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6COSC023W – Final Project Report

Delish

A Recipe Recommendation System for a Healthy Life

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Document Scope: “The purpose of this document is to describe and reflect on the processes that took place for developing the Final Year Project of Recipe/Diet Recommendation System mobile application designed by Binari Samarasinghe, discuss any ethical issues associated with it, describe the methodology that was adopted to develop the project, its design, implementation and testing”)

All chapter word counts in this document are approximate and are not intended to be prescriptive.

Declaration

This report has been prepared based on my own work. Where other published and unpublished source materials have been used, these have been acknowledged in references.

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Abstract

The process of “human metabolism” is an essential element of cellular function. Obesity, diabetes, hypertension, heart disease, and cancer are only a few of the diseases linked to disordered metabolic states. In the recent past, it has been identified that Sri Lanka is having a rising number of cases in these areas mainly due to lack of control on daily nutrient intake and other lifestyle choices of the individuals. This has become an epidemic among various age groups in Sri Lanka and it concerns not only the urban population's health, but also rural regions’ as well due to rapid growth. Hence, it is critical that improper metabolic states be addressed all across the country as a proactive measure. This project intends to address the problem of increased incidence of diseases connected to incorrect metabolic states in Sri Lanka, by preventing the main cause of this, which is inability to maintain a healthy weight. “Delish”, an attempt to support this through a technical standpoint, was established and deployed after analysing the existing gaps in current procedures and comprehending the challenges faced by consumers and industry professionals. The proposed mobile application will be utilised to tackle observed challenges in the Sri Lankan Health care industry as a self-care application. Although there are quite a number of self-help applications available to plan diets for free and for cheap price ranges, they lack evidence-based practices and leave users frustrated. Therefore, the proposed solution is focused on providing a result-oriented solution to those who need support to develop and maintain their healthy metabolic state by addressing some identified problems. Development of the application backed by in-depth research was conducted in the hope of supporting the general public through lifestyle modification strategies or maintain their healthy body weight, as well as keep continual communication with industry professionals, which will increase the process' overall productivity. Many industry experts, technical experts and non-experts reviewed the implemented prototype to determine the project's overall performance in addressing the concerns stated, and the feedback received confirmed the solution's utility and effectiveness in managing inappropriate metabolic states in Sri Lanka.

Keywords: Metabolism, Obesity, Malnutrition, Nutritional Health, Lifestyle Modification, Personalized Diet Plan, Online Consultation, Natural Language Processing, Android Development, API integration

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List of Abbreviations

AI - Artificial Intelligence

API - Application Programming Interface

BFC - Body Fat Calculator

BMI - Body Mass Index

CSS - Cascade Style Sheets

DE - Domain Expert

FR - Functional Requirements

GUI - Graphical User Interface

HTML - Hypertext Markup Language

IDE - Integrated Development Environment

JSON - JavaScript Object Notation

MoSCoW - Must/ Should/ Could/ Would have requirement prioritization

ML - Machine Language

NCD - Non Communicable Diseases

NE - Non-expert

NFR - Non Functional Requirements

NIR - Near Infrared

NLP - Natural Language Processing

OOA - Object Oriented Approach

OOP - Object Oriented Programming

PC - Personal Computer

PHP - Hypertext Pre-processor

PSPD - Project Specification Design and Prototype document

RAM - Random Access Memory

RESTful - Representational State Transfer

SRS - System Requirement Specification document

TE - Technical Expert

UI - User Interface

UML - Unified Modelling Language

UX - User Experience

WBS - Work Breakdown Structure

1. Introduction

"Delish" is a mobile self-care application which supports to get dietary recommendations according to preferences. It is a result-oriented, evidence-based app that can be used to maintain and/or reach healthy weight goals. Considered parameters are not just limited to BMI value, the most common denominator on the existing applications in providing the status of users' bodily health which helps to choose diet types and recipes. Rather, body fat percentage and weekly calorie requirement for the body type are also taken into consideration. Additionally, personal information (age, gender assigned-at-birth and allergies) are used to make decisions. It allows professional, qualified users to suggest edits and enhancements for the recipes present. They can submit new recipes to the application which lets users to see a wide range of accurate recipes. Furthermore, this is a platform where users can connect with professionals for guidance.

1.1 Problem Statement

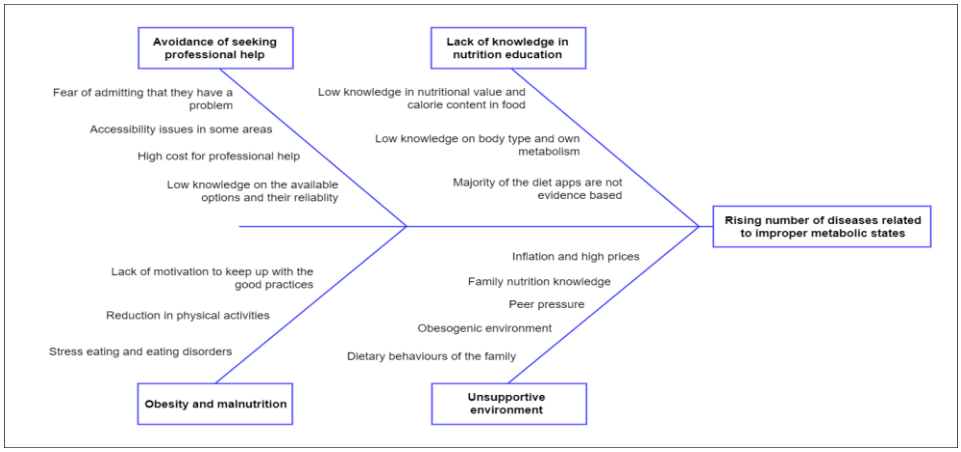


Figure 1-1: Fish Bone: Cause and Effect Diagram

Obesity, diabetes, hypertension, heart disease, and cancer are a few of the diseases linked to disordered metabolic states (Robinson, 2020). In the recent past, it has been identified that Sri Lanka is having a rising number of cases mainly due to lack of control on daily nutrient intake and other lifestyle choices. This is expected to be spread as an epidemic in both urban and rural areas due to the economic crisis (De Silva, 2022). Hence, it is critical that improper metabolic states be addressed (Wickramasingha et al., 2018) as a proactive measure. Further factors contributing to this main problem are shown in *Figure 1-1*. "Delish" will be utilised to tackle these. Although there are quite a number of self-help

applications available, the fact that they lack evidence-based practices and recommend vague ranges of diets leave users frustrated (Hall, 2013).

1.1.1 Lack of Knowledge in Nutrition Education

Majority suffer from the lack of knowledge and struggle to find the suitable diet type for their body type (West, 2013). This greatly affects one's healthy lifestyle, especially when it comes to children and adolescents who solely depend on the nutrient knowledge of their family/guardians (Wickramasingha et al., 2018). Affected children have a higher chance of carrying the burden of non-communicable diseases in their later life (Canavan, 2019). Lack of knowledge among pregnant mothers has its own consequences as it is the biggest cause of death for adolescent girls aged 15–19 due to complications during their conceiving (Canavan, 2019).

1.1.2 Avoidance of Seeking Professional Help

Majority of obese people is reluctant to seek the help they require despite carrying a risk of getting NCDs in the future. Only 54% of obese patients worry that their condition will affect their future well-being while 94% of medical professionals believe obese patients' future will be affected greatly due to current circumstances. Patients tend to conclude it is their own responsibility rather than seeking external support (ACTION, 2018). Majority is reluctant to identify obesity as a disease despite it being named as a one by the international scientific community which causes patients to underestimate their conditions (Clement, 2020).

1.1.3 Unsupportive Environment

A person who is suffering from an improper metabolic state or a person who is at-risk will have the risk of approaching a worse condition due to negative reinforcement (Wickramasingha et al., 2018). Behavioural Change Theories (BCT) have an enormous impact on changing the lifestyle and unsupportive environments become a main culprit (Sogari, 2018) promoting obesogenic surroundings (Wickramasingha et al., 2018).

1.1.4 Obesity and Malnutrition

Globally, obesity is the leading factor for NCDs and it is also linked to a variety of emotional, physical, and biological issues. Premature death owing to obesity-related organ damage accounts for 9.5% of all life years lost in females and 8.4% in men when compared to life expectancy (McGuigan and Wilkinson, 2015). In Sri Lanka, malnutrition of children

and maternal obesity have become serious health issues that need to be addressed immediately (Gunasekara et al., 2019).

1.2 Delivered Aim and Objectives

1.2.1 Achieved Project Aims

The aim is to analyse the current practices in dietary and nutrition field in Sri Lanka and to design, develop, evaluate and test a solution that suggests personalised recipes according to personal preferences, BMI, BFC and ideal calorie intake parameters on an all-in-one platform where users are able to connect with professional dietitians. This will serve as a mechanism to maintain healthy weight as a proactive measure to prevent the NCDs in the future.

1.2.2 Achieved Objectives

ID	Objective	Status
Literature Survey		
PO1	Conduct research on the problem domain to understand the focal areas that need to be addressed through the solution, document initial findings and finalise the scope.	Achieved
PO2	Analyse the existing systems that are used to obtain dietary recommendations and generic nutrition education in order to identify the gaps and areas that could be enhanced.	Achieved
PO3	Evaluate the skills, technologies, possible challenges and tools that need to be utilised to implement the proposed solution.	Achieved
PO4	Confirm the most suitable approach and methodology to manage the project and execute.	Achieved
PO5	Conduct primary research (surveys, interviews etc.) to get input from relevant stakeholders. (Dieticians, nutrition experts and general users)	Achieved
PO6	Identify the related legal, social and ethical considerations that are associated with each phase of the project.	Achieved
Requirement Analysis		

PO7	Prepare the SRS (Software Requirement Specifications) document based on the feedback obtained through in-depth interviews and surveys that are distributed to dietitians and target user audience.	Achieved
Planning		
PO8	Prepare a project execution plan with proper phases and deadlines.	Achieved
Designing		
PO9	Design the interfaces of the mobile app solution according to the identified requirements.	Achieved
PO10	Design the interfaces of the web application for the admin panel.	Achieved
Development		
PO11	Develop the mobile application with recommendation system for the designed prototype.	Achieved
PO12	Connect the application with relevant APIs.	Achieved
PO13	Develop the admin panel as a web application.	Achieved
Testing		
PO14	Review the incremental deliveries and fully integrated product after each phase to check whether expected standards are met.	Achieved
PO15	Obtain test data samples and carry out testing and evaluating after each phase.	Achieved
PO16	Evaluate the finished prototype with stakeholders (domain experts such as dieticians and general users) and technical experts.	Achieved
PO17	Cross check the prototype with the SRS and propose future enhancements.	Achieved
PO18	Document the progress on the final report.	Achieved

Table 1-1: Achieved Objectives

1.2.3 Timeline of Deliverables

Formative and summative assessments favoured greatly in deciding the flow of the project and timeline was planned and captured through a Gantt chart created on Microsoft Project Professional 2013 which are shown below. Please refer to the Appendix II for further details.

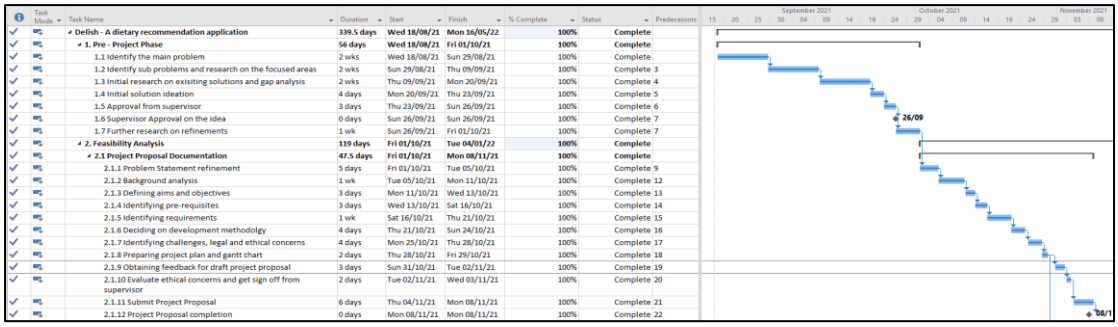


Figure 1-2: Gantt Chart Sample

Deliverable	Objective
Project proposal	4th of November 2021
Literature review – initial draft (Iteratively developed this document based on the changes that were taken to the project till the beginning of April 2022)	25th of November 2021
Software requirement specification	27th of December
Project specifications design and prototype	3rd of March 2022
Prototype demonstration and progress update	21st of March 2022
Draft final year project report	25th of April 2022
Final tested and evaluated prototype	29th of May 2022
Final year project report	21st of July 2022

Table 1-2: Deliverables and Delivered Dates

2. Background

This chapter discusses thoroughly about the root causes that contribute to the rising number of cases in NCDs in Sri Lanka and how nutrition education plays a role in raising awareness in the general public to support making informed decisions regarding their lifestyle choices for the betterment of their health. Furthermore, it discusses the current measures, available tools, and existing applications which specifically focus on the dietary recommendation perspective of this problem and analyses their effectiveness and the limitations. Finally, this covers which tools and technologies are being used to implement the proposed solution for these identified gaps.

2.1 Literature Survey

2.1.1 Improper Metabolic States and Nutrition Education

Introduction to Nutrition Education and Its Importance

Any combination of learning experiences aimed to support the voluntary adoption of eating and other nutrition-related behaviours beneficial to health and well-being is referred to as nutrition education. It is an important aspect of delivering dietary assistance to the elderly as well as the school children. Physical strength, mobility, endurance, hearing, vision, and cognitive capacities are all enhanced by a good diet (Washington Department of Social and Health Services, 2020). In the clinic, community, or long-term health-care facility, health professionals have a varied role in educating an individual. The dietitian's or nutritionist's role in these contexts is to help or enable people to make changes in their eating habits and behaviour. This form of nutrition focuses on the development of long-term behavioural changes rather than knowledge and facts. This can be declared as the procedure of nutrition education: breaking down a vast body of knowledge into small, specific components that are provided to a patient or a client at a rate and a level that they can absorb and apply (Deshpande, 2003). Nutrition education tools in a variety of formats have been used in a vast range of clinical nutrition settings. Guidelines, menu approaches, counting procedures, and exchange systems are among them. The Food Guide Pyramid, for example, is a tool

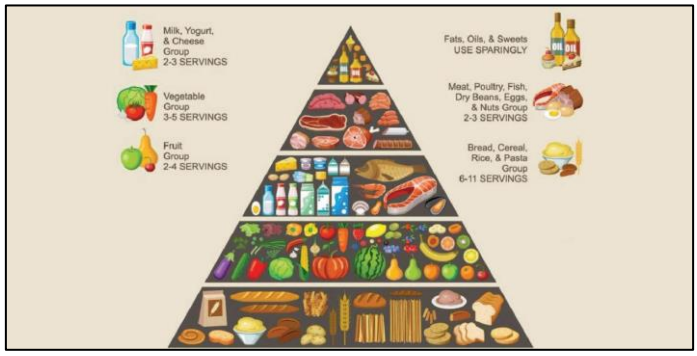


Figure 1-3:The Food Guide Pyramid

that provides basic information to assist people in making healthy food choices. They may offer some information on serving sizes and food preparation, but they lack the specificity of nutrient data that other approaches provide. The *figure 1-3* is a of recommended food guide pyramid for Sri Lanka. If precision in nutrient consumption is not necessary, guidelines function well as a tool for first teaching. They may provide enough information for some persons to adopt dietary adjustments that minimize health risks and enhance clinical markers (Arafat, 2018). In addition to nutrition, nutrition education should incorporate information on physical activity (Washington Department of Social and Health Services, 2020). To summarize,

Nutrition Education Goals:

- To promote and maintain an individual's best possible state of wellbeing by instilling positive attitudes toward good diet and physical activity and providing incentive for better nutrition and lifestyle habits.
- To equip individuals with the required knowledge and abilities for critical thinking about nutrition and health so that they can make good food choices from an increasingly complex food supply.
- To assist the individual in locating resources that will allow them to continue to have access to accurate food and nutrition information.

Nutrition Education Content:

- Food, including the types and quantities needed to meet one's daily nutritional requirements.
- Processes through which the body acquires substances necessary for the maintenance of its activities as well as the growth and regeneration of its components. (Ingestion, Digestion, Absorption, Metabolism and Elimination)
- Behavioural factors that influence one's eating and food preparation habits.
- Consumer difficulties, such as how to manage food purchasing power to get the maximum out of spent money
- Physical activity information.

Diseases Associated with Improper Nutrition Practices

Any nutrient-related sickness or condition that causes illness in humans is referred to as nutritional disease. Dietary deficiencies or excesses, obesity and eating disorders, and chronic diseases like cardiovascular disease, hypertension, cancer, and diabetes mellitus are only a few examples (Weininger, 2019) which affects 87% of the elderly population in the United States (Washington Department of Social and Health Services, 2020).

Below table summarizes a range of nutritional diseases. However, only diseases that are related to the project scope are shown.

Disease Name	Description
Chronic undernutrition and malnutrition: A situation in which there is not enough food to meet one's energy requirements **Types:** Protein energy malnutrition Carbohydrates Essential fatty acids Vitamins (A, B - Thiamin/Riboflavin/Niacin etc., D, E, K) Minerals (Iron, Iodine, Zinc, Calcium, Fluoride, Sodium. Potassium etc.)	More than 925 million people in the world is affected (Weininger, 2019) Asia including Sri Lanka has the largest number of current cases (Rumaisa et al., 2021).
	Characteristics: • Weight loss • Low birth weight in infants • Body fat and muscle wasting • Low growth and development ratio in children • Decreased mental function
Hypertension: Usually defined as a blood pressure of 140/90 mm Hg or higher, i.e., the pressure exerted by a column of mercury 140 mm high during heart contraction (systole) and 90 mm high during heart relaxation (diastole); either systolic or diastolic blood pressure, or both, may be elevated in hypertension	Other disorders such as coronary heart disease, congestive heart failure, stroke, aneurysm, and kidney disease are also linked to it (Weininger, 2019).
	Excess weight, physical inactivity, high alcohol consumption, and high-salt diets have a role in the disease's development
	Overweight people, with extra abdominal fat, are more likely than lean people to develop hypertension.
	Weight loss by itself, even as little as 4.5 kg, can lower the risk
Cancer: Cancer is a condition in which some cells in the body grow out of control and spread to other parts of the body (National Cancer Institute, 2020) **Types:** Colorectal Cancer	Even for those with identical genetic composition, studies of identical twins demonstrate that the incidence of most malignancies is still significantly influenced by environmental circumstances (Weininger, 2019)

Prostate Cancer	Proper dietary practices might prevent 30 to 40% of all cancers.
Diabetes Mellitus: A set of carbohydrate metabolism disorders defined by high blood glucose levels (hyperglycemia) and mainly caused by insufficient insulin synthesis (type 1 diabetes) or an inefficient insulin response in cells (type 2 diabetes) (Weininger, 2019).	A main cause of adult blindness and a major risk factor for cardiovascular disease. Long-term risks: Kidney failure, nerve damage, and lower limb amputation due to poor circulation.
	Although type 2 diabetes usually develops in middle age, it is becoming more common in youth, particularly in obese children.
Obesity	World Health Organization (WHO) recognizes as a global epidemic impacting more than 500 million adults globally, strangely coexisting with undernutrition in both developing and developed countries.
	High blood pressure, blood lipid abnormalities, coronary heart disease, congestive heart failure, ischemic stroke, type 2 diabetes, gallbladder disease, osteoarthritis, several common cancers (including colorectal, uterine, and postmenopausal breast cancers), and reduced life expectancy are all linked to obesity (excess body fat for stature) (Weininger, 2019).

Table 2-1: Diseases related to Improper Nutrition Practices

2.1.2 Risk Factors and Prevalence of Improper Metabolic State

Risk Factors

Unhealthy Lifestyle Habits:

Lack of Physical Activity: A high BMI has been linked to a lack of physical exercise due to excessive screen usage. Healthy lifestyle adjustments, such as getting more exercise and cutting down on screen time helps in achieving a healthy weight.

Unhealthy Eating Habits: Certain unhealthy eating habits such as overconsumption of saturated and trans fats and eating foods with a lot of sugar added to them can raise the chances of being overweight or obese when consumed calories are greater than burned calories. The number of required calories depends on gender, age, and level of physical activity.

Sleep Deprivation: Persons who do not get adequate sleep have a high BMI. Some studies have discovered a link between sleep and how our bodies use foods for energy, as well as how a lack of sleep might impact hunger-controlling hormones (NIH, 2021). According to a 2012 study published in the Journal Sleep, not getting enough sleep causes metabolic alterations that can lead to weight gain. Subjects who slept 4 hours a night had greater levels of ghrelin, an appetite-stimulating hormone, in the study. The authors of the study believe that not getting enough sleep contributes to weight gain by increasing hunger signals, which leads to overeating. Experts recommend 7-9 hours of unbroken sleep per night (Ali, 2016).

High Levels of Stress: Both acute and chronic, affect the brain and cause the release of hormones like cortisol, which regulate energy levels and hunger. Acute stress might cause hormonal changes that result in feeling deprived of food. Persistency of this can cause consuming more and accumulate more fat (NIH, 2021).

Unhealthy Environments:

Social Factors: Having a low socioeconomic status or living in an unhealthy social or unsafe environment.

Environment Factors: Easy access to unhealthy fast foods, limited access to recreational facilities or parks, and few safe or easy ways to walk in the neighbourhood.

Exposure to Chemicals: Obesogenic are substances that can alter hormones and increase fatty tissue in humans.

Family History and Genetics: Obesity and overweight can run in families, according to genetic studies, thus it's likely that genes or DNA are to blame. Obesity has been linked to specific DNA components, according to studies (NIH, 2021).

Race or Ethnicity: Obesity rates in adults in the United States are highest among blacks, followed by Hispanics, and finally whites. This holds true for both men and women. While Asian men and women have the lowest percentages of unhealthy BMIs, they are more likely to have excessive abdominal fat. Because they may contain a DNA variation linked to

increased BMI but not to prevalent obesity-related problems, Samoans may be at-risk for being overweight and obesity (NIH, 2021)

Gender: The way a person's body retains fat may also be influenced by their gender. Women, for example, retain less harmful fat in the abdomen than men. Women with polycystic ovarian syndrome are more likely to be overweight or obese (PCOS) (NIH, 2021).

Prevalence of Improper Metabolic States in Sri Lanka

Obesity: According to the Sri Lanka Diabetes and Cardiovascular Study (SLDCS), a national study on diabetes and cardiovascular disease, they collected data on anthropometric features and their associations in order to study the prevalence of obesity within the country.

Ethnicity	Overweight	Obesity	WC (male)	WC (female)
Asian cut-offs	BMI ≥ 23.0*	BMI ≥ 27.5*	≥90 cm†	80 cm†
Caucasian cut-offs	BMI ≥ 25.0†	BMI ≥ 30.0†	≥102 cm†	≥88 cm†

*Cut-offs proposed for Asians (9).
†International cut-offs recommended by World Health Organization (10).
BMI, body mass index; WC, waist circumference.

Figure 2-1: Definitions of Anthropometric Cut Offs

Characteristic	Male	Female	*P* value
Age (years) ± SD	46.3 (15.8)	46.0 (14.6)	0.510
Urban (%)	17.4	17.7	0.821
BMI (kg m^{-2}) ± SD	21.1 (3.7)	22.8 (4.5)	<0.001
WC (cm) ± SD	78.1 (11.0)	76.7 (12.1)	<0.001
WHR ± SD	0.89 (0.07)	0.85 (0.08)	<0.001

BMI, body mass index; SD, standard deviation; WC, waist circumference; WHR, waist-hip-ratio.

Figure 2-2: Baselines Characteristics of the Sample

	Overweight (%)	Obese (%)	Centrally obese (%)
Men*	22.6 (21.6–25.5)	7.2 (6.6–7.8)	16.5 (15.6–17.3)
Women*	28.0 (26.9–28.1)	11.3 (10.5–12.0)	36.3 (35.1–37.4)
Overall*	25.2 (24.5–26.0)	9.2 (8.7–9.7)	26.2 (25.5–26.9)
Men†	14.3 (13.5–15.1)	2.6 (2.2–2.9)	3.1 (2.7–3.5)
Women†	19.4 (18.5–20.4)	4.8 (4.3–5.3)	18.9 (17.9–19.8)
Overall†	16.8 (16.2–17.4)	3.7 (3.4–4.0)	10.8 (10.3–11.3)

*According to the existing cut-offs for Asians.
†According to the existing cut-offs for Caucasians.
CI, confidence interval.

Figure 2-3: Prevalence of Overweight and Obesity by Gender

		Overweight	Obese	Centrally obese
Urban	Male	30.6 (28.2–32.9)	16.4 (14.5–18.3)	28.9 (26.6–31.2)
	Female	34.8 (32.3–37.3)	20.7 (18.6–22.8)	53.2 (50.6–55.7)
	Overall	32.7 (30.9–34.7)	18.5 (17.1–19.9)	40.8 (39.0–42.6)
Rural	Male	20.4 (19.4–21.5)	4.7 (4.1–5.2)	13.2 (12.3–14.0)
	Female	26.2 (25.0–27.4)	8.7 (8.0–9.5)	31.8 (30.5–33.0)
	Overall	23.3 (22.5–24.1)	6.7 (6.2–7.1)	22.3 (21.5–23.1)

CI, confidence interval.

Figure 2-4: Prevalence of Overweight and Obesity by the Area

	Age (years)	Overweight	Obese	Centrally obese
Male	20–29	17.5 (15.8–19.2)	4.4 (3.5–5.4)	7.5 (6.3–8.6)
	30–39	26.7 (24.6–28.8)	11.3 (9.7–12.8)	22.7 (20.7–24.7)
	40–49	22.6 (20.5–24.8)	10.7 (9.2–12.3)	19.0 (17.0–21.0)
	50–59	29.3 (26.6–32.1)	4.1 (2.9–5.3)	18.9 (16.6–21.2)
	60–69	21.2 (17.9–24.4)	1.0 (0.2–1.8)	16.5 (13.6–19.5)
	>70	13.6 (10.4–16.9)	8.0 (5.4–10.6)	17.3 (13.7–20.9)
Female	20–29	23.7 (21.7–25.6)	5.3 (4.3–6.3)	23.1 (25.1–27.0)
	30–39	29.1 (26.9–31.3)	15.9 (14.1–17.7)	40.6 (43.1–45.5)
	40–49	33.6 (31.0–36.0)	16.4 (14.4–18.3)	44.4 (47.0–49.7)
	50–59	33.0 (30.0–36.0)	12.8 (10.7–15.0)	41.1 (44.3–47.4)
	60–69	23.2 (20.0–26.4)	9.4 (7.1–11.6)	35.1 (38.9–42.6)
	>70	22.8 (19.2–26.3)	4.6 (2.9–6.4)	7.9 (10.5–13.1)

CI, confidence interval.

Figure 2-5: Age Specific Prevalence of Obesity by gender

According to these it was discovered that the country's overweight and obesity rates, particularly abdominal obesity, are disturbingly high. When compared to earlier studies, there appears to be an upward tendency in obesity over time. Obesity is linked to being a woman, physical inactivity, a greater income, a higher level of education, living in a city, and being in 40s among Sri Lankan adults. To counteract this trend, comprehensive public health initiatives are urgently required (Katulanda et al., 2010). Global Nutrition Reports (2015) suggest that, Sri Lanka has made only modest progress on its diet-related non communicable disease (NCD) goals. With an estimated 8.9% of adult (aged 18 years and up) women and 3.7% of adult men living with obesity, the country has made little progress toward meeting the target. Sri Lanka has a lower obesity rate than the regional average, which is 10.3% for women and 7.5% for men. For further trends on prevalence please refer below figures from *Figure 2-6* to *Figure 2-14*.

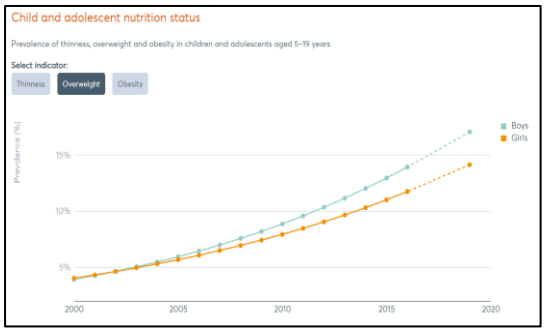


Figure 2-6: Child and Adolescent Overweight Trendline

Figure 2-7: Child and Adolescent Obesity Trendline

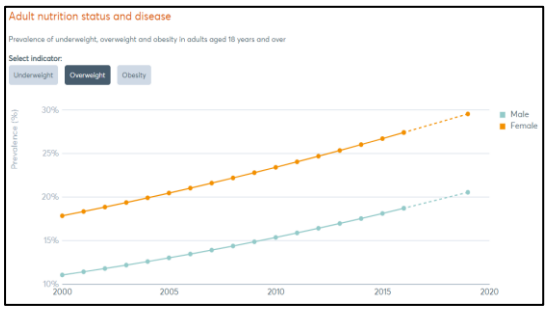


Figure 2-8: Adult Overweight Trendline

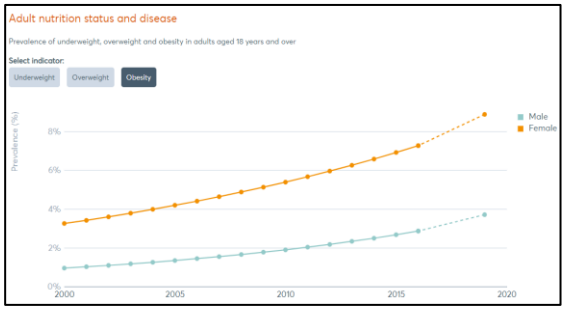


Figure 2-9: Adult Obesity Trendline

Malnutrition: Graphs that are shown below depict trends on the prevalence of the trends of malnutrition in Sri Lanka till 2015.

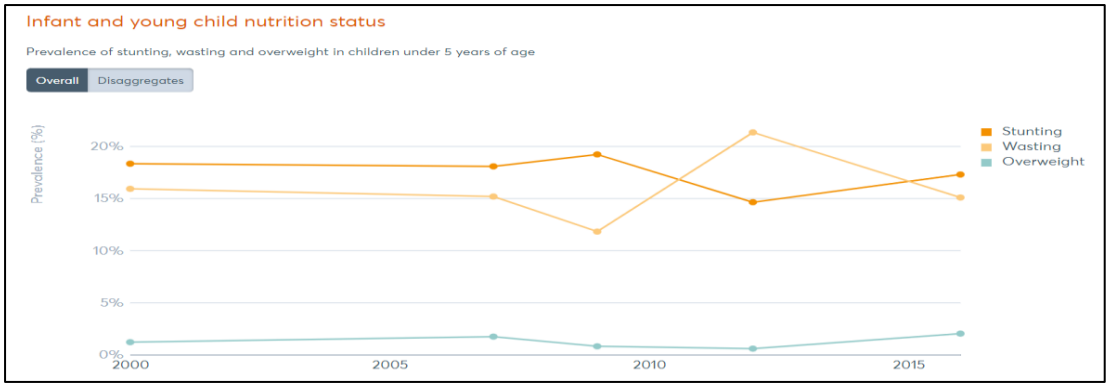


Figure 2-10: Infant and Young Child Stunting, Wasting and Overweight Trendlines

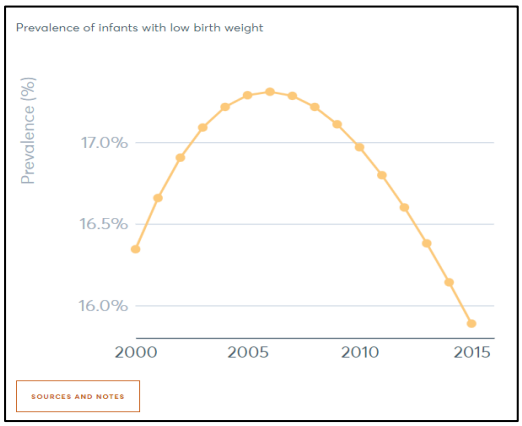


Figure 2-11: Prevalence of Infants with Lower Birth Weight

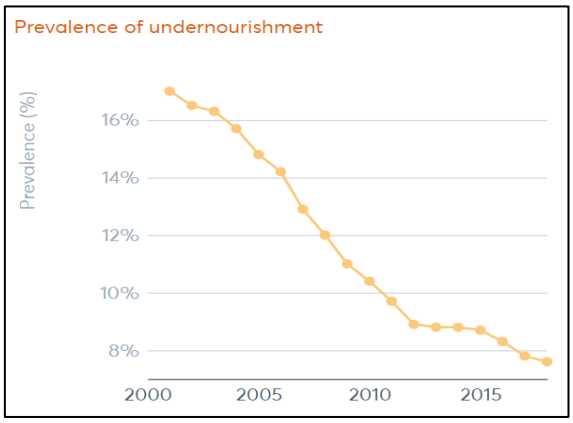


Figure 2-12: Prevalence of Undernourishment

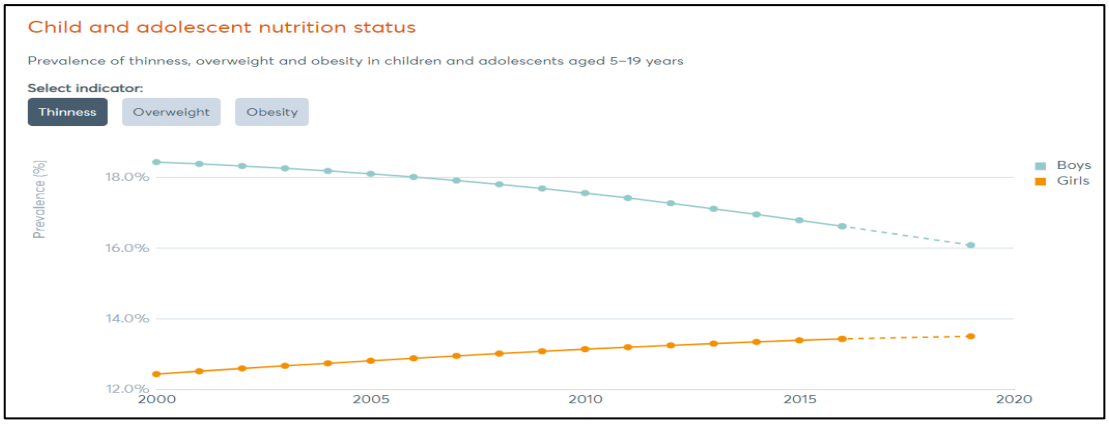


Figure 2-13: Child and Adolescent Thinness Trendline

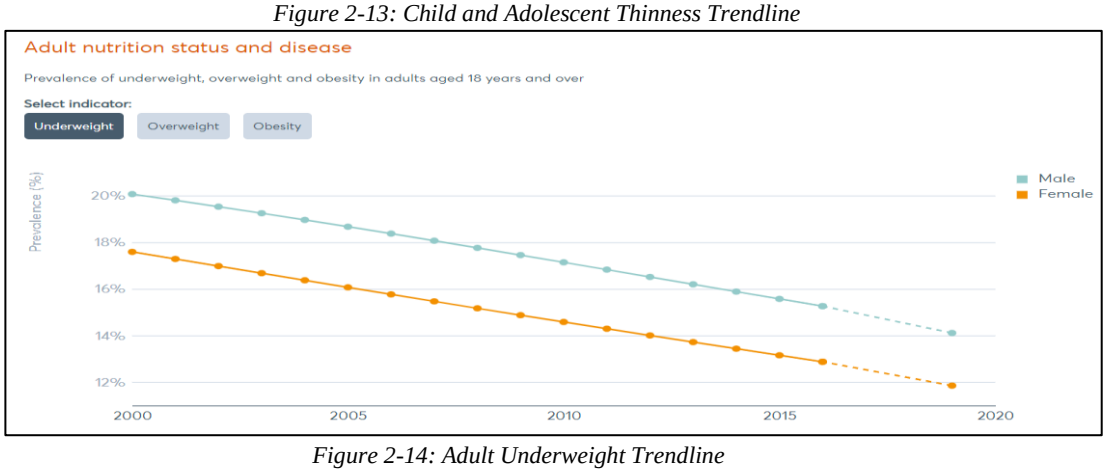


Figure 2-14: Adult Underweight Trendline

2.1.3 Prevention of Improper Metabolic States

BMI - Body Mass Index: The BMI is calculated by dividing a person's weight in kilograms by the square of their height in meters. It is a simple and economical way of determining weight categories such as underweight, healthy weight, overweight, and obesity. Although BMI does not directly measure body fat, it is marginally associated with more direct measures. In addition, BMI appears to be just as closely linked to many metabolic and illness outcomes as these more direct measures of body fatness (CDCP, 2018). BMI is a screening tool; however, it does not diagnose an individual's body fatness or health. A healthcare provider will do additional tests to evaluate if BMI is a health risk. BMI and body fatness have a reasonably good relationship,

BMI	Weight Status
Below 18.5	Underweight
18.5 - 24.9	Healthy Weight
25.0 - 29.9	Overweight
30 and above	Obesity

Table 2-2: BMI Value and Representation

yet even if 2 people have the same BMI, they may have different level of body fatness. This may differ on gender ethnicity, activity level, age group etc. Therefore, BMI alone cannot be used as a tool for dietary recommendations especially in self-care perspective where professional input is absent (CDCP, 2018).

Lifestyle Modifications: People choose what they consume based on different factors. The application of psychological frameworks such as the Theory of Planned Behaviour or the Stages of Change model is required to comprehend these elements (Cade, 2003). These models look into things like food perceptions and motives for changing eating habits. Consumer shopping and eating habits can be influenced by health education (Cade, 2003). The model predicts purposeful behaviour because it implies that activity is planned (Ryan, 2010). Any action a person takes is guided by three types of considerations (Arafat, 2018).

- Behavioural beliefs - beliefs about the likely consequences
- Normative beliefs - beliefs about other people's normative expectations
- Control beliefs - beliefs about the presence of factors that may enable or obstruct the performance of the behaviour

Behavioural beliefs usually lead to a positive or negative attitude toward a particular conduct, normative beliefs to perceived social pressure or subjective norms, and control beliefs to perceived behavioural control. The stronger the person's purpose to conduct the activity in question, the higher the favourable behaviour, subjective norm, and perceived

control (Weininger, 2019). Hence why the importance of the community praise and point system was adhered to in this proposed solution as positive reinforcement on positive behaviour.

Weight Maintenance and Effect of Physical Exercise: There is a clear connection between an individual's weight and his physical health especially in NCDs. As an example, although type 2 diabetes usually develops in middle age, it is becoming more common in youth, particularly in obese children showing obvious correlation between the weight and the condition. Regardless, weight loss and the use of oral antidiabetic medications can assist to normalize blood glucose regulation. In high-risk patients, lifestyle intervention (i.e., Diet and exercise) is highly successful in delaying or preventing type 2 diabetes (Weininger, 2019). Regular physical activity helps older folks maintain their capacity to live independently, as well as people with arthritis, depression, and anxiety. It has been shown to help manage numerous chronic conditions and may lessen the risk of cognitive impairment in older persons (Washington Department of Social and Health Services, 2020). Furthermore, even at a healthy weight range it is vital to maintain that healthy weight constantly. Hence, weight maintenance and physical exercises should be two peas in a pod.

Role of Personalized Diets: Menus are a tool for giving customers detailed instructions on what to eat, such as the type of food, cooking method, and serving size. Several days of menus can be designed for survival instruction utilizing familiar foods to maintain proper nutrition. The popularity of this technique can be seen in the number of patients who meticulously gather their tray menus during their hospital stay. In order to take into account, the patient's culinary preferences and dislikes, most menu planning software rely on input from the patient. Menu planning can be used at both the practical and continuing education levels, and it can be coupled with various teaching modalities (Heins and Delahanty, 2001). Menus can now be planned using computer systems that take into consideration nutrient prescriptions and personal food preferences. Several hundred studies have demonstrated a strong link between a high-vegetable and fruit rich diet and a reduced risk of several malignancies. The dietary approach that is most likely to reduce cancer risk is one that is rich in foods from plant sources, such as fruits, vegetables (especially cruciferous ones), whole grains, beans, and nuts; has a limited intake of fat, especially animal fat; maintains a healthy body weight through a balance of energy intake and physical activity; and includes alcohol in moderation, if at all (Weininger, 2019). However, as we discussed so far due to many factors revolving around an individual a personalized diet will be the most suitable fit when it comes to recommendation. Below *Figure 2-15* shows how different

demographics have different accesses and different requirements for dietary recommendations.

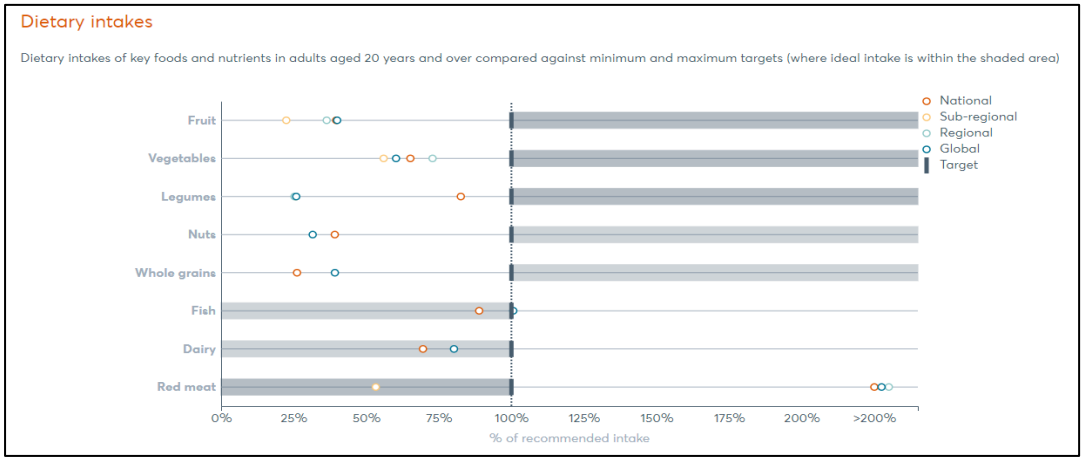


Figure 2-15: Dietary Intake Spread

2.2 Review of Projects / Applications

2.2.1 Usage of New Innovation and Technology

Food decisions can be influenced by information technology. Self-scanners deliver nutrition information that can help you make better food choices right now. Technology can also be employed to assist diners in making educated judgements. 76% of the population said they were aiming to consume healthier restaurant meals than they were 10 years ago (Ross and Srinivas, 2004). Customers can get nutrition information from some restaurants via Web sites, kiosks, staff handheld devices, and receipt printouts. Handheld devices or phones with scanners could read a bar code including nutrient content information and report cumulative daily intake of various nutrients. Some devices can help people become more mindful of their everyday energy consumption. The device calculates and reports total energy expenditure, total number of steps, physical activity duration, sleep length, and other information using complex algorithms, and is more than 90% accurate in reporting the energy expended. It remains to be seen whether such devices will grab the attention and interests of the less driven consumer. The feasibility of widespread usage, the identification of the most successful solutions, and the level of integration required in daily life to be effective are all study subjects (Lewis and Burton-Freeman, 2010). The National Mindless Eating Challenge of America looked into how to help people eat healthier even when they were lacking in enthusiasm. Individuals who were given a decision were found to be less obedient than those who were told what to do. According to the findings, there are four concepts that can be employed to boost the likelihood of weight loss success:

1. Demonstrate that the change is effective
2. Present a stylized but precise set of improvements
3. Provide an accountability instrument
4. Offer encouragement and reassurance (Lewis and Burton-Freeman, 2010).

Consumers can benefit from targeted nutrition innovation, which can also be employed in medical procedures and food production. Targeted nutrition regimens, for example, can be used by health services to help recuperating hospital patients or people with micronutrient shortages. Furthermore, by better understanding the wants and demands of their customers, the food business may improve the nutritional profiles of their products. The market for customized nutrition products is developing at a 15% average rate (EIT Food, 2021).

2.2.2 Feature Comparison with Existing Applications

Feature	Global solutions used in Sri Lanka	Global solutions						Proposed Solution
	Calorie Counter - My Net Diary	My Plate – Calorie Tracker	Calorie Counter -My Fitness Pal	Fitocracy Macros	Shop Well	Nutrinets	Food Intolerance	Delish
Set weight goal								
Enter a target date								
Calculate calorie goal								
Record daily calorie goal achievement								
Recipe recommendation								

according to chosen diet type								
Barcode scanner to calculate calories								Not in the initial version
Allergy setup/reminders								
Connect with dietician (Chat/Video)								
Obtain points for achievements								
Contribute to recipe database								
Book appointments								
Food Database								
Approve/Reject appointments								

Table 2-3: Feature Comparison Table

The biggest and the closest competitor among the existing applications is Calorie Counter by My Fitness Pal. However, the application is not used by Sri Lankans at the moment and the existing "calorie counting" is a mechanism that is not medically recommended to be used without supervision of a qualified personnel and therefore, highly recommended to not be used as a self-care application. Rather it is used currently by people who are already getting medical attention on their dietary behaviours. Moreover, other than the energy calculations, the rest of the calculations are deemed to be less accurate and therefore having a tendency for danger for users (Evenepoel and Clevers, 2020). Since Dieting and nutritional health is not a widespread topic in healthcare aspect of Sri Lanka, calorie counting methodologies or any rules that prohibit, omit or add lifestyle changes using

algorithms have not been included in “Delish” to ensure there is no danger caused to the users by unsupervised usage of the application. Rather, “Delish” caters to work as an informative platform where users can know where they stand and what options are available for them. Furthermore, MyFitnessPal does not have any Sri Lankan cuisines which leaves users in the target demography frustrated if they were to use it. Similarly, all their calculations are developed in generic ways whereas “Delish” has calculations that are specifically accurate for Sri Lankan region thus raising the accuracy of BMI and BFC points of a user. Almost all the applications in the table are only using BMI as a benchmark to determine whether an individual is in a healthy state in terms of their weight. None of these applications provide room for professional feedback within the application despite dietary guidelines should always be reviewed by professionals before distribution to the general public.

2.3 Review of Tools and Techniques

Tools and techniques that were used for the similar kinds of applications have been analysed in order to find the perfect combination of tools for this project. Below sections summarize the findings of this research. Please refer to the Appendix I for further list of tools that were analysed.

2.3.1 Review of Existing Techniques

Technique & Description	Advantages	Disadvantages
Project Planning Stage		
Gantt Chart: This was used to visualize the project's tasks on a temporal scale. This was beneficial in meeting the project deadlines.	Provides a good visual representation of the task durations and milestones An efficient way to track the progress. It forces to understand how tasks are interrelated to each other and how to make the ideal plan. It supports to see the bigger picture and helps to effective time	More effort is required to create and manage the chart and takes a long time to update a chart. However, in a single Gantt view, all tasks are not visible (Analysis Tabs, 2018).

	and resource management (Cuartin, 2022).	
Work Breakdown Structure: This was designed to break down large jobs into smaller, more manageable activities that could be assigned deadlines.	Aids in the definition and organization of the required tasks. In the case of a poorly defined branch, it helps to identify scope hazards. Provides the scope of the overall project. It can help with resource allocation by displaying milestones. (University of Waterloo, 2016)	The step-by-step approach implied by the WBS will collide with the different approaches used for development (Reddy, 2019).
Requirement Elicitation Stage		
Literature Review: This aided to get an understanding regarding the problems, challenges in the problem domain and existing solutions that are provided along with the gaps that need to be addressed.	It aids in the development of knowledge by introducing key concepts, research methods, and experimental techniques utilized in the discipline. It can help to understand how scholars apply principles to real-world challenges.	A literature review takes a long time to complete since it entails gathering and assessing research and summarizing the findings. Because of the large number of sources available in their chosen field, it may be difficult for students to pick the best sources. It could also be due to a lack of prior empirical study, especially if the chosen issue is controversial (Rahman, 2022).
Surveys: The questionnaires were distributed among the general public ranging	Inexpensive, practical, allows to gain responses from a large amount efficiently and provides results quickly. Gathered data can	Respondents may not be 100% truthful about their responses and there could be some questions that are left

from age 18 to 60 to obtain their viewpoints on the desired requirements of the solution.	be compared easily, and can be used to analysis purposes straight away. We can easily handle anonymity factor and there is no constraint on the anonymity (Debois, 2022).	unanswered or not answered to the expected quality (Debois, 2022). The room to personalization is very limited and the respondent might provide unconscientious answers. Questions could be understood or interpreted differently than it was intended to be. Open ended questions could be hard to analysed. Respondent may have a hidden agenda.
Interviews: Interviews were carried out with the dietitians and nutrient advisors to understand the problem domain.	Helps with more accurate screening and the interviewer can keep the conversation focused. We can capture verbal and non-verbal cues including body language, emotions and behaviour (DeFranzo, 2017).	Gathered data needs to be organized and structured manually with more time and effort (DeFranzo, 2017). Sample size needs to be significantly limited due to many constraints that come in to play.
Design and Development Stage		
Use Case Diagram: The relationship between the actors and the system's functionalities were mapped.	Ensures the correct system is developed by capturing user requirements. It helps to document Blackbox functionalities. Use cases offer an objective method of project tracking, allowing earned value to be stated in terms of use cases that	Structure and flow are poorly identified. Geometric and temporal data are difficult to describe. Creating unexpected combinations of aberrant events is time-consuming. Abstract use cases are difficult to generalize from scenario

	have been created, tested, and delivered (Firesmith, 2000).	therefore scenario management is challenging (UX Apprentice, 2011).
Activity Diagram: The workflow of the functions is represented.	Ability to demonstrate the steps performed in a complex UML use case which helps to simplify, clarify and develop processes further (Lucidchart, 2021). It shows how users and the system interact in a business process or workflow.	Do not specify which objects do particular activities or how communicating between them works. Although you can mark each activity with the responsible object, the interactions between the objects will remain unclear (UNC, 2010).
Class Diagram: This was used to represent the system's high-level design.	Helps to establish boundaries and thorough understanding of the structure of the system. It provides a rapid summary of the synergy that occurs among the various system elements, as well as their qualities and interactions (Microtool, 2019).	Takes time to set up and maintain the synchronization with the program code. The diagram could become cluttered and difficult to deal with if you map out every single situation (Pedamkar, 2019).
Wireframes: Wireframes were utilized to envision how the solution would look before it was developed, and they served as the foundation for the UI design.	Clarify the features on the UI and visualize the structure clearly. With a blueprint, content development and overall development become more efficient. Aids in the improvement of usability and navigation (Lynch, 2022).	The client may struggle to grasp the concept because the wireframes do not incorporate any design or account for technical issues. Furthermore, as material is added, it may be too much to fit within the wireframe layout at first, therefore the designer will need to collaborate closely to make

		this work (Mubeenuddin, 2017).
Prototyping: The wireframes were used to create the final prototype which was then tested to ensure that it was fully functional and of high quality.	Provides features and interactions that aid in the establishment of true user communication. Errors are easier to notice and correct at an earlier stage. Incorporate user input and develop additional improvements (Liu, 2017).	Focusing on a small prototype can prevent developers from thoroughly examining the entire project. The potential end result: Better solutions may be overlooked, specifications may be insufficient, or limited prototypes may be converted into poorly engineered and created final projects that are difficult to manage (Rapids Reproduction Inc., 2017).

Table 2-4: Review of Existing Technologies

2.3.2 Review of Existing Tools

Tool	Advantages	Disadvantages
Project Management		
MS Project 2016	Helps to keep projects on track with the timeline, easier to organize work and gives insights to make informed decisions.	Software is expensive compared to the functionalities offered, time consuming to create reports, has too many advanced features that are not generally used and not compatible with many PCs.
Project Documentation		
Microsoft Word 365	Allows access from anywhere with the internet, provides regular automatic updates, has advanced	Expensive, most users never use 50% of functionalities available in the product (Cook, 2021), some functions

	security and powerful integration with any software in office suite.	are not intuitive and time consuming to get desire results (Cook, 2021).
Microsoft Excel 365	Information can be easily organized in more meaningful ways and has streamlined calculations (Natter, 2019).	It can be less user friendly and has a steep learning curve to take up the skills on syntaxes.
Referencing		
Mendeley	Available for free and has a powerful PDF reading function. It is academically well known.	Desktop UI is less appealing, less user friendly, cannot see the existing citations automatically and in some citations the format gets glitched.
MyBib	Can be added as a plugin or/and a website for multiple projects at once, available for free, offers multiple formats, provides notifications on the credibility of the source and automatically shows repeated citations.	Some information on sources is not fetched automatically and needs to be filled manually.
Requirement Elicitation		
Google Meet	Real-time captions for English, cannot record calls in the free plan (excluding IIT accounts) and well secured (Kumar, 2020).	It limits the meeting time up to 60 minutes and does not offer integration with any third-party tool.
Google Forms	Anyone with a Google account can get free access and easy to navigate, can create unlimited forms with vast range of features that can be distributed in multiple ways and can	Only questionnaires and surveys are provided and cannot integrate with 3P applications. Only offers basic reporting and analysis (ClickyDrip Team, 2022).

	be integrated with other Google applications.	
System Design Phase		
Astah.net	Specialized in UML and correct notations are automatically suggested.	Hard to navigate and less control over designing.
Draw.io	Very flexible and easy to use and has templates.	No suggestions are given when drawing and some given templates might not be compliant with UML (SaaSHub, 2022).
Wireframes		
Adobe Figma	Allows real-time collaboration, files can be shared easily, an all-in-one tool for designing, prototyping and hands off, cloud based and can be accessible from any device. Various plugins are available (Ferdian, 2019).	An internet connection is needed and files saved in drafts can be viewed and claimed by anyone if it is published in the free version. The device needs a considerable amount of RAM and a graphic card to run the software properly.
Balsamiq	Provides rapid prototyping with many useful features and shortcuts, can export clickable PDFs and online and cloud version is available in addition to the desktop version.	When the wireframes are complex it tends to lag.
Development and Implementation Phase		
Android Studio	Offers an intelligent code editing system with an emulator that helps to test the applications. It has code templates, lint checks and testing	It cannot be run in a low-end computer and tends to freeze in the middle of a process. The emulator is slower than the third-party emulators. It needs a

	tools and frameworks such as Junit4 and Functional UI. UI is flexible to customize.	higher RAM capacity and the Installation process is long (Arnab, 2022).
Firebase	Flexible, cloud-hosted and scalable databases and learning materials (technical documentation) are available. Many services are free up-to a certain amount of memory used. Easy to integrate.	Limited querying capabilities and data migration. Only Android based (Sykutera, 2020).
Onesignal	Push notifications are available. All the testing related features are available.	Lack of design choices system lags.
Postman API Platform	User friendly and templates are there to test. Seamless accessibility and vast number of functions are supported. The requests can be tracked.	Only ideal for RESTful APIs and cannot add pre-written scripts. It has low integration capabilities (Howard, 2020).
Java	Straight forward and an OOP language which makes it more secured. Due to the nature of its build, it is easier to maintain and cheap. Follows a WORA (write once run anywhere) approach which makes it not dependable on platforms.	It can be slow and perform poorly and has the issue of being weak in the aspect of GUI. It has no means of backing up available and large space is needed. Steep learning curve and complex concepts/codes (Dataflair, 2018).
XML	It is platform independent and Unicode supporting allows to transmit any information in any human language. The stored data can	Syntax is redundant and it causes higher storage cost. It is less readable than other text-based data

	be changed without affecting data presentation (Singh, 2018)	transmissions and arrays are not supported. File sizes could be large.

Table 2-5: Review of Existing Tools

3. Legal, Social and Ethical Issues

3.1. Legal Issues

Sri Lanka's Code of Conduct for Health Research: The National Health Research Council (NHRC) established this to apply to all human health research conducted in the country. It emphasizes the obligations and responsibilities of researchers and relevant organizations to perform research solely for the sake of human health promotion, disease prevention, patient management, and social benefit through improved health systems. (Code of Conduct for Health Research in Sri Lanka, 2018) This code highlights research standards and provides information on how to practice research integrity.

The National eHealth Standards and Guidelines (NeGS): A collection of principles and standards to follow while adopting eHealth solutions in both the public and private sectors in Sri Lanka. eHealth Architecture, ICT Governance, Network and Connectivity, Communication Interface, Security, Confidentiality and Privacy, and Data Communication Standards are the six primary topics that should be considered in Sri Lanka's eHealth policy (National eHealth Guidelines and Standards, 2016).

3.2. Social Issues

Attitude of the Users: The use of mobile applications for eHealth is on the rise. Despite this, some customers regard the use of mobile devices as an addiction that must be avoided. Furthermore, some users are suspicious about new tech-related solutions. As a result, the proposed solution would suffer (Kemp, 2020).

Mobile Literacy: Some users may be unable to use mobile-related technology effectively. This is especially prevalent among older and/or rural users. They would be hesitant to use mobile applications or new technologies, preferring instead non-technical therapy techniques (Department of Census and Statistics Sri Lanka, 2019).

Failure to Capture User Segments: There is a chance the app will not reach specific client segments in the target market (for example, customers who cannot afford to participate in

fitness/diet programs because they are expensive, or customers who are hesitant to believe a technological solution can help them treat ailments) (Haputhanthri, 2021).

3.3. Ethical Issues

Privacy Settings: Private information of users should not be shared or made public without their consent (Ranasinghe, 2020). Proper measures should be taken to ensure the security of this data that is been stored in the application. Furthermore, data should not be used for any other purposes rather than for calculations within the application. It should be highlighted that these practices should be performed during the data gathering phase as well where it is assured that only required data is gathered (Fernando, 2020).

Accuracy: Dietary information should be properly reviewed and validated by nutritionists, dietitians, and physical trainers. It should also not be false or misleading in any way that might cause the user injury or distress.

4. Design

4.1 System Design for the Prototype

4.1.1 System Architecture Diagram

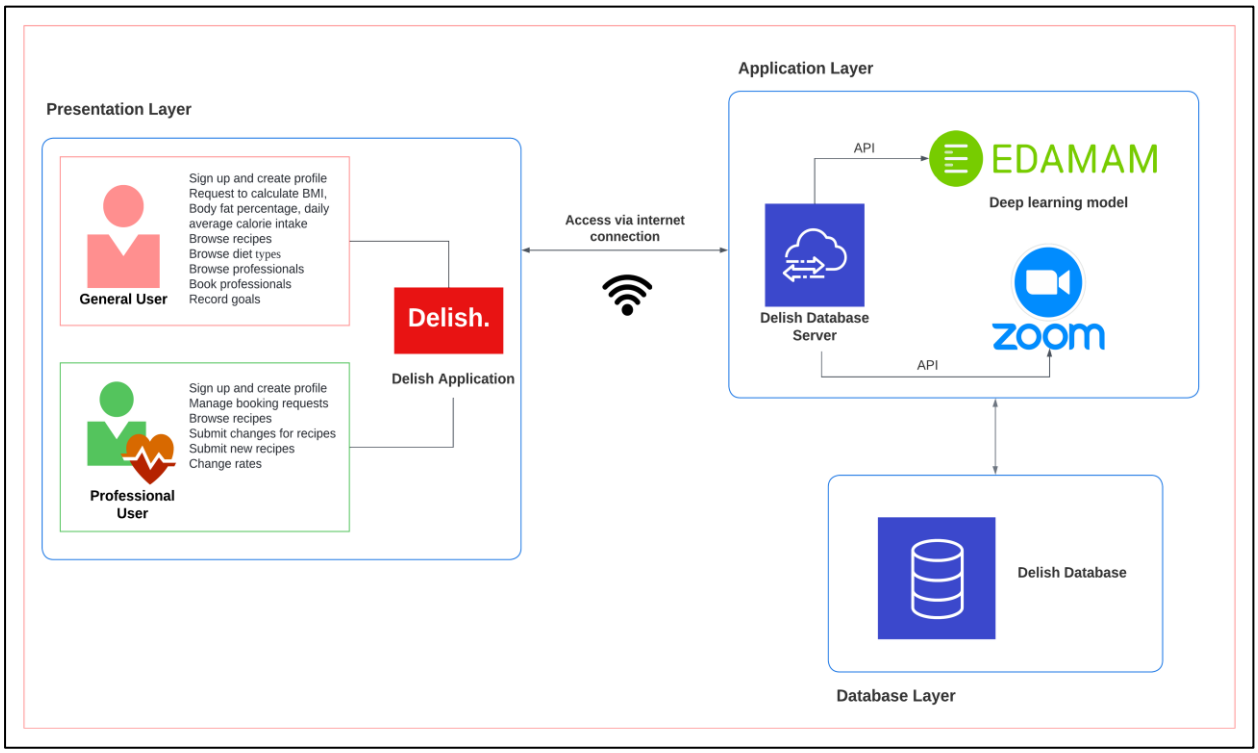


Figure 4-1: High Level Architecture Diagram

4.1.2 Class Diagram

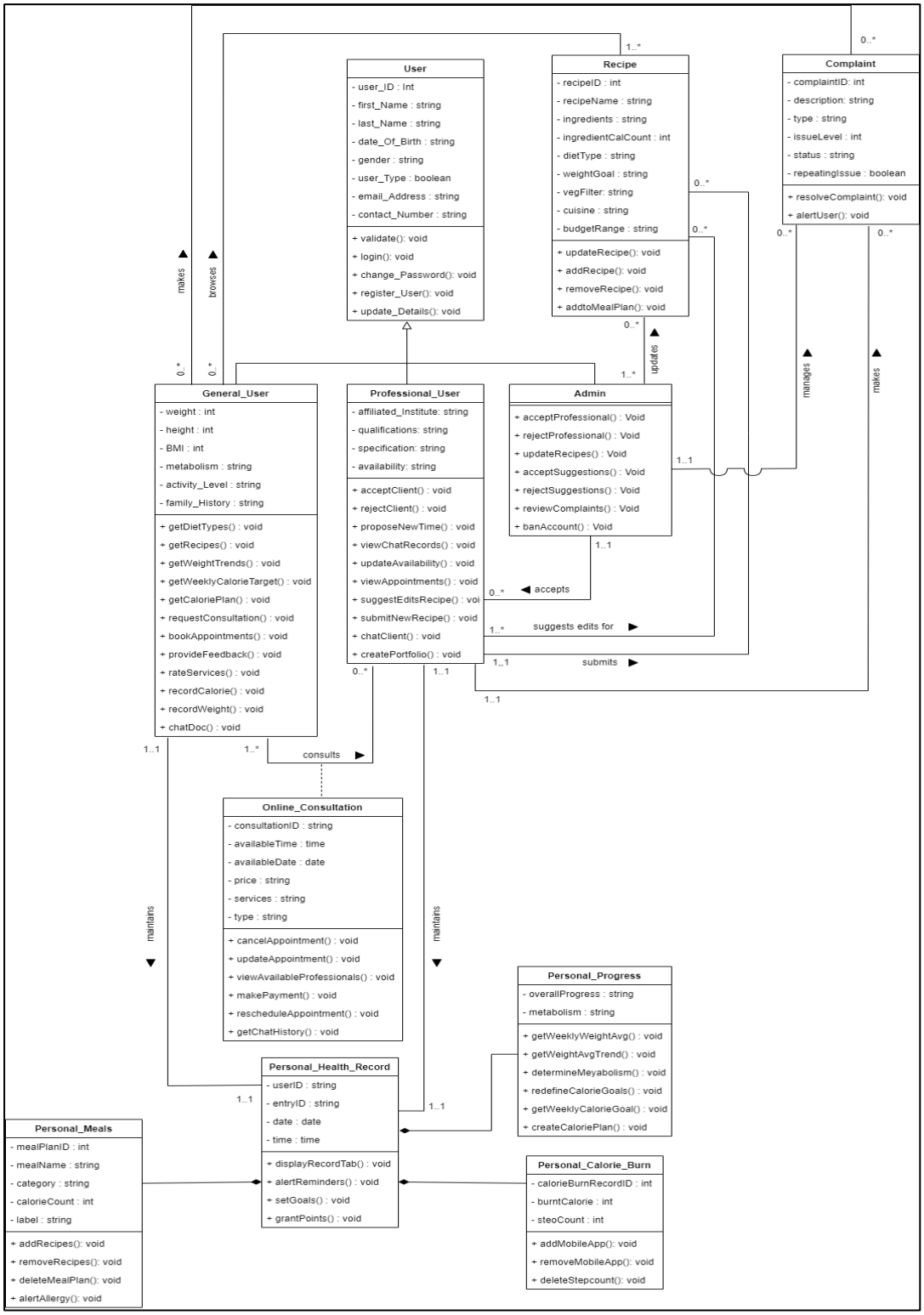


Figure 4-2: Class Diagram

In this section, high-level system architecture created under the three-tier approach and the class diagram designed to plan the structure of the proposed system are depicted in *Figure 4-1* and *Figure 4-2*. These depict the clear and concise overview on the relationships

between the components of the system. How the user interface was designed to deliver the finalized requirements (*Table 3-1* and *Table 3-2*) through these structures are later on described in the section 4.2 and 4.3.

4.2 Final List of Requirements

4.2.1 Functional Requirements

ID	User Type	Requirement Description	Page	MoSCoW	Sprint
FR01	General User, Dietitian	User should be able to choose their account type (general user, dietitian)	Login	M	01
FR02	Dietitian	User should be able to submit proof documents for their professional account setup		M	01
FR03	Admin	User should be able to verify and accept professional account		M	01
FR04	General User, Dietitian	User should be able to input details (age, gender, height, weight, allergies)		M	01
FR05	General User, Dietitian	User should be able to choose a diet type Weight Loss - Plant Based, Low Carb Weight Gain - Plant based, non-Vegetarian		M	01
FR06	General User, Dietitian and Admin	User should be able to sign up and login		M	01
FR07	General User, Dietitian	User should be able to logout		M	01

	and Admin				
FR08	General User, Dietitian and Admin	User should be able to change credentials (password)		M	01
FR09	General User, Dietitian	User should be able to view information on diet types (introduction, advantages, disadvantages)	Profile	M	01
FR10	System	System should be able to automatically calculate BMI and show status (underweight, healthy weight, overweight)		S	01
FR11	General User, Dietitian	User should be able to browse recipes	Search bar	M	02
FR12	General User, Dietitian	User should be able to filter recipes (Sri Lankan, Veg, Non-Veg, Asian, Indian etc.)	Recipes Page	M	02
FR13	System	System should be able to recommend recipes according to profile information	Recipes Page	M	02
FR14	System	System should be able to prompt a warning when a chosen recipe contains allergic ingredients	Recipes Page	M	02
FR15	Dietitian	User should be able to add new recipes and suggest edits for recipes	Recipes Page	S	02
FR16	Admin	User should be able to verify and accept new entries to the recipe database	Recipes Page	S	02

FR17	General User	User should be able to search for dietitians	Search Bar	M	03
FR18	General User	User should be able to book appointments	Dietitian Profile	M	03
FR19	General User, Dietitian	User should be able to join scheduled appointments through the app	General User Profile	M	03
FR20	General User	User should be able to view the portfolio of a dietitian	Dietitian Profile	M	03
FR21	Dietitian	User should be able to respond to appointment requests	Dietitian Profile	M	03
FR22	Dietitian	User should be able to post charges for the sessions on their portfolio page	Dietitian's Profile	M	03
FR23	General User, Dietitian	User should be able to record goal progress and change status	Profile	S	04
FR24	System	System should be able to change user profile status according to the usage of the app.	Profile	W	04
FR25	General User	User should be able to get weekly calorie goals	Profile	C	04
FR26	System	System should be able to add recipes that were added by a dietician to recipe database	Recipe page	W	04

Table 3-1: Functional Requirements Table

Some of the requirements shown in the PSPD were deemed not crucial to deliver a viable product (luxury and could have/Would have priority) and subsequently were removed from the final prototype due to the time constraints and significant skill gaps. Furthermore, recipe recommendation functionality's ML algorithm was later changed into a simple rule-based approach due to the code being unnecessarily complex.

4.2.2 Non-Functional Requirements

ID	Constraint	Non-Functional Requirement
NFR01	Usability	1.1 The application should be clear and should have a user-friendly interface 1.2 The user should be able to easily navigate through the application
NFR02	Performance	2.1 The system should be able to handle multiple users at any given time without being affected by the performance 2.2 The application should load within three seconds and the videos should load within a maximum of five seconds 2.3 The system should not crash when invalid data is provided 2.4 The system should not compress or stretch out high-quality videos and images
NFR03	Availability	3.1 The system should be available 24/7
NFR04	Security	4.1 The user passwords should be kept confidential and should be encrypted 4.2 The application should be accessed only by users with valid credentials 4.3 The personal details and health records of the users should not be disclosed to the general public 4.4 The database should be backed up constantly
NFR05	Scalability	5.1 The application should be able to incorporate new features without affecting its existing functionalities as the application progresses
NFR06	Reliability	6.1 The system should provide accurate and personalised recommendations to improve the disease conditions

Table 3-2: Non-functional Requirements Table

4.3 Design Considerations and Implementation

4.3.1 User Interface

When designing the UI, the key goal was to create a goal-oriented and user-friendly platform that users from any background could understand. Delish's consumers include people who want to maintain or achieve a healthy weight, as well as industry experts (Nutritionist, dietitians and fitness coaches). According to the results of the survey, the majority of users are between the ages of 18-60 and come from various technological literacy backgrounds. As a result, a simplified user interface was necessary, as well as a clear page navigation structure with a minimum number of clicks to accomplish the goal. Below screen designs show how it is designed in an easy navigational manner for even admins.

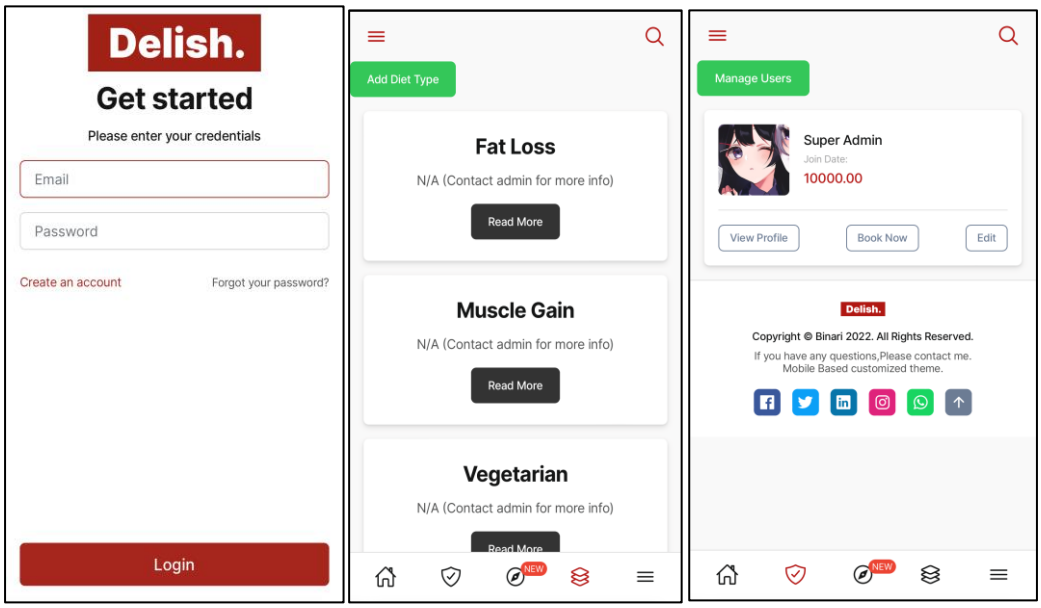


Figure 4-3: Registration, Add Diet types page, Check professionals

All the information is shown in a direct manner for an average user to understand the ideas and navigate easily.

Below examples show how it is easy for a user to get the idea of a recipe even before clicking on it by the key details that are shown graphically. When they enter a profile of a professional user, as shown above they are able to see their contributions to the recipe

database. Professionals can add any other information as well as per their liking.

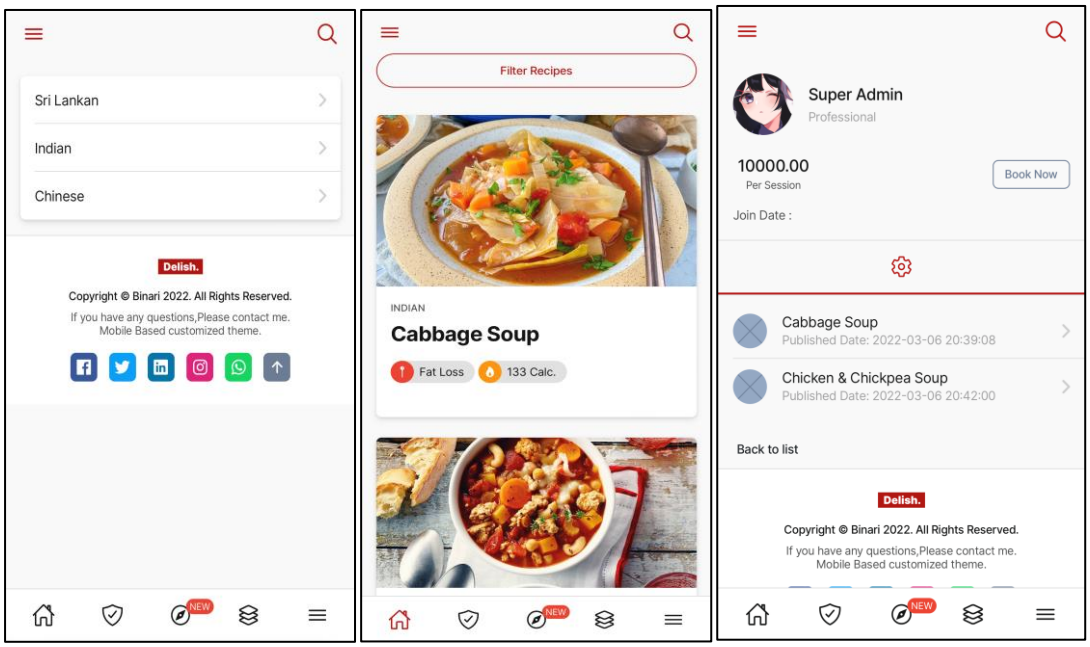


Figure 4-4: Filter Recipes, Browse Recipes, Professional Profile

Easy booking through simplistic forms and calculating bodily health through simple yet practical calculators are shown below. Colour schemes are used to give an idea on whether the weight is healthy or not for the body type.

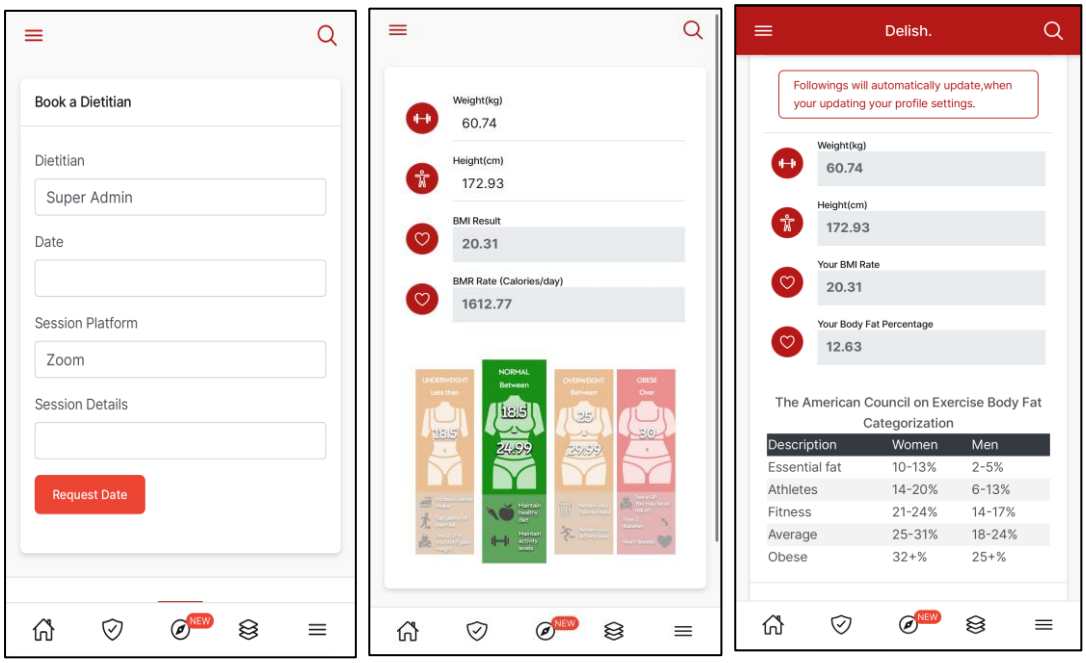


Figure 4-5: Book a Professional, Calculators

Below screen designs show adding goals for your personal profile and submitting recipes to the database which works as value additions. These features have potential to be evolved into more sophisticated customer retention features that can urge users to keep using the

application. Moreover, the application comes with both generic light them and dark theme where it has high contrast UI designs.

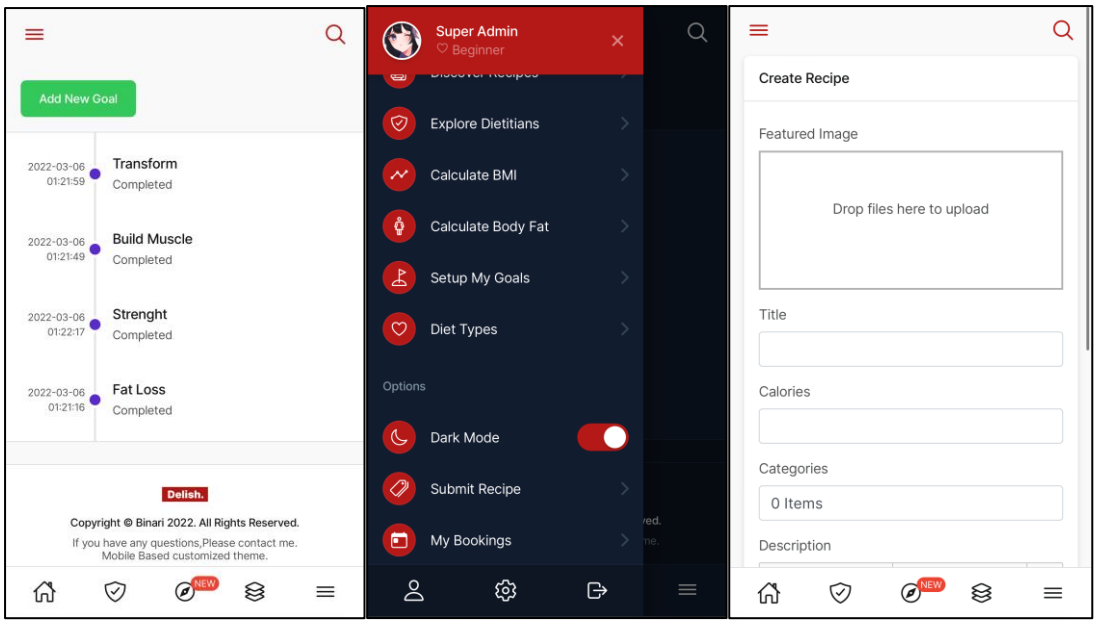


Figure 4-6: Add my goal, Dark theme, Submit Recipe

Below shown are a few screen designs that are created for more informative pages where the user can see their personal information and past bookings. Action buttons are contrasted with the usage of colours.

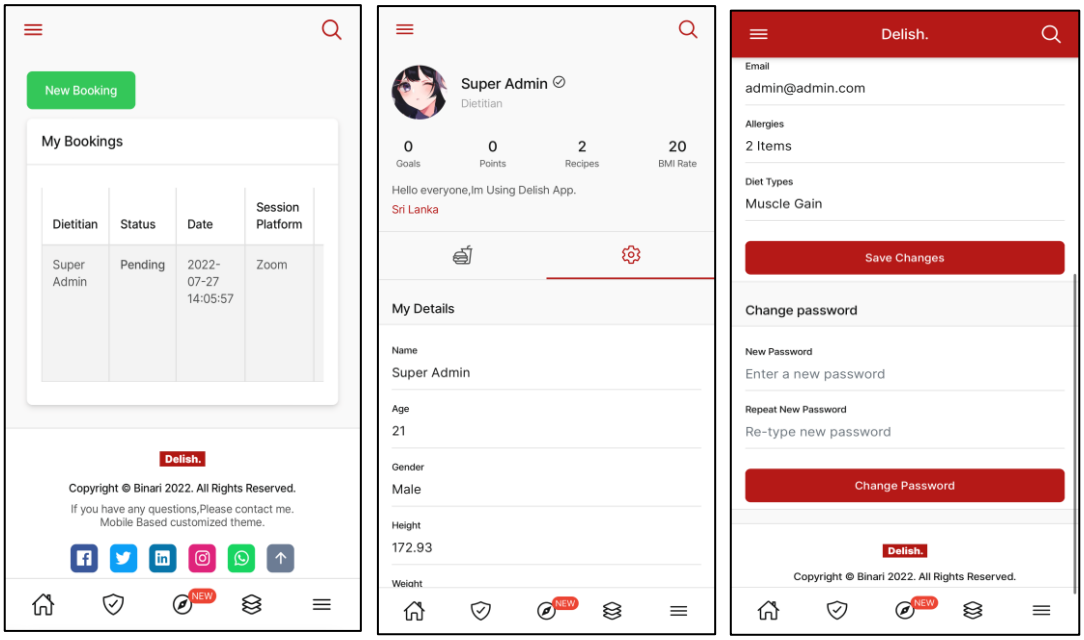


Figure 4-7: My Bookings, My Profile, Profile Details

Furthermore, below screen designs show the view once a user clicks on a specific recipe to see further details. This UI clearly shows who published the recipe, ingredients, instructions and a form to suggest edits according to your own expertise. Furthermore,

under Laravel framework, admin dashboard has been created to review professional user requests, recipe submissions, allergy information management. This is created as a standard following standard admin dashboard formats.

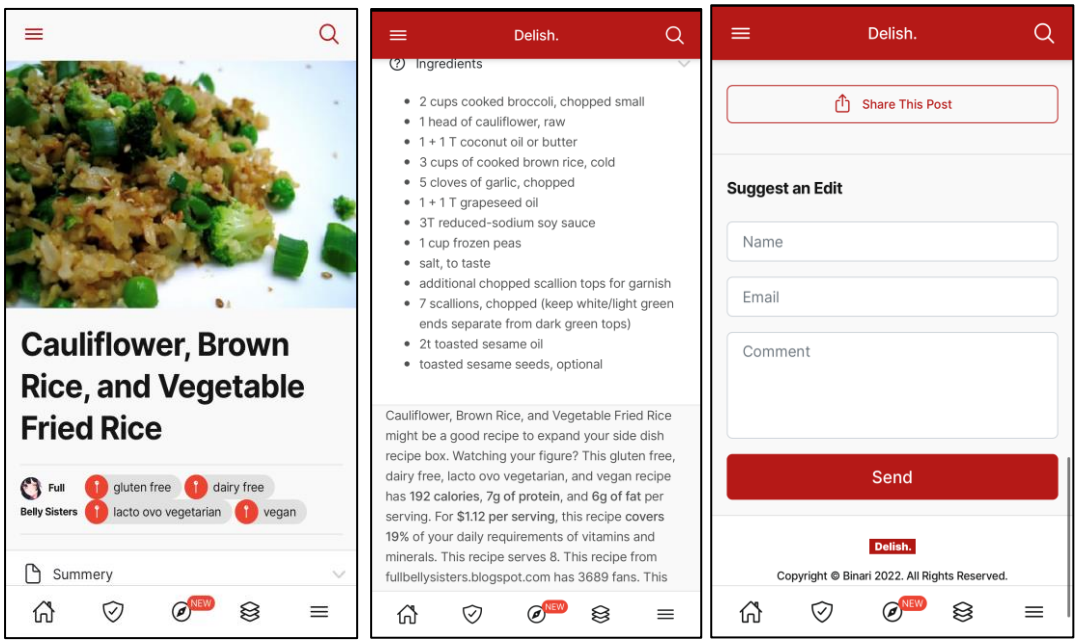


Figure 4-8: View Recipe, Edit Recipe, Share Recipe

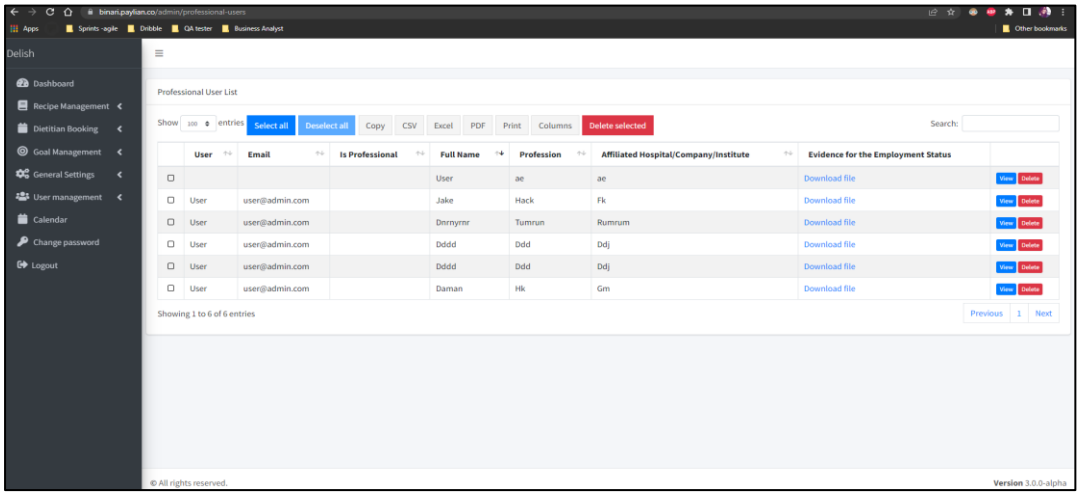


Figure 4-9: Admin Panel

4.3.2 Content of the Application

Content of the application was built with the consumer needs in mind. Because the majority of users lack in-depth understanding of the subject, all information was created to be straightforward and obvious without being monotonous to read. The content was kept to a bare minimum to avoid confusing or alienating consumers. Superfluous content was avoided, saving users from being burdened with irrelevant details. Approach of

the language was kept basic and clear, and specific instructions were offered for each action, trying to make the app accessible to all users.

4.3.3 Functionality Design and Development

Because of the schedule constraints for the project, the application was only determined to be developed as an Android mobile application. As a result, the end-user Android application was created using the Android Studio IDE, and the admin panel was created on the web using the "Laravel" framework. Initially, it was decided to build the app using Flutter and “Dart” language, but owing to time and knowledge constraints, it was decided to use the frameworks indicated above. To install and use this program, the user must have an Android device with an internet connection. Furthermore, there was no dataset available that contained cuisine or dish suggestions specific to Sri Lanka. As a result, the “Edamam” API framework, which gives diet and meal recommendations based on the physiological health needs of the user, was chosen to construct the fundamental functionalities of the system, which is to present users with tailored recipe suggestions. It provides the best customised meal ideas using Natural Language Processing (NLP) and Deep Learning algorithms.

4.3.4 Designing Tools

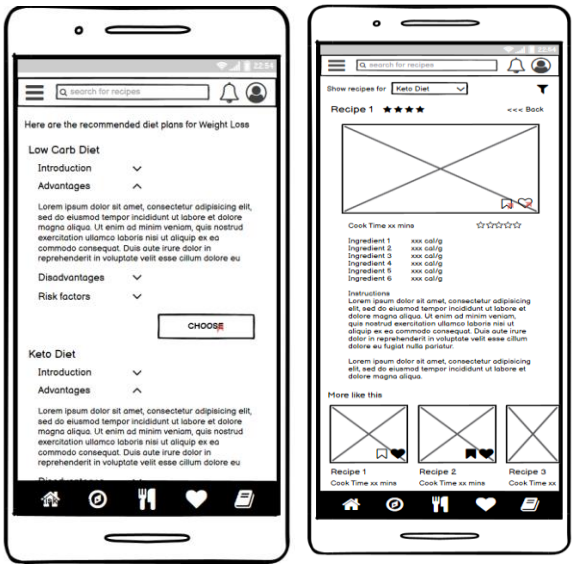


Figure 4-10: Low fidelity wireframes - Balsamiq

For low fidelity wireframes Balsamiq was used since it is a tool that supports in rapid wireframe creating which helps to get feedback earlier. Hence, it is ideal to get the sign off for the basic design before moving on to the high fidelity designing. Below are a few screens from designed low-fidelity wireframes. For the high-fidelity prototypes shown above, Adobe Figma was used as it is web based and cloud hosted which secures the created designs and helped me to save few versions till, I got to the last version.

5. Methodology

5.1 General Approach

This project was completed using an **iterative and incremental method**. Because the technology to be employed for the completion of the project could not be determined at the outset, this was determined to be the best method for this project. The iterative and incremental method is a flexible approach that allows for changes throughout the project's development cycle (Alshamrani, 2015), which has proven to be extremely useful in dealing with unforeseen challenges that arise during implementation and must be addressed by making necessary changes to the requirements. Delish is a miniscule initiative that one amateur developer is expected to complete in 8 months. This method saves time by identifying and resolving problems at each cycle. It also aids in implementing improvements recommended by the supervisor and industry professionals with minimal disturbance after each iteration. As a result, this technique was quite helpful in dealing with such scenarios, and the finished product will be more aligned with the user's objectives.

5.2 Project Management Approach

For this project, the **PRINCE2 project management approach** was adopted. PRINCE2 is extensively used around the world because of its flexibility and assistance for effectively managing projects of any size and scope that can be adjusted to meet the individual needs of a project (Vanková, 2017). It's a methodical strategy that emphasizes structure and control throughout the project, from conception to finish. That means projects are well-planned before they begin, each stage of the process is well-structured, and any loose ends are neatly tucked away once the project is over (Slate, 2022). This strategy was chosen since the project had to be done in stages to fulfil the university's deadlines. The project's complicated requirements could be planned and accomplished on time. It also helps to keep the project on track by maintaining comprehensive evaluations of the progress of the project, which minimizes any damage potential (Haputhanthri, 2021). Furthermore, this methodology welcomes the possibility of incorporating new features and change management in the future which works well as this is just the initial first version prototype of a product that has a long way to go. Refer to the Appendix II to see the Gantt chart that was utilized as a tool for this.

5.3 Software Development Approach

Due to the unpredictability of the proposed system due to knowledge gaps as a new developer, the **Object-Oriented Approach (OOA)** was used as the software development approach along with the **Rational Unified Process (RUP)** since it encourages UML for the design procedure. This comes in handy when creating new objects at any moment without interfering with the existing functions. It is also quite useful for keeping a clean and straightforward code structure. The availability of separate objects makes it simple to discover and correct code errors. Furthermore, this is a flexible technique that allows code components to be reused (Silva, 2018) which was helpful with many features in the app such as recipe filtering and consultant filtering. The development process was divided into few categories for better tracking and management. They are; inception, elaboration, construction and transition where a clear structure is given for the development to reduce the wastage of resources during the course (Magfiroh, 2020).

6. Tools and Implementation

6.1 Used Skills and Tools

6.1.1 Utilized Tools

Tool	Justification
Libraries	
Glide	The image loading and handling API on Android is dreadful and even resizing an image without generating an "OutOfMemoryException" is a rare occurrence. Glide is an image loading library with a beautiful API that lets the developer to alter images in any way they desire. This API makes it simple to load a remote picture into an ImageView, set fallback images, cache and resize photos, and much more. It even comes with some basic changes, such as a circular image cropping. Therefore, this was used to manage the images that are used in the recipes (Korman, 2018).
Database	

Firebase	This database lets storing user details, and other metadata. And the in-built cloud storage is utilized to store user-generated content to be stored. Furthermore, the same can be used for authentication purposes as well. Quality and the smooth UIs help with the learning process for an amateur developer. Laravel is a PHP framework based on the MVC model that enables a clear separation between presentation and business logic which is ideal for this project (Singla, 2022)
Framework	
Laravel Framework	This is a backend PHP framework that provides a platform for developing PHP web applications that provides code libraries of commonly used functions to reduce development time and aid in the creation of more secure and scalable web applications.
Gradle	Gradle is a software development tool that is noted for its versatility. The construction of applications is automated using a build automation tool. Compiling, linking, and packaging the code are all part of the construction process. With the help of build automation tools, the process becomes more uniform. It is highly customizable and can be used in Java projects, Android projects and Groovy projects. Furthermore, it supports many numbers of IDEs (Gaba, 2022) including Android Studio.
Integrated Development Environment (IDE)	
Android Studio	This is the official integrated development environment for Android application development and it has code editing and developer tools. This can support for development, testing and packaging Android applications. It has a wide range of third-party plugins that offer different services. For UI development it offers, text, design and blueprint views along with style and theme editors. Furthermore, it is considerably faster than many other competitors out there (Mathur, 2018).
Dependency Management	

Composer	Coding in PHP is easier when using a dependency management tool. It helps to work with bundles that are created for different types of frameworks. Specially for tasks such as authentication, database management and request routing it can be exhausting to repeat the same process repeatedly. This tool handles with all these kinds of dependencies that comes with PHP (Nagare, 2018).
Languages	
Admin Panel	
PHP	This is a scripting language for creating dynamic and interactive webpages. It was one of the first server-side languages to be integrated in HTML, making it easy to add functionality to web pages without having to access data from separate files. Its functionality has grown over time, with regular updates introducing new features and unlocking new capabilities. It is easy to use and learn and it is open source all of which are ideal deals in this context to manage resources and time (Mino, 2022). Hence, this was a perfect choice to create the admin panel.
Javascript	This is light-weight, object oriented and used to create the website for admin panel. When applied to an HTML document, JavaScript allows for dynamic interactivity on websites. It allows to develop modern web applications that allow users to interact without having to reload the page every time (JavaTPoint, 2020). Therefore, this was chosen to use during the development of the admin panel.
CSS	CSS is a stylesheet language for web pages. It specifies how a document created in a markup language looks and is formatted. It adds to the functionality of HTML. It's commonly used in conjunction with HTML to change the look of web pages and user interfaces. This was useful in creating the webapp since I have a basic understanding as well (JavaTPoint, 2018).

Bootstrap (AdminLTE 3 template)	This is a versatile front-end framework for building modern webpages and web applications. It is free to use and open-source, however it comes with a lot of HTML and CSS templates for UI elements like buttons and forms. JavaScript extensions are also supported by Bootstrap. It's simple to set up and master, with a large number of components, a strong grid system, styling for numerous HTML elements ranging from typography to buttons, and JavaScript plugin compatibility, making it even more versatile (Bacinger. 2021).
Android App	
Java	Java may be used to create apps for a variety of platforms. Because Java complies with WORA criteria, the same code can be run on every platform that supports the Java Runtime Environment (JRE) without having to recompile it. Java is an OOP language and has good security (Aternity, 2021). Therefore, I incorporated Java to develop the mobile application.
XML	This is often used to separate data from presentation as it does not carry any information on how it should be displayed. The same XML can be interpreted differently according to the scenario. Therefore, this can be used to transact data (w3schools, 2019). Therefore, this was used as a medium of transaction in the mobile application.
RESTful APIs	
Onesignal	This API was used as a method to send push notifications.
Edamam	Edamam is a nutrition analysis API and database that uses Natural Language Processing (NLP) to extract food entities from unstructured text and uses deep learning algorithms to deliver customised meal suggestions. This includes the most cutting-edge nutrition analysis technologies on the market. This was utilized to provide users with individualized meal recommendations (Haputhanthri, 2021).

Postman API platform	Postman is a program that is used to test APIs. It's an HTTP client that uses a graphical user interface to test HTTP queries, allowing developers to get various forms of answers that must then be validated. Therefore, this platform was used to find APIs and also to test out APIs that are implemented (Romero, 2021).
Code Editor	
Visual Studio	Microsoft Visual Studio is an integrated development environment (IDE) developed by Microsoft for several types of software development, including computer programs, websites, web apps, online services, and mobile apps. Completion tools, compilers, and other capabilities are included to make the software development process easier. Therefore, this was used as the code editor for the development of this project (Incredibuild, 2021)

Table 6-1: Utilized Tools and justifications

6.1.2 Utilized Skills

Due to the lack of experience and knowledge in mobile application development, and handling the tools that are mentioned above, new skills were necessary to be learned. However, due to the time spent studying, the project timeline progressively became somewhat tight, and as a result, a few of the functions (including barcode scanning) and special technologies (including machine learning) were omitted in the final version to make it simpler. As a result, the anticipated skills mentioned in project proposal may differ from the skills specified in this document. Using Android Studio and Gaddle to create mobile applications was a major new skill that I gained from this project. Using the programming languages Java for the mobile app and Bootstrap for the admin panel were also new abilities learned through this project. Furthermore, due to the scope of needs in this project, my basic understanding of CSS, Javascript, and PHP had to be developed and refined further. In addition, the system's integration of other services such as the Edamam API, libraries, frameworks, and other APIs was self-taught throughout the course of this study. This is a key skill learned during the project's implementation. Furthermore, I refined my time management and project management skills, documentation skills and soft skills such as communication between different stakeholders with different backgrounds and knowledge

levels in the subject area. It was also crucial for me to learn the risk management, testing and version management perspective of the software development lifecycle in order to fulfil project requirements. Last but not least, all the development was backed through thorough research I have conducted in order to understand the domain and demand better which required me to fine tune my researching, problem solving and critical thinking skills.

6.2 Implementation

6.2.1 Personalized Recipe Suggestions

A registered user is asked to search for a food item by providing a keyword on the search bar in order to receive meal options for that item, as depicted in *figure 6-1*. They can also choose their dietary limitations choices as shown. For each food item, nutritional information such as calorie count, suitability for diet goals (e.g., Fat loss, weight gain) and preparation information are provided which is shown in *figure 6-2 and 6-3*.

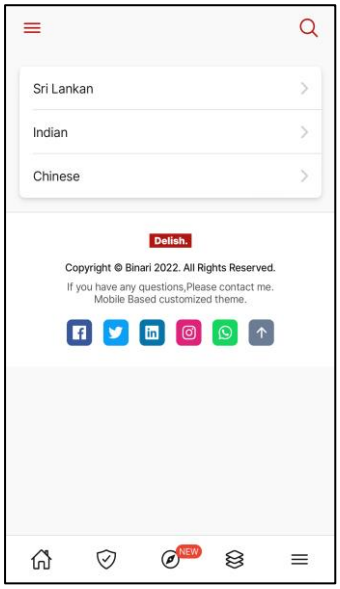


Figure 6-1: Filter Recipes

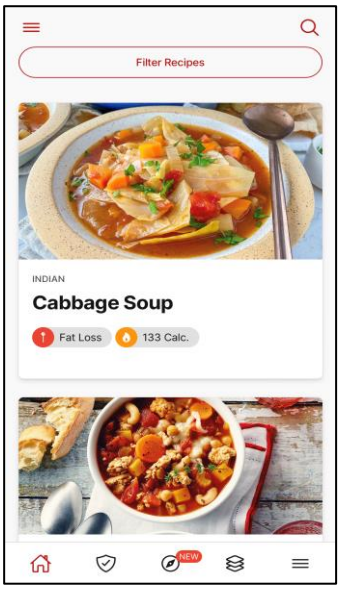


Figure 6-2: Nutrition information of the recipe

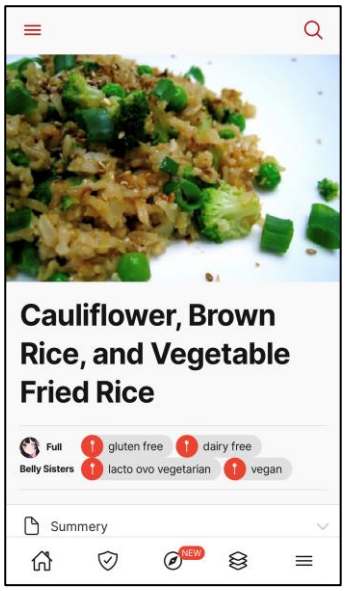
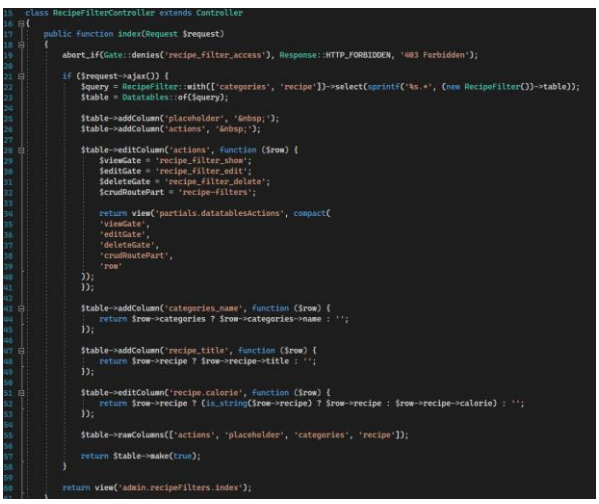


Figure 6-3: Ingredient information

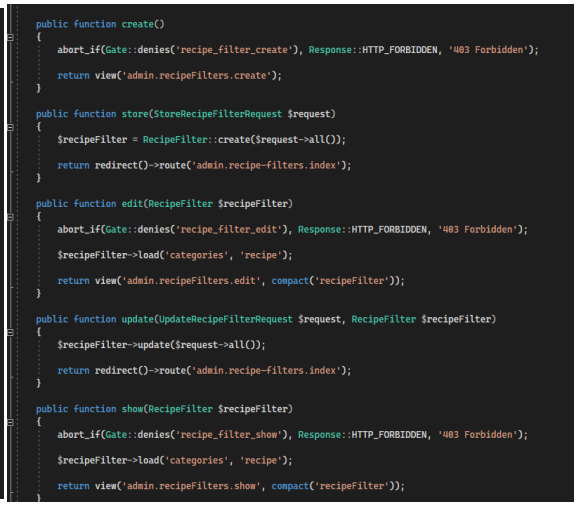
"Delish" makes use of the Edamam Diet Recommendation external API, which is detailed in section 6.1.2, to deliver individualized meal recommendations utilizing Natural Language Processing (NLP) and Deep Learning Algorithms. It contains around 25 pre-built diet components that cater to different diet kinds and allergy limitations. It is renowned as the largest food database and the most up-to-date nutrition analysis tool in the world. When a user searches for food items using keywords, semantic analysis is

performed. This is used to interpret the user preferences and return meal options based on the keyword chosen.



```
class RecipeFilterController extends Controller
{
    public function index(Request $request)
    {
        abort_if(Gate::denies('recipe_filter_access'), Response::HTTP_FORBIDDEN, '403 Forbidden');

        if ($request->ajax()) {
            $query = RecipeFilter::with(['categories', 'recipe'])->select(sprintf('%s.*', (new RecipeFilter())->table));
            $table = Datatables::of($query);

            $table->addColumn('placeholder', ' ');
            $table->addColumn('actions', ' ');

            $table->editColumn('actions', function ($row) {
                $viewGate = 'recipe_filter_show';
                $editGate = 'recipe_filter_edit';
                $deleteGate = 'recipe_filter_delete';
                $crudRoutePart = 'recipe-filters';

                return view('partials.datatablesActions', compact(
                'viewGate',
                'editGate',
                'deleteGate',
                'crudRoutePart',
                'row'
            ));
            });

            $table->addColumn('categories_name', function ($row) {
                return $row->categories ? $row->categories->name : '';
            });

            $table->addColumn('recipe_title', function ($row) {
                return $row->recipe ? $row->recipe->title : '';
            });

            $table->editColumn('recipe.calorie', function ($row) {
                return $row->recipe ? (is_string($row->recipe) ? $row->recipe : $row->recipe->calorie) : '';
            });

            $table->rawColumns(['actions', 'placeholder', 'categories', 'recipe']);

            return $table->make(true);
        }

        return view('admin.recipeFilters.index');
    }
```

Figure 6-4: Recipe Filters - 1



```
public function create()
{
    abort_if(Gate::denies('recipe_filter_create'), Response::HTTP_FORBIDDEN, '403 Forbidden');

    return view('admin.recipeFilters.create');
}

public function store(StoreRecipeFilterRequest $request)
{
    $recipeFilter = RecipeFilter::create($request->all());

    return redirect()->route('admin.recipe-filters.index');
}

public function edit(RecipeFilter $recipeFilter)
{
    abort_if(Gate::denies('recipe_filter_edit'), Response::HTTP_FORBIDDEN, '403 Forbidden');

    $recipeFilter->load('categories', 'recipe');

    return view('admin.recipeFilters.edit', compact('recipeFilter'));
}

public function update(UpdateRecipeFilterRequest $request, RecipeFilter $recipeFilter)
{
    $recipeFilter->update($request->all());

    return redirect()->route('admin.recipe-filters.index');
}

public function show(RecipeFilter $recipeFilter)
{
    abort_if(Gate::denies('recipe_filter_show'), Response::HTTP_FORBIDDEN, '403 Forbidden');

    $recipeFilter->load('categories', 'recipe');

    return view('admin.recipeFilters.show', compact('recipeFilter'));
}
```

Figure 6-5: Recipe Filters -2

Above shows how the recipe filters are built to be edited by the admin to add categories and such which are mapped to the recipes so that the mapped results will be shown for the user according to their keyword inputs.

6.2.2 BMI Calculator

Specific inputs are taken from a form from the users in order to obtain their data to provide an output on their bodily weight. The output is cross-referenced to metrics that are unique to Sri Lanka (obtained from DIASL) to show the output on whether their weight is healthy for the region or not. Based on this output and the outputs from BMR, body fat percentage, users can determine their end goal that they wish to fulfil from the app (whether they should focus on weight gain recipes or weight loss recipes). Whatever the input that is provided by the user is sent through the JSON as objects from front end form input to the back end to perform these calculations.

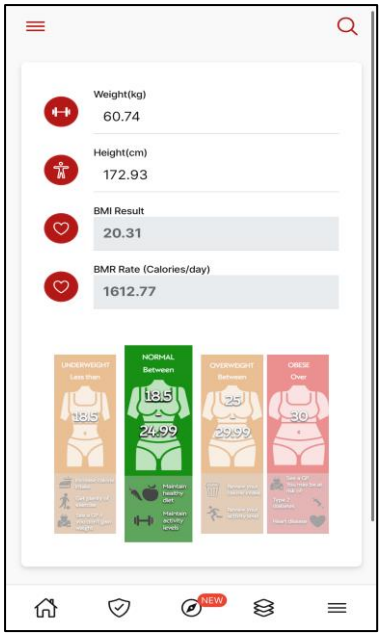
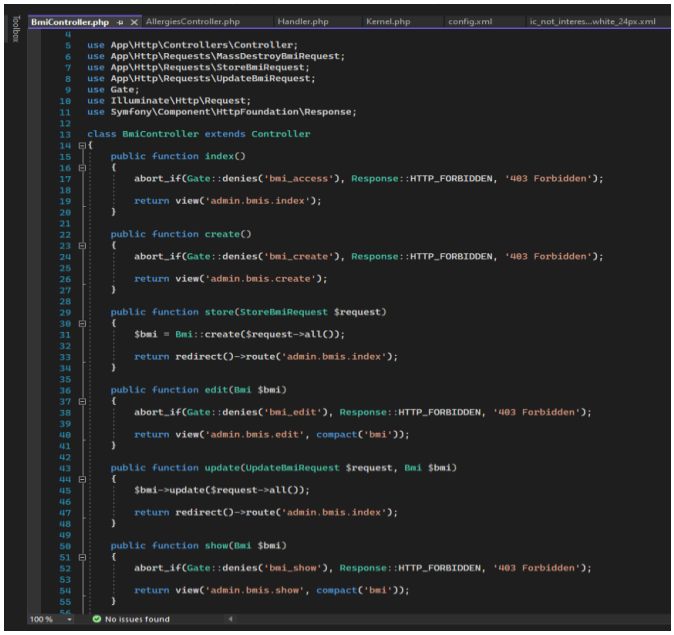


Figure 6-6: BMI Calculator UI Form



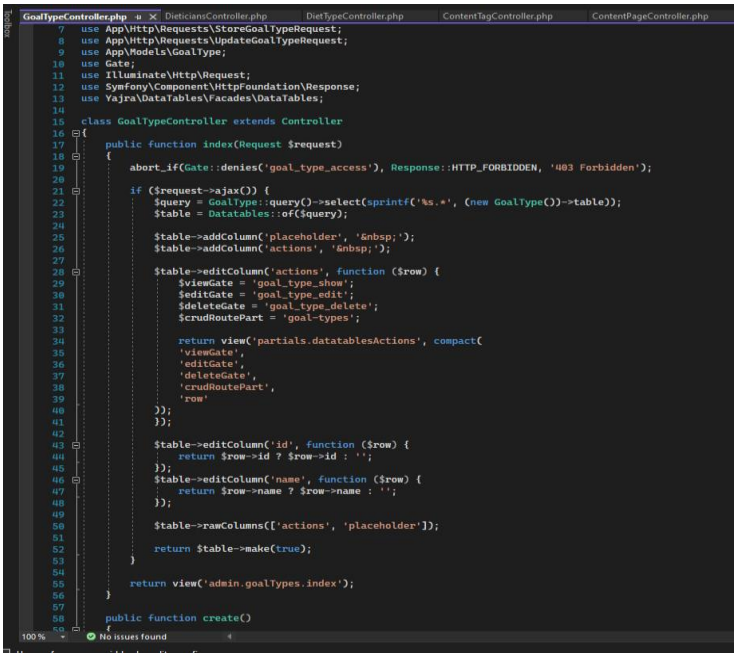
```
use App\Http\Controllers\Controller;
use App\Http\Requests\MassDestroyBmiRequest;
use App\Http\Requests\StoreBmiRequest;
use App\Http\Requests\UpdateBmiRequest;
use Gate;
use Illuminate\Http\Request;
use Symfony\Component\HttpFoundation\Response;

class BmiController extends Controller
{
    public function index()
    {
        abort_if(Gate::denies('bmi_access'), Response::HTTP_FORBIDDEN, '403 Forbidden');

        return view('admin.bmis.index');
    }

    public function create()
    {
        abort_if(Gate::denies('bmi_create'), Response::HTTP_FORBIDDEN, '403 Forbidden');

        return view('admin.bmis.create');
    }

    public function store(StoreBmiRequest $request)
    {
        $bmi = Bmi::create($request->all());

        return redirect()->route('admin.bmis.index');
    }

    public function edit(Bmi $bmi)
    {
        abort_if(Gate::denies('bmi_edit'), Response::HTTP_FORBIDDEN, '403 Forbidden');

        return view('admin.bmis.edit', compact('bmi'));
    }

    public function update(UpdateBmiRequest $request, Bmi $bmi)
    {
        $bmi->update($request->all());

        return redirect()->route('admin.bmis.index');
    }

    public function show(Bmi $bmi)
    {
        abort_if(Gate::denies('bmi_show'), Response::HTTP_FORBIDDEN, '403 Forbidden');

        return view('admin.bmis.show', compact('bmi'));
    }
```

Figure 6-7: BMI controller

6.2.3 Adding Goals

Users can add specific goals to reach their health goals and to manage their fitness journey through a simple form. They can add what exactly the goal is about with a target date and change the status one it is completed. This will be further enhanced in the next version as a way of retention technique to grant points for each achievement. The current functionality is also implemented using JSON files as described above.

Figure 6-8: Add Goals UI



```
use App\Http\Requests\StoreGoalTypeRequest;
use App\Http\Requests\UpdateGoalTypeRequest;
use App\Models\GoalType;
use Gate;
use Illuminate\Http\Request;
use Symfony\Component\HttpFoundation\Response;
use Yajra\DataTables\Facades\DataTables;

class GoalTypeController extends Controller
{
    public function index(Request $request)
    {
        abort_if(Gate::denies('goal_type_access'), Response::HTTP_FORBIDDEN, '403 Forbidden');

        if ($request->ajax()) {
            $query = GoalType::query()->select(sprintf('%s.*', (new GoalType())->table));
            $table = Datatables::of($query);

            $table->addColumn('placeholder', ' ');
            $table->addColumn('actions', ' ');

            $table->editColumn('actions', function ($row) {
                $viewGate = 'goal_type_show';
                $editGate = 'goal_type_edit';
                $deleteGate = 'goal_type_delete';
                $crudRoutePart = 'goal-types';

                return view('partials.datatablesActions', compact(
                'viewGate',
                'editGate',
                'deleteGate',
                'crudRoutePart',
                'row'
            ));
            });

            $table->editColumn('id', function ($row) {
                return $row->id ? $row->id : '';
            });
            $table->editColumn('name', function ($row) {
                return $row->name ? $row->name : '';
            });

            $table->rawColumns(['actions', 'placeholder']);

            return $table->make(true);
        }

        return view('admin.goalTypes.index');
    }

    public function create()
```

Figure 6-9: Add Goals Code

Please refer to the Appendix VII to check the implementation of more functionalities.

7. Testing

7.1 Functional Testing using Black Box Testing

Description	Sample Input	Expected Output	Actual Output	Status
TC01 Register	Username: Miraj Perera User Type: General Email: binari@inforwaves.com Password: binari123 Confirm Password: binari123	Registration page should say “Please verify the email”	Same as expected	Pass
TC02 Register	Username: Miraj Perera User Type: General Email: binariinforwaves.com Password: binari123 Confirm Password: binari123	Registration page should request to enter a valid email address	Same as expected	Pass
TC03 Register	Username: Miraj Perera User Type: General Email: binari@inforwaves.com Password: binari123 Confirm Password: Binari123	Registration page should notify that the passwords do not match	Same as expected	Pass
TC04 Login	Email: binari@inforwaves.com Password: binari123	User gets directed to the homepage	Same as expected	Pass

TC05 Login	Email: binari@inforwaves.com Password: binari1234	Login page notifies that the credentials do not match	Same as expected	Pass
TC06 Register	Username: Binari Samarasinghe User Type: Dietitian Email: admin@admin.com Password: password Confirm Password: password	Registration page should say “Please verify the email”	Same as expected	Pass
TC07 Verifying Email	Username: Binari Samarasinghe User Type: Dietitian Email: admin@admin.com Password: password Confirm Password: password	Login page directs the user to the become a professional form	Same as expected	Pass
TC08 Verifying documents	Username: Binari Samarasinghe User Type: Dietitian Email: admin@admin.com Password: password Confirm Password: password Institute: Mirage Clinic Profession: Nutritionist Qualifications/Evidence: PDF file	Form gets submitted and will be visible on admin panel	Same as expected	Pass

TC09 Verifying documents	Rejects the request for Binari Samarasinghe	Binari Samarasinghe will not be listed as a dietitian	Same as expected	Pass
TC10 Verifying documents	Accepts the request for Binari Samarasinghe	Binari Samarasinghe be listed as a dietitian with a verified tick near the user's name	Same as expected	Pass
TC11 Calculate BMI	Height: 172.93 Weight: 60.74	BMI Result = 20.31 Calories per day = 1441.07	Same as expected	Pass
TC12 Calculate Body Fat	Height: 172.93 Weight: 60.74 BMI = 24.12	Body fat percentage = 24.12 with the tables to refer	Same as expected	Pass
TC13 Filter Recipes	Filter: Chinese	All Chinese recipes should be shown	Only local database results were shown. Edamam API results were not taken.	Fail
TC14 Search for Recipes	Word: Pea	All the recipes that have the word "pea" included should be shown.	Same as expected	Pass
TC15 Check Recipe	Click on: "Cabbage Soup"	Shows the ingredients, which diet it is included in	Same as expected	Pass

		and other available information.		
TC16 Share Recipe	Click on “Share this Post”	Shows sharing options.	Server timeout	Fail
TC17 Suggest an Edit	Name: Binari Samarasinghe Email: binary.pramada@gmail.com Comment: number of calories should be 1200	Form gets submitted and will be visible to admin	Same as expected	Pass
TC18 Submit Recipe	Image: JPG Title: Barbeque Sauce Calories: 1200 Categories: Sri Lankan Ingredients: Sauce and Pea Diet Type: Weight Gain	Form gets submitted and will be visible to the admin	Same as expected	Pass
TC19 Verify Recipes	Admin accepts recipe submission from “Binari Samarasinghe”	Recipe will be shown in the app and it will be listed under the dietitian’s profile	Same as expected	Pass
TC20 Verify Recipes	Admin rejects recipe submission from “Binari Samarasinghe”	Recipe will not be shown in the app	Same as expected	Pass
TC21 Add Goal	Goal: Weight loos by 2 kilos Date: 24/05/2022 Status: In progress	Goal will be added	Same as expected	Pass

TC22 Change goal status	Goal: Weight loss by 2 kilos Date: 24/05/2022 Status: Completed	Goal status will be changed	Same as expected	Pass
TC23 Book a professional	Booking date: 24/05/2022	Booking will be added to my booking with the status as "pending"	Same as expected	Pass
TC24 Confirm booking	User: Binari Samarasinghe Booking date: 24/05/2022	Booking status will be changed to "accepted"	Same as expected	Pass
TC25 Dark mode	Click on the dark mode toggle button	Theme will turn dark	Same as expected	Pass

Table 7-1: Blackbox Functional testing

Functional test pass rate = (n/N) x100% = (23/25) x100% = 92%

n = Number of tests passed

N = Number of tests performed

7.2 User Testing

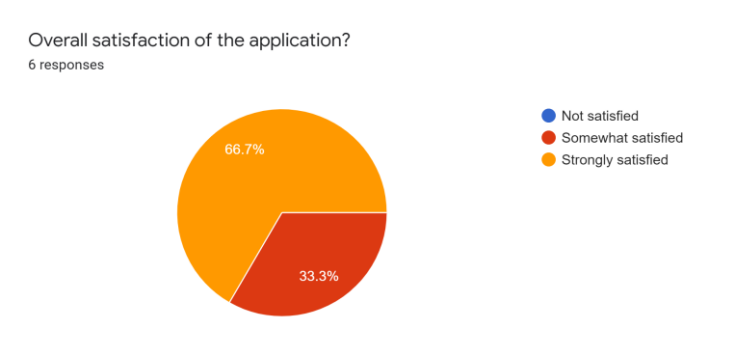
To evaluate various parts of the solution, the application was tested with industry experts, non-experts, and technical experts. Some of them were shown a video presentation of the program, and some of them were able to use it in real time after which they were interviewed and their feedback was recorded. Table 7-3 shows the business concept evaluation plan, which includes the evaluation criteria and information.

ID	Type	Name	Designation
TE01	Technical Expert	Mr. Nimila Hiranya Samarasinghe	Technical Lead, Applova Inc. – Hsenid Mobile (PVT) Ltd.

TE02		Mrs. Shehara Hewage	IT-Customer Development Business Partner, Unilever Sri Lanka Ltd.
DE01	Domain Expert	Ms. Chamari Gunawardena	Nutritionist, Fitness Coach for Sri Lankan Paralympics Team & National Sport Teams
DE02		Ms. Thasmeeha Marliya	Dietitian, Nutritionist - Balasooriya Hospital, Puttalam Nutrition Society of Sri Lanka (NSSL) Dietitians Association of Sri Lanka (DIASL)
NE01	Non-expert	Ms. K. K. Kumudini	Divisional Educational Director
NE02		Mr. Miraj Perera	Freelance Digital Marketer

Table 7-2: Evaluator Details

ID	Feedback
Q01	**What are your thoughts on the user interface and user experience of the app?**
TE01	*"Overall, it is pretty okay and navigational structure is well made. The colour theme suits the idea. However, in certain parts such as tables with information could have been improved more in a way it's more appealing to a generic user"*
TE02	*"Contrasting of the colours are very well done and the UI is pleasing to look at"*
DE03	*"I think it shows the idea pretty clearly, but I would have preferred it more if the calculators were to be on the opening screen"*
DE04	*"Well structured"*
NE05	*"I like the theme and it is easy to go on and about"*
NE06	*"80% of the pages are to my liking but there are some areas that could be improved"*

Q02	**Are you satisfied with the functionalities? Explain why.** 33.3% - Somewhat Satisfied | 66.67% - Strongly Satisfied  *Figure 7-1: Survey - Satisfaction Score*
TE01	*"Basic functionalities are captured in the given circumstances well. But the filtering function was not up-to my satisfaction since it was not properly working for the API generated recipes"*
TE02	*"In general, it has covered the scope but I think there are couple of things that can be added in future versions"*
DE03	*"It is good that it has three calculations other than just using BMI to get the results. But rather than giving one average daily calorie intake try giving a weekly total intake with an option to delegate the total among the 7 days. Perhaps you can take it up as a future enhancement"*
DE04	*"It is okay"*
NE05	*"I am satisfied cause it gave measurements I was not aware of and had articles on different diet types. I think it's helpful"*
NE06	*"All good except I like to see the dates and times doctors will be available before sending the booking request"*
Q03	**Do you think this application is useful to the target audience?**
TE01	*"It is, few patch-ups and enhancements would make it better gain mass profits. So, look into more ways of adding value to the solution"*

TE02	*"It is useful for both who are aware of these and not. A lot of Sri Lankans are not even aware that they can go to nutritionists for advice. This is a good way to implement those good habits within the community"*
DE03	*"It is useful for generic people who are keen to know more about what they eat and what they can eat. They can know how much they weigh and how much they should weigh. Surprising amount of people in our country are not aware of this. Even avid gym enthusiasts since most of them are driven on exterior look of staying fit."*
DE04	*"It is useful for healthy people to stay on in their healthy routines and to others to know that they have an issue that needs to resolved. But I would not recommend the solution for a user with nutritional disease such as morbid obesity or extreme malnutrition to follow this app since they need to evaluated by professional in person in my opinion"*
NE05	*"It is helpful"*
NE06	*"It helps people to be cautious about their health"*
Q04	**What are your thoughts on the application as a whole?**
TE01	*"I believe this is a good tool that will considerably aid me in managing and improving myself in order to attain my goal weight. The ability to receive individualized meal suggestions is really beneficial because it encourages consumers to eat healthier and continue eating healthy"*
TE02	*"This solution will assist users in keeping track of their health and motivating them to improve their situation in my opinion. The app's features addressed the main concerns and were presented in a clear and user-friendly manner"*
DE03	*"This can be easily improved into an all-in-one solution with the established set of features. Sure, they need to be refined but it is a good start. There are no products like these in Sri Lanka and all other apps consider BMI for the standard US region which is inaccurate for Sri Lankans"*

DE04	*"I have to say that the solution's architecture has me really impressed. This is relevant to the users since it deployed at a time when online consultation popularity is at its peak. Given the short timeframe and difficult repercussions imposed by the country's predicament, the utilization of technology, design, and rigorous research is commended"*
NE05	*"Helpful at a time like this where everyone should be more health conscious"*
NE06	*"I like the solution and would definitely use it as an addition to my gym workout routine"*
Q05	**Please specify any suggestions on future enhancements.**
TE01	*"Go for a better API integration technique where you can streamline all functions with local database and API data. This might require more space and better hosting solutions"*
TE02	*"Develop an iOS version as well and research further on what can add more value to the solution so that you can add them to the solution"*
DE03	*"I believe there are no published recipes or nutritional values for Sri Lankan food and recipes that are given proper approval from dietitians. But do look into the possibility of collaborating with industry professionals to create a database in that nature to add to the application. Many of my clients suffer from the fact that published recipes are non-Sri Lankan and therefore have difficulties of finding the ingredients"*
DE04	*"Add a point system to motivate user to keep coming back as I know as professional the hardest task for my patients is to stick to their good practices"*
NE05	*"Make an iOS app"*
NE06	*"Synchronize data from fitness health apps in user's phone to get physical activity rates too"*

Table 7-3: Concept Evaluation Feedback

The above-mentioned suggestions and recommendations for the generated prototype have been taken into account in the solution's future developments.

8. Conclusions and Reflections

With the given time frame and with the skill gaps I had as a new developer who has never developed a mobile software before, achieved results are up to my satisfaction level. However, it should be noted that my initial idea for this prototype has been changed quite a lot throughout the process proving the importance of the agile framework. As the project progressed, I noticed how less of a time I actually have to develop the product with the time I have to spend on learning and other prevailing situations in Sri Lanka. Therefore, I re-prioritized the requirements I finalized and focused on most crucial and basic functionalities rather than luxury functionalities such as synchronizing with the fitness applications, barcode scanning since the objective was to provide a minimum viable product by the end of these months all the while making sure upskill my knowledge. Therefore, I suppose by the end of the project many of the value addition functions were dropped which are planned to be taken as further research areas to develop a more fleshed out version of this prototype.

8.1 Further Research Areas

Nutrition is critical for disease prevention as well as the restoration of health and quality of life. The next step in illness prevention through nutrition is to personalize dietary recommendations. Personalized nutrition using NLP and AI requires the development of a corpus of scientific information on which preventive dietary advice can be based. In this scenario, incorporating genetic history and blood group is deemed necessary. Understanding the human genome is paving the way for tailored medicine and nutrition. However, individualized nutrition is complicated by the diversity of human genetic backgrounds, individual nutrition (e.g., changes in dietary composition, cultural impacts on food preparation, and food processing), and the heterogeneity of disease and health pathways. This research gap bridging could result in a smart application for diet recommendation with a vast range of features such as; registering household IoT devices, such as refrigerators, smart pantries, and other smart kitchen gadgets; and perhaps connecting to purchasing systems to track what has been purchased as a manner of automatically managing kitchen inventory. This will supply personal fixed and temporal data to the system. The system could employ AI to produce diet, meal planning, and

(possibly automated) food purchase suggestions based on this and internet databases of food product composition and dietary recommendations. The system can be used to learn about eating habits and preferences over time and change its recommendations accordingly. It can also keep track of the progress towards the specific objectives and adjust food suggestions accordingly. Furthermore, this can be designed to employ a pocket NIR scanner, a smart digital scale, and a smartphone app to estimate the approximate composition and weight of components in a meal and provide nutritional advice. Crowdsourcing can also be used to keep track of new products in the supermarket. Image analysis and other direct ways to diet monitoring can be applied. However, this technology should be incorporated only if it is feasible because current image processing technologies, on the other hand, are still too resource-intensive for smartphone capability.

8.2 Strengths and Weaknesses

Strengths	
Only available diet app in Sri Lanka	According to Sri Lankan dietitians, there are no available applications within Sri Lanka at the moment and they are relying on excel sheets or mostly on notebooks when they are performing their consultation. An app like this that is customized to Sri Lanka can come in handy for them in this case to perform more effectively efficiently.
Easy Access	Since the application can be accessed through mobile it can be accessed by anyone and easily can deploy target marketing techniques to attract customers.
Ability to get the support from the nutrition experts in Sri Lanka	As of now Sri Lankan general public are not that enthusiastic about consulting a professional for their nutritional health. This can be overcome and attitudes can be changed by an application like this. Which in turn gives the positive exposure for professionals in the field as well. This can aid in getting their support to bridge more domain related gaps that I might have not noticed.
Rates used to measure health are strictly	According to the professionals I spoke to, it was clear they were very enthusiastic about using an application like this due to the fact that it is customized to the parameters that are published by Sri Lankan nutrition

customized to Sri Lankans	bodies. Which gives a unique edge over other international brands who do not consider this aspect and in turn give less accurate results for Sri Lankan/Asian users.
Using more than BMI to measure health	Many other applications in the market are only using BMI to measure and recommend recipes whereas Delish takes three measurements to provide most accurate possible recommendations.
Weaknesses	
Only diet perspective is covered	Nutritional health cannot be only covered through dietary habits and it should incorporate the physical activity aspect as well. **Recommendation:** The application should have synchronization settings with physical health applications in future.
Sri Lankan cuisine need to be added	To get the maximum benefit out of this application there should be a composition of recipes that are only in Sri Lanka which can be done with further research with the support of experts. According to Ms. Chamari, the lack of recipes with familiar ingredients is one of the biggest turn offs for Sri Lankans who try to get into proper dieting. Unfortunately, there is no such database created at the moment for Sri Lankan cuisines and a solid, research-based database creation for a course like this is expected to take up to at least 3 months and was omitted due to this very reason. **Recommendation:** Setup an evidence-based and accurate database on traditional Sri Lankan recipes and spin-offs of Sri Lankan recipes within the application to cater appropriately to the target market.
Diet planning could be improved	At the moment this only provides a list of information on what to consume and not and therefore, further improvements can be added to this. **Recommendations:** Ability to add the liked recipes to different meal

	plans and to add more filters. Furthermore, image processing technology can be incorporated in case the user wants to upload a meal they consumed for their diet records with the ability to estimate calorie content.
Notifications feature is not accommodated	Notifications can be added as a feature that helps the application and the user both in the future. As an example, the best practice when measuring weight is to daily measure and get the average for the week as the true measurement. Therefore, customizable reminders could be utilized to support the user to stick into these good practices. Furthermore, BMI, BMR and body fat percentage is best depicted when it is measured once in two weeks. Even for the goals that are set by users, they can vastly benefit from reminders. **Recommendation:** Customizable reminders/notifications
Skill gap	Due to the skill gap of myself some functions are not created up-to my satisfaction and they need to be further improved with better technologies.

Table 8-1: Strengths and Weaknesses of the Application

8.3 Acquisition of New Knowledge and Skills

Throughout the project lifetime, major competences were practiced (through project management, research and analysis, and documentation). Author managed to utilize proper communication skills during the requirement elicitation approaches and prioritizing. The author was also able to learn, decide and practice UI/UX principles and relevant tools. Using Android Studio and the Laravel framework, the author became acquainted with Android application development. In addition, the technical skills, critical thinking and problem-solving skills were developed during the solution's implementation. Furthermore, dietary education-related domain knowledge was also acquired. The author discovered the history of risk factors, linked diseases, causes, severity, challenges in current procedures, struggles, knowledge gaps among the generic public as well as experts in managing the condition. In addition, the author learned how to use efficient lifestyle modification and BCT approaches to maintain a healthy weight.

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Worsley, A. (2002). Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? *Asia Pacific Journal of Clinical Nutrition*, [online] 11(s3), pp.S579–S585. doi:10.1046/j.1440-6047.11.supp3.7.x. / [Accessed 20 Apr. 2022]

Appendix I – Other Tools Considered

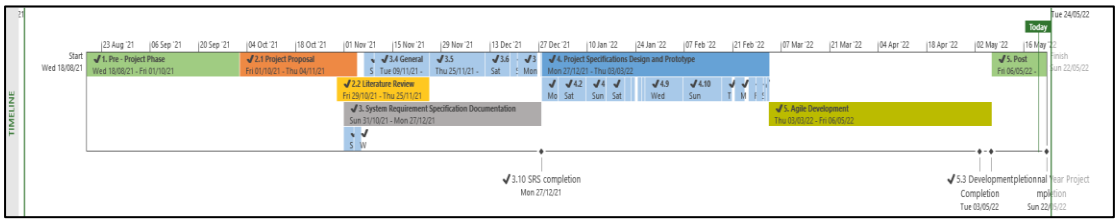
Tool	Advantages	Disadvantages
Project Management		
Trello	1. Pricing structures are simple. 2. Upcoming deadlines can be easily understood and notified. 3. Mobile friendly 4. Follows the Kanban system.	1. Needs a working internet connection to access the software. 2. Although there is no limit for the number attachments, there is a 10MB upload limit for each attachment. 3. Cannot edit a posted comment and cannot review iterations (Oamkumar, 2018).
Requirement Elicitation		
Microsoft Forms	1. Any Microsoft account can use the app for free for personal use. 2. Highly versatile and can create many types of forms. 3. Can be exported easily to analyse.	1. With a premium Microsoft 365 Personal, Microsoft 365 Education, or Microsoft 365 Business membership, you get additional functionalities like a greater respondent limit.
Wireframes		
Adobe XD	1. Offers multiple types of artboards. 2. Offers tutorials. 3. Easy to navigate and friendly UI. 4. Can repeat grids that are already designed to new screens. 5. Allows prototyping.	1. Limitations in repeating objects. 2. Operating system compatibility limitations for prototype testing. 3. Cannot design customized shapes. 4. Cannot export CSS.
Visio 2016	1. Easy to use and navigate on the UI. 2. Consistent interface in all devices. 3. Simple processes (Anwesha, 2016).	1. Not compatible with some devices. 2. Viewer cannot edit comments. 3. No way to manage versions.

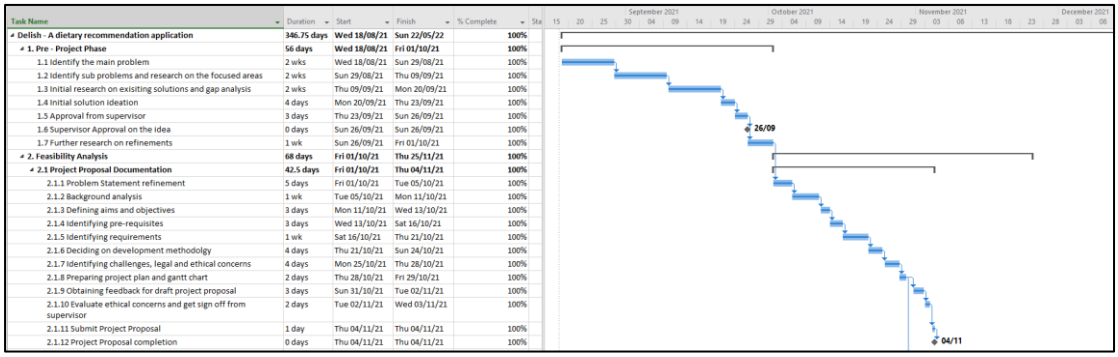
Development and Implementation Phase		
Visual Studio Code	Open source, easy to use, add files and has a wide range of extensions and plugins.	In comparison to Visual Studio, project structuring is not as good (Azam, 2022).
Sublime Text	Wide range of languages are supported.	High cost.
AWS Amplify	1. Free to use until the user reaches a high threshold. 2. Easy UI driven development. 3. Built-in backend support. 4. Web-based analytics dashboards.	1. Constantly changing. 2. Cannot easily manage traffic and latency issues. 3. Steep learning curve (Stud, 2021).
WebEngage	1. Excellent list management. 2. Dynamic content testing. 3. Email deliverability reports.	Some native integrations are not available (Shopify)
Chromium Engine	Well secured and fast (Oosterhof, 2020).	Fewer extensions, add-ons and plugins are available.
Git Bash	1. Fast and easy to use local commits. 2. No configurations are needed to start new repositories (Skeet, 2008).	Harder to use with larger repositories and commit histories (Petr, 2014).
ConEmu	Smooth and has a wide range of features (Github, 2018).	Steep learning curve.
Testfully	API monitoring is easier.	Low integration capabilities.
PHP	1. Opensource and free. 2. Platform independent. 3. Can be loaded easily. 4. Learning is easier and user	1. Less secured since it is open source. 2. Can cause errors and results can be less accurate. 3. Core behaviour cannot be changed.

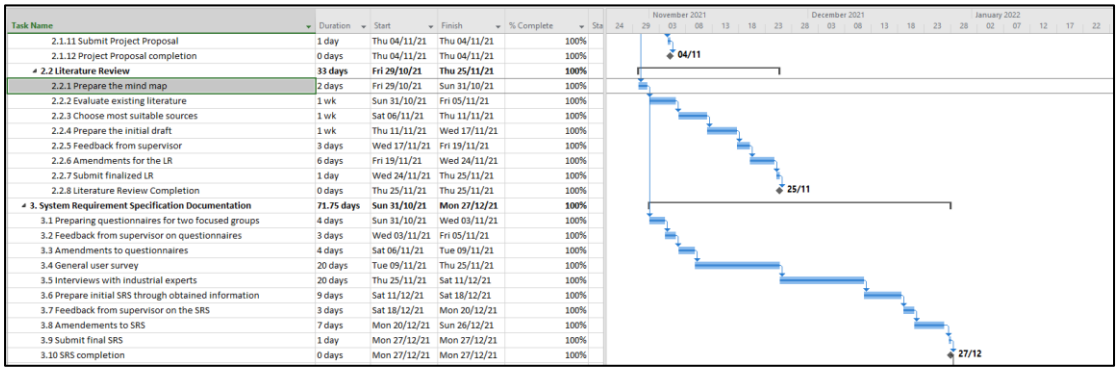
	friendly. 5. Codes are significantly shorter and flexible. 6. Can connect to databases and libraries.	4. Weak framework. 5. Handling is a hassle due to the lack of debugging tools (Prasanna, 2021).

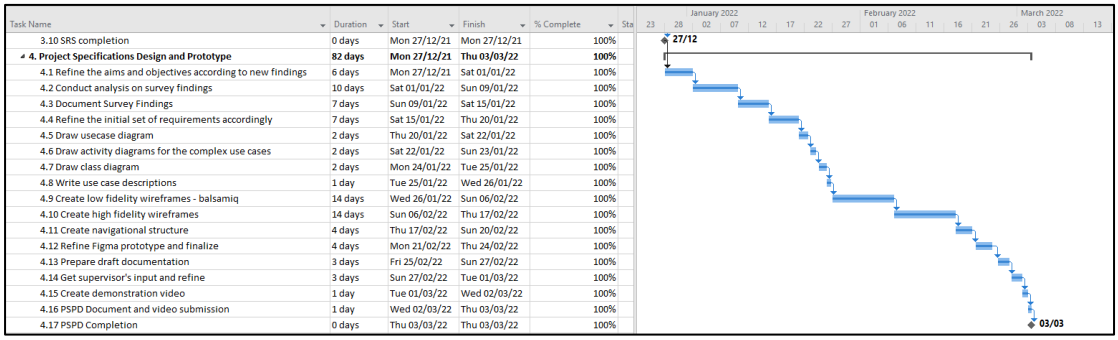
Table A1: Research on Required Tools

Appendix II – Gantt Chart









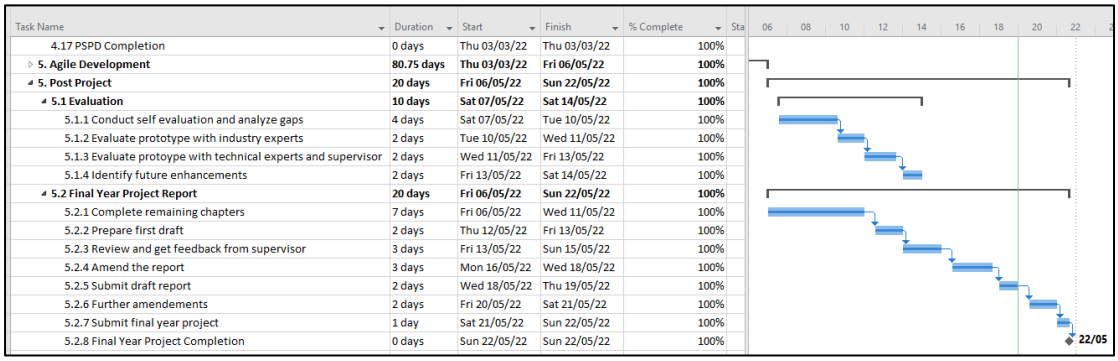
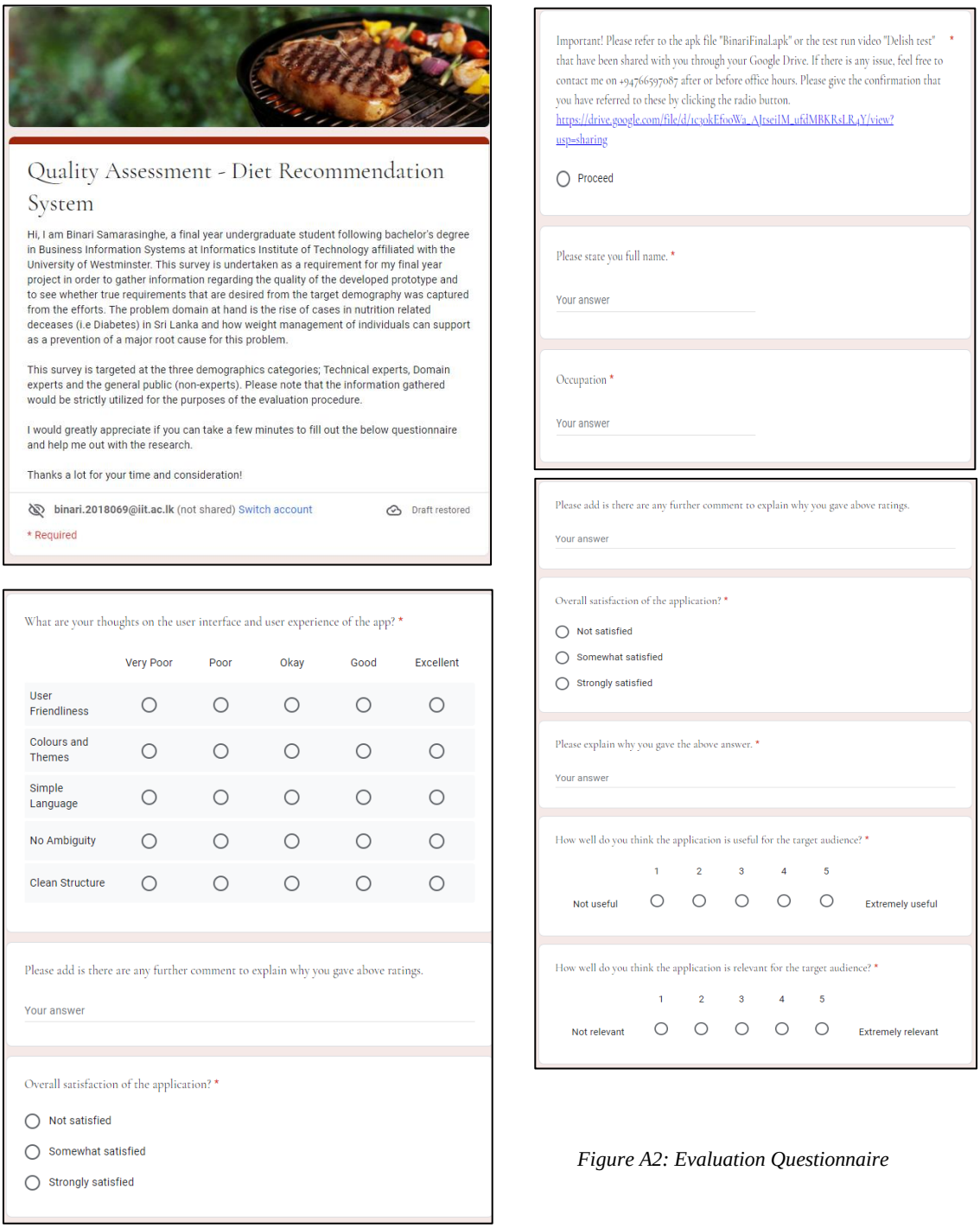


Figure A1: Gantt Chart and Timeline

Appendix II – Evaluation Survey Questionnaires



Quality Assessment - Diet Recommendation System

Hi, I am Binari Samarasinghe, a final year undergraduate student following bachelor's degree in Business Information Systems at Informatics Institute of Technology affiliated with the University of Westminster. This survey is undertaken as a requirement for my final year project in order to gather information regarding the quality of the developed prototype and to see whether true requirements that are desired from the target demography was captured from the efforts. The problem domain at hand is the rise of cases in nutrition related deceases (i.e Diabetes) in Sri Lanka and how weight management of individuals can support as a prevention of a major root cause for this problem.

This survey is targeted at the three demographics categories; Technical experts, Domain experts and the general public (non-experts). Please note that the information gathered would be strictly utilized for the purposes of the evaluation procedure.

I would greatly appreciate if you can take a few minutes to fill out the below questionnaire and help me out with the research.

Thanks a lot for your time and consideration!

binari.2018069@iit.ac.lk (not shared) Switch account — Draft restored

* Required

Important! Please refer to the apk file "BinariFinal.apk" or the test run video "Delish test" that have been shared with you through your Google Drive. If there is any issue, feel free to contact me on +94766597087 after or before office hours. Please give the confirmation that you have referred to these by clicking the radio button. *

https://drive.google.com/file/d/1c30kEfooWa_AJtseiIM_ufdMBKRsLR4Y/view?usp=sharing

- Proceed

Please state you full name. *

Your answer

Occupation *

Your answer

What are your thoughts on the user interface and user experience of the app? *

	Very Poor	Poor	Okay	Good	Excellent
User Friendliness					
Colours and Themes					
Simple Language					
No Ambiguity					
Clean Structure					

Please add is there are any further comment to explain why you gave above ratings.

Your answer

Overall satisfaction of the application? *

- Not satisfied
- Somewhat satisfied
- Strongly satisfied

Please add is there are any further comment to explain why you gave above ratings.

Your answer

Overall satisfaction of the application? *

- Not satisfied
- Somewhat satisfied
- Strongly satisfied

Please explain why you gave the above answer. *

Your answer

How well do you think the application is useful for the target audience? *

	1	2	3	4	5	
Not useful						Extremely useful

How well do you think the application is relevant for the target audience? *

	1	2	3	4	5	
Not relevant						Extremely relevant

Do you have any comments for further improvements in the future? *

Your answer

Submit — Clear form

Figure A2: Evaluation Questionnaire

Appendix III – Evaluation Survey Responses

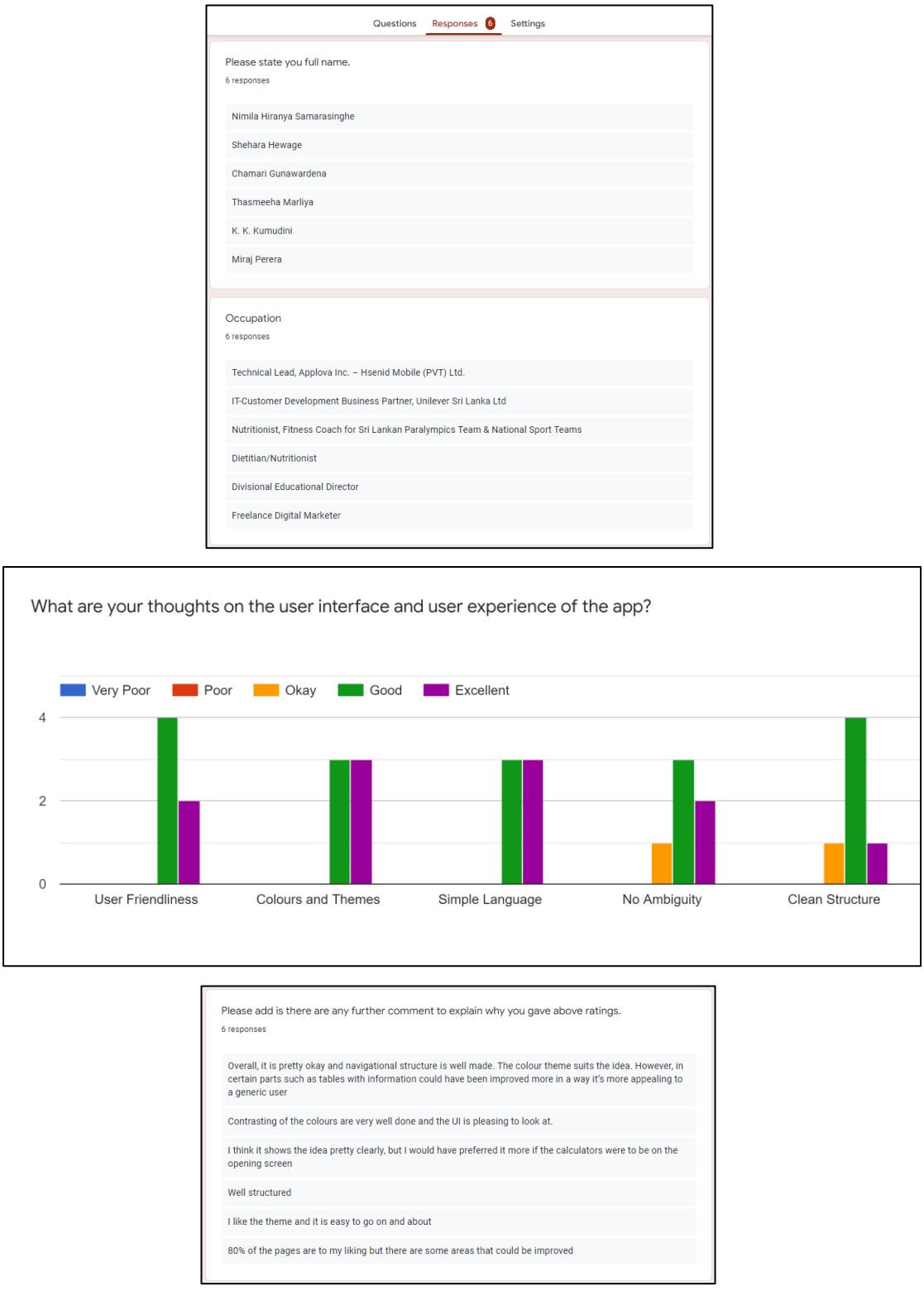
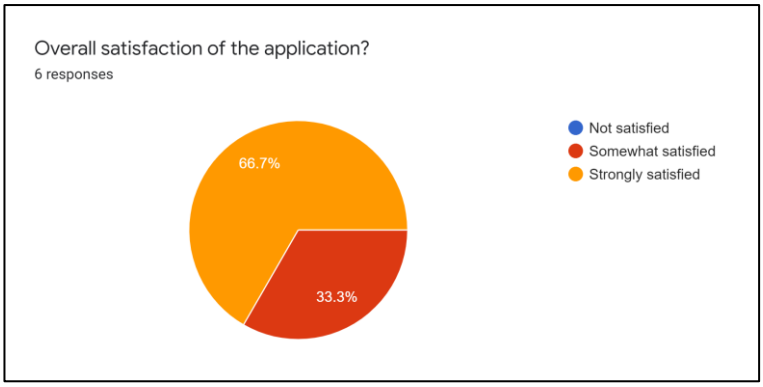
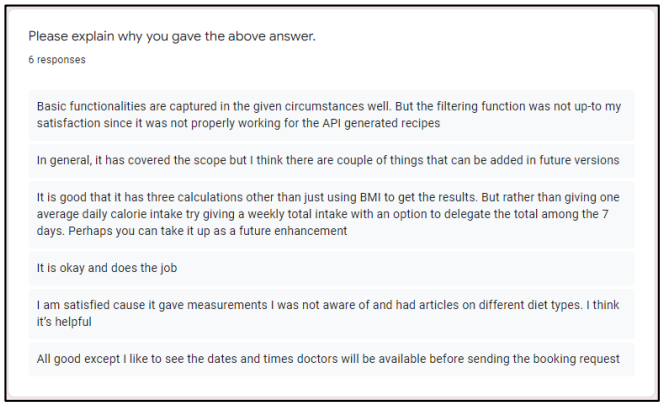
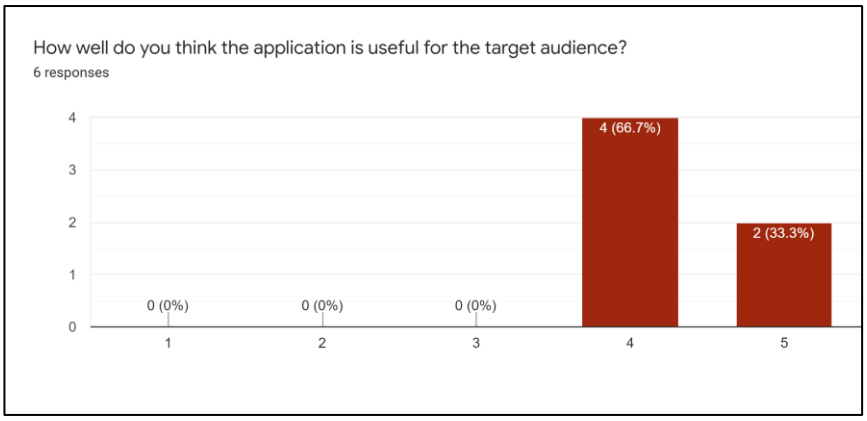


Figure A3-1: Evaluation Survey Answers







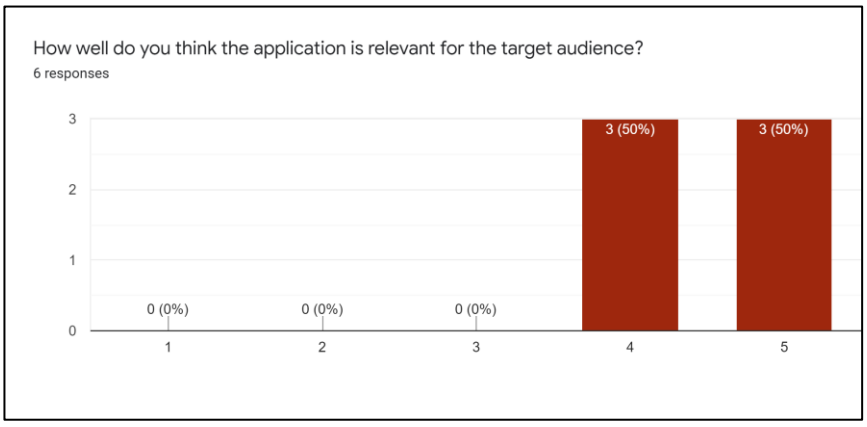


Figure A3 - 2: Evaluation Answers

Figure A3 - 3: Evaluation Answers

Appendix IV – Online Video Demonstration

Please refer to this link.

Watch the YouTube Video Demonstration

Appendix V – Zipped Application Files

Please refer to this link to access the zipped folder of the Application file through Google Drive.

Go to App Folder

Appendix VI – Final Year Project Progress Logbook

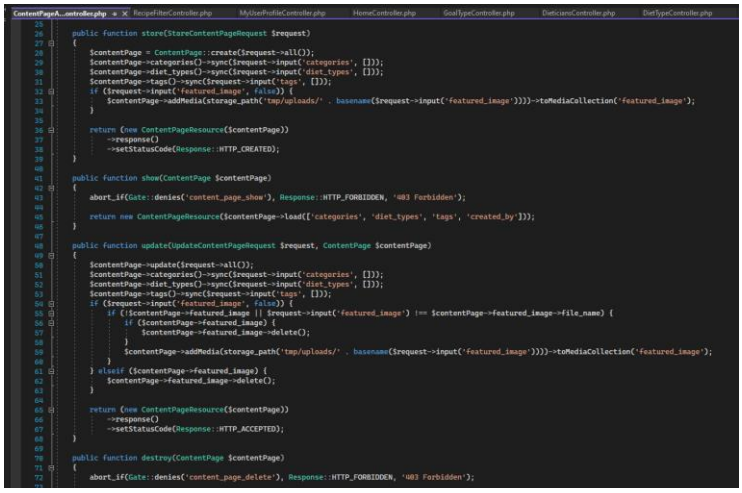
Name of the Supervisee	Binari Samarasinghe
Student ID	w1715295/2018069
Project Title	Delish - Diet Recommendation App

Meeting #	Date	Time	Discussion/Guidance given	Tasks to complete before next meeting	Next Meeting Date	Next Meeting Time	Comments on previously assigned work	Comments on progress as per plan	upervisor sign off
1	16/09/2021	8.00 PM	Introduction to FYP module and milestone overview	More reserach to be put onto problem statement Value proposition area to be found Prominent profit creation tactic to be researched for the idea	23/09/2021	8.30 PM	Look into value addition aspect of the project	Core idea is good but there is more figuring out to do about the scope and the problem itself	Sign off was given
2	23/09/2021	8.30 PM	Review the problem domain and the statement Review the usage of ML in the business case	Redefine the scope of the project idea into a smaller scope that can be completed within the given time period	30/09/2021	8.30 PM	Problem statement is finalized. Further research into value proposition and the methods used by competitors	Good amount of research on the problem statement, more concrete facts are needed for ML	Sign off was given
3	02/10/2021	9.00 PM	Review the newly defined project scope Possible usages of ML for the value proposition	Thorough research on existing applications and how they do the predictions	07/10/2021	8.30 PM	Scope seems to be too wide to be developed within dew months individually. Should be focused on the core value and how it can be enhanced with the value addition.	Project scope is improved. Methodologies and data frameworks should be considered.	Sign off was given
4	07/10/2021	8.30 PM	Brief discussion on existing technologies and factors that could be taken into consideration determine recommendations	Research on factors contributing to recommendations and planning questionnaire to get expert opinions	14/10/2021	8.30 PM	Research into the granular level of the methodologies to understand what kinds of data is gathered, and ethical perspective	Good research on factors. Check on how these factors can be legally and ethically obtained from real life	Sign off was given
5	17/10/2021	9.00 PM	Run through the questionnaire and detected factors and consideration on ethical perspective	Further research on features that needs to be included and thorough research to modify questionnaires	25/10/2021	8.30 PM	Questions seem to lack the backing of research. Research on areas further and use the questions to confirm your opinions, theories and to clarify doubts	Feastures are good but should not take the focus out of the core value	Sign off was given
6	26/10/2021	9.30 PM	Planning the project proposal chapter	Project Proposal Draft	04/11/2021	8.30 PM	Mistakes in the literature were pointed out in the google docs	Ethical clearance forms were reviewed	Sign off was given
7	13/11/2021	8.00 PM	LR chapter, interview and further guidance on diet recommendation feature build up	LR chapter	20/11/2021	8.30 PM	Research on which specific features are required and with explanations	Domain research is good. More research should be done for technical aspect.	Sign off was given

Figure A6: Supervisor Meeting Logbook

Appendix VII – Other Functionalities

Content of the pages are created using a controller layer that takes the information from the Edamem API through the JSON files and different parameters are passed to organize the page structure. Refer to the code snippet shown in *figure A7-1*. Moreover, the admin can create new entries for allergies from the admin panel webpage.



```
public function store(StoreContentPageRequest $request)
{
    $contentPage = ContentPage::create($request->all());
    $contentPage->categories()->sync($request->input('categories', []));
    $contentPage->diet_types()->sync($request->input('diet_types', []));
    $contentPage->tags()->sync($request->input('tags', []));
    if ($request->input('featured_image', false)) {
        $contentPage->addMedia(storage_path('tmp/uploads/' . basename($request->input('featured_image'))))->toMediaCollection('featured_image');
    }

    return (new ContentPageResource($contentPage))
        ->response()
        ->setStatusCode(Response::HTTP_CREATED);
}

public function show(ContentPage $contentPage)
{
    abort_if(Gate::denies('content_page_show'), Response::HTTP_FORBIDDEN, '403 Forbidden');

    return new ContentPageResource($contentPage->load(['categories', 'diet_types', 'tags', 'created_by']));
}

public function update(UpdateContentPageRequest $request, ContentPage $contentPage)
{
    $contentPage->update($request->all());
    $contentPage->categories()->sync($request->input('categories', []));
    $contentPage->diet_types()->sync($request->input('diet_types', []));
    $contentPage->tags()->sync($request->input('tags', []));
    if ($request->input('featured_image', false)) {
        if (!$contentPage->featured_image || $request->input('featured_image') !== $contentPage->featured_image->file_name) {
            if ($contentPage->featured_image) {
                $contentPage->featured_image->delete();
            }
            $contentPage->addMedia(storage_path('tmp/uploads/' . basename($request->input('featured_image'))))->toMediaCollection('featured_image');
        }
    } elseif ($contentPage->featured_image) {
        $contentPage->featured_image->delete();
    }

    return (new ContentPageResource($contentPage))
        ->response()
        ->setStatusCode(Response::HTTP_ACCEPTED);
}

public function destroy(ContentPage $contentPage)
{
    abort_if(Gate::denies('content_page_delete'), Response::HTTP_FORBIDDEN, '403 Forbidden');
```

Figure A7-1: Code for getting content from API

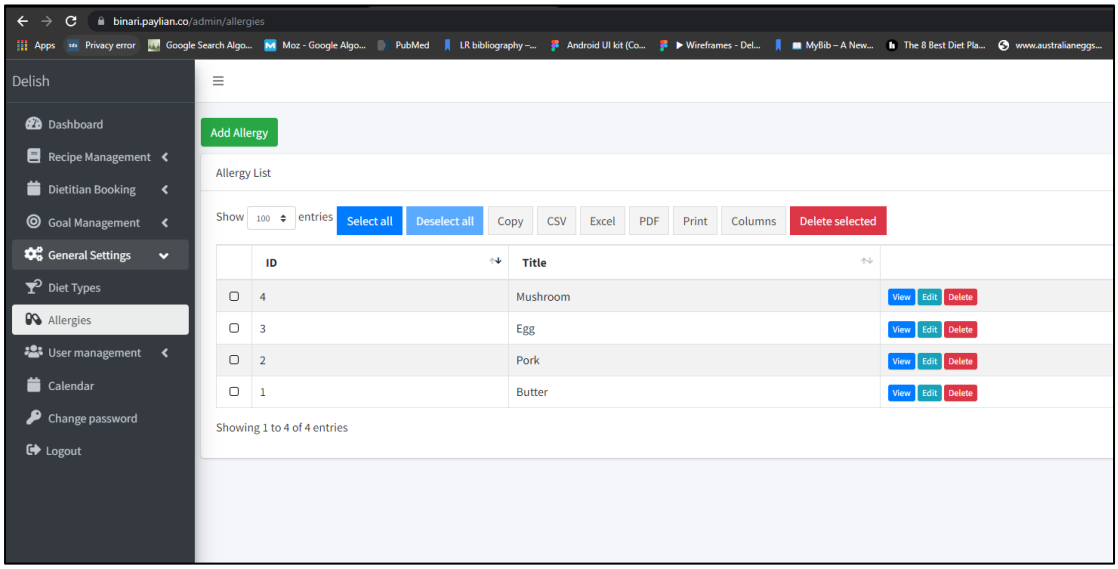


Figure A7 -2: Allergy Information Admin Panel Input

Below code snippet shows how this allergy information input is reflected from the backend. Furthermore, it shows how the admin level privileges are granted for editing this information.

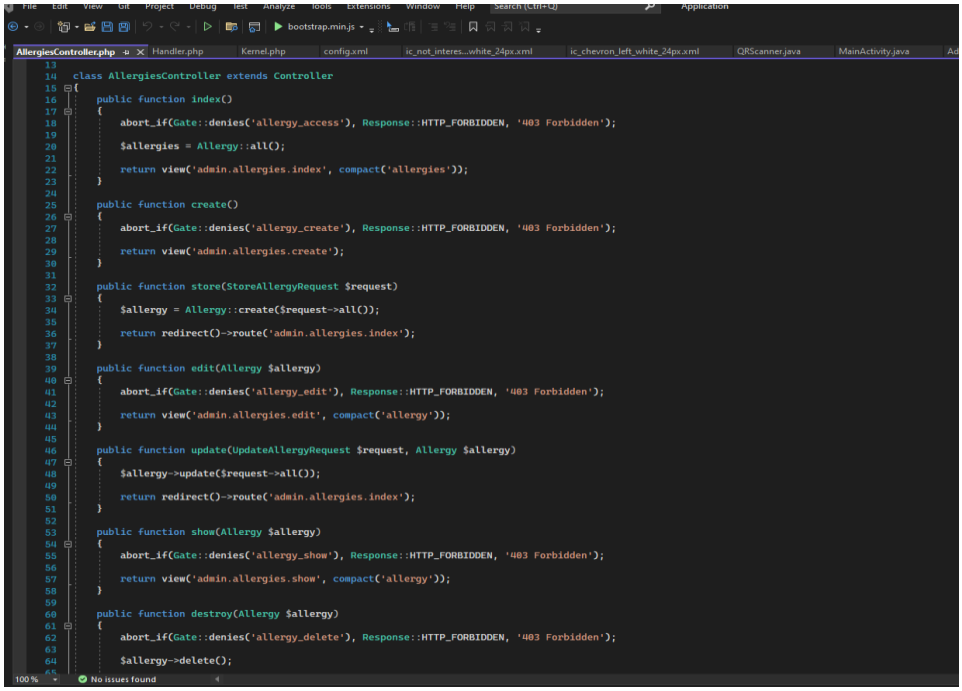


Figure A7 - 3: Allergy Input Backend

Appendix VIII – Plagiarism Report