper human diet should comprise water, carbohydrates, fiber, fat, protein, minerals, and vitamins all in accurate amounts. These amounts differ for each individual because every person has different metabolic rates and levels of action. Therefore, developing a common solution for all types of individuals will be a challenge. The new technological improvements such as machine learning, artificial intelligence, mobile technologies, and the Internet of Things concepts are heavily involved in healthcare solutions. The communication, patient care and hospital workflows are the three major things from the deployment of mobile-based technology in healthcare [9]. The diet planning comes under patient care. Furthermore, a simple patient cares mobile application embedded with mobile-based technologies can support human beings to save money, time, and life. Therefore, the analysing procedures and results of similar studies support for implementing better healthcare solutions for human beings.

2.3. Similar Systems

It is well known that diet planning is a very popular topic today among most people. Furthermore, smartphones are more popular with mobile applications in day today activities of human life. Android AI Diet Consultant is such a mobile application with artificial intelligence related to human diets. It acts as a diet consultant like a real dietician [10] with the support of artificial intelligence key technology to decide the suitable diet based on user inputs. In this application, if the users are not satisfied with the presented diet plan, users were facilitated to connect with real dieticians. The user is being allowed to request the recommended diet plan customization based on their preferences. The requested diet plans can be updated by the real dietician. It is the main feature of this application to provide better user experience. Additionally, the different blood groups details are maintained and users can show their willingness for donating blood. The usage of this application greatly reduces the time required to get the best diet plan as it is a standalone application [10]. An even greater source of concern is poor user experience in application with the loss of network connection. Another weakness of this application is, not having any evidence to prove the level of usability based on provided information. The online artificial dietician [11] is a Bot which is having more similar features when compared with the previously mentioned AI diet consultant application. This is a dietician bot application related with human diets which was also developed using artificial

intelligence technologies. Artificial intelligence technologies were used to make decisions about diet plans based on user inputs such as weight, height and eating times. It was designed with a very simple user interface. Android mobile users will not be able to insert or view details if the server goes down [11] in this bot application like previously mentioned application.

AI-powered Virtual Nutritionist & Robotic Chef is an automated food preparation system that includes a computer-controlled robot specialized in nutrition and healthy eating preparations and recommendations [12]. This was developed by the Go-MaD AI [12] which is an integrated digital health platform. The applying artificial intelligence for meal monitoring was the main goal of this system [13]. Today, most of the people do not have much time for cooking balanced food at home with their busy lifestyles. Consequently, people tend to buy their meals from outside. It is well known that chefs are experts in cooking but not professionals in nutrition. Similarly, most of the nutritionists are not experts in cooking, but they have knowledge about nutrition. Therefore, there is a gap between nutritionists and chefs. The artificial intelligence concepts were applied by Go-MaD AI [12] to fill this existing gap. AI-powered Virtual Nutritionist & Robotic Chef [12] system was developed as a result of filling this gap. The virtual nutritionist and robotic chef together work on preparing proper well-balanced foods for their customers. In 2018, it has been awarded the 'Top 50 Healthcare Companies Award' by Smart Health Dubai 2018 [12]. The Heali AI has introduced an application which allows users to choose a diet or create their own diet. It allows users to scan any food menu available at restaurants and decide which food works on their diet [14]. This application is also implemented using artificial intelligence technologies in an advanced way.

My Diet Coach is another similar application which helps users to find their inner motivation, keep users on track, make healthy lifestyle changes, resist food cravings, avoid exercise laziness and other weight loss difficulties [15]. This application has more advanced features when compared with the previously mentioned AI Diet Consultant [10] application. My Diet Coach [15] includes customized reminders which boost user's motivation, improve user's health and plan user diet. Visual weight tracker, visually see and track how much users have lost so far [15]. Daily challenges program which will help users to improve their fitness and nutrition. This application also requires continuous

internet connection on mobile devices to work properly with this app. Implementation details were not provided for public review, only features were available in the app store with user interface screenshots. The set of features and user interface designing concepts have been used in our system implementation.

The advancement of a specialist framework model on sustenance and diet area utilizing rules-based framework strategy in their research paper which is named "*Developing a Nutrition and Diet Expert System Prototype*" were described by the Balquees Ali and his group [16]. Any mobile application can be evaluated following those evaluation methods which they conducted the user evaluation as explained in the below section.

2.4. Comparison of Similar Systems

System 1	Android AI diet consultant [10]
Features	• Providing the suitable diet based on user inputs. • Facilitating users to connect with real dieticians to customize the given diet plan. • Facilitating users to show their willingness for donating blood
Identified gaps in the study or system	No way to check the application usability based on given information. Users will not be able to insert or view details if the server goes down.
Technologies	Artificial Intelligence

Table 2. 1 Details of the android AI Diet Consultant Application [10]

System 2	Artificial dietician - bot [11]
Features	● Making decisions about diet plans based on user inputs such as weight, height and eating times. ● Very simple user interface
Identified gaps in the study or system	No way to check the application usability based on given information.
Technologies	Artificial Intelligence

Table 2. 2 Details of the Artificial Dietician Bot Application [11]

System 3	AI-powered virtual nutritionist & robotic chef [12]
Features	● An automated food preparation system includes a computer-controlled robot specialized in nutrition and healthy eating preparations and recommendations, ● Filling the existing gap between nutritionists and chefs
Identified gaps in the study or system	Complexity is involved
Technologies	Artificial Intelligence

Table 2. 3 Details of the Virtual Nutritionist & Robotic Chef Application [12]

System 4	Heali AI diet [14]
Features	● Allowing users to choose a diet or create their own diet ● Allowing users to scan any food menu available at restaurants and learn which food works on their diet [14]
Identified gaps in the study or system	Complexity is involved
Technologies	Advanced Artificial Intelligence

Table 2. 4 Details of the Heali AI Diet Application [14]

System 5	My diet coach [15]
Features	● Helping users to find their inner motivation, keep users on track, make healthy lifestyle changes, resist food cravings, avoid exercise laziness and other weight loss difficulties [15], ● Including customized reminders which boost user's motivation, improve user's health and plan user diet
Identified gaps in the study or system	Requires continuous internet connection on mobile devices to function properly.
Technologies	Deep Learning, Artificial Intelligence

Table 2. 5 Details of the My Diet Coach Application [15]

2.5. Usability Evaluations in Related Work

Evaluation methods and user evaluation were explained clearly in "*Developing a Nutrition and Diet Expert System Prototype*" study by the Balquees Ali and his group [16]. This expert system has been confirmed by the specialists and assessed by potential clients to evaluate its advantages and impediments after the completion of development. The five categories of the expert system were explained in this study such as user interface, working memory, knowledge base, inference engine and explanation system [16]. Furthermore, this expert system is developed by using a freeware rule-based shell called eXpertise2Go. This rule-based framework catches nourishment and diet information from human experts and pertinent sites and afterward exhibits it in if-then statements format, and gives arrangements [16]. This is a web-based system. Both benefits and limitations of the system were clearly defined. The finding shows that 40% of users said that the method of calculating waist circumference is unknown [10]. About 26.66% of them indicated that the system lacks images. About 13.33% said that it is not covering everything and it's not good as having a human expert in hand [16]. Based on those figures, the system cannot be opened without java is one of technological difficulties and it might cause negative feedback from the end user's perspective. The user evaluation concepts and procedure of this system can be used in our proposed system.

More studies were discussed how to conduct proper usability evaluations on healthcare mobile applications. The work done by Mohamad Hidir Mhd Salim et. al [17] is one of the studies to evaluate the healthcare specially diet related mobile application that implements a persuasive design for the elderly [17]. In this case, it was mainly focused on how effective using persuasive principles in designing mobile applications to motivate people to change their behaviour for a better lifestyle. There were a lot of well-organized ways of conducting usability evaluation on a healthcare related mobile application using different approaches such as face to face interviews, questionnaires and monitoring how well set of people use the developed mobile application. The work done by Nazlena et. al [18] explored the use of touch screen interaction in developing an educational, nutritional package for elderly. Findings were shown that most of the elderly involved in this work agree that the educational package was helpful in providing an education on nutritional and healthy lifestyle. Meanwhile, a study by Hazwani [19] was shown that elderly participants were interested in learning more advanced smartphone

functionalities. For this group of users, who were dealing with increasing physical impairments due to aging, the application may need to tailor the content based on their physical limitations and suggest relevant physical activities that were feasible for them to perform [20]. The work by Harri Oinas [21] was provided helpful methods for understanding persuasive innovation, yet explicitly for structuring and assessing powerful frameworks they appear to be at an excessively broad level. Also, it is very useful in identifying key issues behind the persuasive systems and user context before starting mobile application development.

2.6. Summary

Most of the human diet specific applications were developed with artificial intelligence and machine learning advanced concepts. Each study and similar projects have both benefits and limitations. Reviewing similar systems is very important to gain deep knowledge of the problem domain. Furthermore, studying the related work was the key success factor of this project as well.

3. ANALYSIS AND DESIGN

3.1. Introduction

This section explains the main features and the analysis of the proposed system along with the system design approaches. The structure of the system is described with appropriate design diagrams. Additionally, each stage in the application development lifecycle is explained separately.

3.2. Approach to the Final Solution

The diet application development is conducted based on software engineering standards and concepts. The actual problem and solution are identified deeply in the requirement gathering stage by using data collecting and analysing methods. The software engineering life cycle is followed in developing the diet application as shown in figure 3.1.

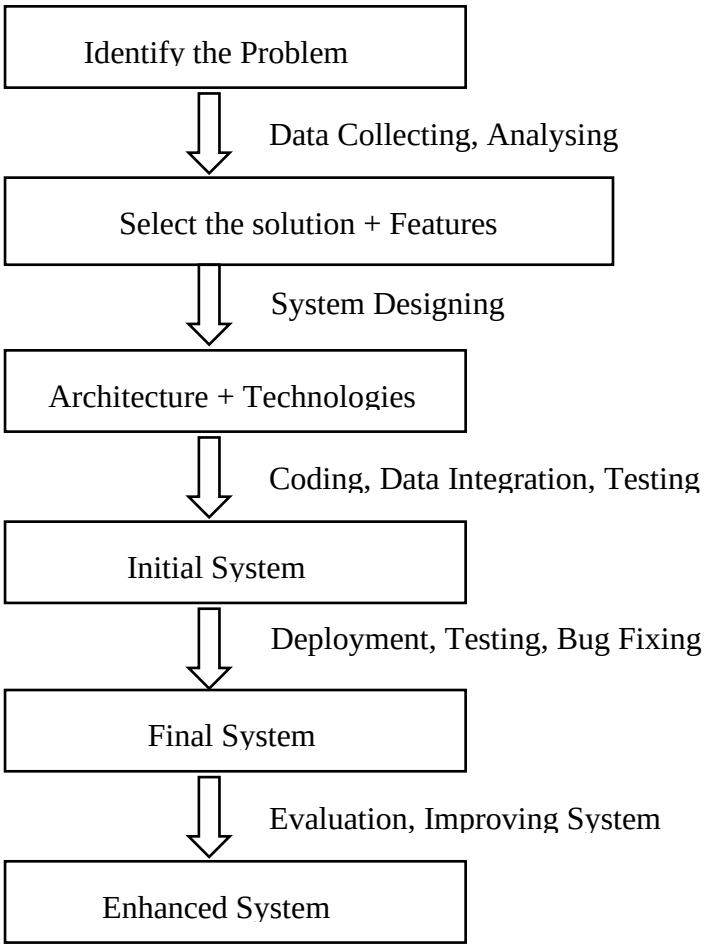


Figure 3. 1 System development life cycle

3.3. Identifying the Problem and Solution

Today, most people can be identified as overweight or underweight. Therefore, overweight people need to lose weight and underweight people need to increase their weight in a healthy way. Not only that, any individual would like to be healthy and get stronger. Common solution will be the consulting dietician or nutritionist to seek a proper diet plan. Because a balanced diet is very important to maintain good health. Most of the people are struggling with time and it will be a big challenge for them to earn free time to meet a diet consultant. But smartphones and mobile applications are very popular with human's busy lives. Therefore, mobile applications and diet plans are playing key roles in human life. Assisting users to create diet plans and follow the plan with the support of their mobile phones will be a very effective solution for the identified problems in human life.

3.4. Collecting and Analysing Data

Collecting and analysing data is very important to finding a better solution and approach to the selected solution. Therefore, collecting, analysing data is conducted in four different stages using one or more methodologies throughout this project. Below are the methodologies used for data gathering in each stage.

- Review similar systems using information that has already been published in books, newspapers, magazines, journals, online portals etc.
- Interacting with domain experts (Expert interviews – dieticians, nutritionist)
- Questionnaires with close ended questions
- App installation
- User reviews

Those different data collection methodologies are supported in different stages in application development life cycle as defined in below table 3.1.

Stage	**Methodology**	**Reason**	**Output**
Initial	Review similar systems	Since there are lots of solutions for the identified problem, referred already built solutions and performed the comparison.	Developed the diet planning mobile application as solution

Requirement gathering	Questionnaires	To ensure a greater level of depth of understanding to give a solution. To identify the value addition for a diet application.	Finalized the set of application features: as defined under 3.5 section
	Review similar systems	To easily identify already developed application features which supported to finalize our system requirements	
	User reviews	To understand user feedback for existing application which supported to build better solution	
	App installation	To verify already built similar application features To get hands-on experience of existing solutions which supported to identify better way to develop our system.	
Development	Interacting with domain experts	To collect real data sets which are used to develop the rule-based model to generate a diet menu based on diet plan and BMI value of the specific user.	Different diet menus for each user based on selected diet plan
Evaluation	Questionnaires App installation	To evaluate application usability from real users To understand the application limitation/ drawbacks To enhance the application features	

Table 3. 1 Data collecting and analysing in different stages

3.5. Application Features

1. Health Profile: This feature will allow users to enter/update their health-related information. That information will be used to provide food recommendations for diet plans of the user.
2. My Diet Planner: This feature will allow users to add one or more plans with the target duration and target weight.
3. Current Diet Plan: The application will present different food recommendations as a daily basis for the different diet plans.
4. Track Daily Progress – Users will be able to add their weight daily which will be used to check the progress.
5. Progress Chart – The application will be generated progress chart and show the user progress to achieve the target weight.
6. Customize Meals – The user will be able to customize the given diet plan and add new food items according to the willingness.
7. Notification – The user will be notified to enter the current weight as a daily basis.
8. Data Analytics Dashboard – A dietician will be able to understand diet menu patterns and progress of each diet plan which can be a good value addition for a dietician to make easy their daily job.

3.6. Non-Functional Requirements

1. The system should be reusable and maintainable. Therefore, future enhancements should be able to easily integrate with the current application.
2. The caching data for optimizing the application performance in offline mode will be implemented.
3. The system should be designed and developed in a very simple and attractive way. Therefore, the end user will take less time to become familiar with the application functionalities.
4. The system should be able to handle typical security issues in the authentication and authorization process.

3.7. Analysis Approach of the Solution

The scope of the proposed solution includes the analysis and design of the diet planning mobile application based on the Android platform. Below are the different analysis approaches which are used to simply the understanding and the finalizing the features of the proposed solution.

- Conducting research on web materials to find out similar systems in order to determine the application to be made and analyse the results.
- Conducting interviews with a nutritionist to acquire accurate information.
- Analysing mobile application user experience factors for implementing the application.
- Compared with existing similar applications.
- Identifying the different components and design requirements necessary for the implementation.

3.8. Design Approach of the Solution

Different UML diagrams are used for better understanding of the application, once analysing the problem and solution. Those different design views of the solution can be used as key input in the solution implementation stage. Therefore, different views of the same solution are initiated in requirement gathering, analysis and design stages and continuously reviewed, updated throughout the development life cycle.

The designing of the system architecture was the foundation of this system. Therefore, several architectural approaches and best practices were studied before designing the system architecture. As a lesson learnt, the overall project implementation depends on the final detailed architecture of the system.

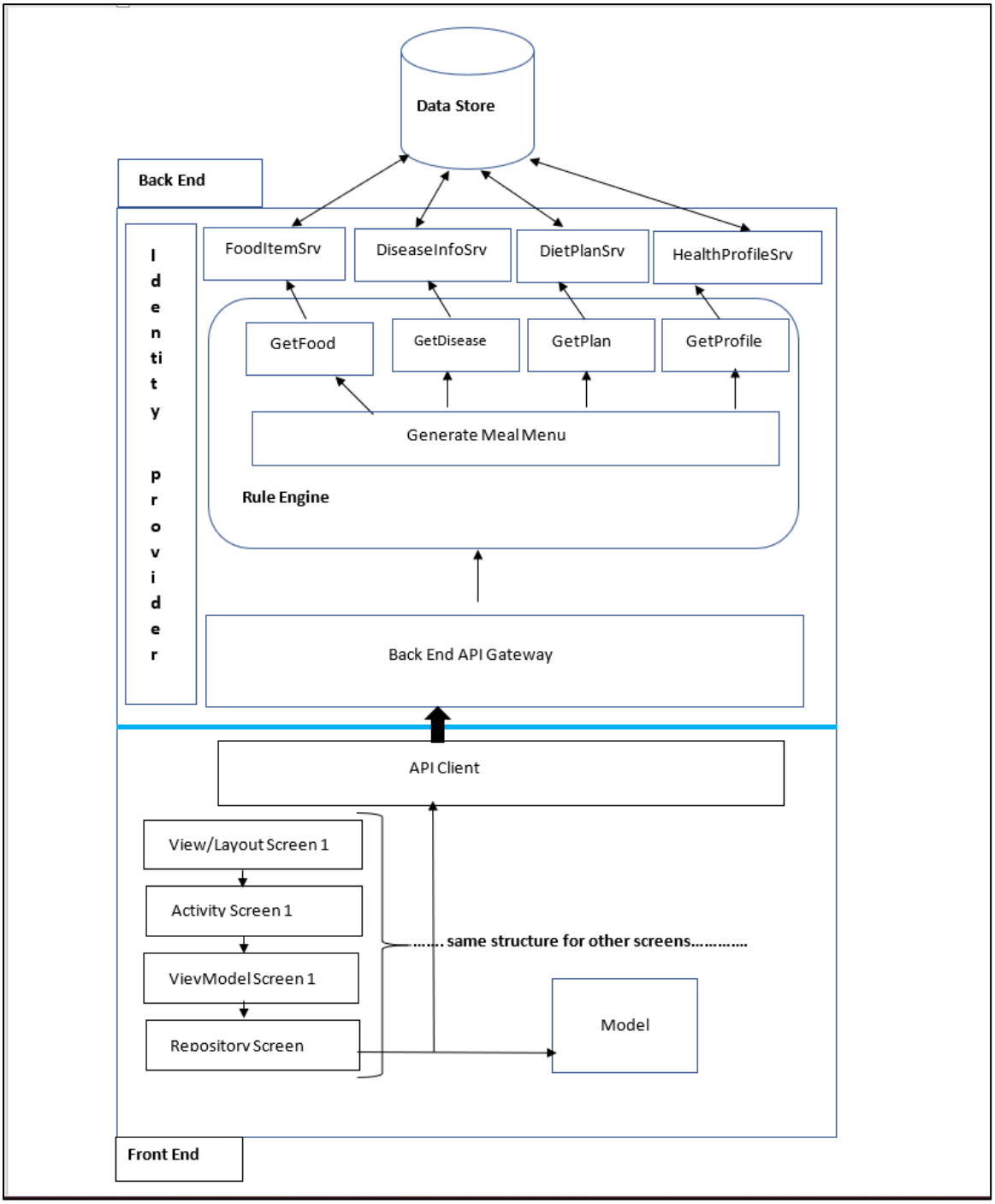


Figure 3. 2 System architecture

There are two main modules as the back end and front end of the system as shown above figure 3.2 architecture diagram. The clean architecture pattern of separation of concern is used when designing the system architecture. It will provide proper maintainability and testability once implemented in the system.

The ER modelling and schema designing was the next step. Identifying the database schema with relations was the main purpose of this ER modelling approach. Therefore, deriving entities based on application features was the first step and defining schema based on identified entities, relations was the next step. The designed ER diagram and schema diagram are shown in below figure 3.3, figure 3.4 respectively.

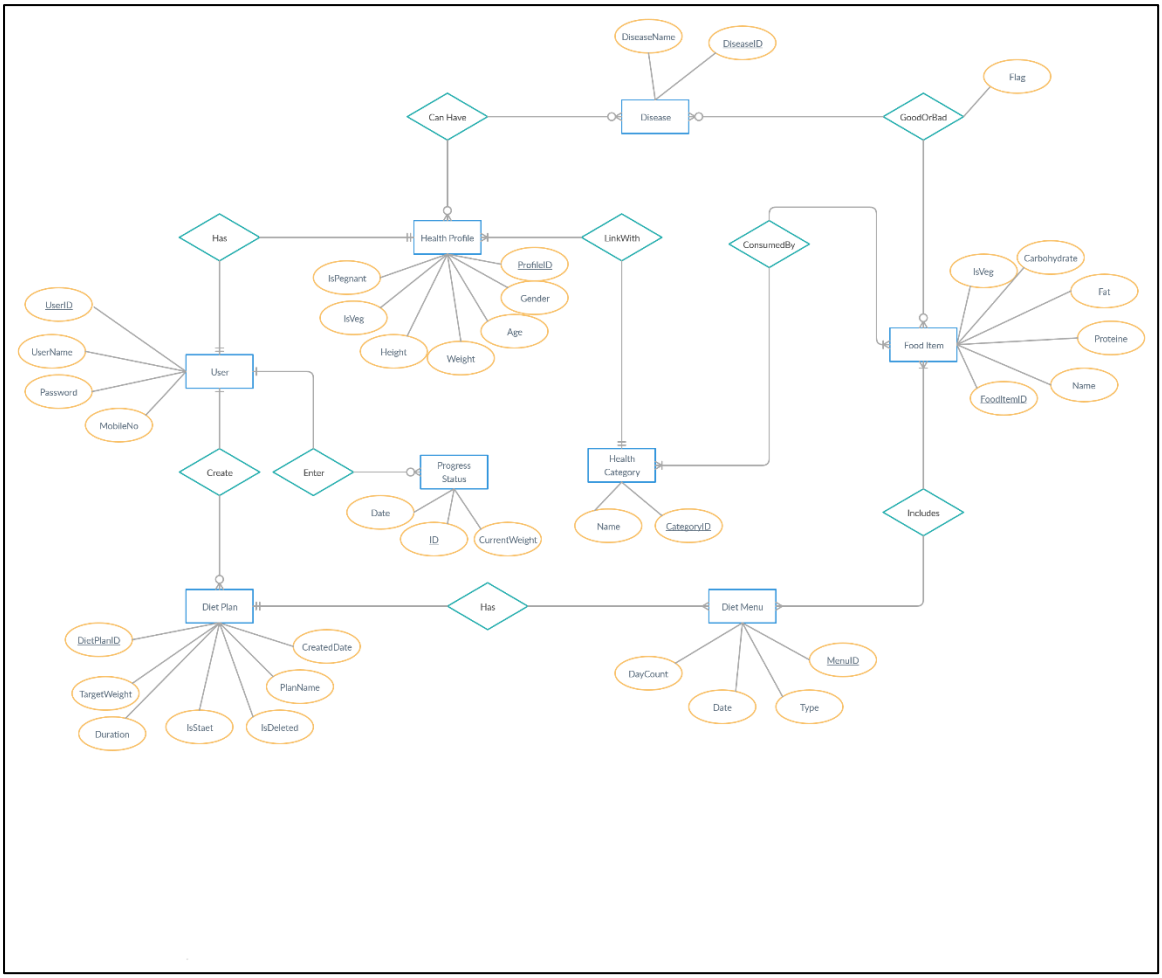


Figure 3. 3 The entity relationship diagram

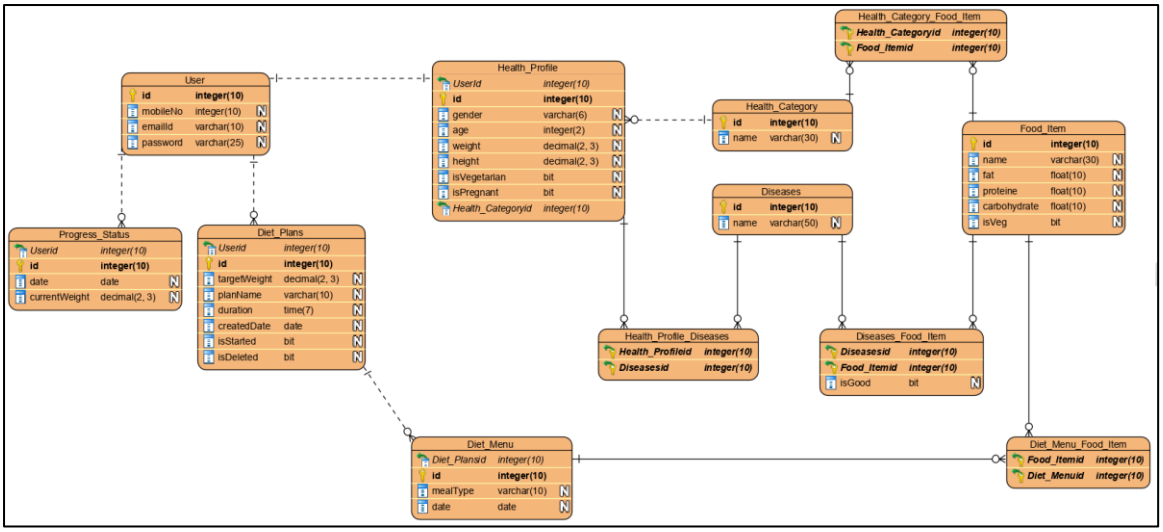


Figure 3. 4 The enhanced entity relationship (schema) diagram

The user interaction with the application was identified through the use case diagram. It will clearly show how application functionalities are aligned with the mobile user. The project work flow and the scope are clearly identified using the use case diagram of the system. The figure 3.5. is represented by the use case diagram of the system. The detailed description use-cases and use case diagrams for each module are represented separately in appendix A section in this document.

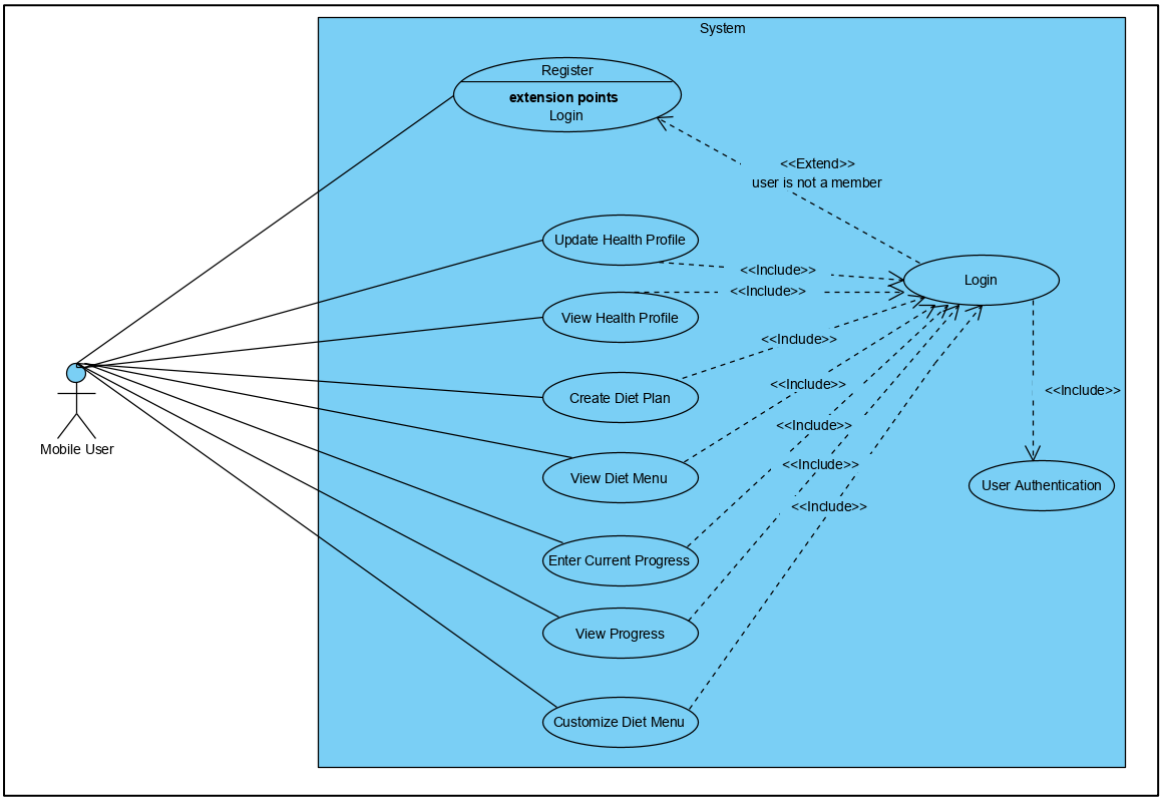


Figure 3. 5 The system use-case diagram

The user interfaces mock-ups are very important before starting the system implementation. The system user interface prototypes are included in Appendix A section of this thesis report. The design assumptions are considered when designing user interface mock-ups. Those design assumptions are listed below.

- Users should update their health profile before creating a diet plan.
- BMI value will calculate assuming height and weight values are correct in the user health profile.
- This application will design and implement considering a limited range of human diseases.
- The user will be allowed to create one or more diet plans and allow to activate only one diet plan at once.
- The progress status graph will depend on user daily entered weight values. Therefore, users should enter current weight on a daily basis.
- To view the progress graph, there should be an active diet plan related to the user profile.

3.9. Summary

The system design and analysing are very important stages in any software development cycle. The better system requirement understanding is provided once analysed the all collected data. Additionally, different graphical UML representations of the same system will be the core foundation for the effective system implementation. All remaining design documentation is included in Appendix A section of this thesis report.

4. IMPLEMENTATION

4.1. Introduction

The detailed explanation in implementation approaches of the proposed system will be explained in this chapter. This will include technologies used for the implementation, deployment environment configuration and evidence of the implementation using attached screenshots. Additionally, the main purposes of using different design patterns, concepts and other technologies are clearly explained in this section.

4.2. System Architecture, Frameworks and Design Patterns

As explained in the previous chapter, two main modules are included in the system architecture defined as front end and back end. Both development environments use separation on concerns with coding best practices and design patterns.

4.2.1. Front-end Implementation

The system front end was the android mobile application development. It is known that the pain involved in maintaining the legacy code-base grows. Therefore, the front end is implemented using the MVP architecture in Kotlin as shown below figure 4.1.

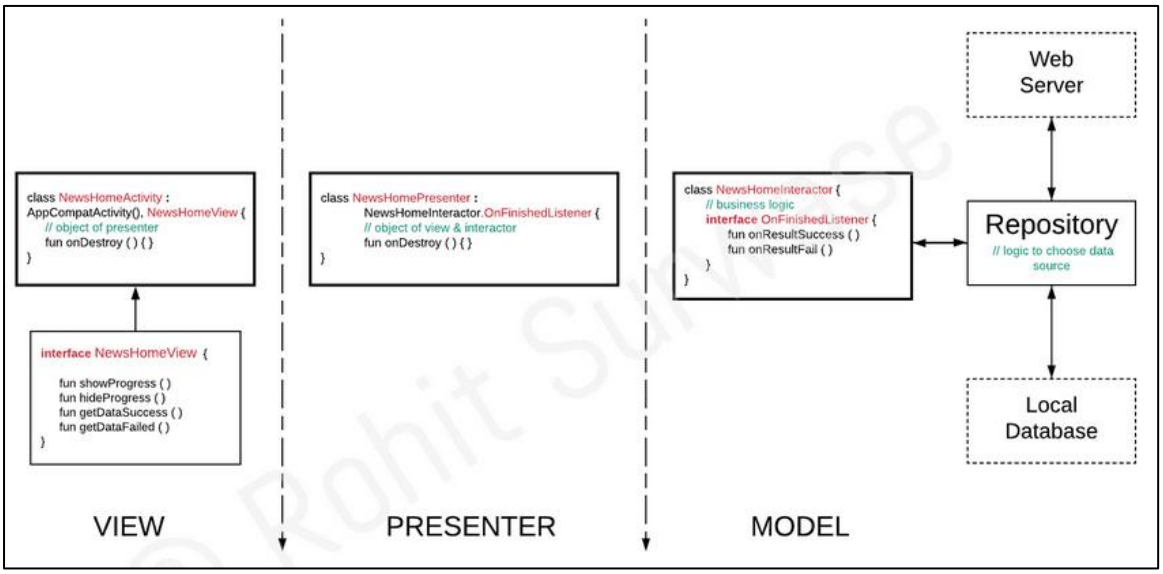
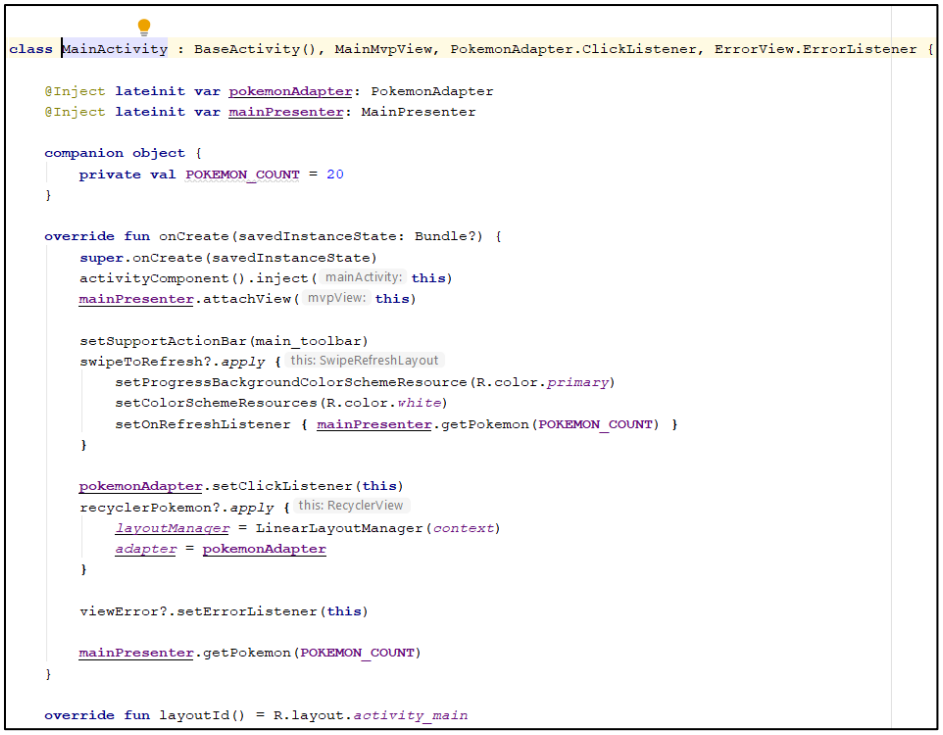


Figure 4. 1 Simple MVP structure [22]

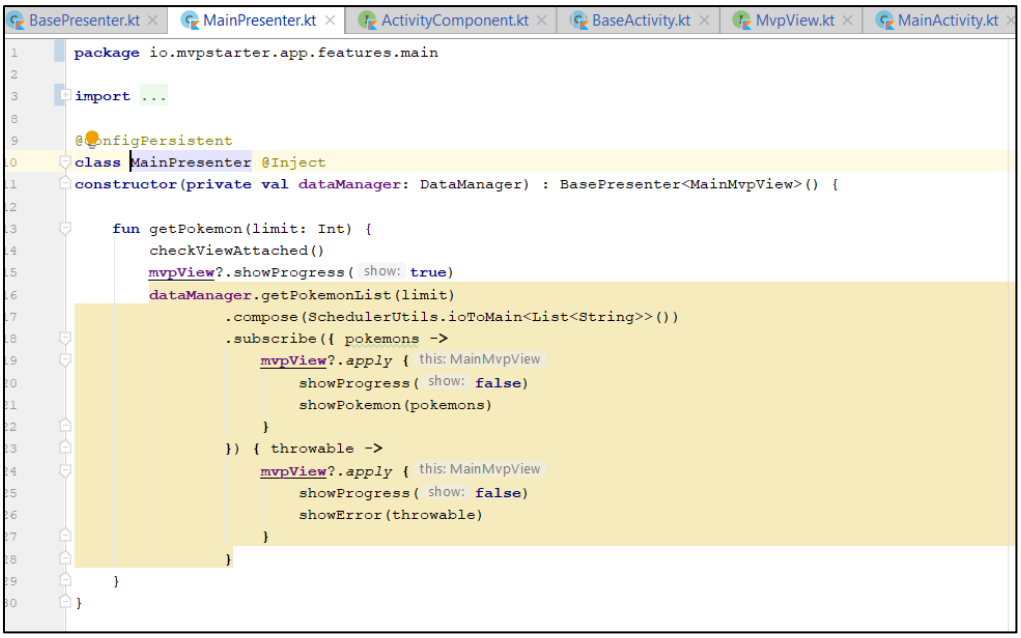
The view indicates all activities, fragments, and its contract together which are used for all user interface and android context related stuff. Below figure 4.2 represents the main view code segment which is taken from front-end source code.



```
class MainActivity : BaseActivity(), MainMvpView, PokemonAdapter.ClickListener, ErrorView.ErrorListener {

    @Inject lateinit var pokemonAdapter: PokemonAdapter
    @Inject lateinit var mainPresenter: MainPresenter

    companion object {
        private val POKEMON_COUNT = 20
    }

    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        activityComponent().inject( mainActivity: this)
        mainPresenter.attachView( mvpView: this)

        setSupportActionBar(main_toolbar)
        swipeToRefresh?.apply { this: SwipeRefreshLayout
            setProgressBackgroundColorSchemeResource(R.color.primary)
            setColorSchemeResources(R.color.white)
            setOnRefreshListener { mainPresenter.getPokemon(POKEMON_COUNT) }
        }

        pokemonAdapter.setClickListener(this)
        recyclerPokemon?.apply { this: RecyclerView
            layoutManager = LinearLayoutManager(context)
            adapter = pokemonAdapter
        }

        viewError?.setErrorListener(this)

        mainPresenter.getPokemon(POKEMON_COUNT)
    }

    override fun layoutId() = R.layout.activity_main
```

Figure 4. 2 The front-end main view code segment

The presenter class is a separate class which does not have the android context. It is playing a mediator role between two basic layers of the architecture model and the view. Presenter class is responsible for triggering the respective function of the model based on the request made by the view. Below figure 4.3 represents the main presenter code segment which is taken from front-end source code.



BasePresenter.kt | MainPresenter.kt | ActivityComponent.kt | BaseActivity.kt | MvpView.kt | MainActivity.kt

```
package io.mvpstarter.app.features.main

import ...

@ConfigPersistent
class MainPresenter @Inject
constructor(private val dataManager: DataManager) : BasePresenter<MainMvpView>() {

    fun getPokemon(limit: Int) {
        checkViewAttached()
        mvpView?.showProgress( show: true)
        dataManager.getPokemonList(limit)
                .compose(SchedulerUtils.ioToMain<List<String>>())
                .subscribe({ pokemons ->
                    mvpView?.apply { this: MainMvpView
                        showProgress( show: false)
                        showPokemon(pokemons)
                    }
                }) { throwable ->
                    mvpView?.apply { this: MainMvpView
                        showProgress( show: false)
                        showError(throwable)
                    }
                }
    }
}
```

Figure 4. 3 The front-end main presenter class code segment

All other business logics, database, schema, and API calls are part of the model layers. Testing the system was easy with this business logic isolation. The separation of concerns was the basic principle that kept in mind while designing the front-end architecture. It is one of the best patterns to separate the presentation layer from the business logic layer [22]. Below figure 4.2 shows the front-end application folder structure in the android IDE environment.

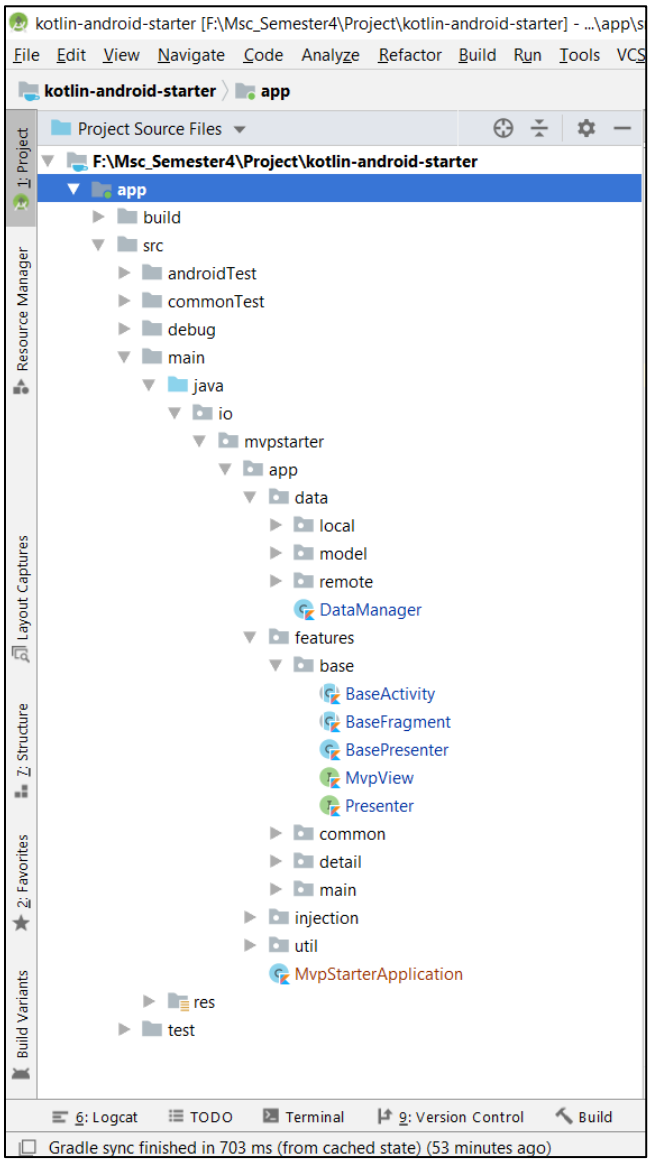


Figure 4. 4 Front-end application folder structure

Additionally, bunch of new supporting libraries and techniques were used in front end implementation as listed in below table 4.1

Library/Framework	Usage in system development
RxJava2	Extends the observer pattern to support sequences of data/events and adds operators [23].
Moshi	Makes it easy to parse JSON into java objects and it is a modern JSON library for Android and Kotlin [24].
Butterknife	It is responsible for binding fields and methods in Android views [25] .
Timber	Provides utility on top of Android's normal Log class [26].
Retrofit	Acts as a type-safe HTTP client for android and kotlin [27].
Dagger 2	Acts as compile time dependency injection framework [28].
Google Play Services	Supports for the google-powered features [29]
Espresso	Acts as the testing framework of the system
Mockito	Supports to mock the objects for unit testing

Table 4. 1 Supporting libraries and frameworks

The implemented diet mobile application look and feel is represented in below screens from figure 4.5 to figure 4.9.

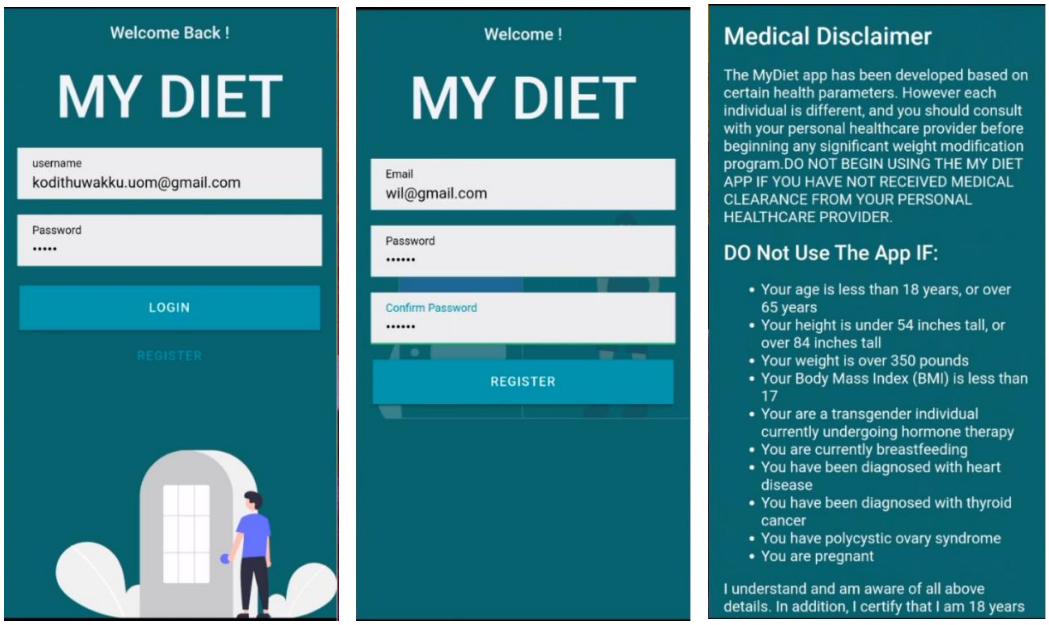


Figure 4. 5 Login, Register and Medical Disclaimer screens

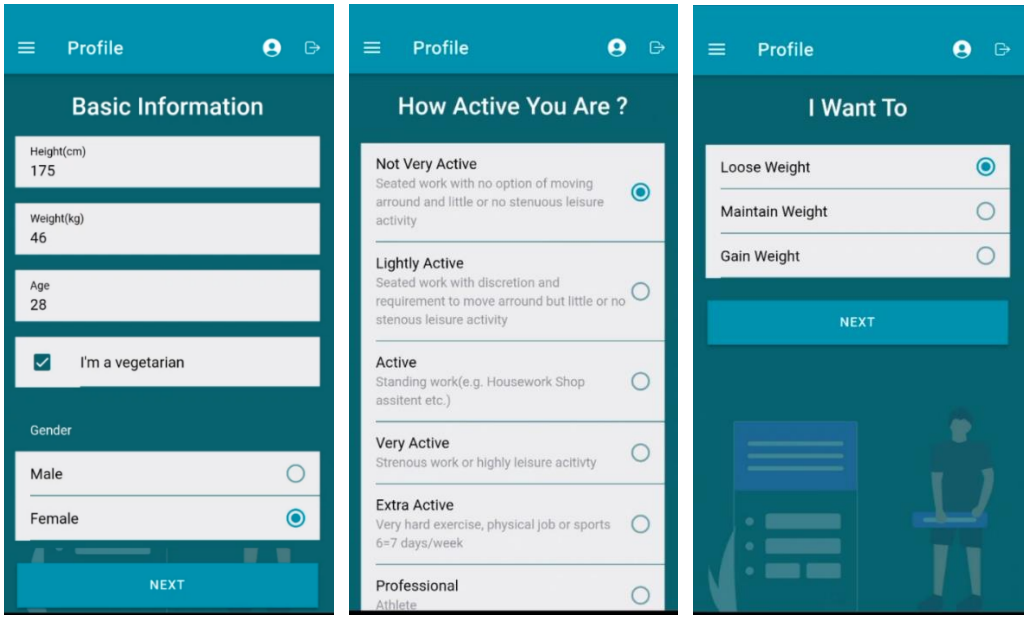


Figure 4. 6 The Profile screens

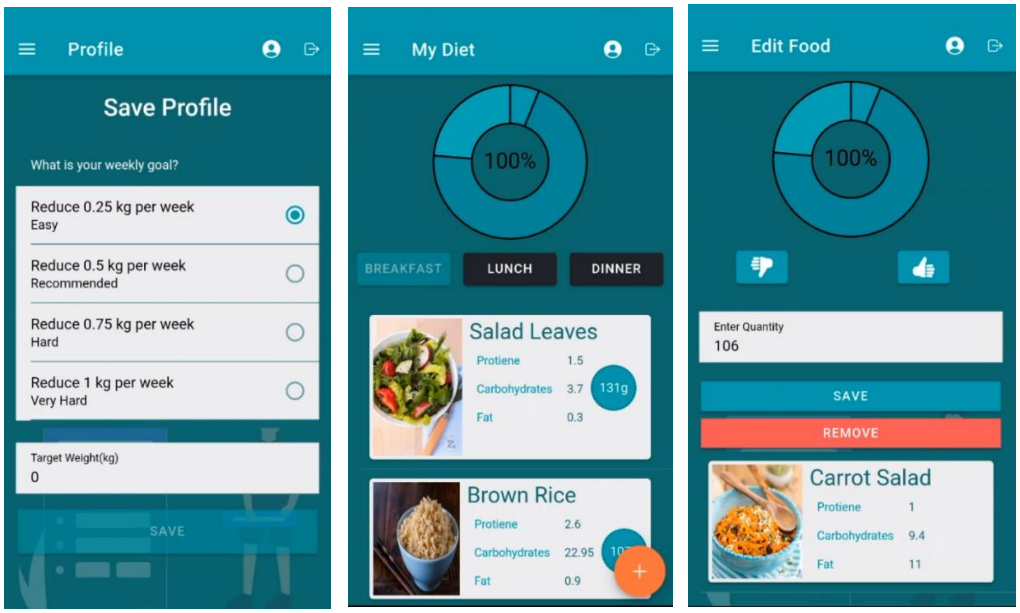


Figure 4. 7 The Profile, Home and Edit Food screens

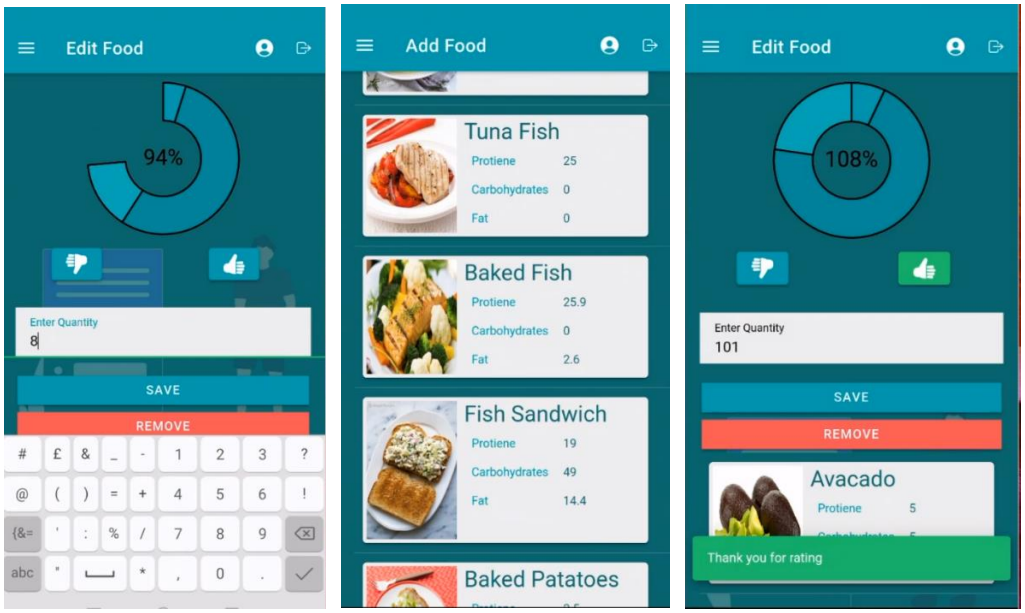


Figure 4. 8 The Editing Food, Add Food and Rating screens

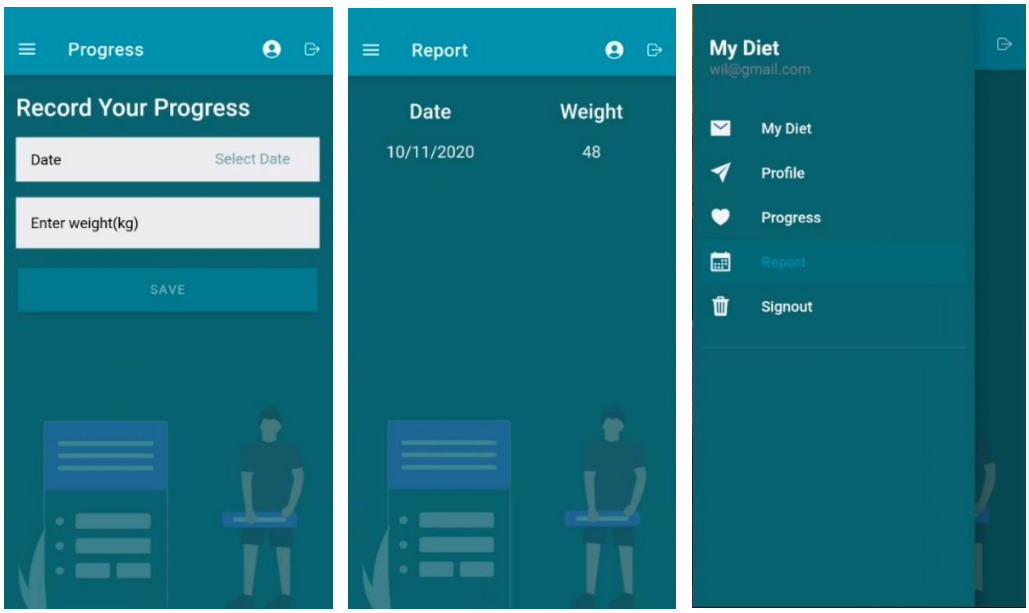


Figure 4. 9 The Progress Tracking, Reporting and App Menu screens

4.2.2. Back-end Implementation

The back-end implementation was done basically with .net core platform for RESTful development. Therefore, the repository pattern was used with asynchronous methods in .net core web API calls. Additionally, the Unit of Work concept was included with a repository pattern to interact with database operations effectively. The object creation was implemented using a factory pattern. Identity server four concept was used to handle simple authentication and authorization processes. The Microsoft SQL Server database was built as the data storage to store application data. Finally, data analytics web-based

dashboard implementation was integrated with the same back-end code base. Below figure 4.5 shows the back-end development environment folder structure in the Visual Studio IDE environment. The swagger API is used as the documentation for the dietitian back end API design as represented in below figure 4.6.

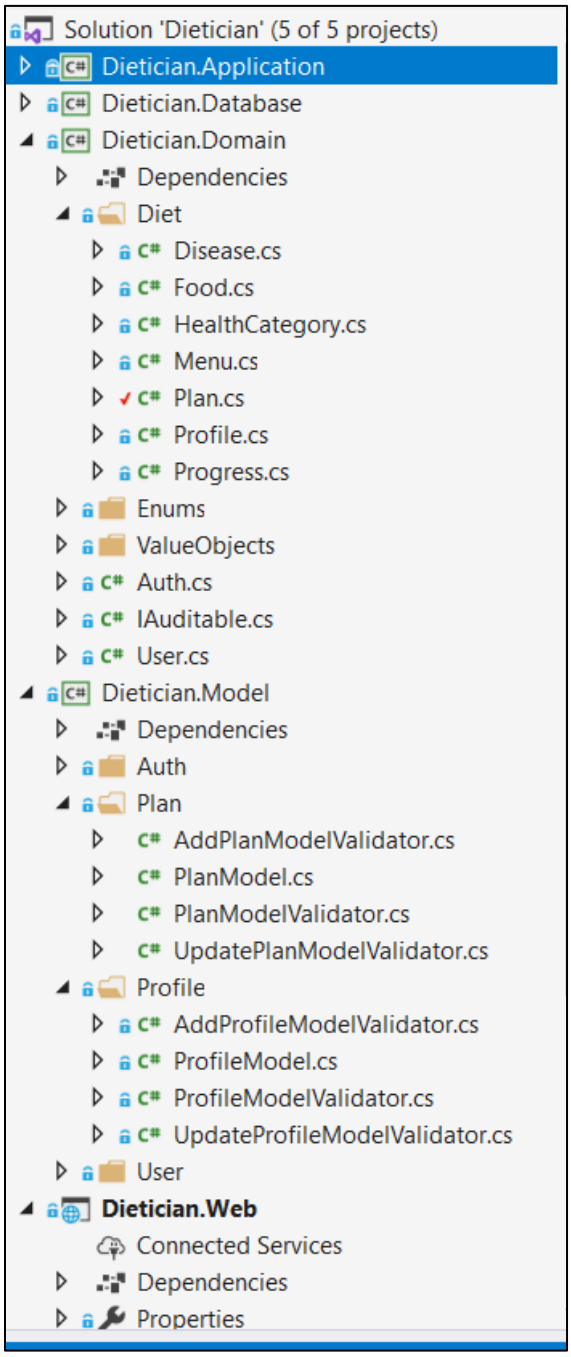


Figure 4. 10 Back-end development environment folder structure

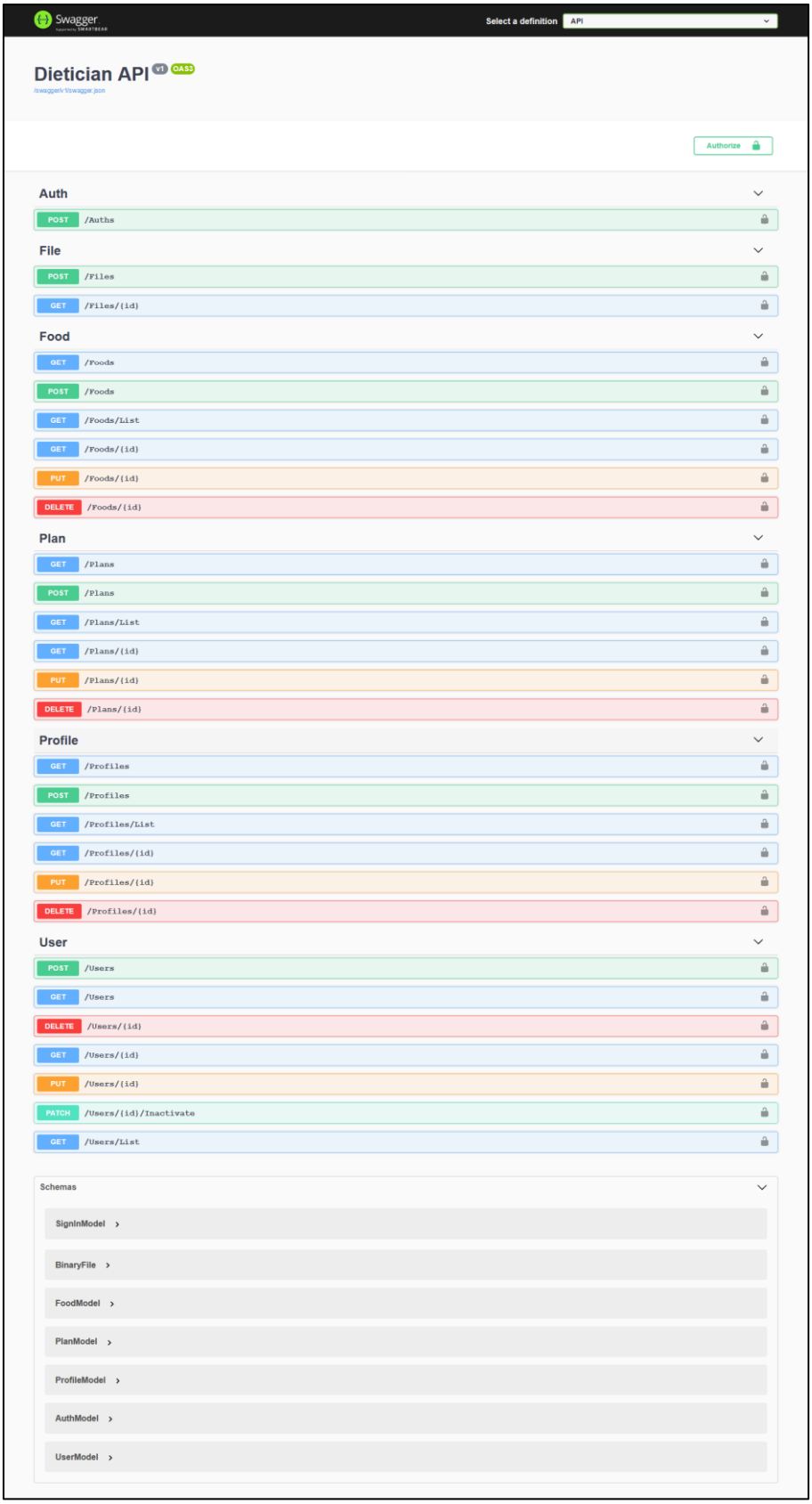


Figure 4. 11 The swagger API documentation of the dietitian API

The rule-based diet generation algorithm is the core part of back-end implementation. The different key considerations are used in diet generation are represented in below figure 4.12 and the flow chart of the diet generation algorithm implementation is shown in figure 4.13.

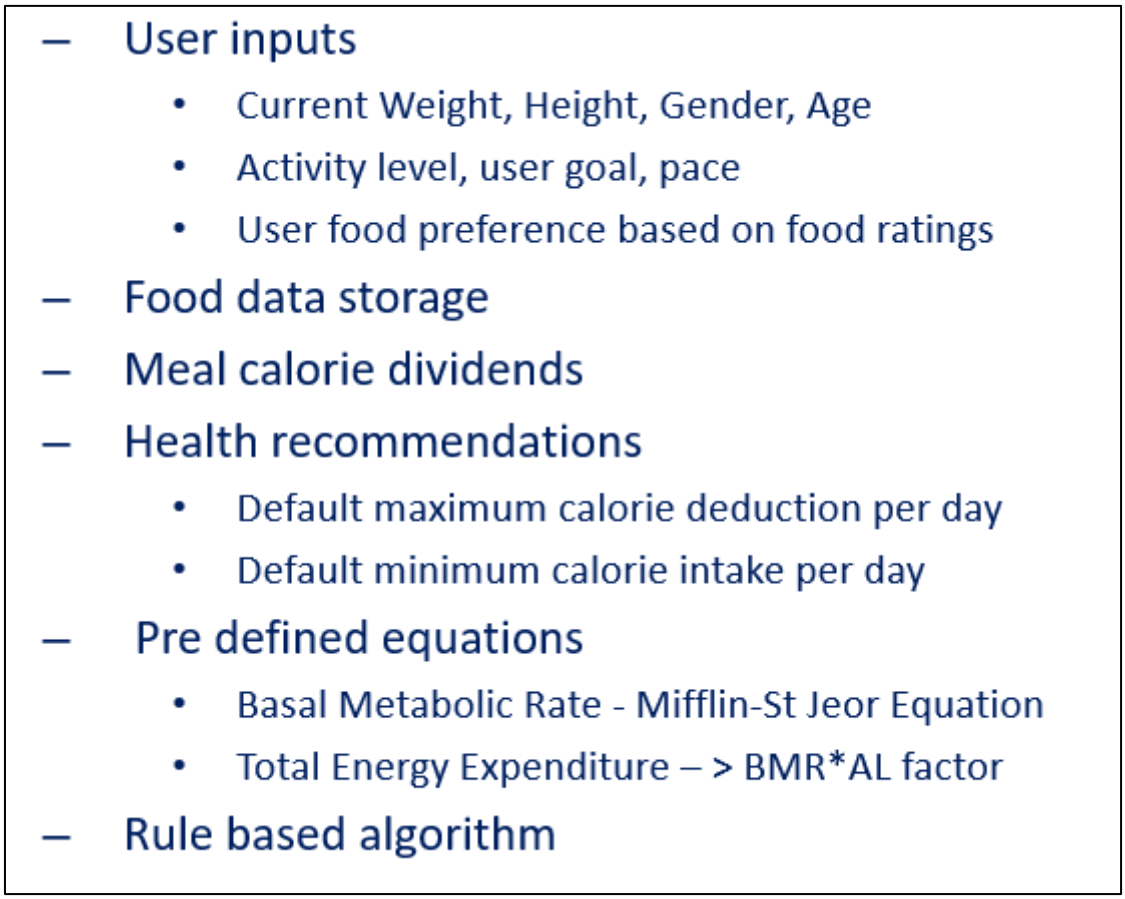


Figure 4. 12 The diet generation key considerations

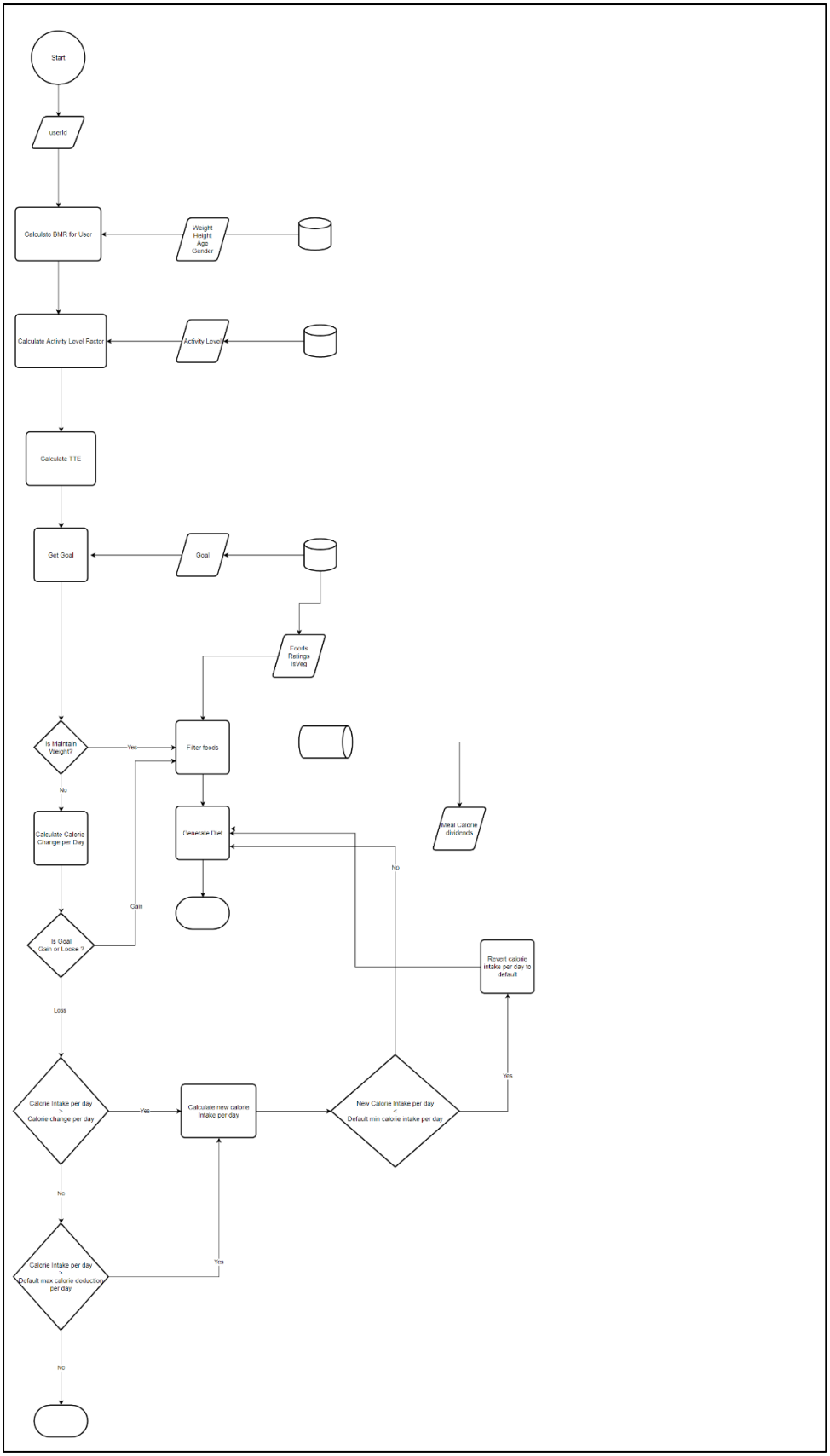


Figure 4. 13 The flow chart of the diet generation algorithm

Additionally, to the back-end web API implementation, data analytics dashboard is implemented mainly focusing the dietitians. They will be able to easily analyse the diet progress, patient records and other details of their patients. The look and feel of the web data analytics dashboard are represented in below screenshots from figure 4.14 to figure 4.19.

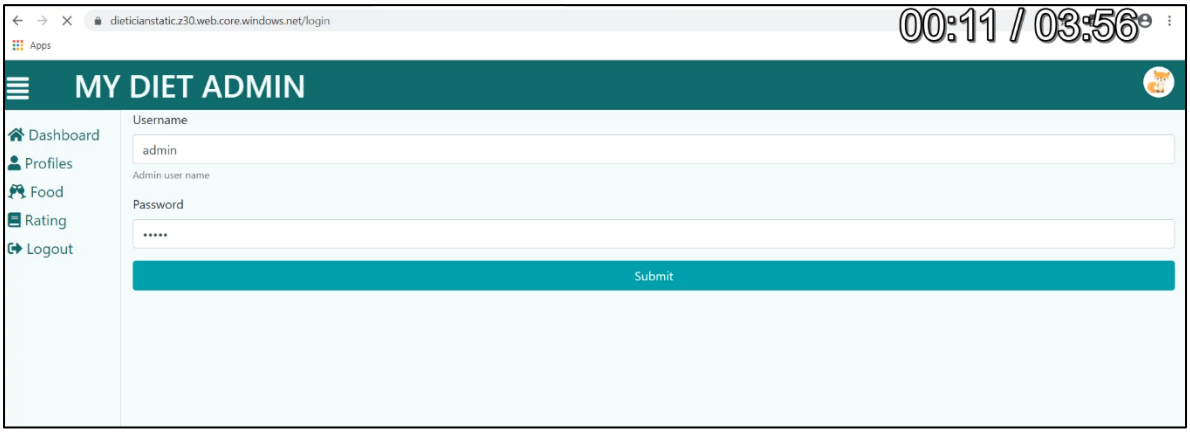


Figure 4. 14 The login page of the dashboard

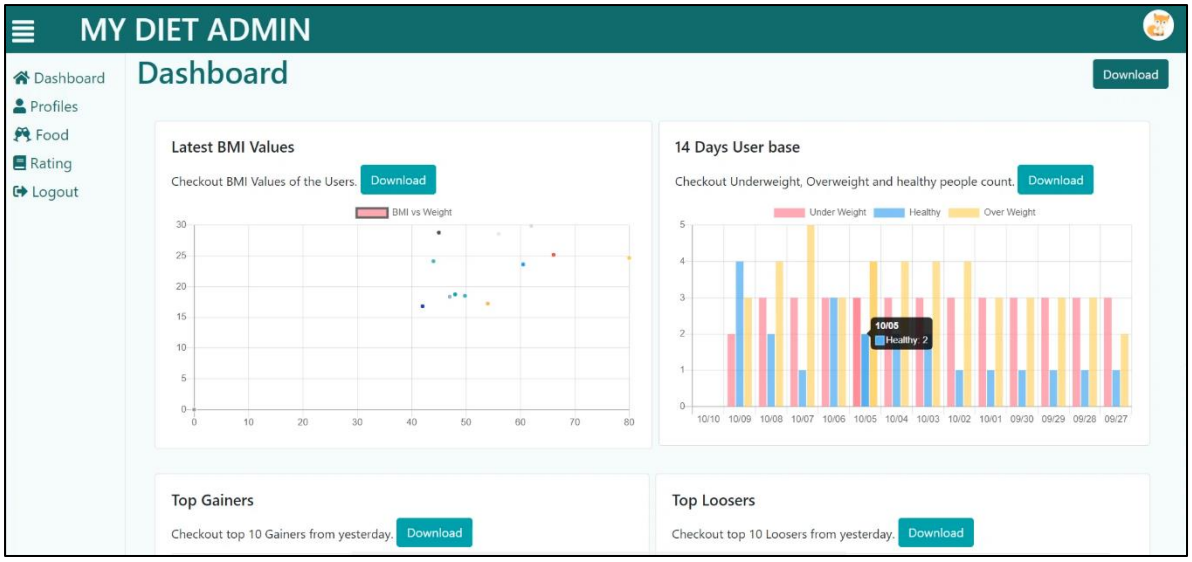


Figure 4. 15 The analytics dashboard home page

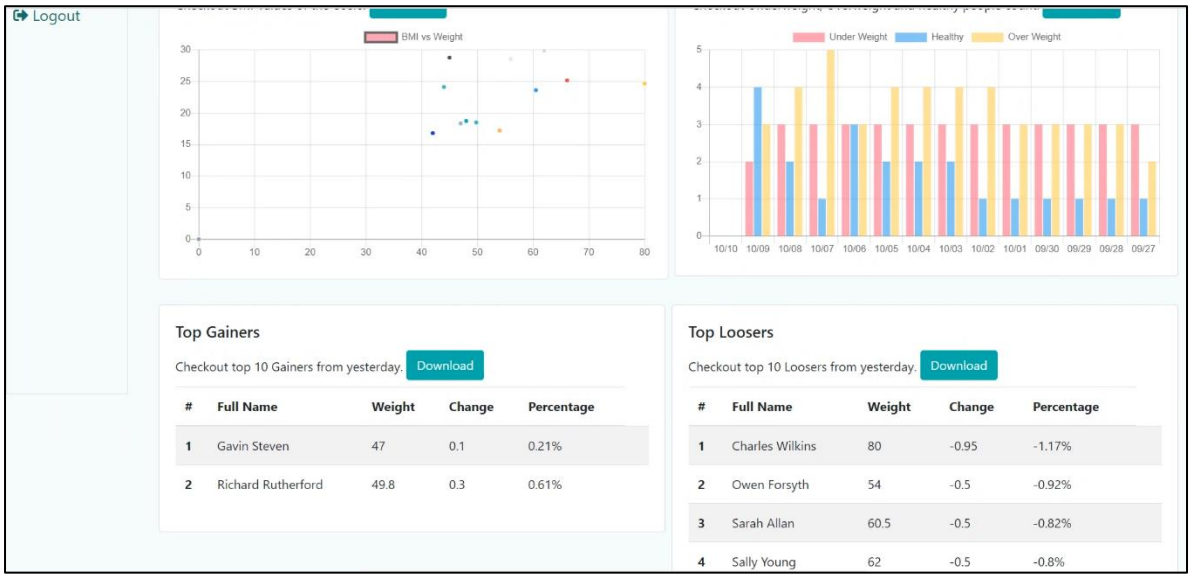


Figure 4. 16 The top gainer and top looser data tables

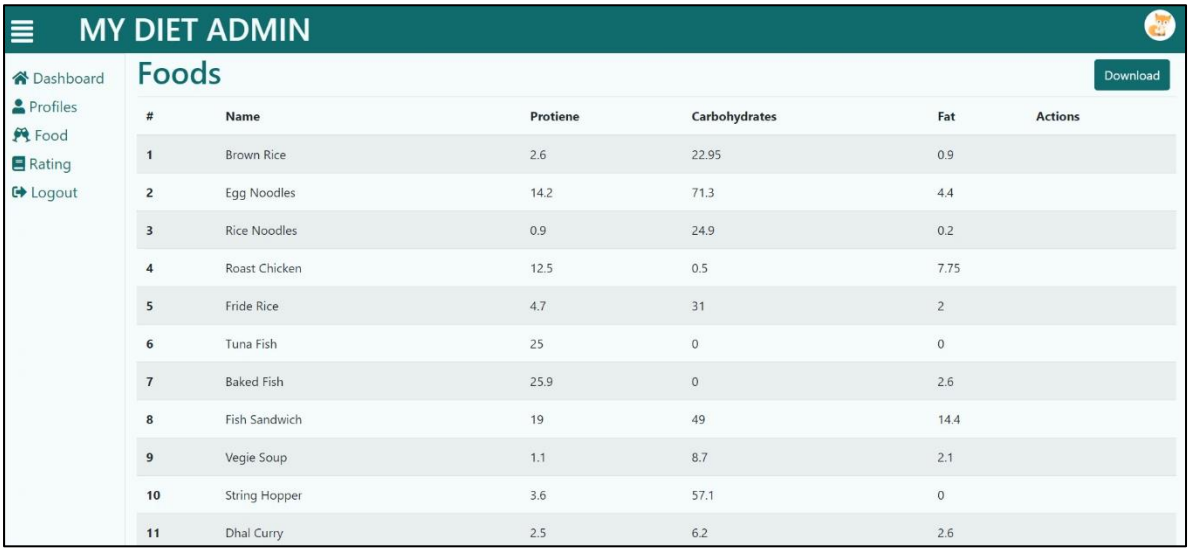


Figure 4. 17 The food database record information

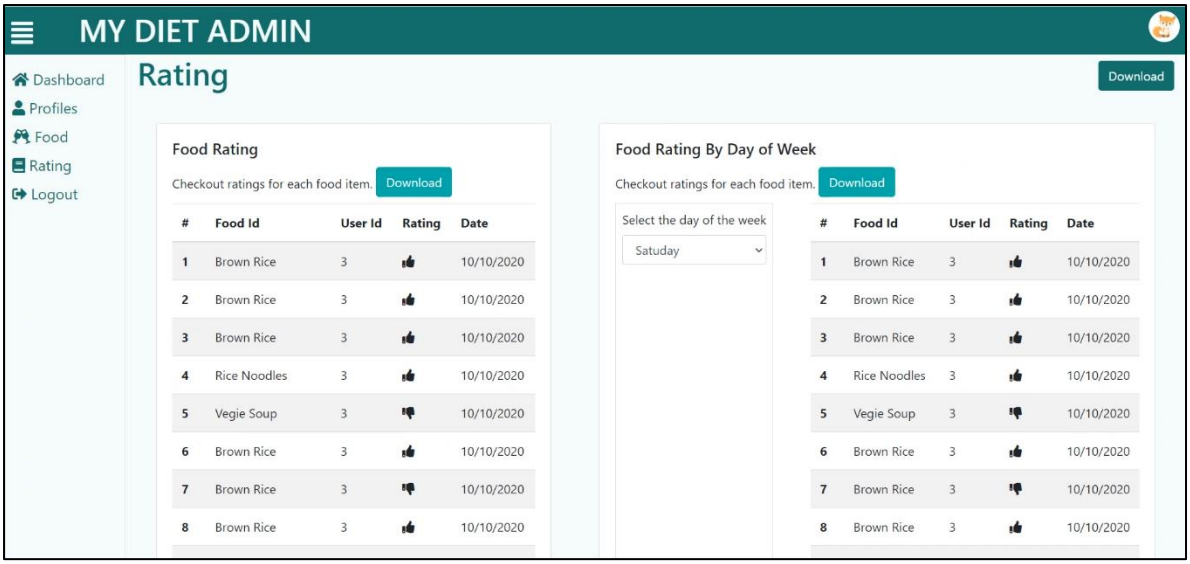


Figure 4. 18 The statics of food preferences related to the different users

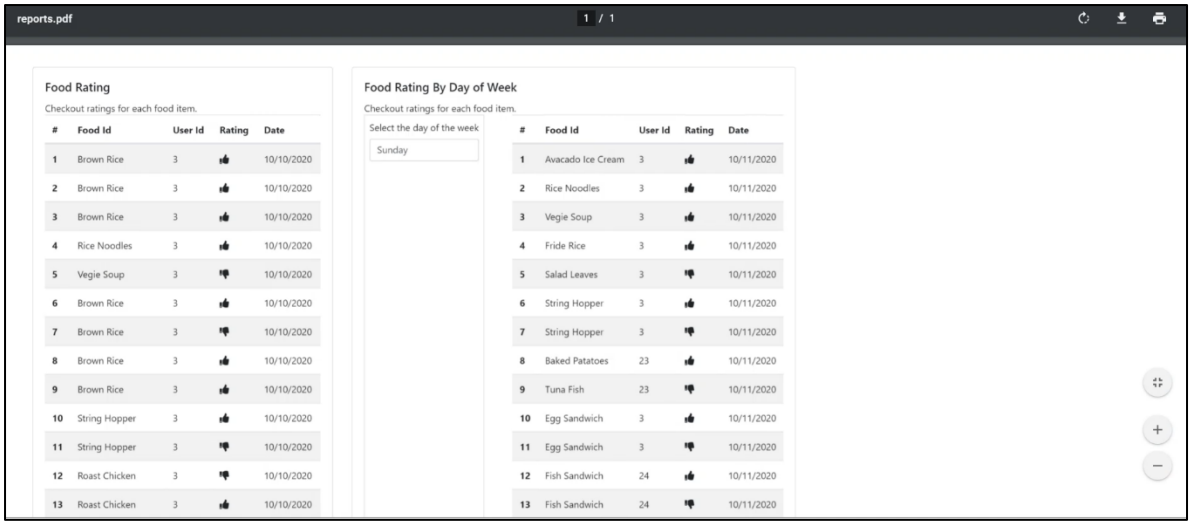


Figure 4. 19 The downloaded food rating report pdf view

4.3. Tools

The development, testing and deployment environments were set up using below tools and software.

Tool / Software	**Purpose**
VS Code	Back-end (web API) development
Android Studio 3.4.2	front-end (mobile) application development
Microsoft SQL Servers	For the data storage
Azure + Microservices	Cloud hosting the back-end services and data storage

Smartphone with android operating system (version 4.4 or upper)	Installing the diet application
GitHub	Source repository
Google Forms	To prepare evaluation questionnaires and collect the user responses.

Table 4. 2 Tools with the purpose

4.4. System Deployment Configuration

Basically, three components need to be deployed to make functioning the full system. The android mobile application, RESTful web API and web-based data analytics dashboard are the three main system components. The microservice oriented architecture is used to host the back-end web API in Azure environment. Figure 4.3 is shown the system hosting overview in Azure environment.

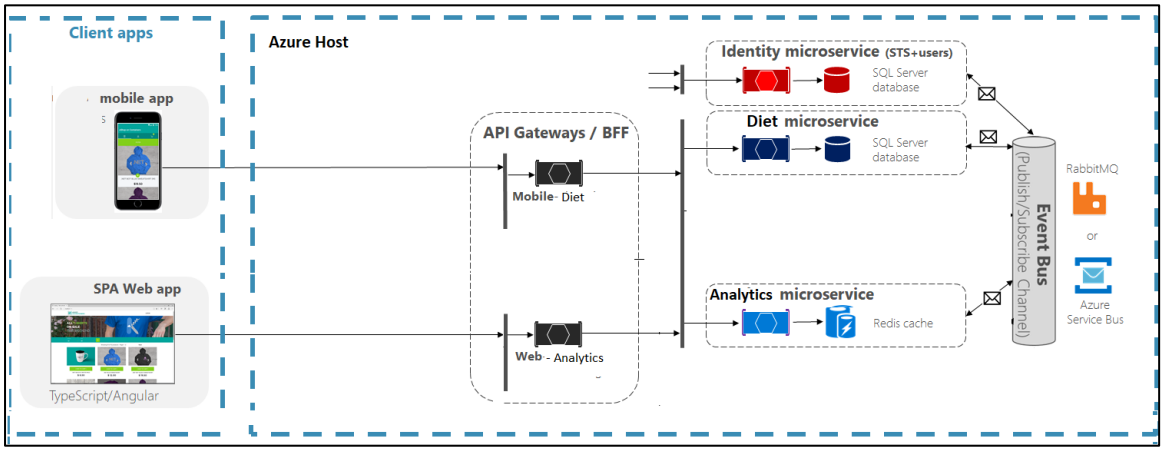


Figure 4. 20 Hosting environment overview

Diet mobile application should be able to deploy in an android mobile device with 4.4 version or upper. Steps for the mobile application deployment are listed below.

- Configure the android device using developer option settings
- Install the USB driver for windows
- Connect the device from android studio by selecting deployment target as the android device
- Deploy the application using ADB or directly install the APK file of the application into a mobile device.

4.5. Summary

This is given the detailed overview of the application implementation process. All the system development technologies and tools were explained clearly with the purpose for the usage.

5. EVALUATION AND TESTING

5.1. Introduction

This chapter is presented as the critical system evaluation process and system testing procedure. Further, this will explain the level of achieving system objectives with justifications. The way conducted the system testing to achieve best quality is also expected to be presented in this chapter.

5.2. System Testing Procedure

In software development, testing is very important. Certain coding mistakes, issues were resolved while testing the application. The two testing cycles were conducted throughout the system development cycle. Initially, the developer test case document was prepared based on application features and functionalities. Once completed the set of functionality development, manual testing was performed based on a prepared test case document. This manual testing process was divided into two sections as user interface testing and functional testing. Additionally, unit testing and API testing were included to test the front-end, back-end functionalities. Bug fixing round was initiated once completed the first cycle for all types of testing. Then the second testing cycle was conducted as a regression testing cycle to verify the fixed issues and to check for any other new issues. The manual test case document and test summary table is displayed in below figure 5.1.

Test Case ID	Category	Severity	Priority	Feature Description	Test Description	Expected Result	Status (Pass/Fail) Cycle 1	Status (Pass/Fail) Cycle 2	Defect Id
TC_C1_01	Functional	High	High	Registration	Enter valid email and new password and click create new account button	The user should direct to login screen after sucessful registration	Pass	Pass	N/A
TC_C1_02	Functional	High	High	Login	Enter registered email and password and click login	The user should be able to login to the system	Fail	Pass	DEF_C1_02
TC_C1_03	Functional	High	High	Update profile	Upadate health profile and submit latest details	The health profile should be saved with latest details	Pass	Pass	N/A
TC_C1_04	Functional	High	High	Create diet plan	Enter targert weight and select duration, click add button	The new diet plan should be displayed in the diet plan list	Pass	Pass	N/A
TC_C1_05	Functional	High	High	View diet menu	Click on one diet plan	The diet menu should display	Fail	Pass	DEF_C1_02
TC_C1_06	Functional	High	High	Customize diet menu	Click on customize button in diet menu, select new food item and click update button	The user should able to select new food item from given food list	Pass	Pass	N/A
TC_C1_07	Functional	High	High	View the progress	Click on "My Progress" button on the home screen	The progress chart should display	Pass	Pass	N/A
TC_C1_08	UI	High	High	View health profile	Click on "My Health Profile" button on the home screen	The user should direct to profile screen and it should display with saved details	Pass	Pass	N/A

Test Cases Summary		Progress in %
Total Number of Test Cases	8	
Number of Test Cases Passed	6	100%
Number of Test Cases Failed	2	100%
Number of Test Cases Not Applicable	0	

Figure 5. 1 The test case document with execution summary

Furthermore, the Espresso android test automation framework is used along with Junit to write unit test methods while developing different application functionalities. This framework has provided a set of predefined functions to write reliable test methods to simulate user interactions with the diet application.

5.3. Target Participants and Evaluation Criteria

There were two main categories in participants for the full system evaluation based on two different evaluation criteria as shown below table 5.1.

Target participants	**Evaluation criteria**
Patients – divided into two groups as 50 participants for initial evaluation and filtered out only 20 for final evaluation	Application usability, learnability
Dieticians/Nutritionists – 2 participants	Analysis the results to evaluate the accuracy

Table 5. 1 Target participants and evaluation criteria

5.4. Diet Application Usability Evaluation Process

The aim of this evaluation was to identify the user satisfaction level with the diet planning application and limitations of the system. Below are the methods and steps conducted for the system evaluation.

1. Full system evaluation model had two questionnaires called primary and secondary.
2. The visibility of some questions depends on the participant's answer for another question in both questionnaires.
3. When the project development started, the primary questionnaire (which can be found in Appendix B of this report) was prepared and distributed to 50 participants to check the user's interest for a diet application and health conditions of participants.
4. Analysed the participants responses and derived that most of the elder participants have different types of diseases. It was clear that there was a risk of taking those elder participants for the final system evaluation. Therefore, twenty participants

are selected randomly based on below conditions derived from primary questionnaire feedback.

- Age range between 18-35 and currently not having known disease(s) as shown in figure 5.1.
- Excluded pregnant participants.
- Selected more participants who have diet improvement goals in future and few participants who have not such a goal as shown in below figure 5.2.
- Selected more participants who would like to achieve their goal via diet application and less participants who would not like to use diet application as shown in below figure 5.3.

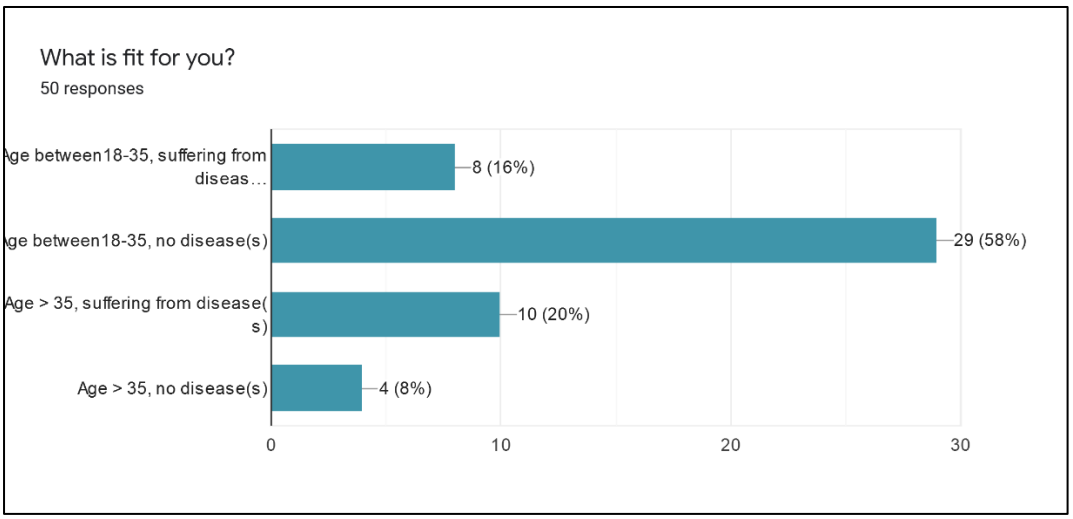


Figure 5. 2 Age ranges and health condition of participants (N=50)

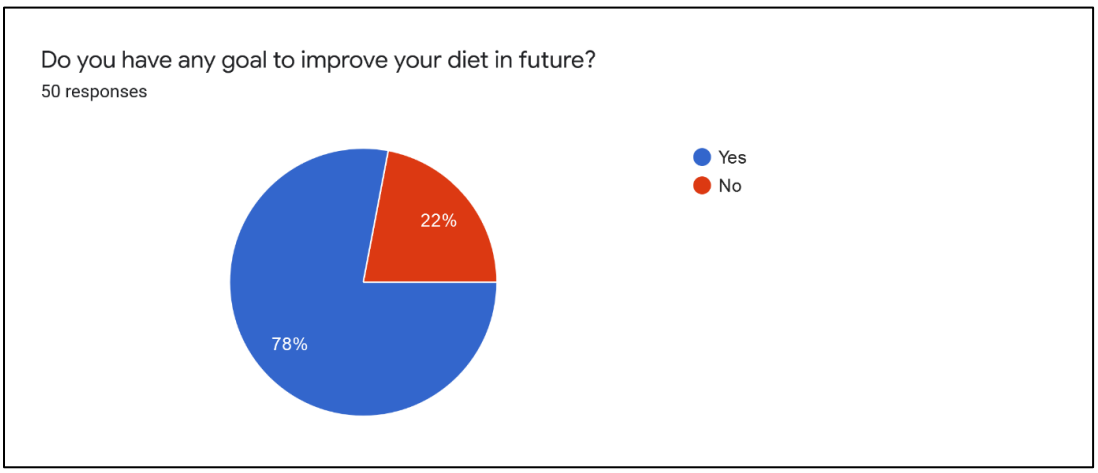


Figure 5. 3 Goal to improve diet in future (N=50)

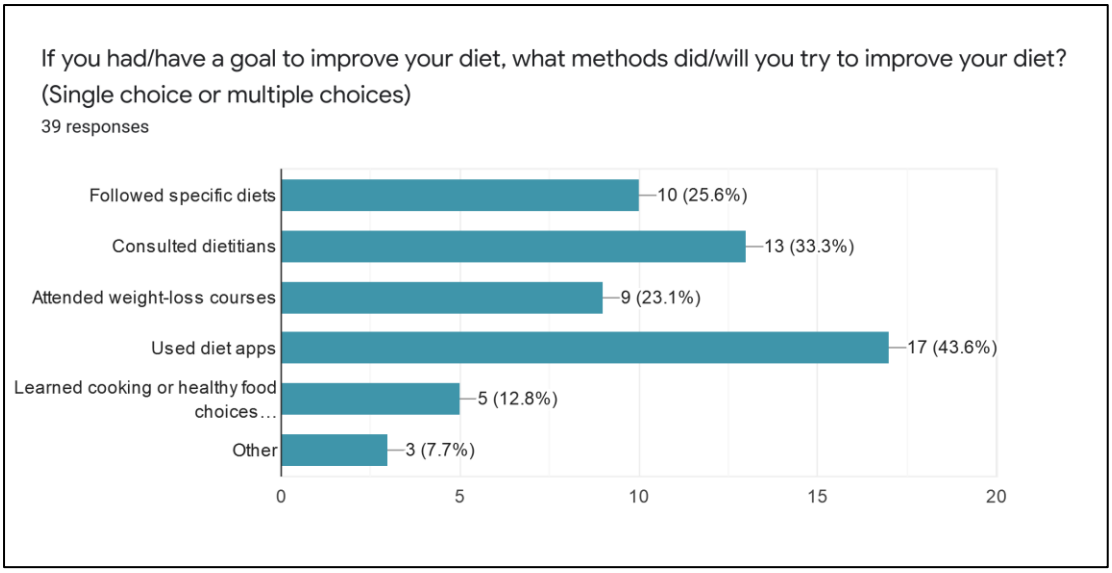


Figure 5. 4 Participants interest in different methods to improve diet (N=50)

5. 20 participants were filtered out based on early mentioned criteria.
6. Secondary questionnaire (which is found in Appendix B of this report) was prepared to evaluate the usability and limitations of the dietician application by targeting selected 20 participants.
7. Participants were instructed to install the "My Diet" application.
8. Participants were given freedom to use the application minimum one month of period.
9. Distributed the secondary questionnaire with the participants and collected the feedback.
10. Analysed the feedback responses and identified the usability level and limitations of the application based on analyse results.

As explained in above steps system evaluation is conducted and summary of evaluation analyses is represented as shown below table 5.2. The graphical representation of the same evaluation result is included in Appendix B section of this report.

Variable		%
Gender	Male	40
	Female	60
BMI	Underweight = <18.5	5
	Normal = 18.5–24.9	55
	Overweight = 25–29.9	30

	Obesity = 30 or greater	10
Employment situation	Employed for wages	30
	Self-employed	15
	Jobless	-
	Staying at home	5
	A student	50
	In the military	-
	Unable to work	-
Food and health concerns	High concern	50
	Low concern	50
Education level	Primary	-
	Secondary	-
	College/University	60
	Graduate/Professional (i.e. Master's/PhD)	40
Marital status	Not married	30
	Married	70

Table 5. 2 Personal attributes of secondary questionnaire participants (N = 20)

Based on the above evaluation analyses below are the conclusions that can be listed.

- 5% of participants are in the underweight category and 55% of participants are in the normal category. Together overweight and obesity categories are having 40% of participants.
- 55% of normal participants are having high possibility of coming into the overweight category in near future with less concern and inefficient food intake.
- Furthermore, 40% of overweight participants also have a high risk going for the obesity category.
- Finally, diet application usage is very important for such a community to maintain better health conditions and improve their diet.

Based on detailed analysis of diet application usability evaluation, it was clear that there were 60% of participants who claimed that they used the application during last month and still they are using it, 10% participants have used the application during last month

and not currently using, 20% participants have not used and expecting to use in near future and finally 10% participants have claimed they will not use the application due to limited features and lack of interest in using diet application. It is clearly shown in below figure 5.4 and 5.5 respectively.

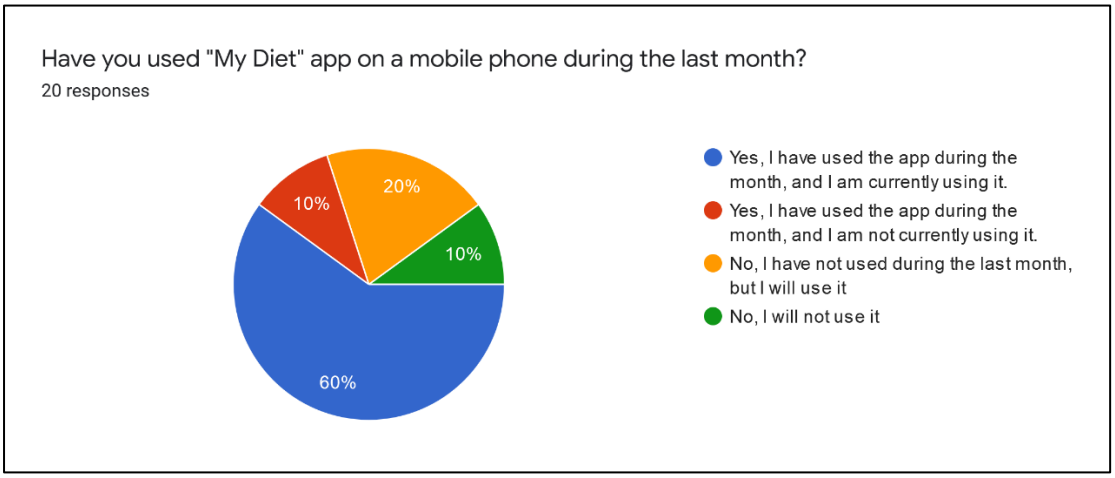


Figure 5. 5 Diet application usage of target participants (N=20)

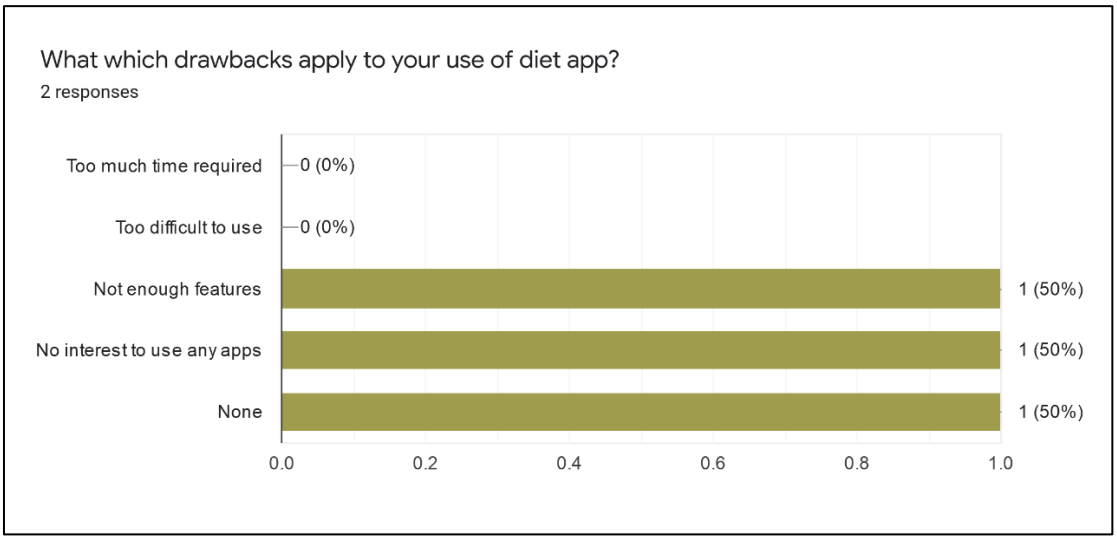


Figure 5. 6 Reasons of the participants who have not used the diet application (N=2)

Rest of the feedback summary for the secondary questionnaire can be concluded as in below table 5.3, table 5.4 and graphical representation of set of data is included in Appendix B of this thesis report.

Opinions	Disagree strongly	Disagree slightly	Agree slightly	Agree strongly
It is easy for me to understand how the diet app works.	-	-	14.3%	87.7%
It is time consuming for me to use the diet app	71.4%	28.6%	-	-
It is easy for me to get information from the diet app.	-	-	35.7%	64.3%
It is boring to use the diet app.	50%	35.7%	14.3%	
It is easy for me to reach my target diet plan by using the diet app.	-	-	28.6%	71.4%
I think it is easy to obtain food information from the diet app.	-	-	21.4%	78.6%
I need to pay attention to my diet, because my family has disease history, (e.g., cardiovascular disease or cancer).	7.1%	14.3%	35.7%	42.9%
I want to have diet competitions with friends or family members.	71.4%	7.1%	-	21.4%
I want to share my diet on social networks.	50%	35.7%	-	14.3%

Table 5. 3 Participants disagreement and agreement for given opinions (N=14)

Opinions	Very effective	Somewhat effective	Slightly effective	Not effective
This diet app has been assisting my diet to eat more low-fat dairy alternatives.	85.7%	7.1%	7.1%	-
This diet app has been assisting my diet to eat more fruit and vegetables.	92.9%	7.1%	-	-
This diet app has been assisting my diet to eat less sausages.	78.6%	21.4%	-	-
This diet app has been assisting my diet to drink less sweetened beverages.	71.4%	28.6%	-	-
This diet app has been assisting my diet to eat less fast food, which is typically high in salt and saturated fat.	92.9%	7.1%	-	-
This diet app has been assisting my diet to choose more healthy food.	50%	28.6%	21.4%	-

This diet app has been assisting my diet to achieve weight goal.	78.6%	14.3%	7.1%	-
Using the app is …. to reach my weight goal, compared specific diets.	28.6%	57.1%	14.3%	-
Using the app is …. to reach my weight goal, compared to weight-loss courses.	100%	-	-	-
Using the app is …. to reach my weight goal, compared to learning cooking or healthy food choices from TV, books, or the Internet.	78.6%	14.3%	7.1%	-
Using the app is …. to reach my weight goal, compared to consulting dietitians.	64.3%	28.6%	7.1%	

Table 5. 4 Diet application effectiveness based on feedback for given opinions (N=14)

The benefits and limitations of the diet application can be clearly identified based on above evaluation results. Based on the above feedback summary 87.7% of participants agreed with the application is an easily understandable opinion. It derived that diet application is easily understandable due to its simplicity. Therefore, it will not take much time for users to become familiar with the application functionalities. That's why 71.4% of participants strongly disagree with the application time consuming opinion. Furthermore, 64.3% of participants were strongly agreeing with the opinion of easy information access from the application. Unfortunately, it can be seen 14.3% of participants were slightly agreeing and 35.7% slightly disagreeing with the application is a boring opinion. Only 50% of participants were strongly disagreeing with this opinion. It means there is a limitation in this application related to the application attractiveness. It is a very important point that should be addressed by improving the user interface attractiveness of the application. More than half of the participants 78.6% pay attention to improve their diet not because they wanted to share diet on social networks, but bad health condition experiences of their families. 71.4% of the participants were able to easily reach their target diet plan by using the diet application. It can be clearly seen on both above table 5.3 results and below figure 5.6 graphical representation.

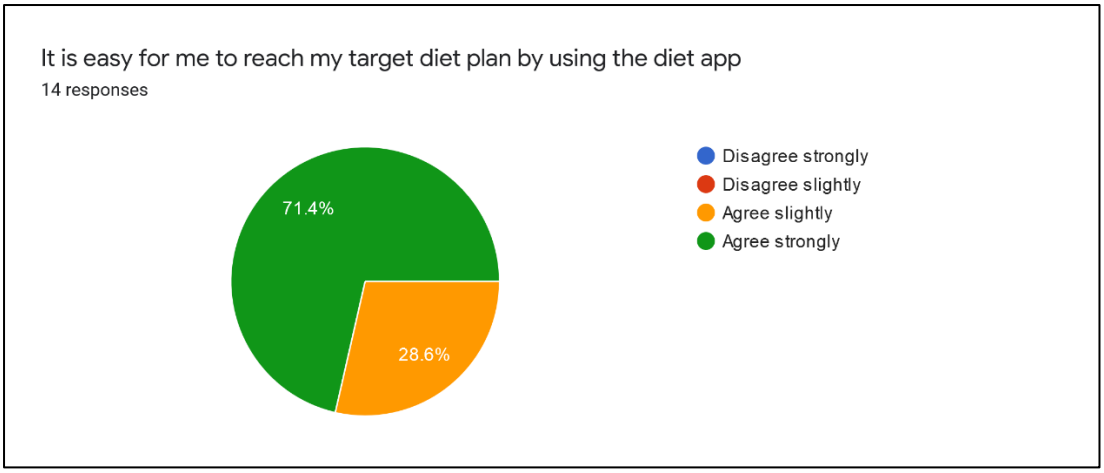


Figure 5. 7 Reach to target diet plan by using the diet application (N=14)

All the participants claimed that using the diet application is more effective to reach their weight goal, compared to weight-loss courses. Only 64.3% of participants said that using the diet application is more effective to reach their weight goal, compared to consulting dieticians. It means that participants would like to connect with dieticians while they are using such a diet application. Therefore, it would be great, if there will be a possibility to link dieticians with the diet application as a future enhancement. As explained, a set of benefits and limitations of the diet application were identified based on the secondary questionnaire feedback. Finally, the participants suggested some future enhancements for the current application as shown in below figure 5.7.

AB
What would the biggest improvement(s) be that you would like to see in "My Diet" app?
Improve the user interface appearance
Add more food item variations
Add more features like physical activity tracking
Add more healthy foods
nice to have way to connect with real dieticians
improve the appearance of screens
This is simple and good
make interface more attractive
provide way to share progress in social media
add attractive food images to this app
need to connect with dieticians as well
add health tips
This app is easy to understand, i like this app
provide this app support for other mobile platforms

Figure 5. 8 Participant's responses for the diet application improvements (N=14)

5.5. Analysis of Results

The results of the system were analysed based on data available in the data analytics dashboard. Selected two dieticians have participated for this evaluation and a separate questionnaire was shared with them. Due to the current situation of the country, it would be difficult to meet dieticians directly. Therefore, the data analytics dashboard was demonstrated to the selected two dieticians via Zoom conference call and asked them to give their feedback for the given questionnaire which is included in Appendix B section of this report. A data analytics dashboard is very important in nutrition analysis and those dieticians have agreed that given dashboard can support in their day today treatments. It can clearly be seen in below figure 5.8 and 5.9 responses.

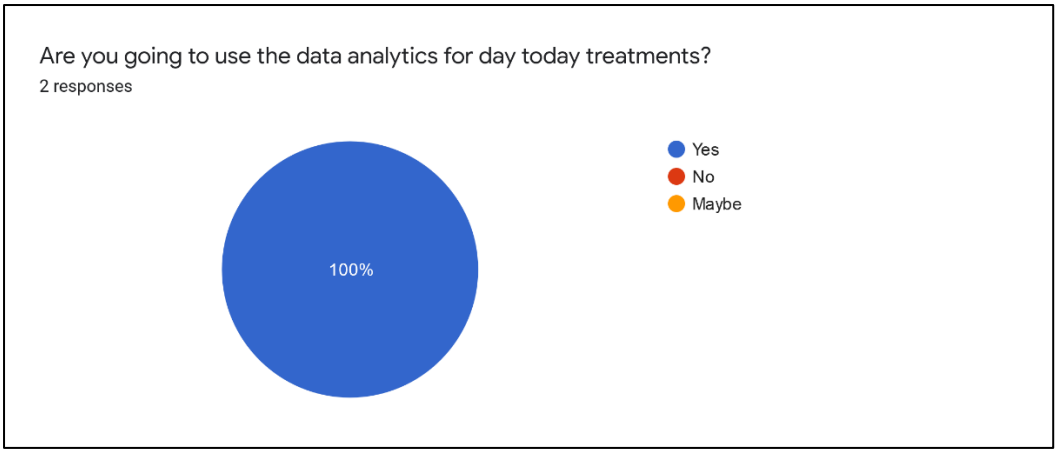


Figure 5. 9 Use case for an analytics dashboard (N=2)

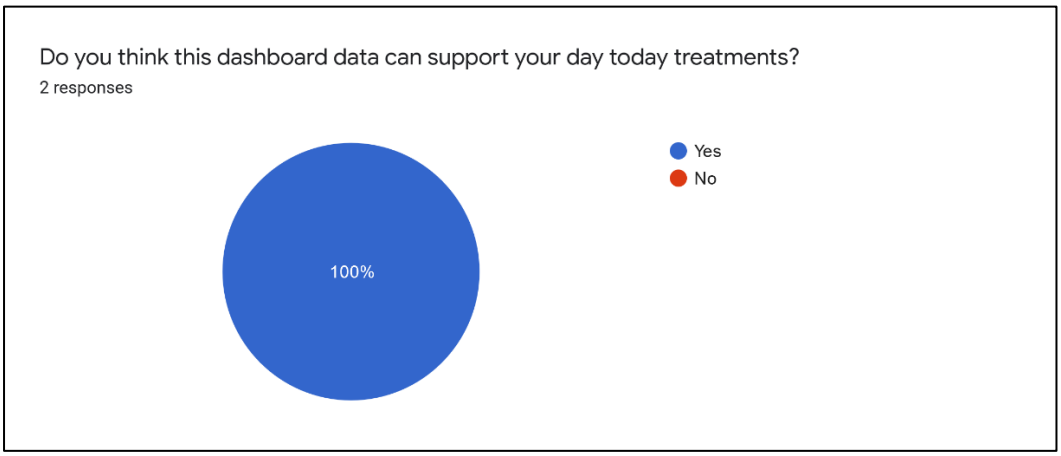


Figure 5. 10 Dashboard support for dieticians (N=2)

The nutrition analysis, collecting data and simplifying consultation by providing visuals for better understanding are the main purposes of using such a data analytics dashboard. It was clearly mentioned in the feedback of dieticians as shown in below 5.10 figure.

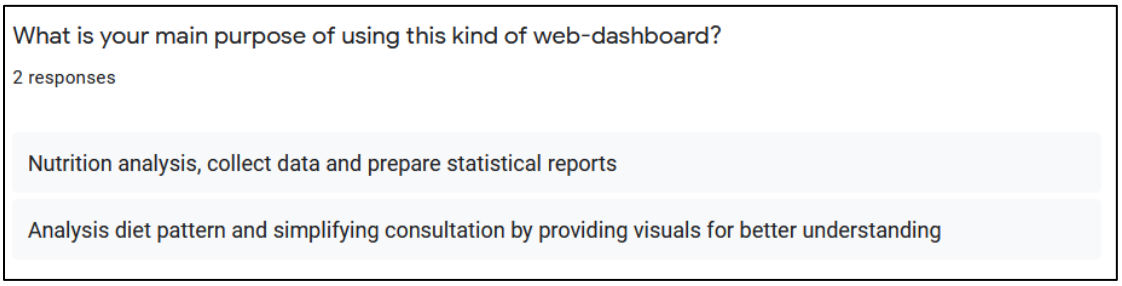


Figure 5. 11 Main purpose of using the data analytics dashboard

There were few data improvements suggested by the selected two dieticians as shown below 5.11 figure.

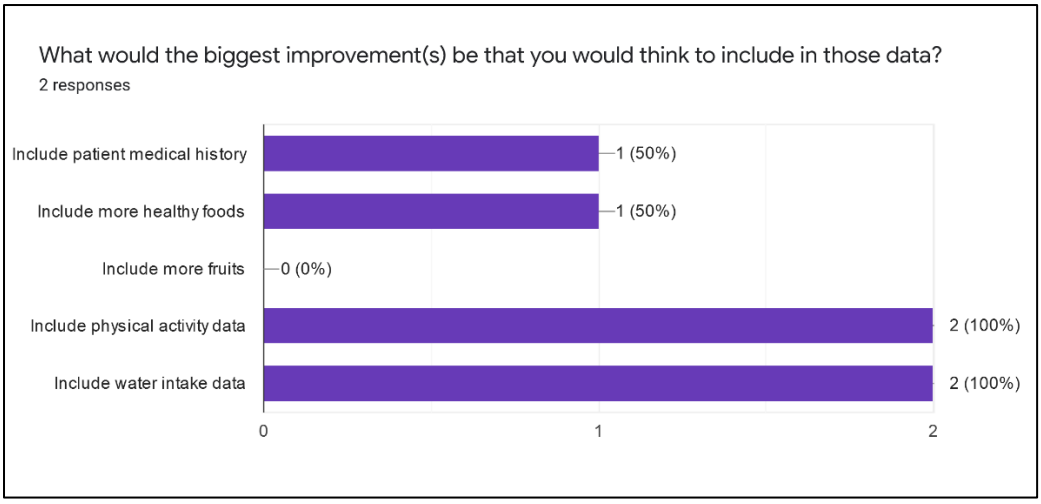


Figure 5. 12 Data improvements for current dashboard

Currently the system is identified as the best diet menu concerning a limited range of patient's diseases. The patient's medical history is a key factor to assign a proper diet menu for a patient who suffers from diseases. Furthermore, current diet application is not concerned with physical activity and water intake of users. Therefore, the current system needs to be improved by addressing those limitations considering the feedback of dieticians. The selected dieticians would like to have integrated patient management features in given web-dashboard additionally to the data visualization as represented in below figure 5.12 responses. Finally, both dieticians recommended the diet application for users with more improvements as they highlighted in their feedback. It is represented in below figure 5.13. The remaining feedback representations of the dieticians are included in Appendix B section of this report.

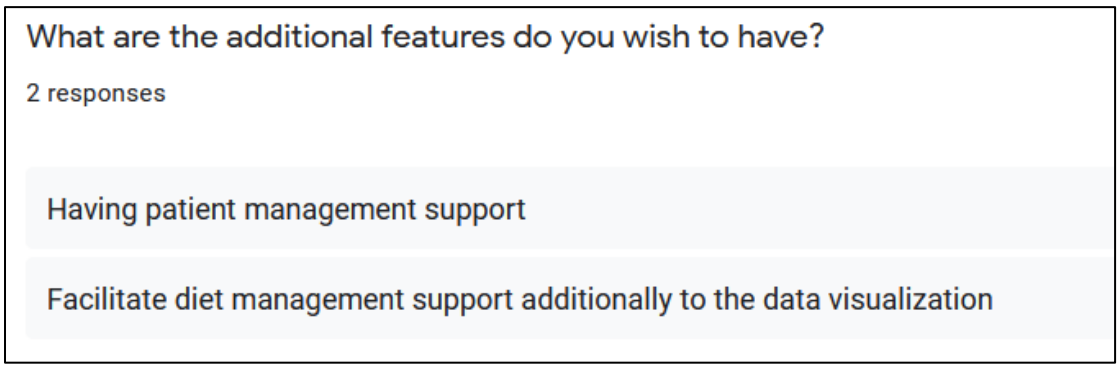


Figure 5. 13 Additional features for dieticians

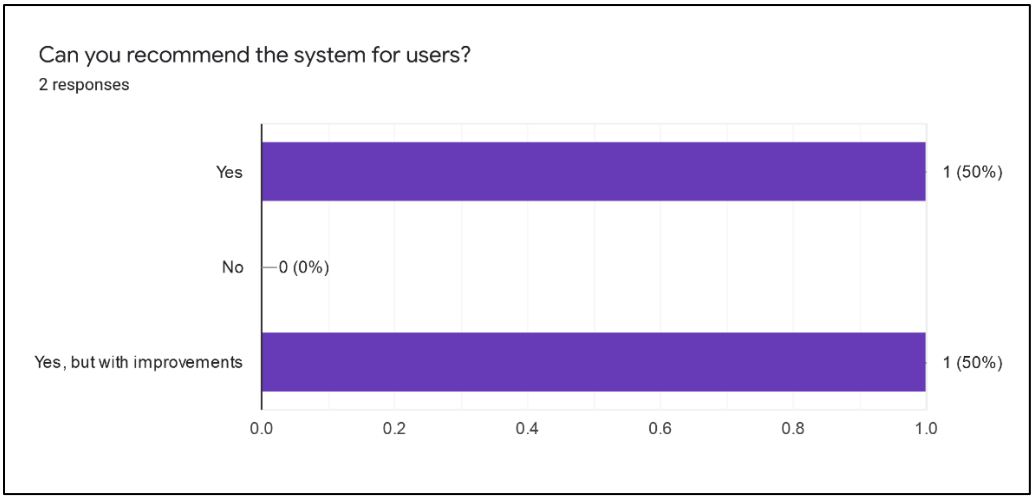


Figure 5. 14 The system recommendation of the dieticians

5.6. Questionnaire Development Process

There were three questionnaires in the full system evaluation process. All those questionnaires development process is as listed below.

1. Collecting usability questionnaire statements from existing usability questionnaires on mobile health app.
2. Creating a draft of the dietician app usability questionnaire & assessing each statement's relevance and clarity.
3. Conducting further refinement on the draft questionnaire.
4. Performing usability studies and psychometric analysis.

5.7. Lessons Learnt

This project was given the opportunity to apply all learnt theories and concepts together. Most of the time a project is delivered by a working set of professionals together in the company. Therefore, people are specializing in one area and not getting a chance to improve new skills, and no chance to touch different responsibilities. The biggest chance doing this master project came with completing a project from beginning to end as an individual. Therefore, significant benefit was the gained experiences in each area of the software development process. Also, each role in the software development process team which has fallen from identifying the problem to implementing a working solution was represented during this project. Therefore, it is given a chance to play each role in the software development process. Furthermore, it has improved many skills such as making

decisions, meeting deadlines, and taking full responsibility in developing the application. Additionally, proper time management and planning were very important aspects learned during this project.

5.8. Summary

The system evaluation and testing are very important stages in any software application development. Final solution quality is decided based on the result derived from those stages. Therefore, this project was considered evaluation, testing as key areas of the system. Based on this evaluation and testing process explained in this chapter, the final system achieved its objectives and met the expectations.

6. CONCLUSION

6.1. Introduction

This final chapter presents the summary of the project result. Additionally, this will highlight system improvements.

6.2. Summary

Today, most people are concerned about their health and search ways to help them be healthier. The diet planning mobile application can assist them to find a proper diet menu and check their diet plan progress. The rule-based approach in diet planning captures nutrition knowledge from the dieticians, and suitable websites and then places in if-else format to build the solution. Finally, the diet application presents the user with a diet menu which includes healthy food items based on the user's health profile and target diet plan. Therefore, the users do not want to go for real dieticians every time and they can use this diet application to find their diet menu. It will save money, time, and healthy life. The application had been evaluated by selected potential users and analysed the results to find out benefits and limitations. The future enhancements are identified based on the system evaluation feedback analysis and 78.6% of participants were agreeing that they would be able to reach the target weight goal using the application provided diet menu. Furthermore, the web-based data analytics dashboard has been verified by the experts and they have claimed that it will be a value addition for a dietician to make their daily job easy with future enhancements.

6.3. Future Enhancements

Based on the results in evaluation and testing phases, below are the system improvements which can be included in this application.

- Facilitate users to connect with real dieticians through the diet application for diet menu customization and getting advice.
- Use a data analytics dashboard for diet menu pattern recognition, build prediction model and enhance user experience through prediction model.
- Use artificial intelligence, machine learning concepts to improve the recommended diet menu.

- Add more features such as physical activity tracking, health bogs, virtual assistant, water consumption tracking etc.
- Modify the data analytics dashboard with additional features based on requirements from dieticians or nutritionists.

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APPENDIX A – DESIGN DOCUMENTATION

1. Use-case Descriptions and Diagrams

System Registration

Use-case	Register
Actors	Mobile User
Overview	
A user create account to login with the system	
Pre-conditions	
The user should have a smartphone with the diet application installed.	
The user should have internet access on mobile phone	
Flow of events	
1. If user is new user, requests to registers himself with the system	
2. The user enters their username as mobile number, password and confirm password and submit the register form.	
3. System differentiates between different users, and accordingly saves them in the system database and registration is successful.	
Post condition	
The user is successfully registered with the system	

Table A. 1 Use-case description for system registration module

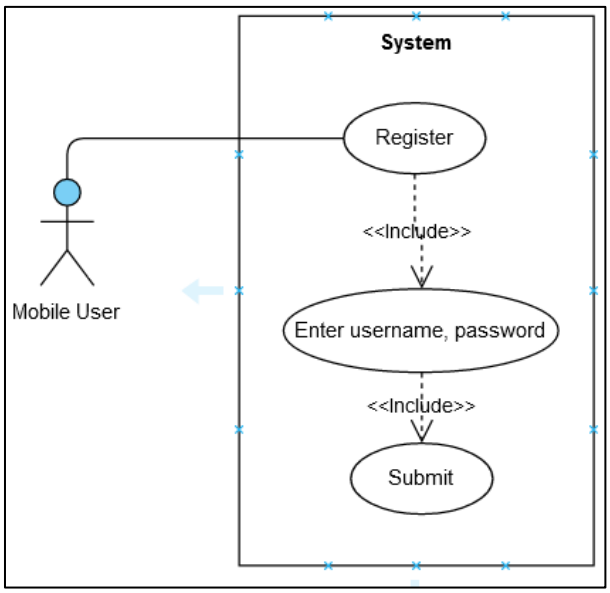

Figure A. 1 Use-case diagram for register module

User Login

Use-case	Login
Actors	Mobile User
Overview	
A user login with the system	
Pre-conditions	
The mobile user should register with the system.	
The mobile should have internet access on the mobile phone.	
The mobile user should have username, password used in system registration.	
Flow of events	
1. The user enters their username as mobile number, password and click login button.	
2. The system validates the given credentials.	
3. If credentials are valid, then allow the user to login to the system. If credentials are invalid, a validation message will be shown.	
Post condition	
The user is successfully logged in with the system and directed to the home screen OR user received an incorrect credentials validation message.	

Table A. 2 Use-case description for login module

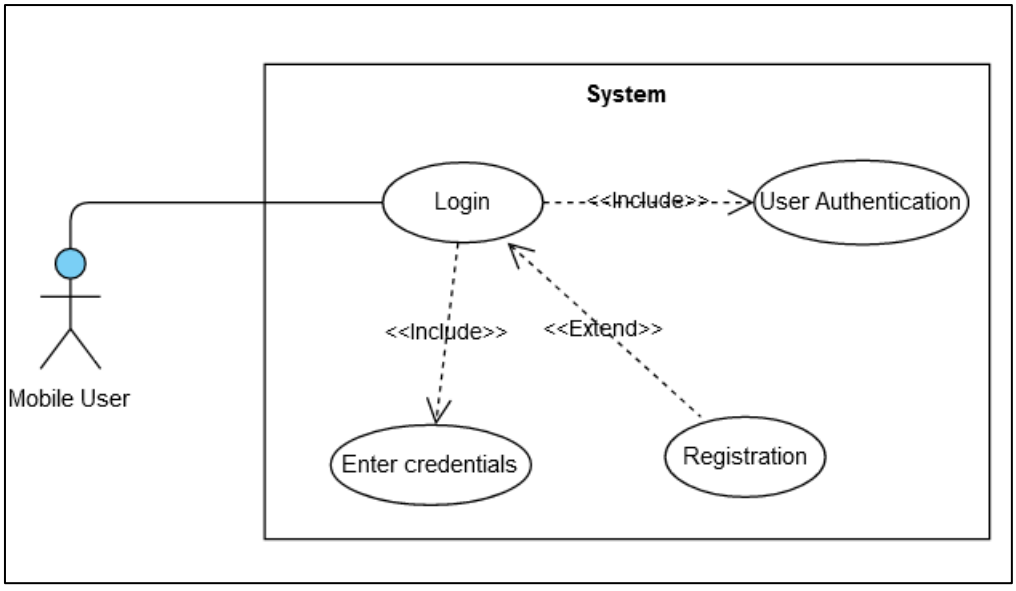

Figure A. 2 Use-case diagram for login module

Updating Health Profile

Use-case	Update health profile
Actors	Mobile User
Overview	
The user can update their own health profile.	
Pre-conditions	
The user should login with the system.	
The user should have internet access on their mobile phone.	
Flow of events	
1. The user clicks on the health profile button which is placed on the home screen.	
2. The user enters all required information such as age, weight, height, diseases etc and clicks on the update button.	
Post condition	
The system saves user information in the database, calculate BMI value of the user.	
The user is directed back to the home screen.	

Table A. 3 Use-case description for update health profile module

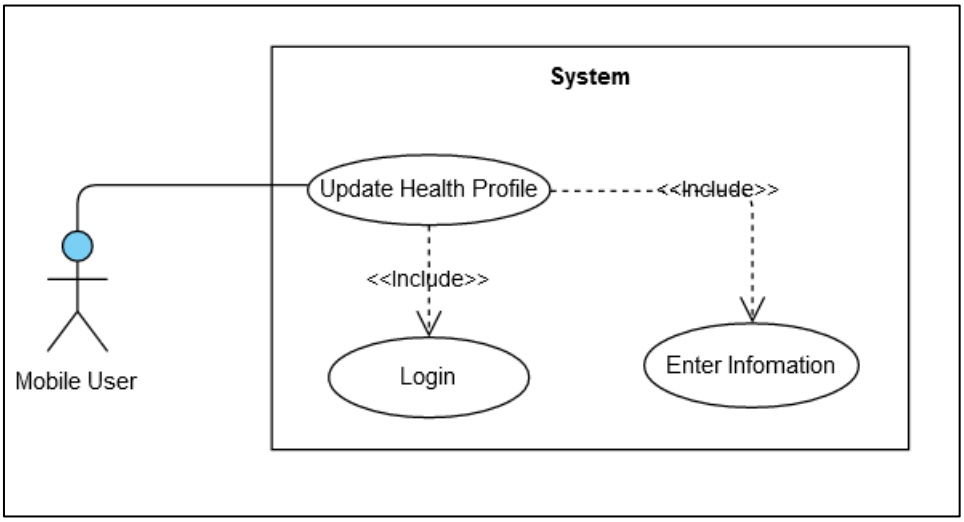

Figure A. 3 Use-case diagram for update health profile module

Creating Diet Plan

Use-case	Create diet plan
Actors	Mobile User
Overview	
The user can create one or more diet plans.	
Pre-conditions	
The user should login with the system.	
The user should have internet access on their mobile phone.	
Flow of events	
1. The user clicks on the “My Diet Plan” button which is placed on the home screen.	
2. The user clicks the “+” (plus) button on the diet plan screen.	
3. Then the user can enter plan name, target weight and plan duration.	
4. Once filled the entries, the user clicks on the “Add” button.	
Post condition	
The system saves plan details in the database, generate the diet menu for that plan.	
The user is directed to the diet plan list screen.	

Table A. 4 Use-case description for diet plan creation module

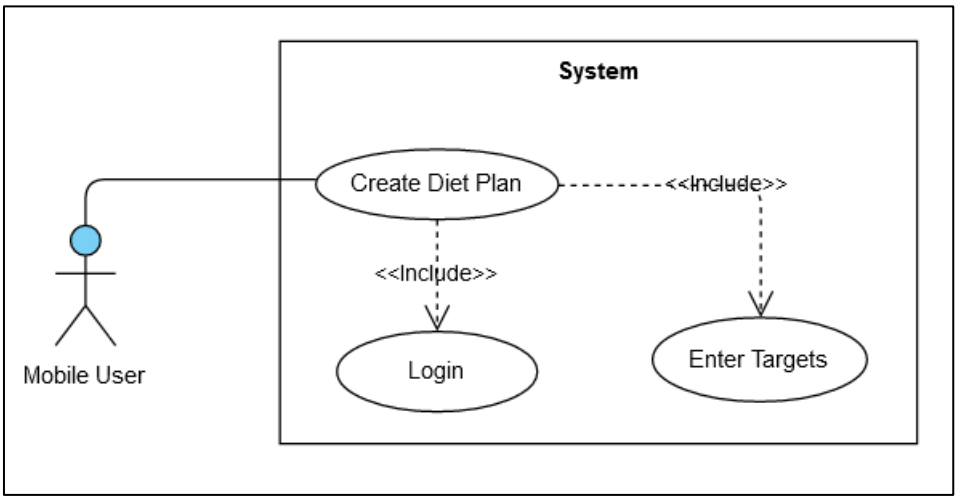

Figure A. 4 Use-case diagram for diet plan creation module

Customize Diet Menu

Use-case	Customize diet menu
Actors	Mobile User
Overview	
The user can customize the recommended diet menu.	
Pre-conditions	
The user should login with the system.	
The user should have active diet plan.	
Flow of events	
1. The user clicks on the “My Diet Plan” button which is placed on the home screen.	
2. The user clicks the active diet plan on the diet plan list screen.	
3. Then the user clicks on the customize button in any meal type (breakfast, lunch, snack or dinner).	
4. The user selects the preferred food item from the given list of foods.	
Post condition	
The system validates the changed diet menu and accepts or rejects the change with a proper message.	

Table A. 5 Use-case description for customizing diet menu module

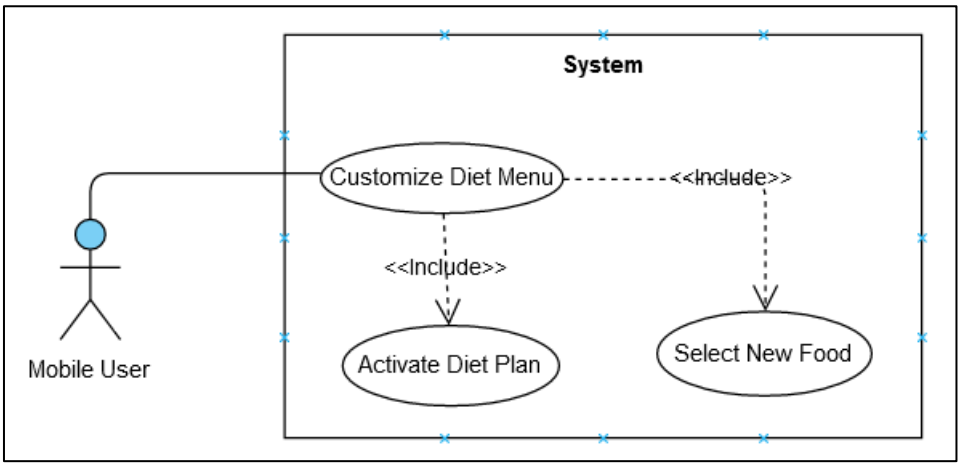

Figure A. 5 Use-case diagram for customizing diet menu module

Enter Current Weight

Use-case	Enter current weight
Actors	Mobile User
Overview	
The user can update the application from current weight daily.	
Pre-conditions	
The user should login with the system.	
The user should have an active diet plan.	
The system should send a daily push notification to the user.	
Flow of events	
1. The user clicks on the “My Current Weight” button which is placed on the home screen.	
2. The user enters their current weight and clicks on the update button.	
Post condition	
The current weight is updated in the user health profile.	
The progress chart is updated based on current weight.	

Table A. 6 Use-case description for weight updating module

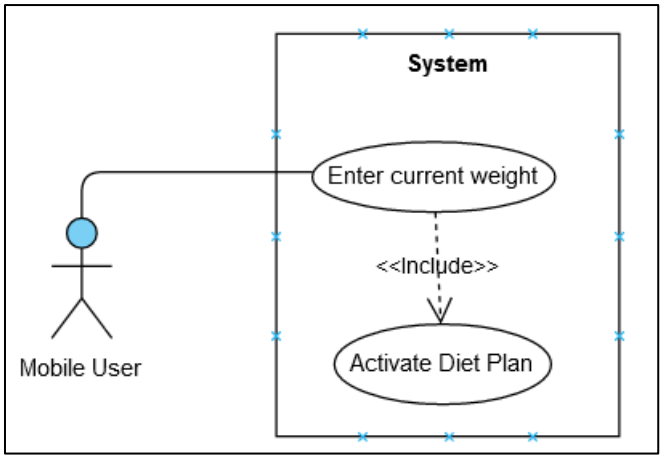

Figure A. 6 Use-case diagram for weight updating module

View Progress Chart

Use-case	View current progress
Actors	Mobile User
Overview	
The user can view current progress based on an active diet plan.	
Pre-conditions	
The user should login with the system.	
The user should have an active diet plan.	
The user should enter weight values on daily basis	
Flow of events	
1. The user clicks on the “My Progress” button which is placed on the home screen.	
2. The user views system generated progress graph.	
Post condition	
The progress chart is presented for users based on an active plan and weight values.	

Table A. 7 Use-case description for progress view module

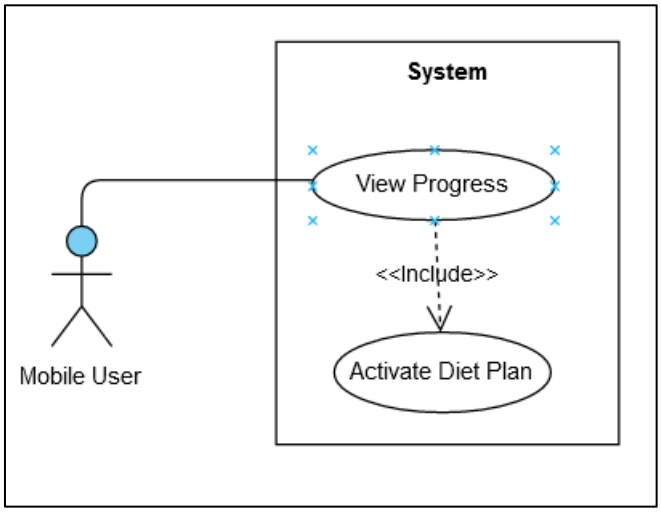

Figure A. 7 Use-case diagram for progress view module

View Data Analytics Dashboard

Use-case	View data analytics dashboard
Actors	Dietician, Nutritionists
Overview	
The dieticians or nutritionists can view graphical representation of patients' diet plan status and diet related information.	
Pre-conditions	
User should login with the web dashboard.	
Flow of events	
1. The user navigates to a web-based analytics dashboard.	
2. The user views different progress and details graphs based on system available data.	
Post condition	
The different charts are presented for the user based on active plans and system data.	

Table A. 8 Use-case description for view web-dashboard module

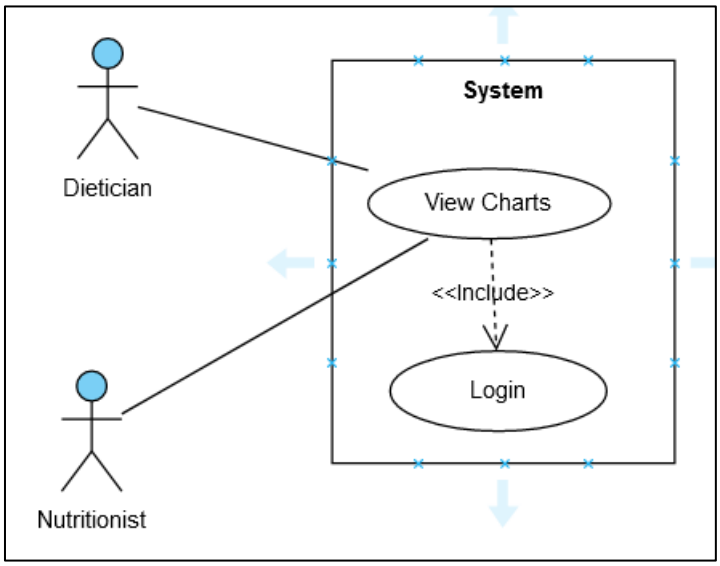

Figure A. 8 Use-case diagram for view web-dashboard module

2. System Sequence Diagrams

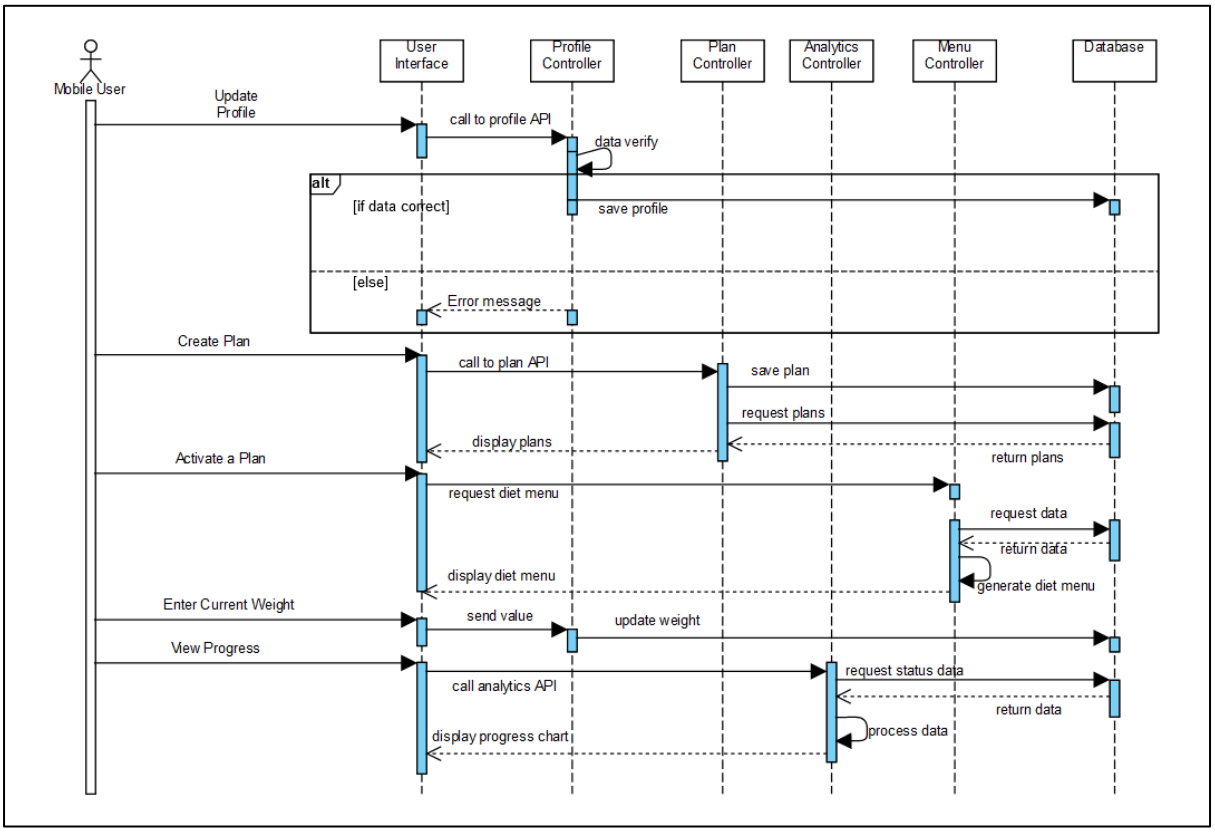

Figure A. 9 Diet application sequence diagram

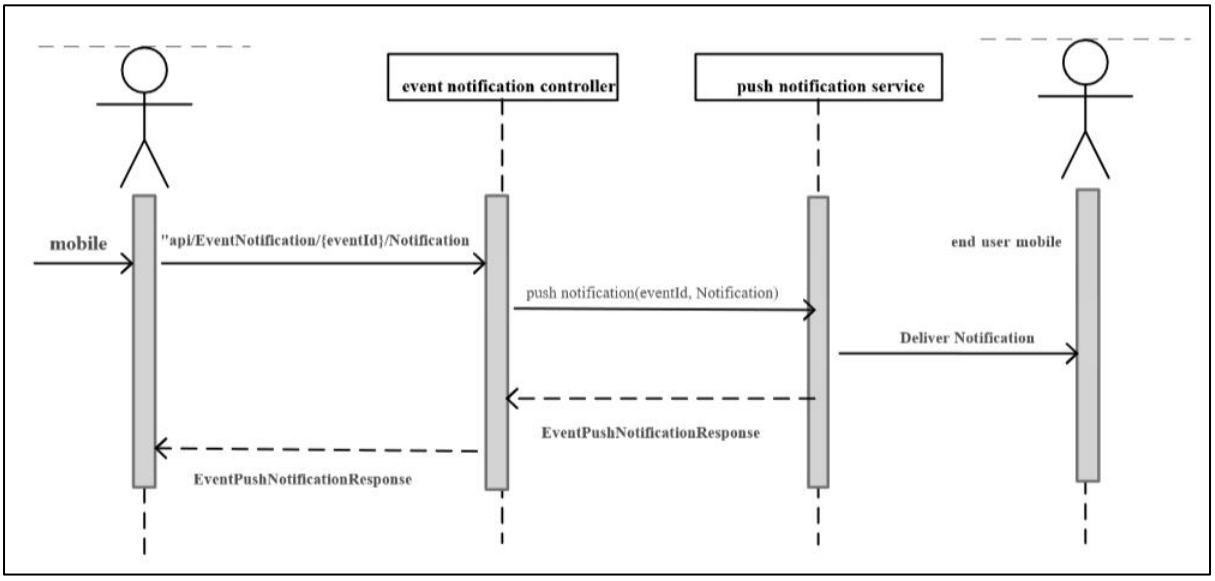

Figure A. 10 Push notification service sequence diagram

3. Application User Interface Prototypes

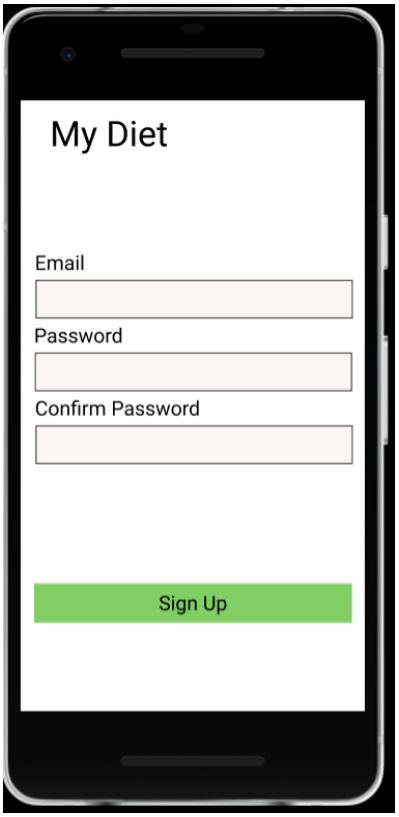	
This is the sign-up screen of the “My Diet” application. The user can enter their email address and new password to get the access of the application.	This is the login screen of the “My Diet” application. The user can enter their username and password to login to the system.

Table A. 9 The login and register screens of the application

	
This is the home screen of the application and the user is directed to this screen once logged in.	This is the health profile screen. The user can go to this screen once clicked on the “My Health Profile” button on the home screen.

Table A. 10 The home screen and health profile screen of the application

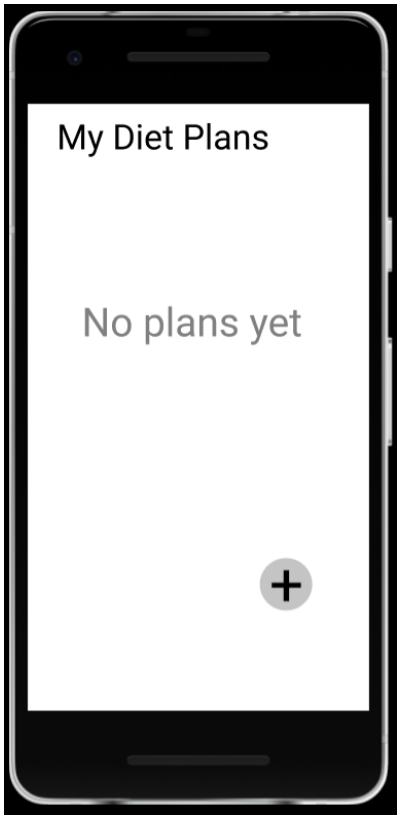	
This is the diet plans screen. The user can go to this screen once clicked on the "My Diet Plans" button on the home screen. The user can create a new diet plan once clicked on the "+" button icon.	The user can create a diet plan using this screen. This screen will be displayed once the user clicked the "+" button on the diet plan screen.

Table A. 11 The diet plan creation screens of the application.

	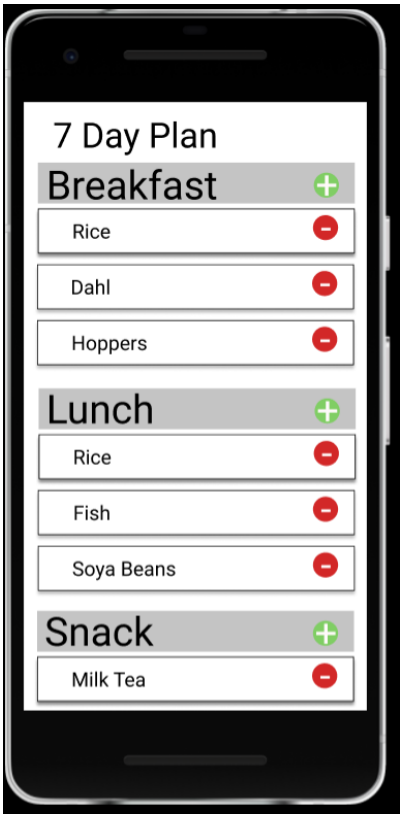
This represents the user created list of diet plans. The user can view or delete created diet plans on this screen.	This is the diet menu for one day based on a selected diet plan. The user can view this diet menu screen once clicked on one of created diet plans. The user can customize the system recommended food items by clicking "+" and "-" buttons on the diet menu.

Table A. 12 The diet plans list screen and diet menu screen of the application.

APPENDIX B – SYSTEM EVALUATION DOCUMENTS

1. System Evaluation - Primary Questionnaire

All question answers are required. Collected all email addresses of responses.

1. What is your age?
2. Gender (multiple-choice to select)? Male, Female
3. Please mention any known disease(s) that you currently suffer?
4. How often do you exercise in a week? (select one answer from given list)
    a. Once a day
    b. Once a week
    c. Sometimes
    d. As often as possible
    e. Never
5. My height is (fill in): _____ centimeters [30]
6. My weight is (fill in): _____ kilograms [30]
7. What is your marital status (select one)? Not Married, Married
8. Are you currently…? [30]
    a. Employed for wages
    b. Self-employed
    c. Jobless
    d. Staying at home
    e. A student
    f. In the military
    g. Unable to work
9. What is your highest level of education attained? [30]
    a. Primary
    b. Secondary
    c. College/University
    d. Graduate/Professional (i.e. Master's/PhD)
10. Do you own a smartphone [31] (select one)? Yes, No, No, but I am planning on getting one soon
11. I am concerned about there being a lot of fat in my food [30].
    a. I am not concerned at all

b. I am concerned a little
c. I am concerned
d. I am concerned a lot
e. I am extremely concerned

12. I am concerned about eating many calories [30].
    a. I am not concerned at all
    b. I am concerned a little
    c. I am concerned
    d. I am concerned a lot
    e. I am extremely concerned
13. I am concerned about there being a lot of sugar in my food [30].
    a. I am not concerned at all
    b. I am concerned a little
    c. I am concerned
    d. I am concerned a lot
    e. I am extremely concerned
14. I am concerned about gaining weight [30].
    a. I am not concerned at all
    b. I am concerned a little
    c. I am concerned
    d. I am concerned a lot
    e. I am extremely concerned
15. Did you have a specific goal to lose weight during the last 12 months [30] (select one)? Yes, No

If the participant given answer for the 15th question is Yes, then show the rest of the questions in "my diet" section, otherwise allow them to submit the questionnaire.

16. If you had/have a goal to improve your diet, what methods did/will you try to improve your diet [30]? (Single choice or multiple choices)
    a. Followed specific diets

b. Consulted dietitians
c. Attended weight-loss courses
d. Used diet apps
e. Learned cooking or healthy food choices from TV, books, or the Internet.
f. Other

17. What drawbacks apply to your use of diet or nutrition apps?
a. Too much time required
b. Too difficult to use
c. Not enough features
d. No interest to use any apps
e. None

Table B. 1 Primary questionnaire

2. Evaluation Result - Primary Questionnaire

Note: Including only the results which are not included in the evaluation chapter.

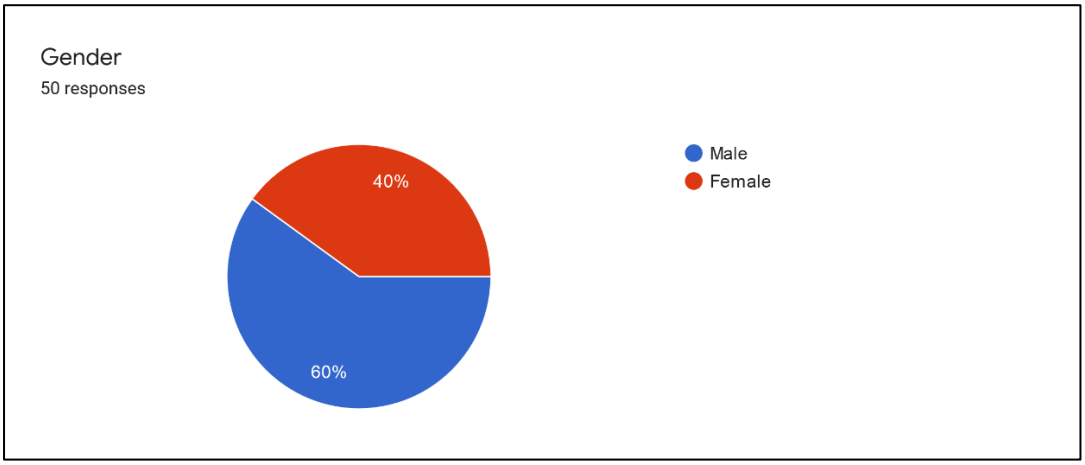

Figure B. 1 Gender distribution of the participants (N=50)

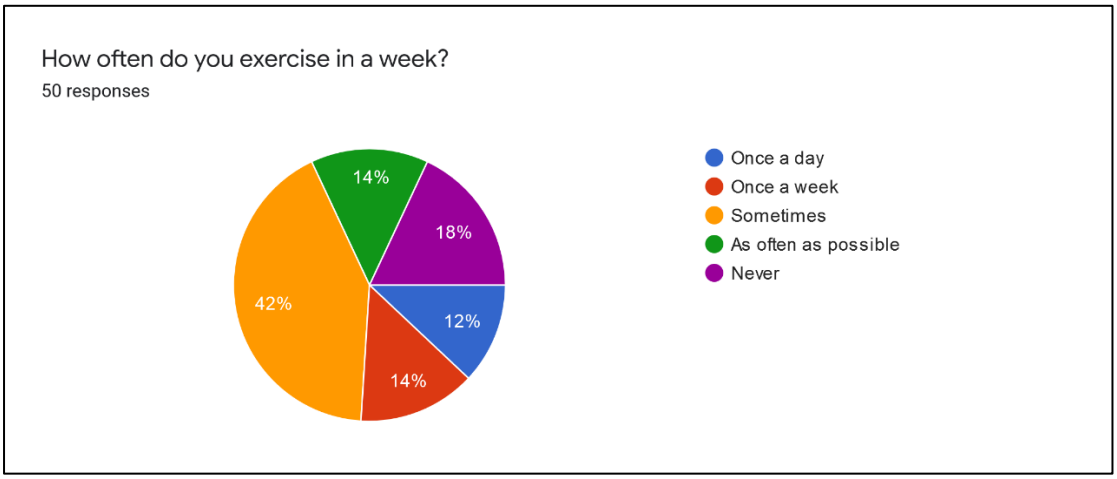

Figure B. 2 Exercise frequency of the participants (N=50)

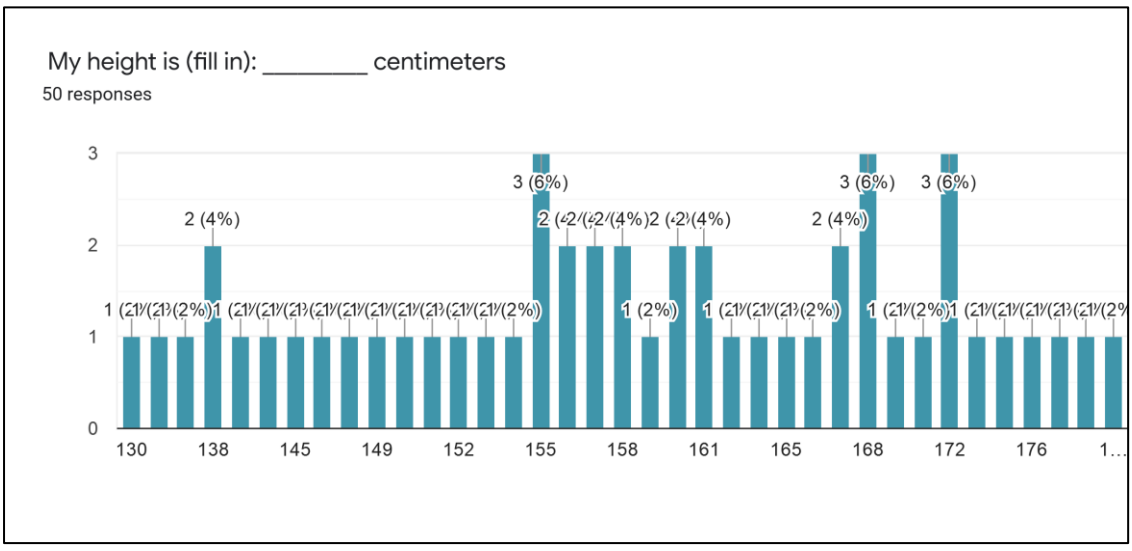

Figure B. 3 The height variance of the participants (N=50)

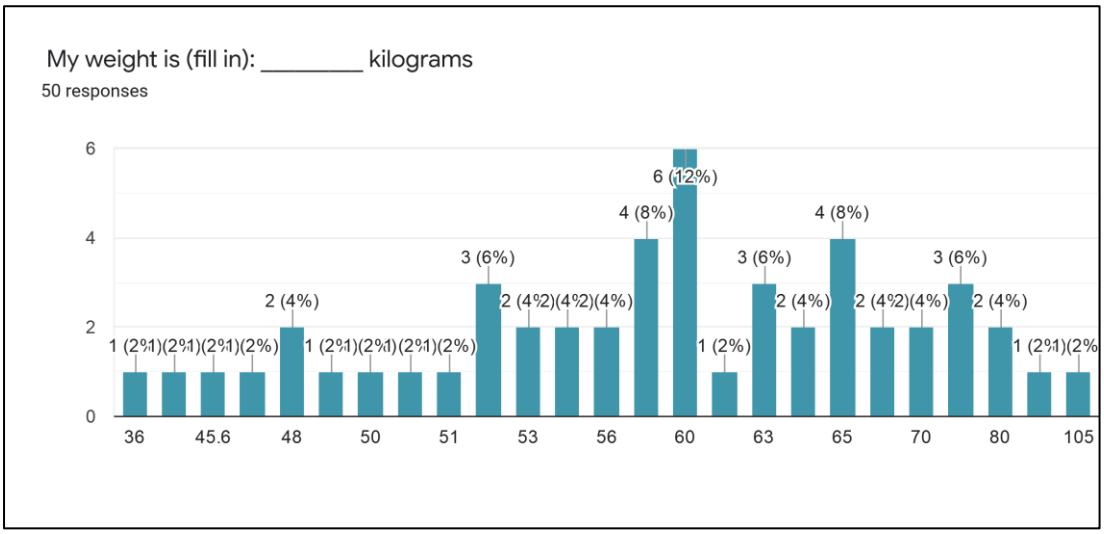

Figure B. 4 The weight variance of the participants (N=50)

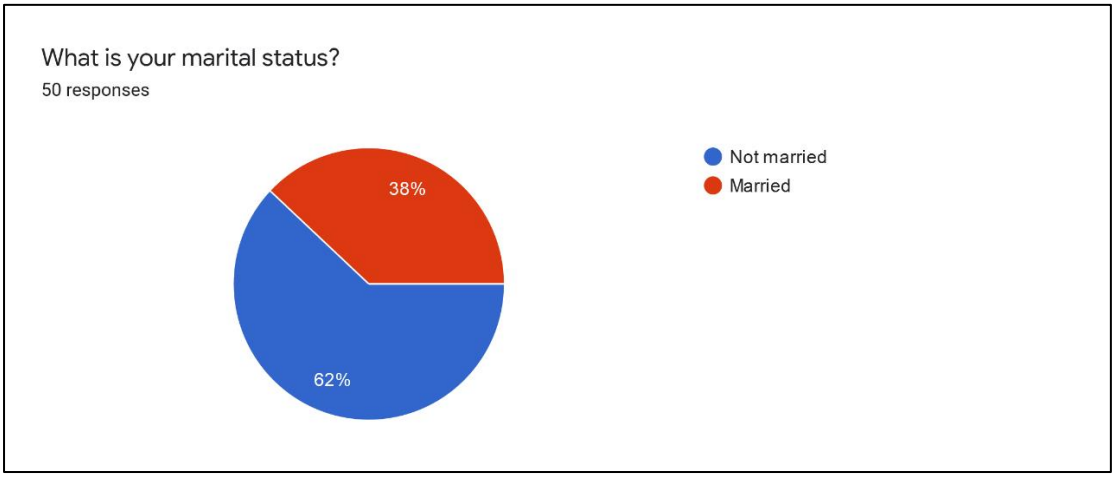

Figure B. 5 The marital status of the participants (N=50)

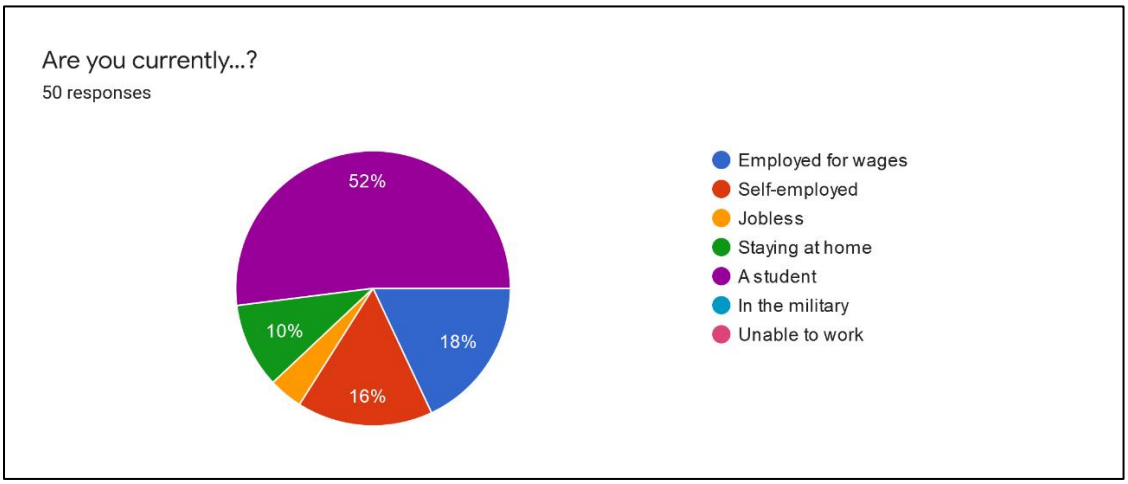

Figure B. 6 Current job status of the participants (N=50)

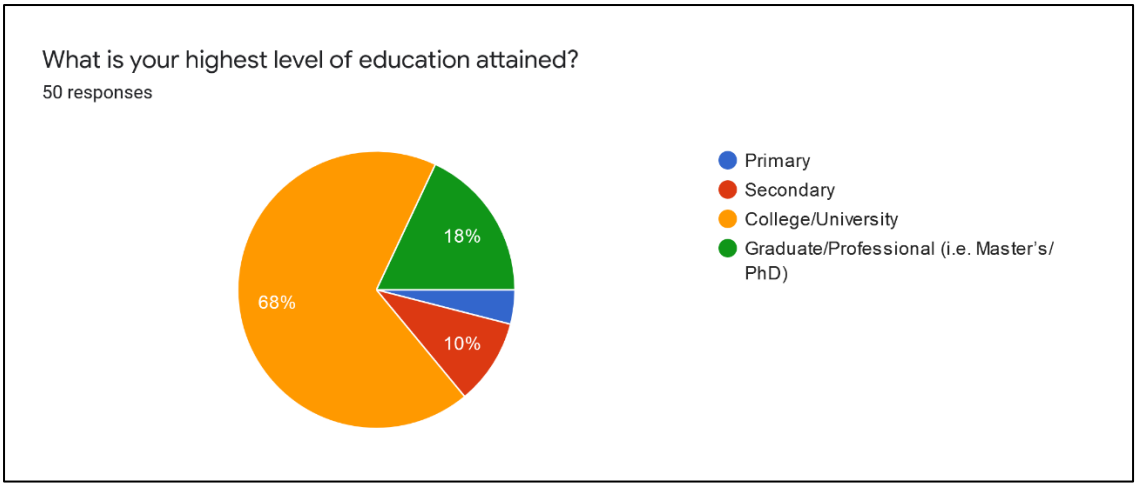

Figure B. 7 Education level of the participants (N=50)

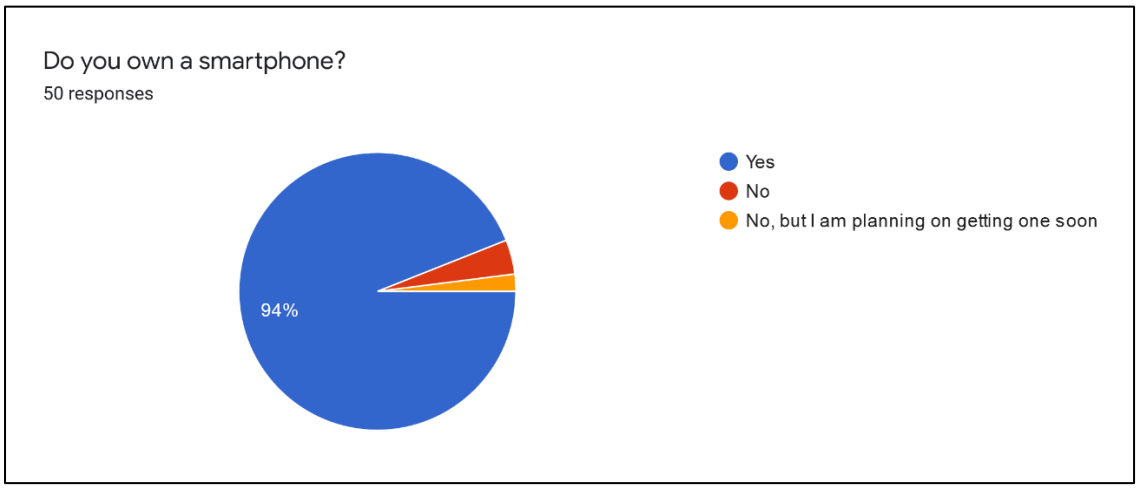

Figure B. 8 The smartphone availability of the participants (N=50)

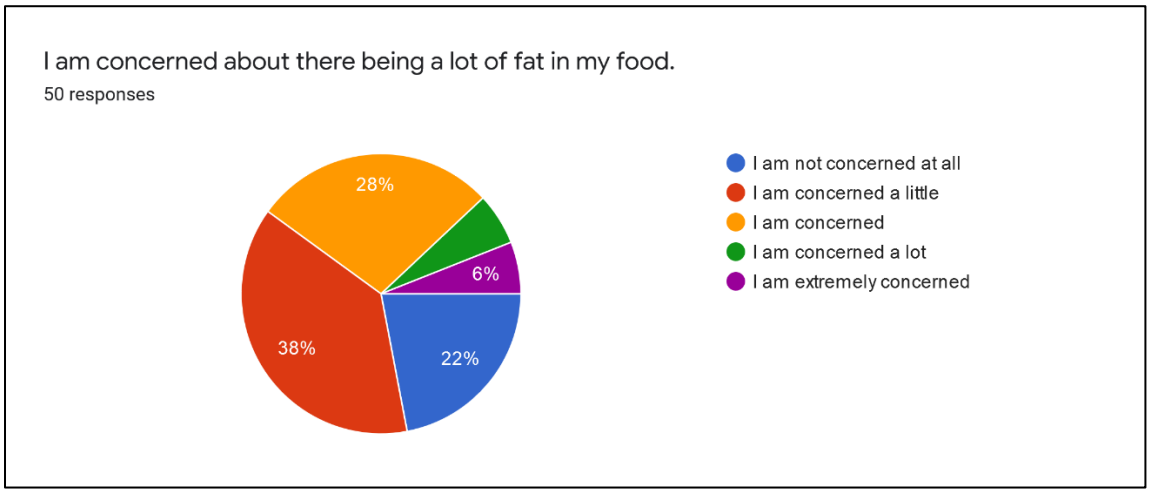

Figure B. 9 The fat food intake concern of the participants (N=50)

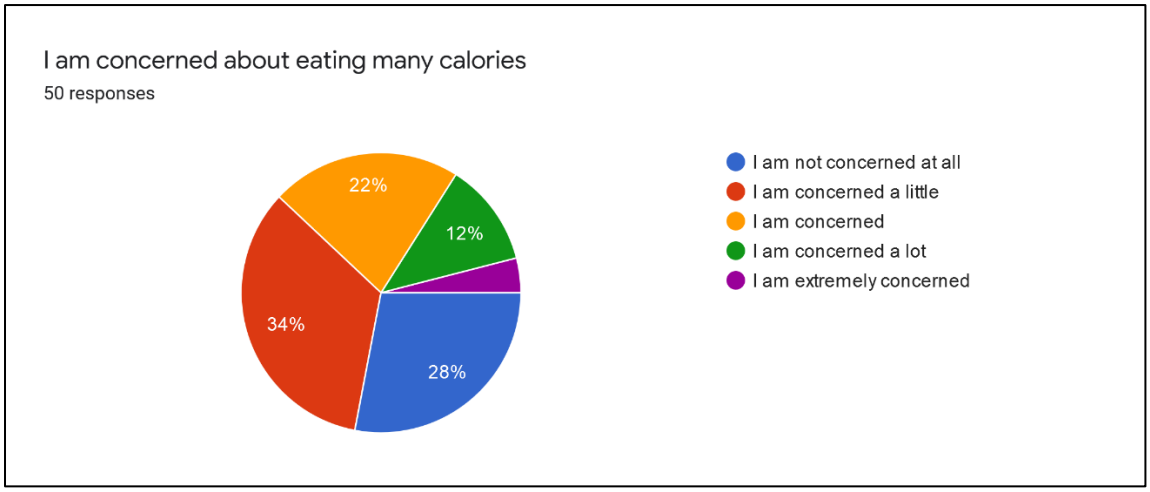

Figure B. 10 The participant's concern on food intake with more calories (N=50)

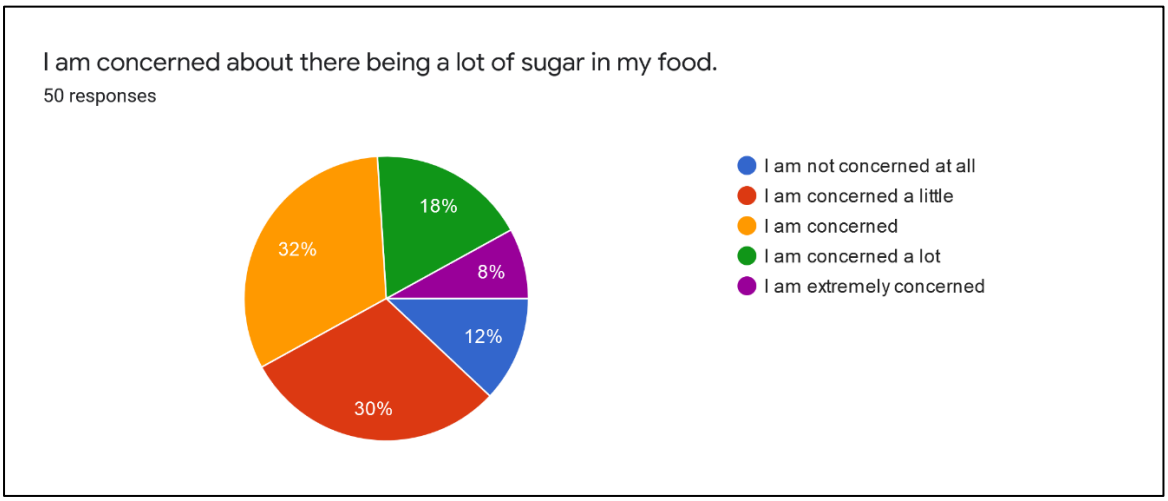

Figure B. 11 The participant's concern on food intake with more sugar (N=50)

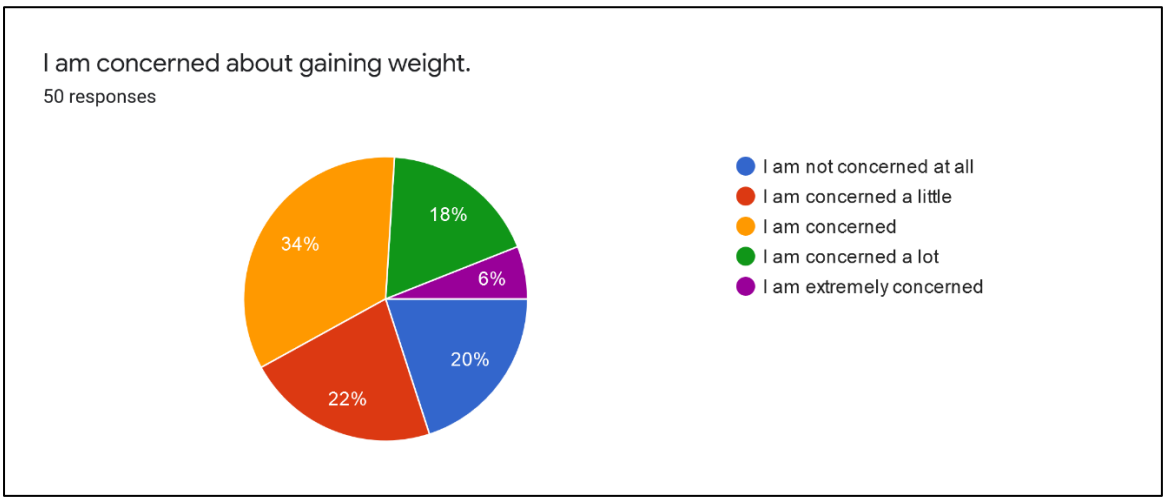

Figure B. 12 The participant's concern about gaining weight (N=50)

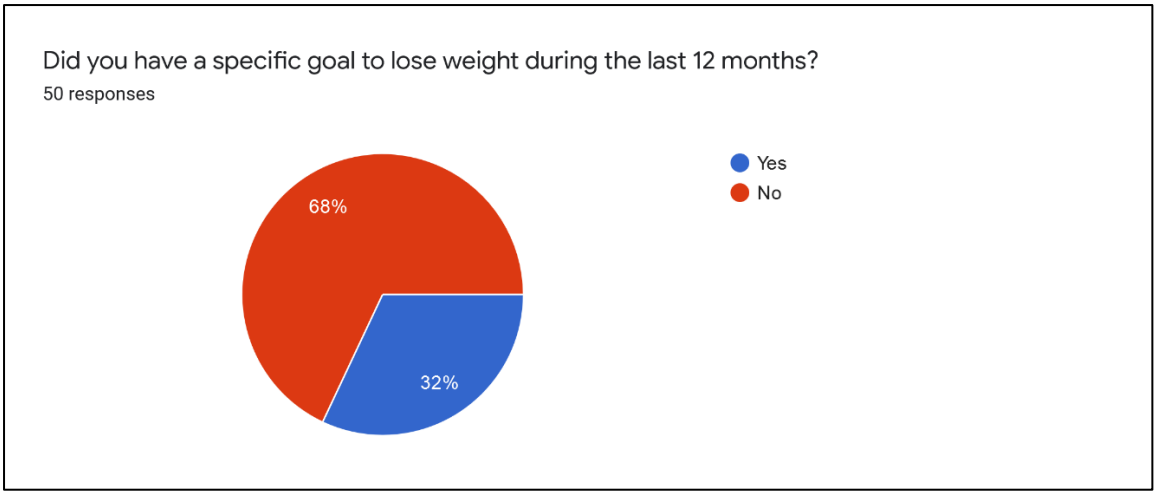

Figure B. 13 The participant's concern to lose weight during last 12 months (N=50)

3. System Evaluation - Secondary Questionnaire

All question answers are required. This is distributed only for twenty selected participants based on primary questionnaire responses.

1. Have you used the "My Diet" app on a mobile phone during the last month?
    a. Yes, I have used the app during the month, and I am currently using it.
    b. Yes, I have used the app during the month, and I am not currently using it.
    c. No, I have not used during the last month, but I will use it
    d. No, I will not use it

If the participant selected answer is a or b, then remaining questions from 4th to 11th are shown, if the selected answer is "c" then allowed participant to submit the form. If the selected answer is "d" then 2nd, 3rd questions are shown and allowed to submit the form.

2. What drawbacks apply to your use of the diet app?
    a. Too much time required
    b. Too difficult to use
    c. Not enough features
    d. No interest to use any apps
    e. None
3. What would be the biggest reason that you would not use "My Diet" app?
4. How long have you used a diet app? Please specify the period that you have used the app: ----------
5. How often did you use the diet app during the last month?
    a. More than once per day
    b. 1 time per day
    c. 1-6 times per week
    d. 1-3 times per month
    e. Less than 1 time per month
    f. Whenever need to check the diet menu as per the plan
6. To what extent do you agree with the following statements [30]? Please choose the answers that fit you the best [30].
    I. It is easy for me to understand how the diet app works.
    II. It is time consuming for me to use the diet app

III. It is easy for me to get information from the diet app

IV. It is boring to use the diet app

V. It is easy for me to reach my target diet plan by using the diet app

Below four answers are provided for each statement, participants need to select one answer for each statement.

a. Disagree strongly
b. Disagree slightly
c. Agree slightly
d. Agree strongly

7. What is your main goal when using the diet app [30]?
    a. To view the progress of diet plan
    b. To facilitate my weight loss goal
    c. To help me to eat healthier in general
    d. None
8. What are your motivations for using the diet app to achieve your goal [30]? Please choose the answers that fit you the best.

I. I think it is easy to obtain food information from the diet app

II. I need to pay attention to my diet, because my family has disease history, (e.g., cardiovascular disease or cancer).

III. I want to have diet competitions with friends or family members

IV. I want to share my diet on social networks.

Below four answers are provided for each statement, participants need to select one answer for each statement.

a. Disagree strongly
b. Disagree slightly
c. Agree slightly
d. Agree strongly

9. How effective has the diet app been in assisting your diet [30] ?

I. To eat more low-fat dairy alternatives

II. To eat more fruit and vegetables

III. To eat less sausages

IV. To drink less sweetened beverages

V. To eat less fast food, which is typically high in salt and saturated fat

VI. To choose more healthy food

VII. To achieve weight goal

Below four answers are provided for each statement, participants need to select one answer for each statement.

a. Very effective
b. Somewhat effective
c. Slightly effective
d. No effective

10. How effective is using the app to reach your weight goal, compared to these methods? [30]
    I. Using the app is …. compared to specific diets
    II. Using the app is …. compared to weight-loss courses
    III. Using the app is …. compared to learning cooking or healthy food choices from TV, books, or the Internet.
    IV. Using the app is …. compared to consulting dietitians
11. What would the biggest improvement(s) be that you would like to see in "My Diet" app?

Table B. 2 Secondary questionnaire

4. Evaluation Result- Secondary Questionnaire

Note: Including only the results which are not included in the evaluation chapter.

4.1.Participant's personal attributes related results

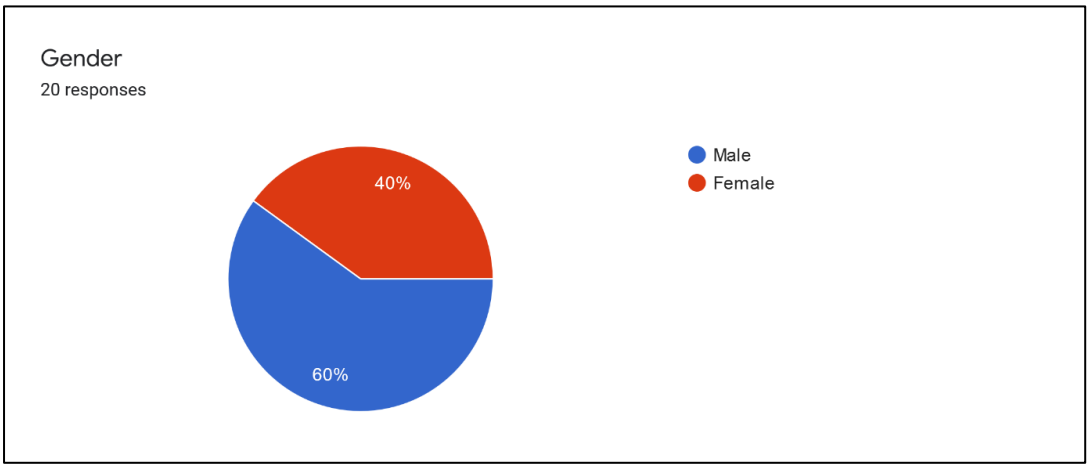

Figure B. 14 Gender distribution of the participants (N=20)

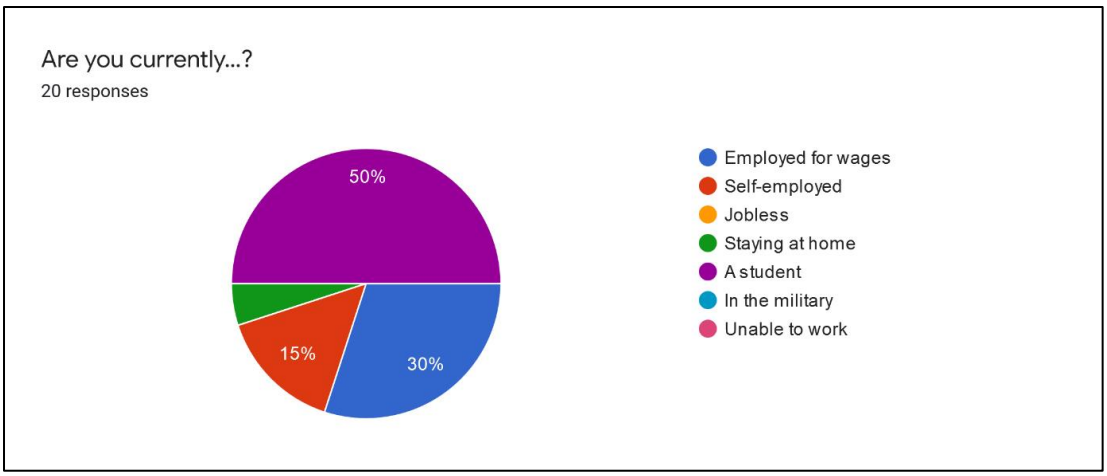

Figure B. 15 Current job status of the participants (N=20)

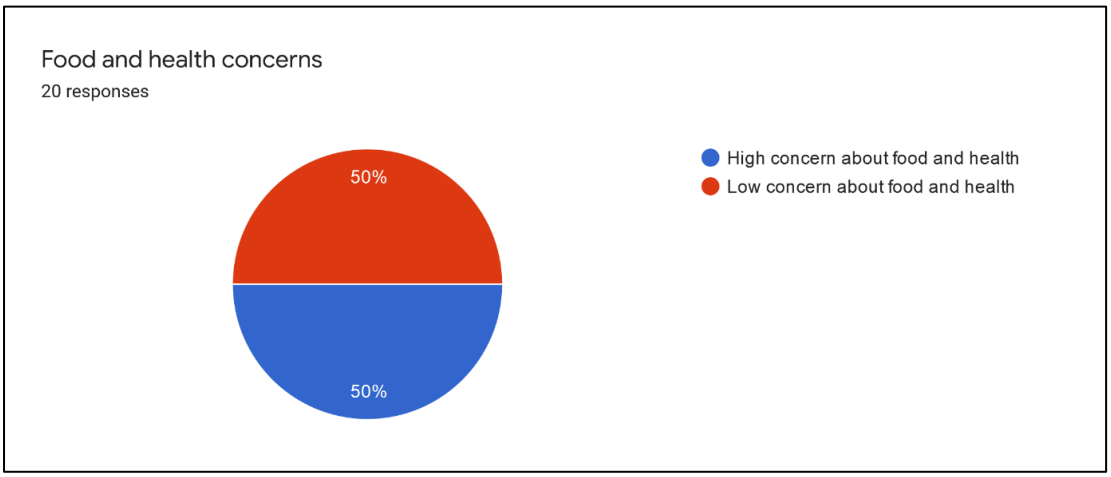

Figure B. 16 The food and health concerns of the participants (N=20)

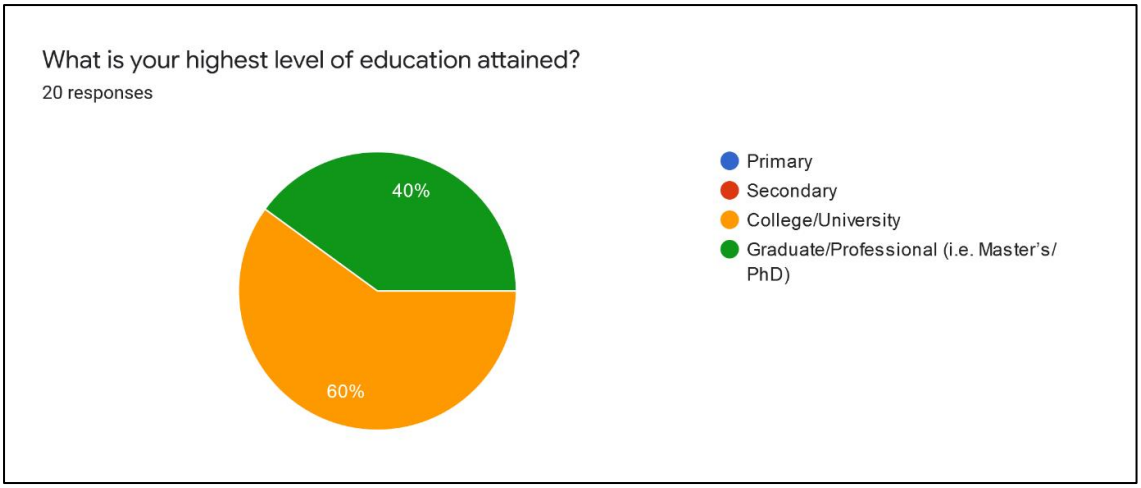

Figure B. 17 The education level of the participants (N=20)

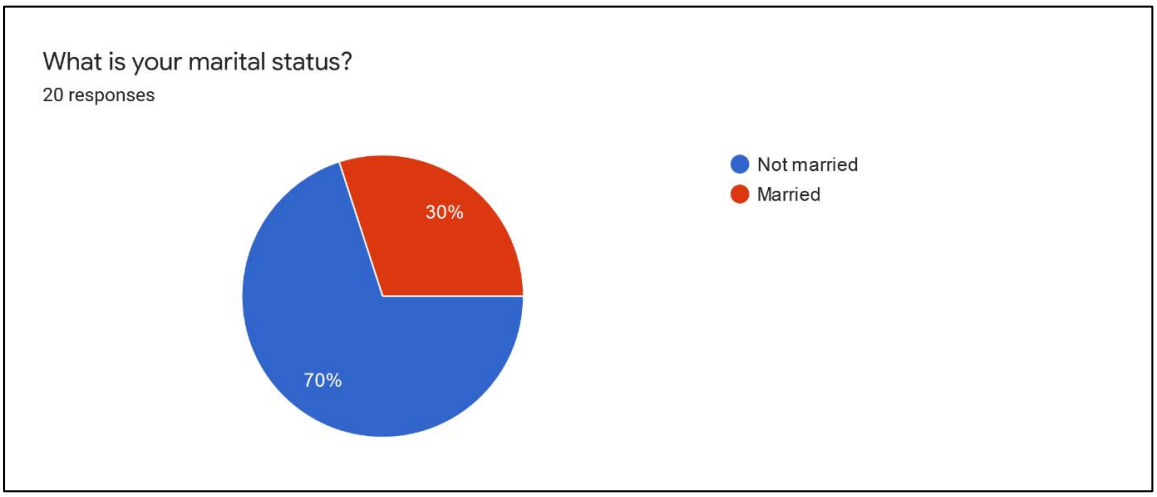

Figure B. 18 The marital status of the participants (N=20)

4.2.The diet application user experience related feedback

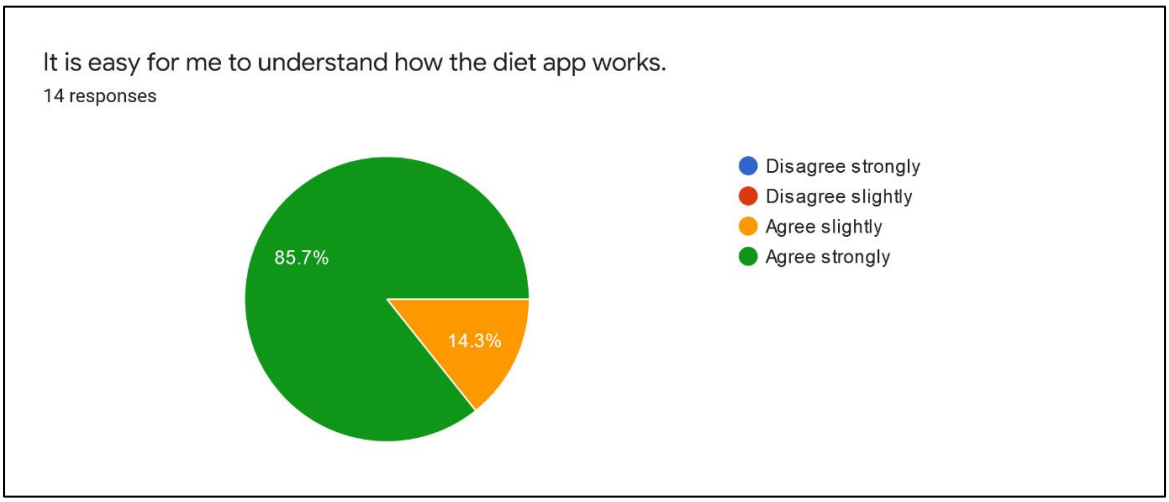

Figure B. 19 The diet application understandability (N=14)

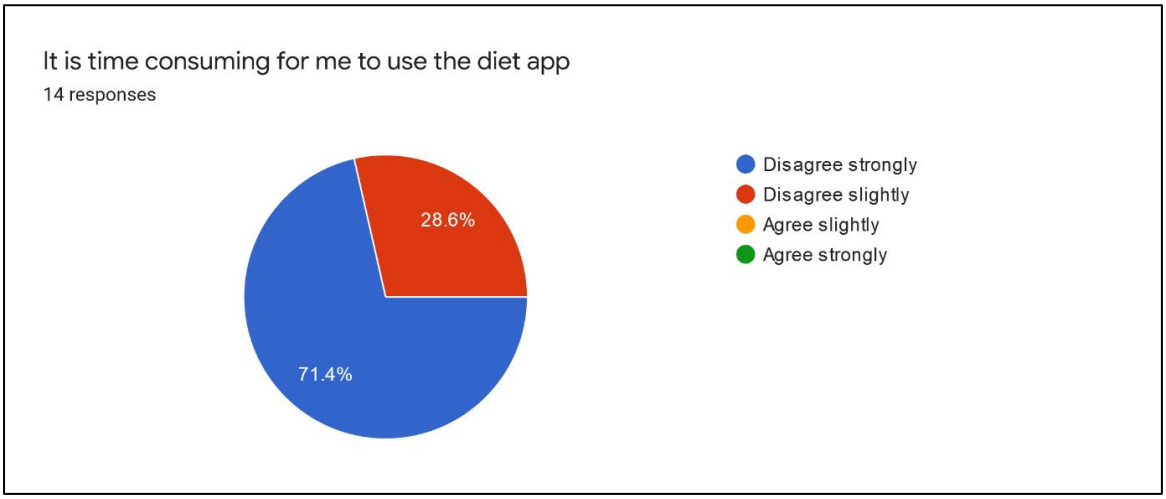

Figure B. 20 Responses for how efficiency the diet application (N=14)

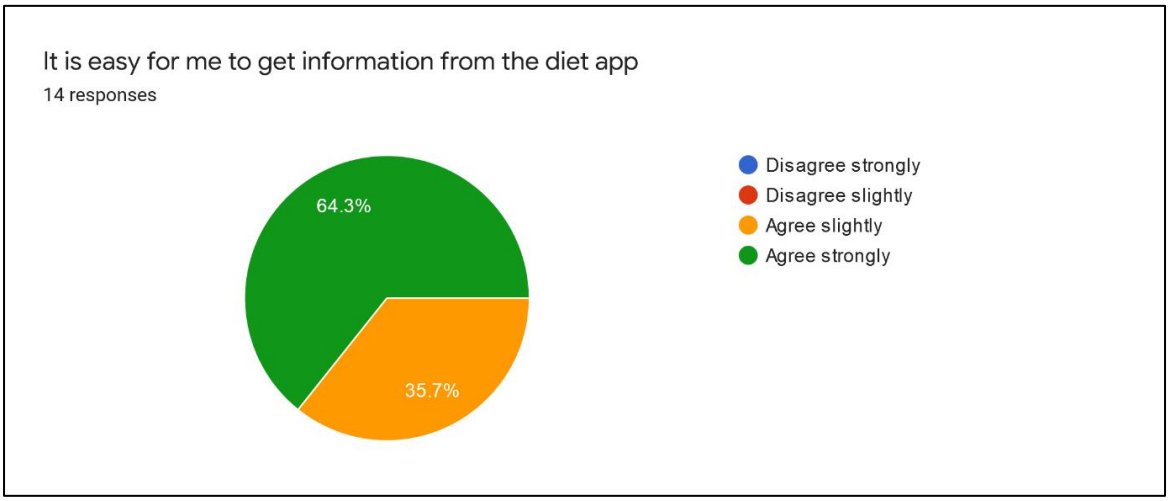

Figure B. 21 Information accessibility of the diet application (N=14)

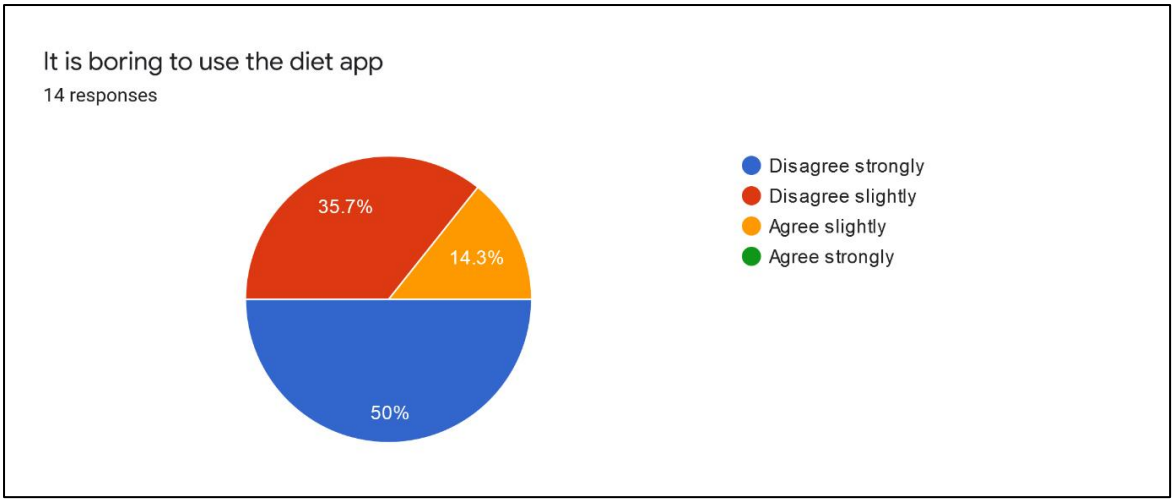

Figure B. 22 Attractiveness of the diet application (N=14)

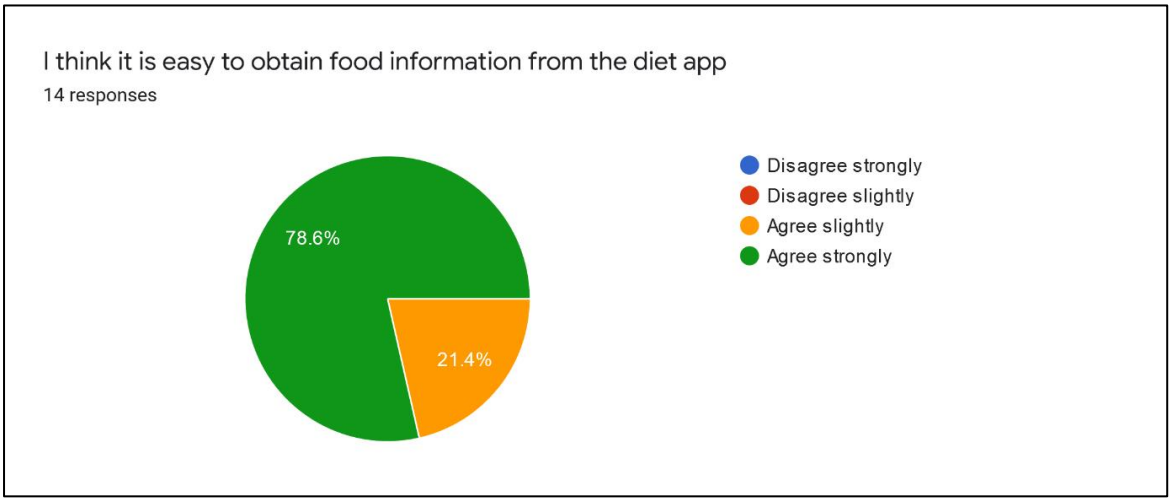

Figure B. 23 The easiness of obtain food information from the diet application

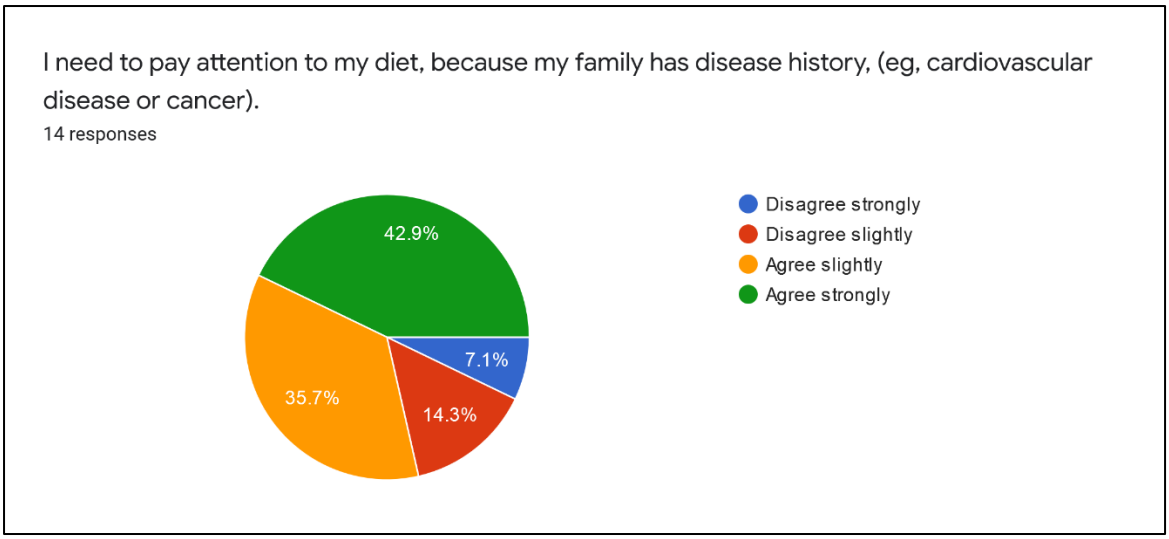

Figure B. 24 The reason of participants to pay attention to the diet

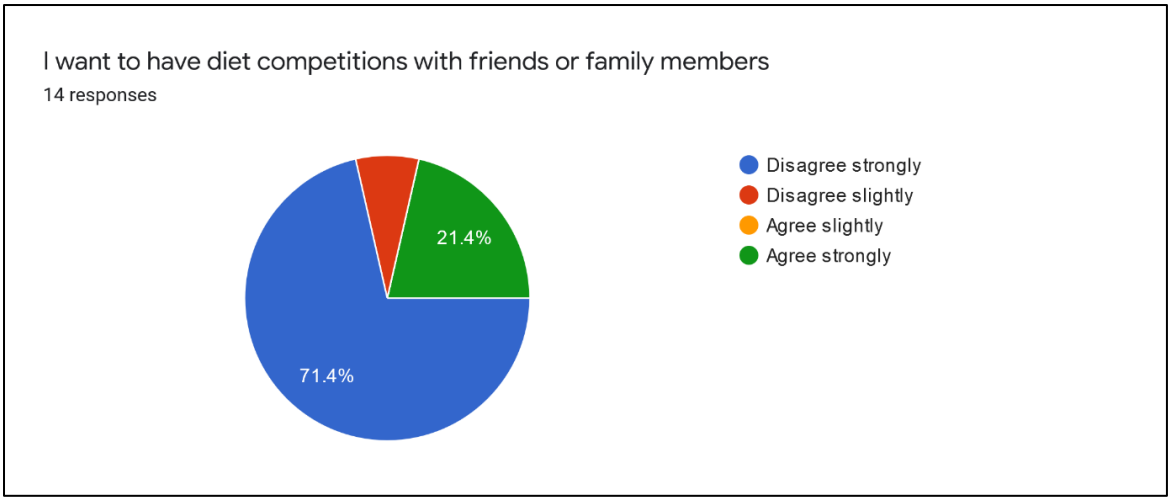

Figure B. 25 Check whether participants have diet competition or not

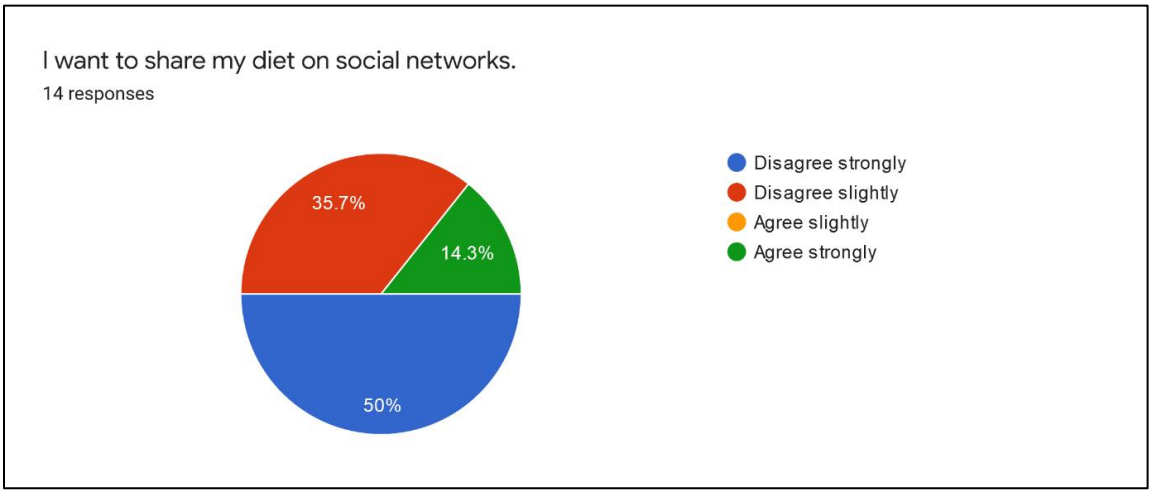

Figure B. 26 The interest of participant to share their diet on social network

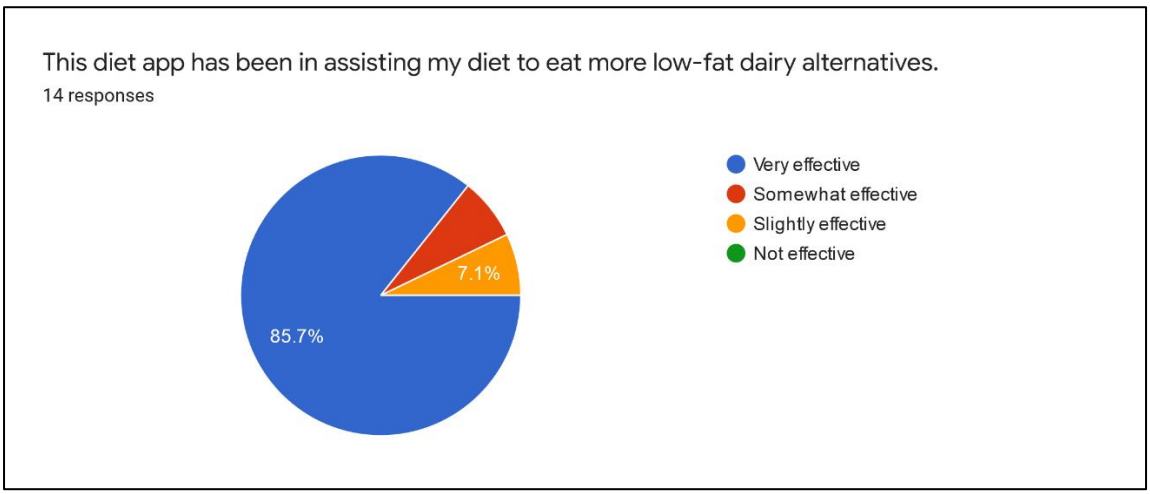

Figure B. 27 The diet app support to eat more low-fat dairy alternatives (N=14)

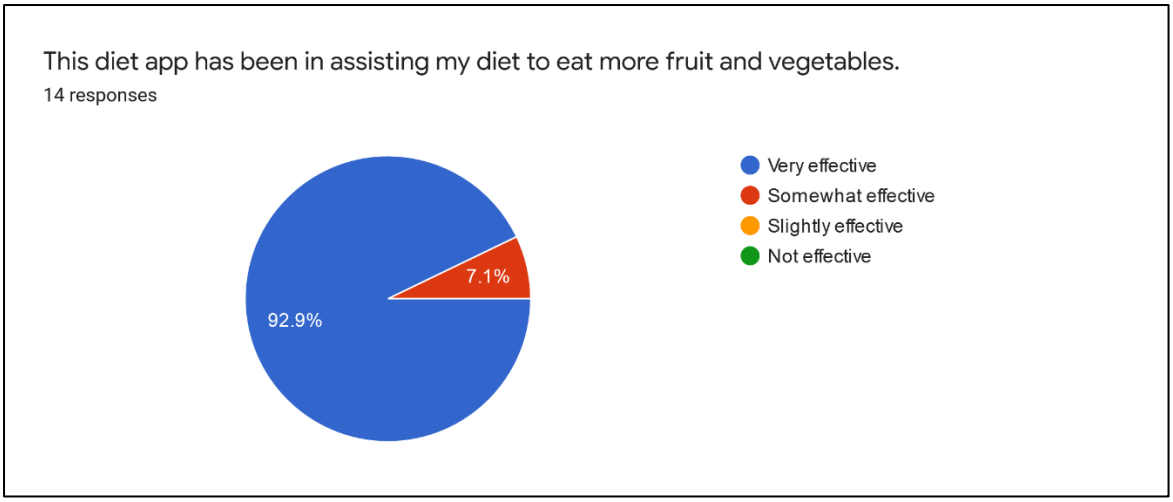

Figure B. 28 The diet app support to eat more fruit and vegetable (N=14)

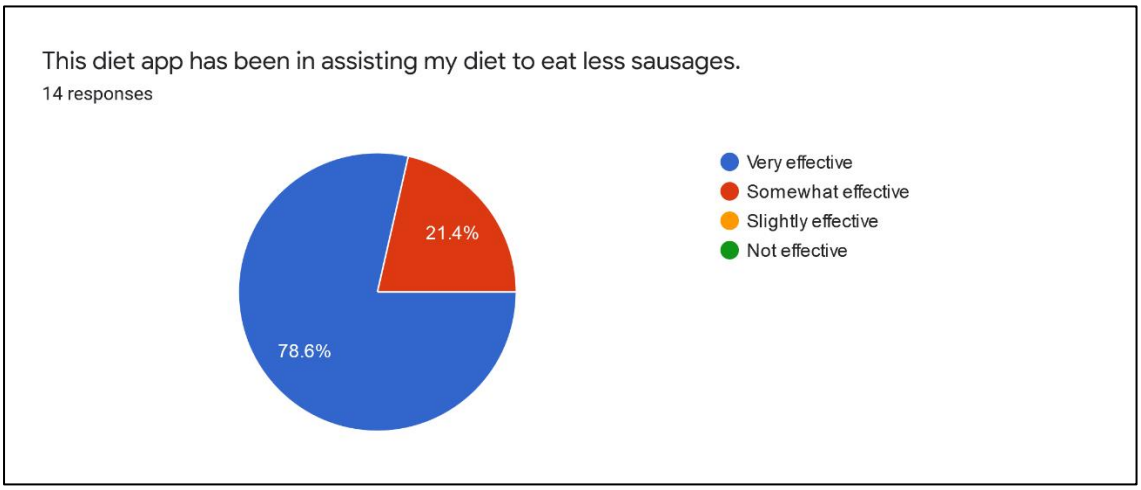

Figure B. 29 The diet app support to eat more less sausages (N=14)

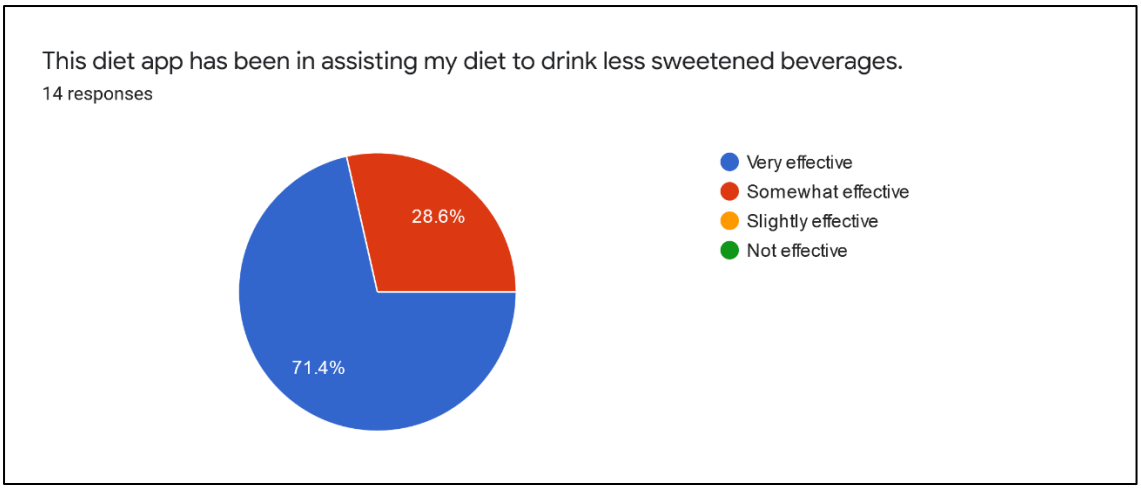

Figure B. 30 The diet app support to drink less sweetened beverages (N=14)

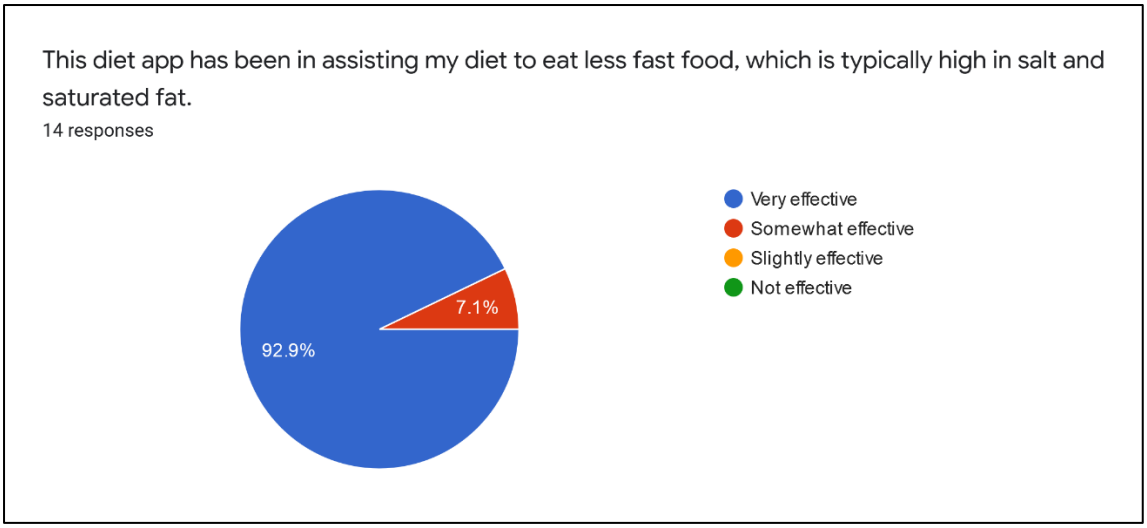

Figure B. 31 The diet app support to eat less fast food (N=14)

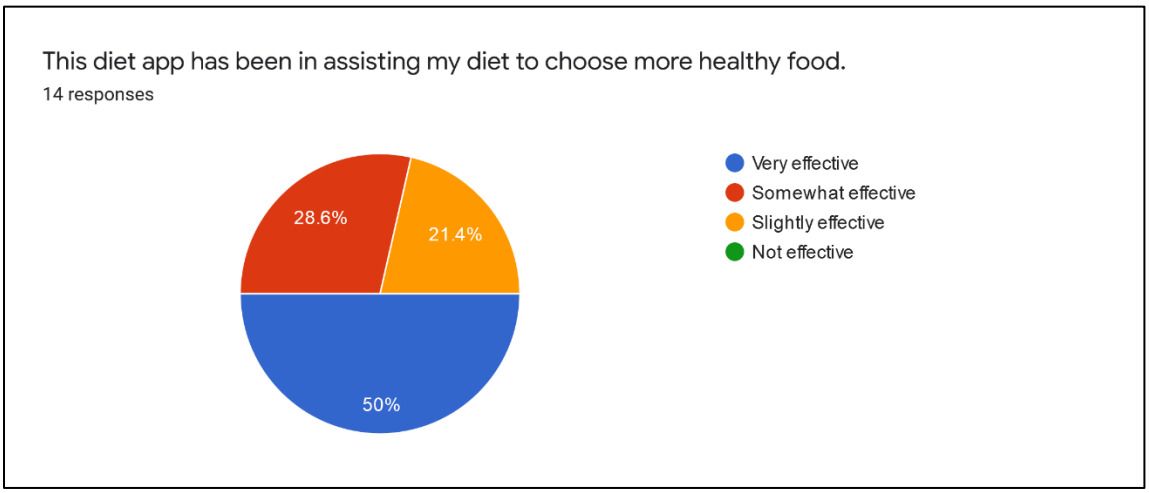

Figure B. 32 The diet app support to choose more health food (N=14)

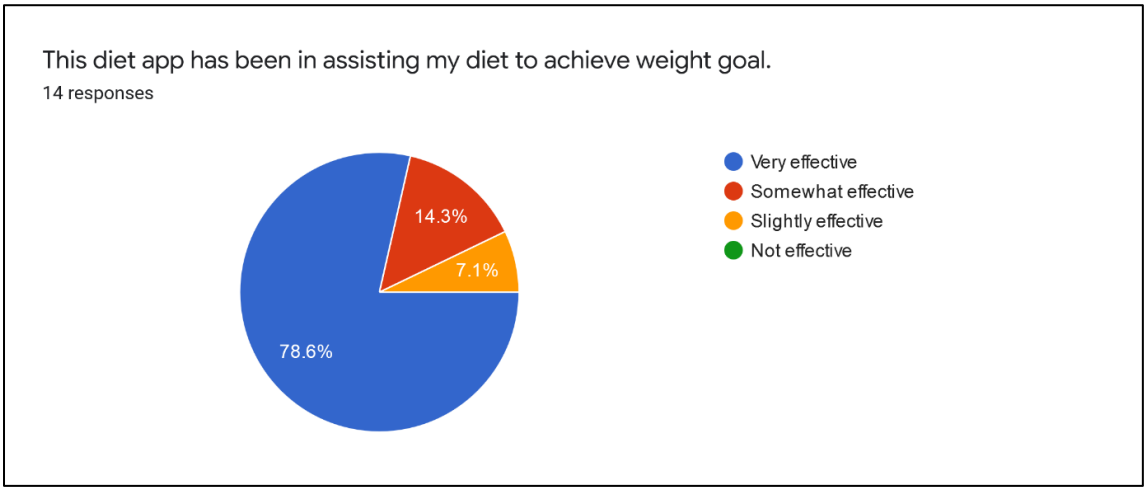

Figure B. 33 The diet app support to achieve weight goal (N=14)

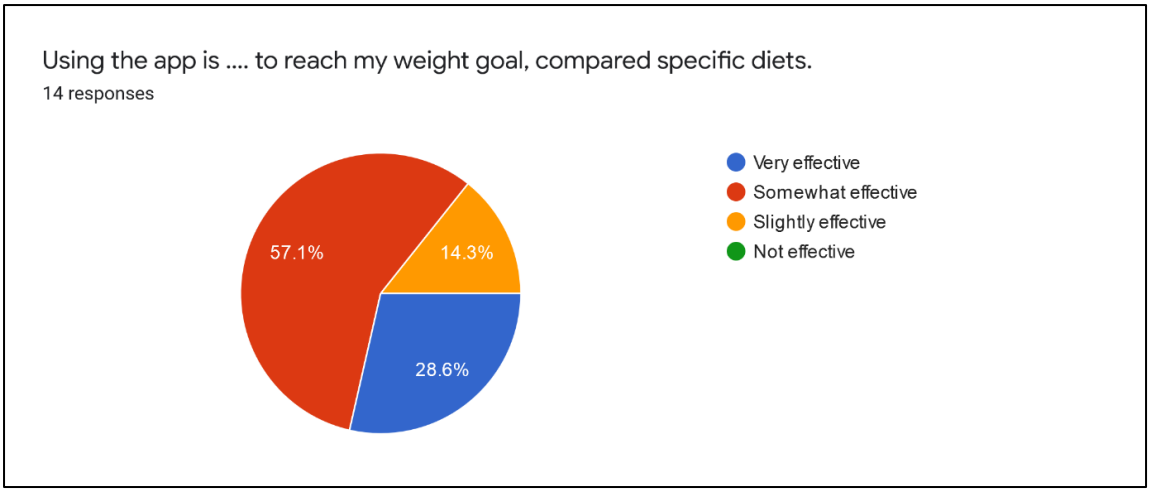

Figure B. 34 The diet app support compared to specific diets (N=14)

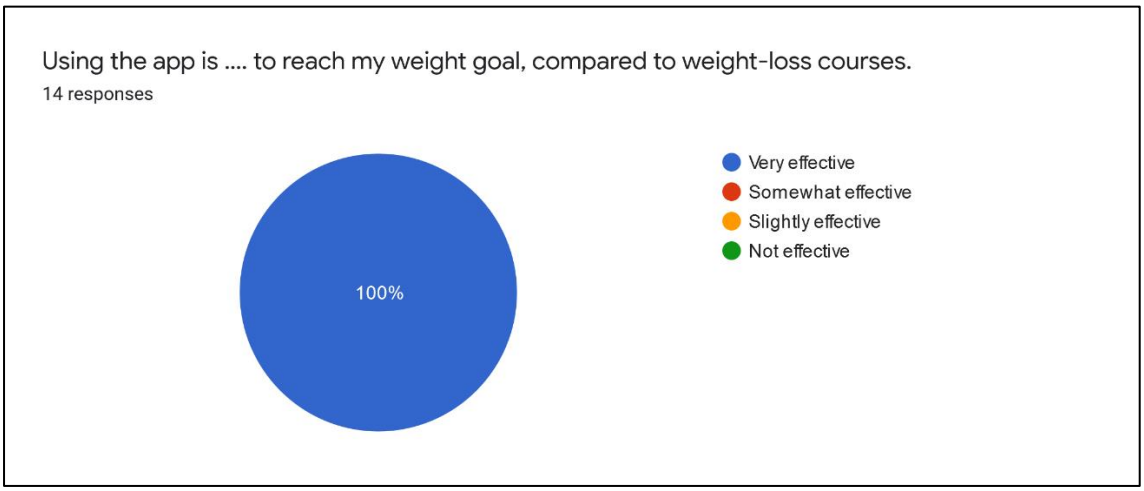

Figure B. 35 The diet app support compared to specific diets (N=14)

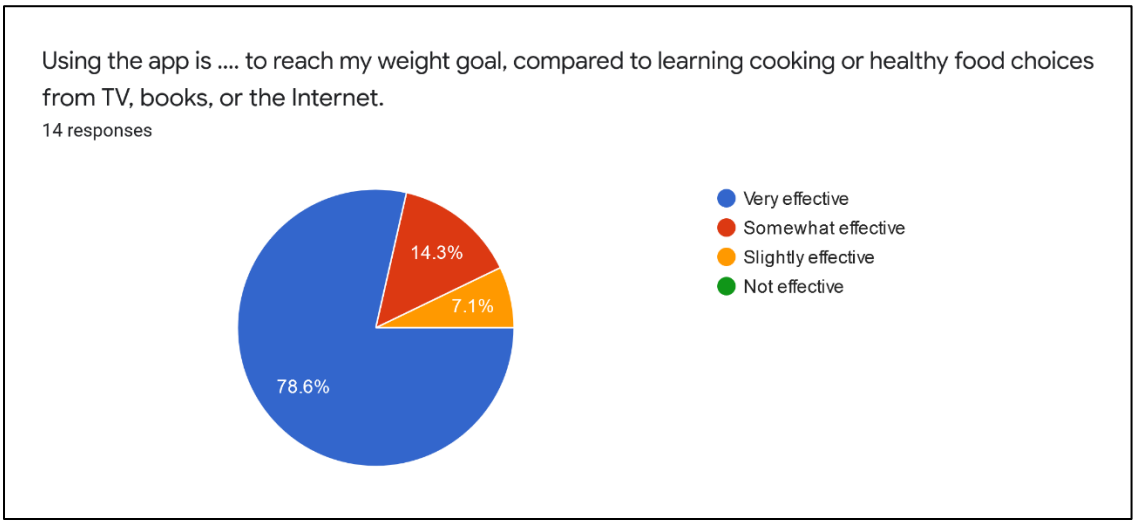

Figure B. 36 The diet app support compared to other healthy food choices (N=14)

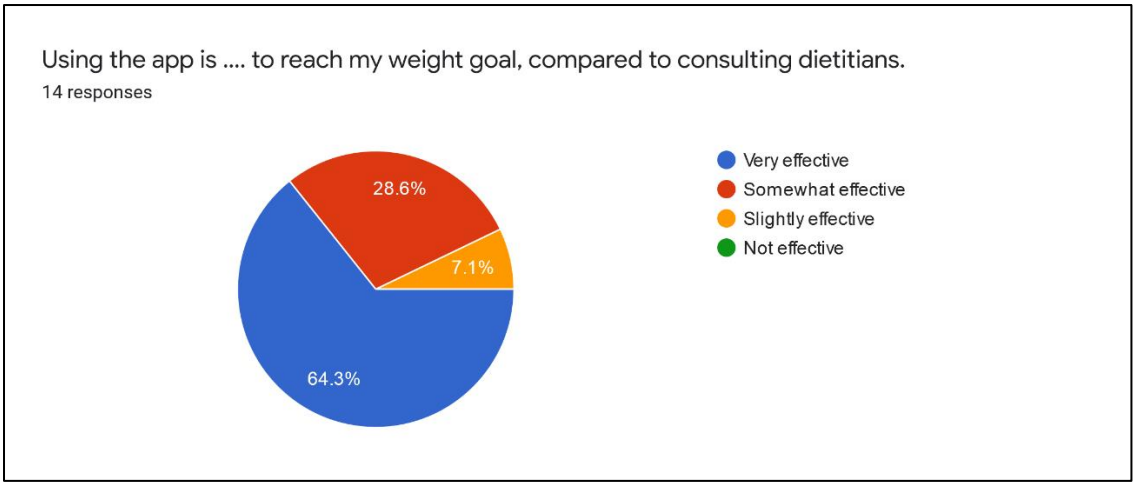

Figure B. 37 The diet app support compared to specific diets (N=14)

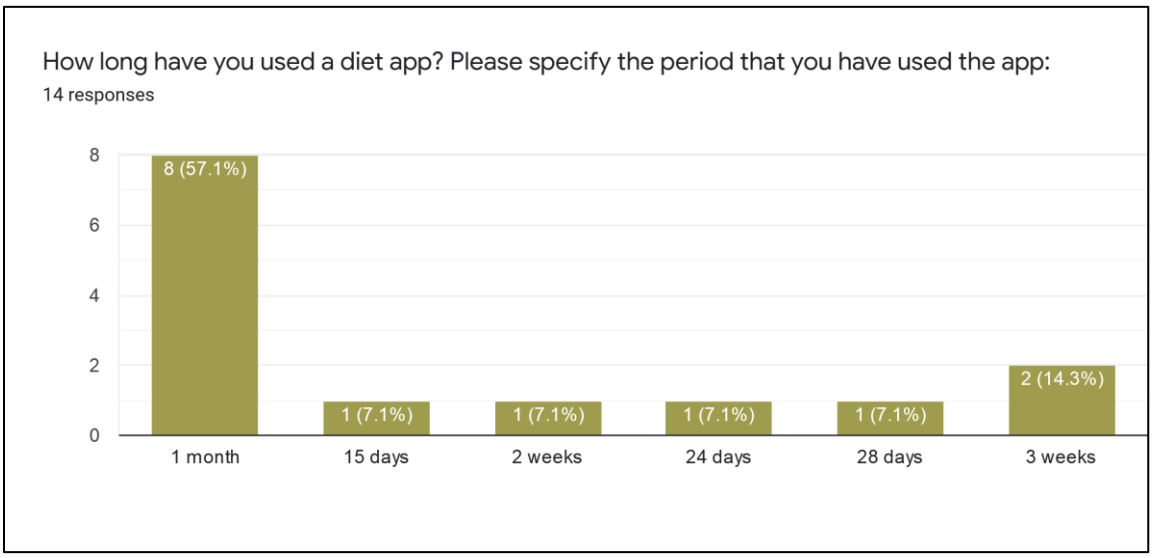

Figure B. 38The diet application usage duration of the participants (N=14)

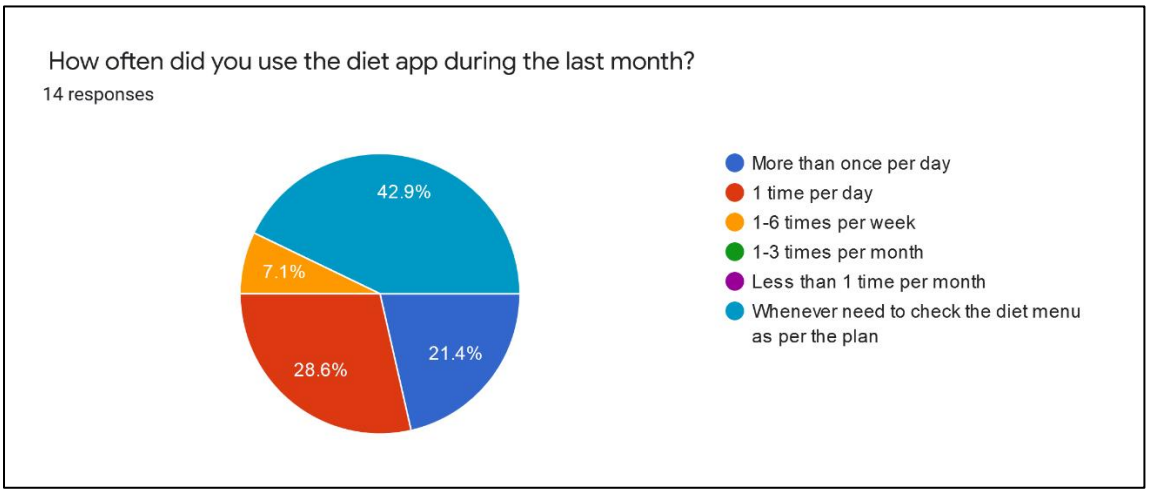

Figure B. 39 The diet app usage frequency of the participants (N=14)

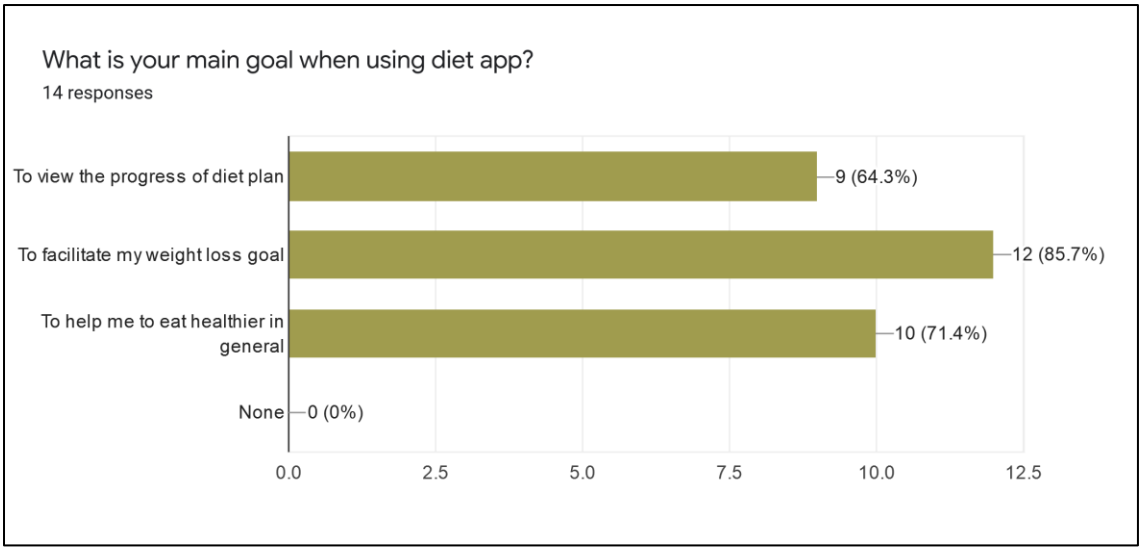

Figure B. 40 The participant's goal of using the diet application (N=14)

5. System Evaluation - Dashboard Questionnaire

All question answers are required.

1. How effectively the system has facilitated users to eat more low-fat dairy alternatives for their meals?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements
2. How effectively the system has facilitated users to eat more fruit and vegetables for their meals?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements
3. How effectively the system has facilitated users to eat less sausages for their meals?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements
4. How effectively the system has facilitated users to drink less sweetened beverages?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements
5. How effectively the system has facilitated users to eat less fast food, which is typically high in salt and saturated fat?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements

6. How effectively the system has facilitated users to choose more healthy food for their meals?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements
7. How effectively the system has facilitated users to achieve weight goal?
    a. Very effective
    b. Slightly effective
    c. Not effective
    d. Need improvements
8. Are you going to use the data analytics for day today treatments?
    a. Yes b. No c. May be
9. Do you think this dashboard data can support your day today treatments?
    a. Yes b. No
10. What is your main purpose of using this kind of web-dashboard (given the short answer text field)?
11. What would the biggest improvement(s) be that you would think to include in those data?
    a. Include patient medical history
    b. Include more healthy foods
    c. Include more fruits
    d. Include physical activity data
    e. Include water intake data
12. What are the additional features do you wish to have? (given the long answer text field)
13. Can you recommend the system for users?
    a. Yes b. No c. Yes, but with improvements

Table B. 3 The dashboard questionnaire given for the dieticians

6. Evaluation Result - Dashboard Questionnaire

Note: Including only the results which are not included in the evaluation chapter.

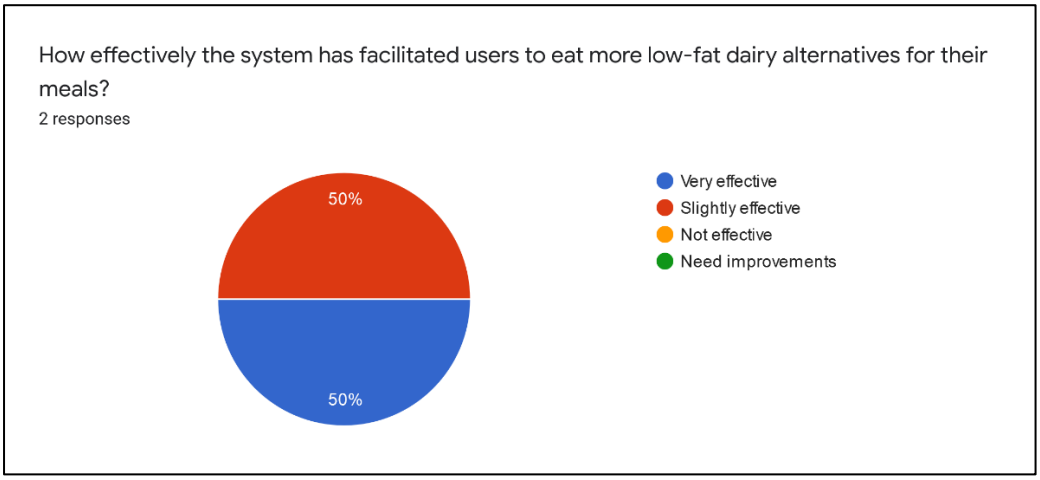

Figure B. 41 How effective to eat more low-fat dairy alternatives (N=2)

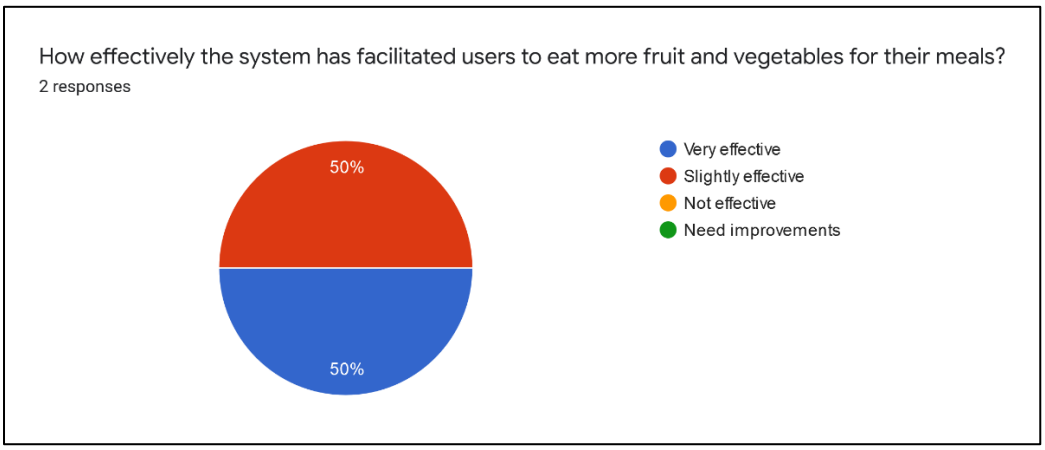

Figure B. 42 How effective to eat more fruit and vegetables (N=2)

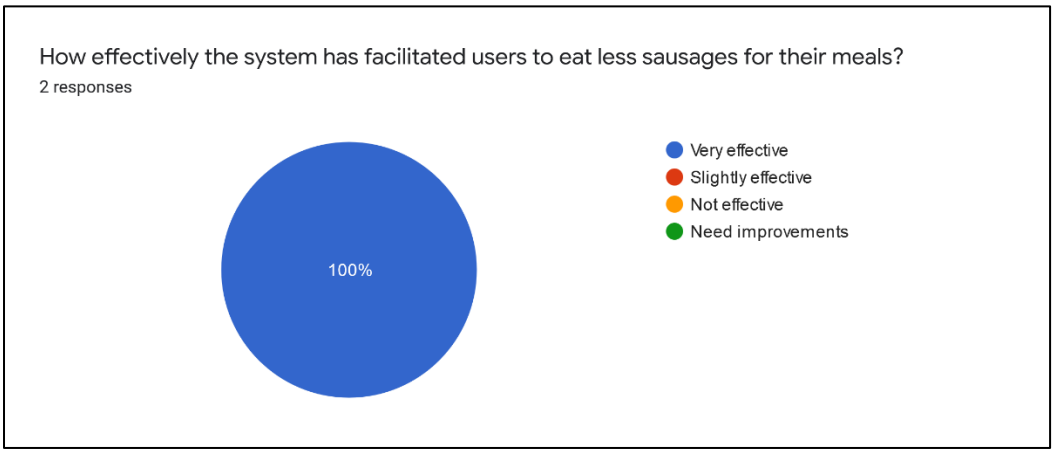

Figure B. 43 How effective to eat less sausages (N=2)

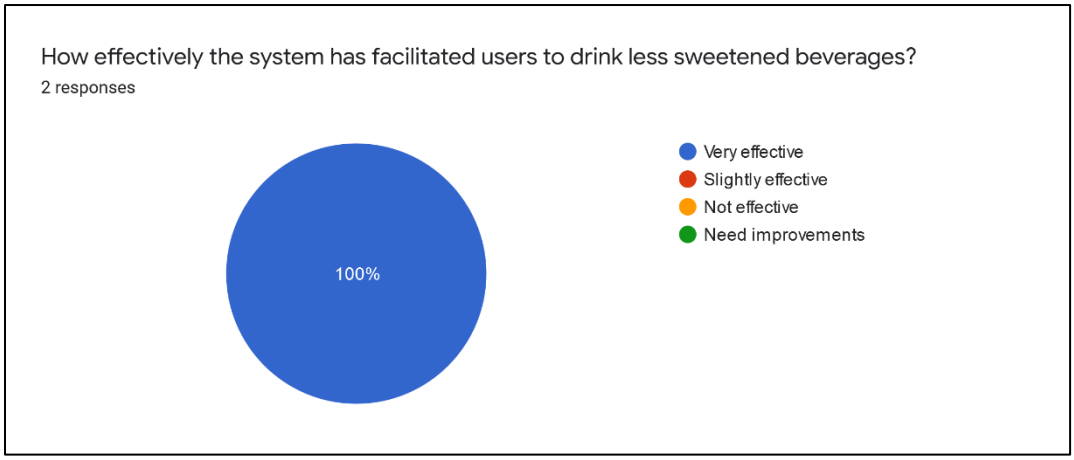

Figure B. 44 How effective to drink less sweetened beverages (N=2)

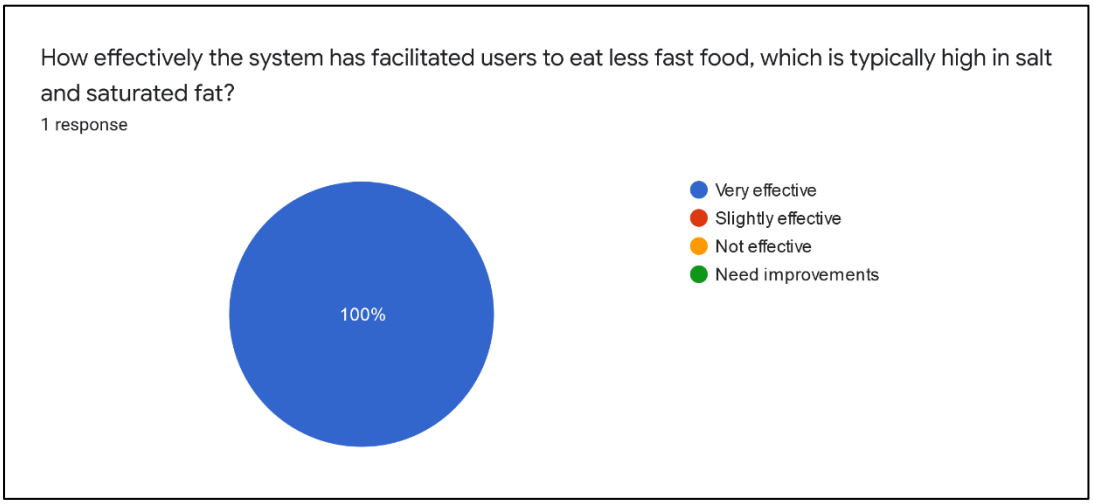

Figure B. 45 How effective to eat less fast food (N=2)

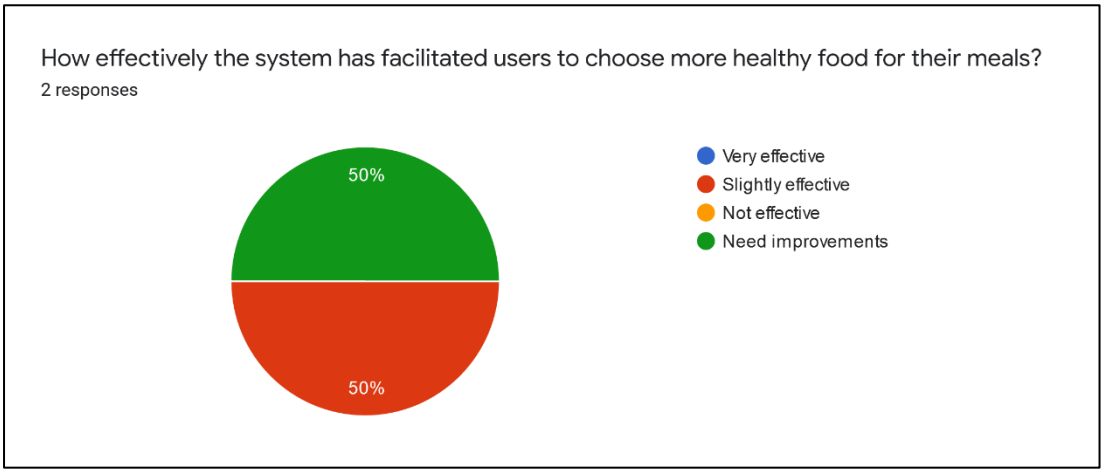

Figure B. 46 How effective to choose more health food (N=2)

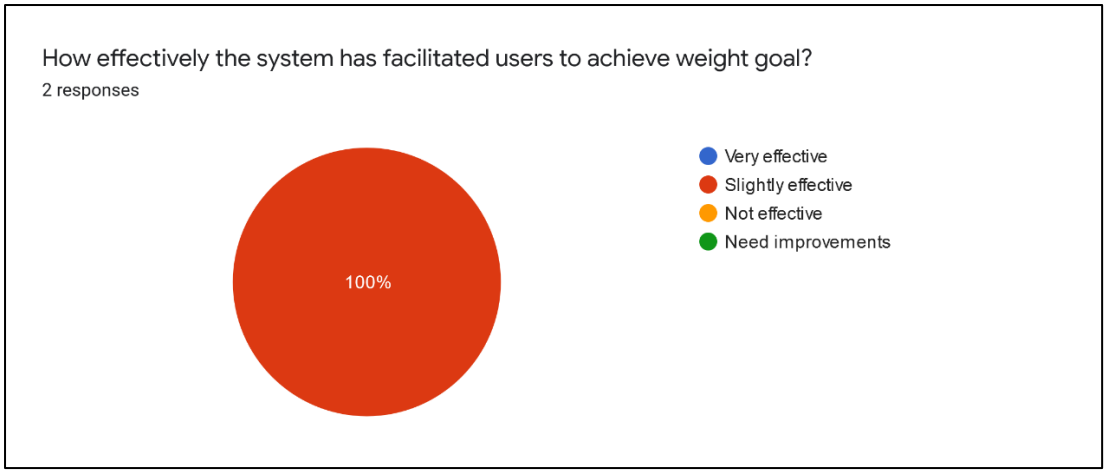

Figure B. 47 How effective to achieve weight goal (N=2)