University of Sheffield

MindPath: Leveraging An iOS App and Web Platforms to Study the Interaction Between Mental Health and Lifestyle Factors

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Declaration

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Date: 07/05/2024

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Abstract

Mental health is critical in today's world because it affects every aspect of our lives. Our thoughts, actions, and interactions can all be influenced by our mental health. Over the years, mental health issues have been mostly associated with biological factors. Recently, there has been a growing interest in how "lifestyle factors" traditionally associated with physical health may also be related to mental health.

MindPath is a comprehensive system comprising an iOS app and a website. It is designed to facilitate the study of the interaction between mental health and lifestyle factors. By harnessing Apple's ResearchKit, MindPath brings the capabilities of detailed research directly to smartphones. The iOS app collects data related to lifestyle factors from participants and the website then allows researchers to visualise and analyse the data.

This approach not only leverages the best available resources but also enriches the depth of research on a subject of considerable public interest. The potential of MindPath to pave the way for future research has been substantiated by its ability to integrate and analyse complex data efficiently. With further development and research, MindPath has the potential to become a efficient tool for exploring topic of mental health in the digital age.

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Chapter 1

Introduction

1.1 Motivation

Positive mental health is crucial in today's world, as it profoundly impacts various aspects of our lives. Mental health impacts our thoughts, actions, decisions and day-to-day interactions. Over the years, mental health has traditionally focused on biological factors and chemical imbalances. Neither of these actually explored the possibility of a person's lifestyle factors affecting their mental health. In recent years, there has been an active and growing interest in mental well-being, which acknowledges the possibility that mental health is strongly correlated to a person's lifestyle choices. Several studies have demonstrated the possibility of lifestyle factors affecting mental health. A meta-review of "lifestyle psychiatry": the role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders proposed that 'There is increasing academic and clinical interest in how "lifestyle factors" traditionally associated with physical health may also relate to mental health and psychological well-being' [1]. Over the years, advancements in technology have undoubtedly enhanced our ability to diagnose, treat and evaluate various conditions. As of 2023, there are estimated to be between 10,000 to 20,000 mental well-being apps available [2]. However, most of these applications focus on helping users improve their emotional well-being and become more mindful. Despite these advancements and the increasing recognition of the role of lifestyle factors in mental health, there still remains a gap in understanding the magnitude of this interaction.

1.2 Objectives

The main objective of this project is to build a system called **MindPath**. This would involve a) Designing and developing an iOS application using Apple's Research Kit - an open source framework that allows researchers and developers to create applications for medical research [3] and b) Designing and developing a website that visualises the data collected by the iOS application. The iOS app and website would work together to form MindPath. The primary purpose of the application will be to collect real-world data on participants' daily lifestyle choices such as work, diet, sleep cycle, profession etc. As the data collected will be used for research, the first priority would be to anonymise and protect participant data. The data can then be used by researchers to formulate a possible answer to the question of "How

much does lifestyle choices affect one's mental health".The website will visually present the data using multifaceted data visualisations. This would enable researchers to gain a deeper understanding of the factors affecting mental health beyond theoretical constructs. It is important to note that this application and the website are not intended to be used as diagnostic tools. The sole purpose of this application and website is to try and provide a valuable perspective to foster the increasing academic and medical interest in the topic

1.3 Overview

The introductory chapter laid the foundation by elucidating the motivation and objective behind the project and emphasised on the increasing awareness of lifestyle choices' impact on mental health.

Chapter 2 delves into a literature survey. This includes tracing the historical evolution of mental health and the shift towards recognising the role of lifestyle choices in mental well-being. This chapter also involves a brief introduction of Apple's ResearchKit, CareKit and some existing applications using the two frameworks. Additionally, this chapter also discusses the regulations in place for medical devices.

Chapter 3 navigates essential aspects of the project. It establishes the technical direction for the project. It gives an overview of how MindPath would work, what features it will have, implementation and success metrics. The chapter concludes with discussing the potential risks.

Chapter 4 will include insights on the software, tools, and relevant technical skills in the context of this project. This technology survey and analysis will be instrumental in guiding the project as it would provide a clear understanding of the technological landscape.

Chapter 5 delves into the MindPath's design aspects. It covers topics from database structure to design choices for the iOS app and website. The chapter also highlights the rationale behind the design choices. It concludes by showcasing how these decisions contribute to a seamless user experience.

Chapter 6 presents how the iOS App and website were developed by integrating frameworks and tools .The chapter also includes information about testing.

Chapter 7 discusses results and achievements accomplished. It also includes insights on the user evaluation. Additionally, the chapter identifies the main limitations, and future works.

Chapter 8 concludes the report by revisiting the main objective of the project and summarising what has been done so far.

Chapter 2

Literature Survey

This chapter explores the interaction between mental health and lifestyle factors and underscores its importance. It sets the stage for gaining a deeper understanding of the intersection between mental health, lifestyle, and technology. It provides a comprehensive background of mental health and traces its evolution over the years. Furthermore, it digs into the potential of technology in healthcare and discusses how it is being leveraged to enhance medical services. The chapter concludes by introducing the regulations governing medical applications.

2.1 Mental Health and Lifestyle Factors

2.1.1 What is Mental Health?

Mental health can be explained as a state of mental well-being that enables people to cope with the stresses of life, realise their abilities, learn well and work well, and contribute to their community. Mental Health is something that is an integral component of health and well-being. Not only does it affect our health, but it also underpins our individual and collective abilities to make decisions, build relationships and shape the world we live in [4]. The concept of mental health is more than the absence of mental disorders. Mental Health is not a binary state and can be experienced differently from one person to the next with varying degrees of difficulty and distress. In conclusion, having a positive mental health is crucial in today's world, as it profoundly influences essential aspects of our lives [5].

2.1.2 History of Mental Health

Over the years, the understanding of mental health has undergone significant evolution. The roots of what is commonly recognised as "mental health" today can be found in advancements in clinical psychiatry, public health, and other fields of study. Historically, mental disorders have had three major explanations, namely, the supernatural, biological and psychological models[6]. These distinct models have shaped societal attitudes, treatment approaches, and the perception of individuals grappling with mental health challenges. Over the years, the historical understanding has undergone a transformative evolution across the three major models. In the ancient times, mental afflictions were often attributed to supernatural causes, with various cultures attributing psychological distress to something supernatural. Although references to mental health as a state can be found in the English language well before

the 20th century, technical references to mental health as a discipline are not found before 1946. During that year, the International Health Conference, held in New York, decided to establish the World Health Organization (WHO) and a Mental Health Association was founded in London[7]. These changes in the late 19th and early 20th centuries witnessed a significant shift with the emergence of the biological model. This perspective proposed that mental disorders have physiological origins, emphasising abnormalities in the human brain. During this time - there were also advancements in the psychological model. This model focused on mental processes, emotions, and behavioural patterns, exploring the impact of early experiences and unconscious conflicts on mental health [8]. This whole transition from the supernatural model to the psychological model represents an intriguing evolution.

2.2 Healthy Lifestyle

In today's fast-paced and demanding world, maintaining a healthy lifestyle has become crucial. A healthy lifestyle, which includes regular physical activity, balanced nutrition, stress management, and self-care, is integral to enhancing one's quality of life [9]. The benefits of living a healthy lifestyle are extensive. It can lead to a longer life, fewer health problems, increased energy, enhanced mental health. It can also potentially protect us against serious health problems: diabetes, high blood pressure, heart disease, strokes, cancer, and more. In terms of maintaining a healthy lifestyle, it can be characterised as a multifaceted endeavour. In addition to the different ways mentioned above, a healthy lifestyle can also be influenced by different lifestyle factors. Lifestyle factors can be explained as adaptable and modifiable habits or choices in your life [10]. These lifestyle factors can range across various aspects of life. Some examples can be sleep quality, dietary habits, work-life balance and effective stress management strategies. They play a significant role as they can greatly influence overall health and well-being. Considering the advantages that it promotes, people have been making alterations to their daily lives by incorporating healthy eating choices, efficient sleeping schedules and regular physical exercise. For example, a survey commissioned by the British Nutrition Foundation reveals that 62% of Britons have made a change to their diet to adopt a healthier lifestyle [11]. In conclusion, pursuing a healthy lifestyle in our fast-paced world is not only a necessity, but also a lifelong commitment with substantial benefits.

2.3 Healthy Lifestyle and Mental Health

A healthy lifestyle is not just about physical well-being, but also about nurturing mental health. It's about making choices that make us feel good and happy. These choices range from regular exercise and balanced nutrition to quality sleep and stress management techniques. Each of these elements plays a significant role in our mental well-being. Regular exercise and a balanced diet do more than just keep our bodies healthy; they also contribute to our mental well-being. A nutritionally balanced diet supports cognitive function, while regular exercise can boost mood and reduce stress. Quality sleep is another crucial aspect of a healthy lifestyle. It plays a key role in mood regulation and overall mental health. Similarly, stress management techniques, such as mindfulness and meditation, are pivotal in preventing and addressing mental health challenges.In addition to these, fostering social connections, achieving a harmonious work-life balance, and engaging in activities that stimulate the mind

can all serve as proactive measures for mental well-being. These lifestyle choices can act as preventive measures against disorders and enhance overall psychological well-being. In conclusion, the choices we make in our daily lives, from physical activities to sleep patterns and stress management, collectively contribute to a healthier and happier mental state. This underscores the importance of adopting a holistic approach to well-being, where physical and mental health are equally prioritised. A healthy lifestyle, in the context of mental health, emerges as a dynamic force for enhancing psychological well-being.

2.4 What are Health Applications?

They way people manage and record their health has changed over the few years.According to the World Health Organization (WHO), mobile health (mHealth) is a general term that covers public health and medical practice through the use of smartphones, sensors, personal digital assistants, wireless monitoring devices, or other wireless devices [12].Health applications, also known as health apps or medical apps are software designed to cover a range of functionalities and cater to diverse health needs. Some common categories of health apps include - fitness/exercise , nutritional , mental well-being, sleep tracking and many more. The existing health applications have two main goals - a) produce insights/reports for the users b) to facilitate large-scale data collection for research.

When it comes to applications related to Mental Health, they offer unique opportunities for self-management of mental health and well-being in mobile, cost-effective ways. The number of mobile health (mHealth) apps focused on mental health has rapidly increased; a 2015 World Health Organization (WHO) survey of 15,000 mHealth apps revealed that 29% focus on mental health diagnosis, treatment, or support [13]. These medical apps leverage the advancements in technologies (sensors in smartphones and other devices) and represent a unique opportunity to expand the availability and quality of mental health treatment. They track vital signs and lifestyle habits, providing users with valuable insights into their health and promoting healthier behaviours. The data collected by these apps not only empowers individuals with knowledge about their own health but can also be shared with healthcare providers. In summary, the rise of mental health-focused mobile health (mHealth) apps marks a transformative shift in healthcare.

2.5 Smartphones and Wearable Technologies as Medical Devices

Smartphones and wearable technology have been one of the most innovations introduced in the recent year. Statista reports that as of 2023 there are around 4.6 billion active smartphone users [14]. Out of which, more than a billion are active iPhone users [15]. These technologies have been leveraged in a way that has allowed them to make impeccable advancements in different fields. Medicine is among the disciplines which have been greatly benefiting from the availability of smartphones. Over the years, there have been several medical apps that have been developed with specific purposes. Just by browsing through the Apple's App Store, one can find an assortment of applications that could be downloaded. These applications have functionalities such as screening and diagnosis, monitoring, and clinical communication. Such

applications can range from booking a consultation, tracking body temperature, menstrual cycle tracker to getting personalised acne treatment. With the ever growing adoption rate of smartphones, as well as the introduction of new wearable technologies and softwares, it is anticipated that smartphones will become an essential part of healthcare. While these advancements have been quite successful, others believe that more high-quality studies are needed to come to a definite conclusion about the smartphone's role in the field [16].

2.6 Apple's ResearchKit

In 2015, Apple launched an open-source software framework called ResearchKit, designed to facilitate medical and health research [17]. ResearchKit aims to simplify app development for research purposes by a) taking advantage of sensors ,capabilities from a user's Apple devices (iPhones, iPads, Apple Watches) and user input to collect data that can be correlated to produce meaningful results about specific health-related topics and b) providing a variety of customisable modules to, for example, create informed consent forms, participant reported outcome surveys, and real-time dynamic active tasks (e.g., gait, tapping, spatial memory)[18].This provides the path for the implementation of remote, smartphone-based research trials and allows the monitoring and analysis of the health and behaviour of users of these apps. Recruiting participants for research is something that researchers often tend to struggle with With around 2 billion (2023) active Apple devices across the world [19], ResearchKit provides the platform researchers have been longing for.

When it comes to research, there are a few key things that make a big difference: consent, surveys and interactive tasks. Consent ensures people know what they're signing up for, keeping things ethical and trustworthy. Meanwhile, interactive tasks, using phone sensors, bring a new level of engagement to studies, letting us collect more detailed and real-time data. Together, these elements not only make research smoother but also more insightful. To facilitate these elements, the ResearchKit is made up of three customisable modules addressing the most common elements of research:

Consent: Research studies that involve human subjects typically require some form of ethics review.For some studies, consent may be required to conduct a research study, which means that the researcher must ensure that each participant is fully informed about the nature of the study, and must obtain a signed consent from each participant[20]. The ResearchKit framework makes it easy for the developers to create and display their consent document.

Survey: This module provides predefined user interfaces to build surveys efficiently. These surveys can have a variety of questions and answer formats including scales, image selection, or location inputs, and can be responsive, changing based on previous answers [21].

Active Tasks: Using the sensors (built-in iPhones) to actively gather data, active tasks allow users to engage in activities in partially controlled environments.This provides a way of retrieving data about a user that cannot be achieved through surveys. Some examples of activities include motor activities (range of motion, gait and balance), cognition (reaction time, spatial memory), and speech (sustained phonation, speech recognition) [22].

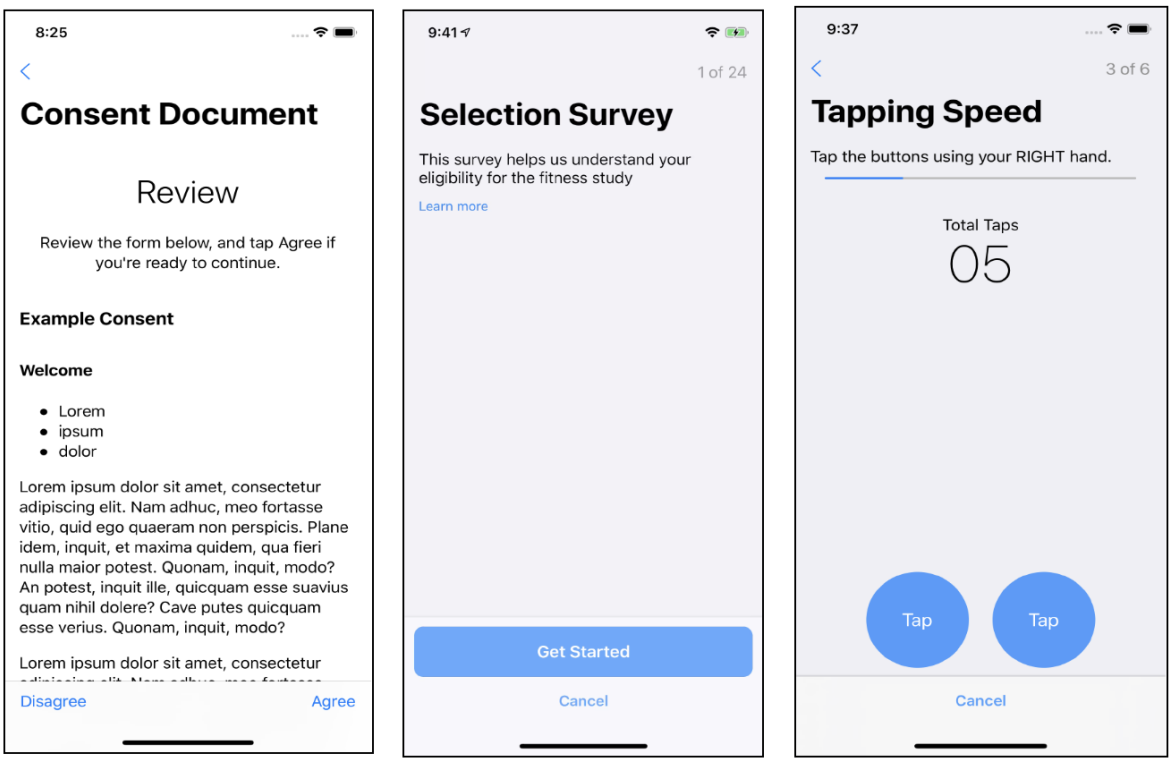


Figure 2.1: *ResearchKit Modules [20]–[22]*

2.6.1 Apple's CareKit

Introduced by Apple in 2016 [23], CareKit is an open source framework for developing apps, CareKit helps users better understand and manage their health by creating dynamic care plans, tracking symptoms, connecting to care teams, and more [24]. This framework makes it easier for individuals to keep track of care plans and monitor symptoms and medication; providing insights that help people better understand their own health. While the CareKit won't be directly utilised for this project, it's still crucial to acknowledge its features. As ResearchKit and CareKit provide individual customizable modules, both frameworks can be used together to build a feature-rich app. The flexibility and adaptability of these frameworks enhance the app's functionality, catering to a wide range of user needs. Despite their distinct purposes, the integration of ResearchKit and CareKit can lead to the development of comprehensive health . An example is the CheckCOVID app (available in the USA only), developed by the University of Nebraska Medical Center [25]. This application integrates ResearchKit and CareKit. The ResearchKit enables the users to complete a questionnaire about symptoms and exposure. Using CareKit, the data can then be shared with a healthcare provider.

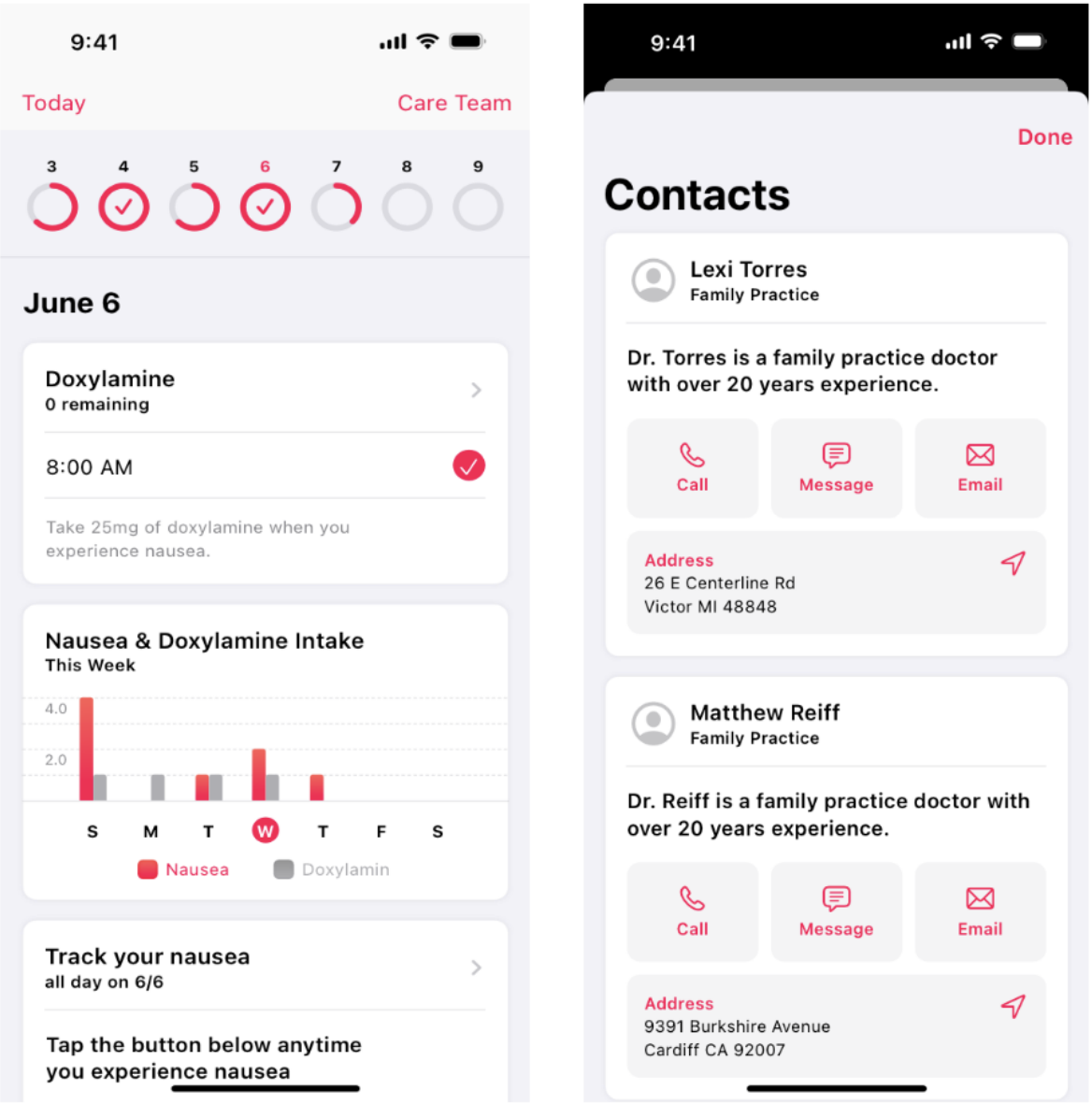


Figure 2.2: *Apple's CareKit [25]*

2.6.2 ResearchKit for Mental Health Applications

Since its launch in 2015, numerous apps have been developed with the help of ResearchKit. However, studies have primarily focused on physical conditions and ResearchKit-based mental health apps have been developed far less frequently [26]. An example that uses ResearchKit for the development of a mental health app, is the study by Egger and colleagues [27], in which an app to collect videos of young children with the aims of detecting autism-related behaviours was designed. Egger investigated the acceptability and feasibility of conducting an AST with young children and their caregivers. The entire study procedure was designed with ResearchKit (i.e., e-Consent process, stimuli presentation, data collection) and, over the course of one year, 1,756 families participated in the study by uploading 4,441 videos and completing 5,618 caregiver-reported surveys. Further, Byrom tested ResearchKit for delivering a Paced Visual Addition Test and concluded that ResearchKit provided a straightforward approach to app development, that participant acceptance was good and that ResearchKit is a promising tool to enable cognitive testing on mobile devices [28]. In summary, these studies collectively suggest that ResearchKit can be effectively utilised in the development of mental health apps. The acceptability and feasibility of using ResearchKit for data collection, surveys, and cognitive testing in mental health studies have been demonstrated in the examples, paving the way for potential future applications in this field.

2.7 Medical Applications: Regulations

Currently, the Medicines and Healthcare products Regulatory Agency (MHRA) is responsible for regulating medicines, medical devices and blood components in the UK. According to the MHRA, A 'Medical device' means any instrument, apparatus, appliance, software, implant, reagent, material or other article intended by the manufacturer to be used, alone or in combination, for human beings [29]. Medical devices are categorised into several classes, from Class I (low risk) to Class III (high risk). The MHRA has provided guidelines for Class I medical devices, which includes details of the obligations that manufacturers must adhere to. For the low-risk devices, they still need to follow some regulations. These include preparing technical documentation, carrying out a clinical evaluation by a certified 3rd party, as well as implementing procedures for reviewing the experience post-production[30]. Some software products/applications also fall under the directive for medical devices. Under the Medical Devices Regulations 2002, if the intended purpose of a software is to prevent, diagnose or monitor a disease, it is classified as a medical device[31]. An application does not classify as a medical device if the sole purpose of the application is to allow the users to log their answers (about their lifestyle factors). It also not classified as a medical device if it proves recommendations to appropriate services or general advice. Taking into account the points mentioned above, the iOS application will include an introduction/onboarding screen. This would include detailed information about the aims and objectives of the application. It will be clearly mentioned that the application has been built as a part of a dissertation project and evaluation will only be based on the overall functionality of the application. The users in an order to take part in the survey (as participants) will be required to agree with terms. This would include information about how their data would be collected and how it would be utilised anonymously by researchers.

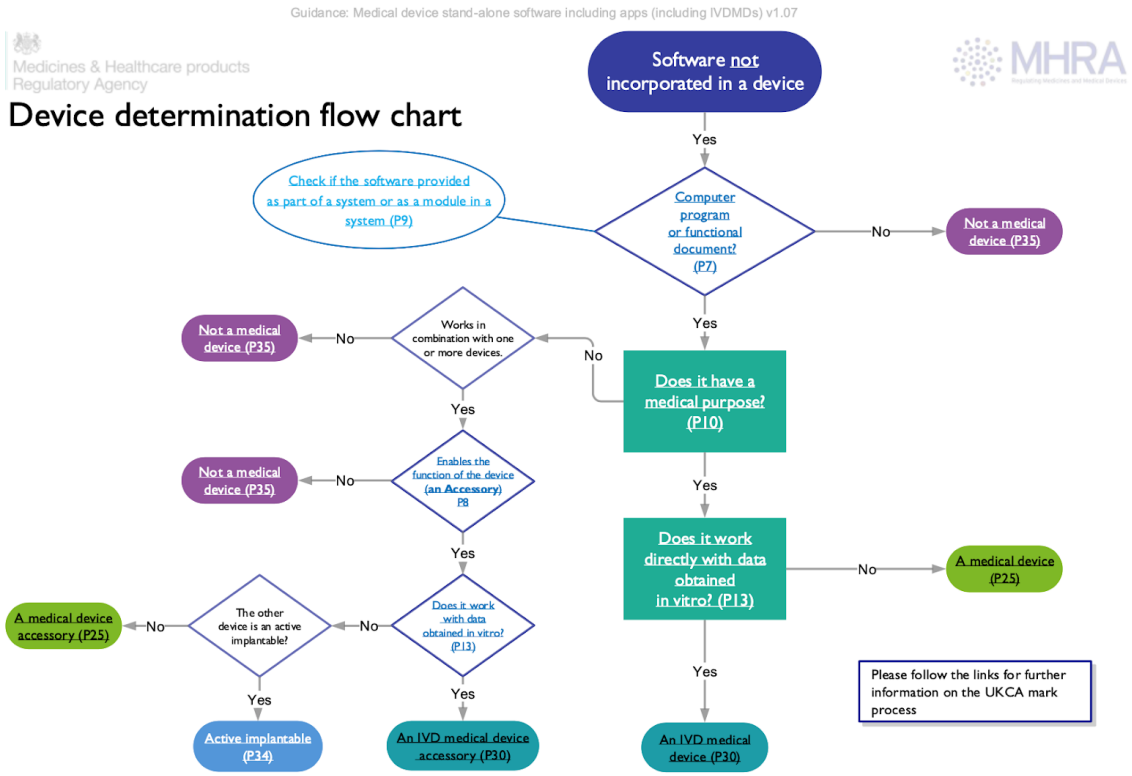


Figure 2.3: *MHRA Device Determination Flow Chart [32]*

Chapter 3

Requirements and Analysis

This navigates essential technical aspects of the project . It gives an overview of how the MindPath will function, user stories, non-functional requirements of the system and discusses the data protection regulations. The chapter concludes with discussing the risks identified.

3.1 System Description

The proposed system "MindPath" consists of an iOS application and a website designed to collectively facilitate a research to study the interaction between mental health and lifestyle factors.

- The iOS application, developed using Apple's Research Kit, serves as the primary tool for participants to take part in the research.This would provide a user-friendly interface for data collection on various lifestyle factors.
- The iOS application will securely collect the data from the participants by asking them to answer a series of questions - a survey.
- Participants will take part in the research by entering a few details, getting familiar with the terms, answer particular questions related to their lifestyle, check data privacy within the app and withdraw from the research at any point.
- The website will be the tool used by the researchers that would facilitate data visualisation.
- It will allow the researchers to visualise the data collected from the iOS app.
- The system "MindPath" prioritise data security, participant privacy, and ethical research practices. The seamless integration of different components aims to offer a holistic and user-centric approach to exploring the intricate relationship between lifestyle choices and mental health.

The iOS application will require the participants to participate in the research by giving their consent and some details. The application will ask the participants to complete a survey about different lifestyle factors (The participants would be invited to complete the

survey). These questions will include topics such sleep quality, working environment, diet etc. Each question will have a follow up rating question asking the participants to rate how much the particular factor affects their mental well-being. The anonymised and visualised data from each participant will then be available on the website. The website will provide a comprehensive and visually engaging platform for researchers to gain insights into the data and foster a deeper understanding the interaction between mental health and lifestyle factors.

3.2 Key Factors for Investigating the Interaction

To better understand the interactions between mental health and lifestyle factors, the following parameters will be used. By collecting and analysing the data based on these parameters, the researchers can gain insights into how the interaction between mental and lifestyle factor works.

- **Physical Activity Levels**: This parameter assesses the individual's engagement in regular physical activity. It includes activities such as exercise, sports, and other forms of movement.Regular physical activity has been associated with improved mood, reduced stress, and enhanced overall mental well-being.
- **Sleep Patterns:** This parameter assesses an individual's sleep patterns by analysing the quality and quantity of the sleep. Stress, anxiety, and mood disorders are just a few of the mental health problems that can be exacerbated by inadequate or irregular sleep patterns.
- **Stress**: This parameter assesses an individual's perceived stress. High stress levels can adversely affect mental health. It has the potential to contributing to anxiety, depression, and other psychological issues.
- **Nutritional Habits:** This parameter assesses an individual's dietary choices. Nutrition plays a crucial role in determining the overall mood. It can also potentially impact an individual's cognitive function.
- **Social Interaction:** This parameter assesses the extent and quality of an individual's social connections and interactions. A strong social support is often linked to positive mental outcomes, while social isolation may contribute towards negative feelings.
- **Profession:** This parameter assesses an individual's occupation. Work-related factors can significantly impact mental health. High levels of stress, burnout, or dissatisfaction in an individual's profession may contribute to mental health challenges.

The DASS-21 is a well-established tool that helps to understand the impact of depression, anxiety, and stress on an individual's life. However, it's important to note that the DASS-21 is not a clinical instrument and cannot diagnose these conditions. It merely indicates whether these issues are currently having a significant effect on the person's life [33]. The DASS-21 is helpful, but it has limits. The survey's generic questions might not gather the precise information needed for our investigation. The aim is to collect data that would allow researchers to establish the correlation between mental health and lifestyle factors, and

the DASS-21 might not offer the level of detail we need. Consequently, even though the effeciency of the DASS-21 is acknowledged, the idea to shift over to other variables can have the potential to yield more relevant and targeted data for the study's objectives.

3.3 Functional Requirements

The requirements for this system will be presented as user stories. The user stories will have the following structure:

> As a <**type of user**> I want/should <**goal**> so that <**type of user**>.
> The possible <**type of user**> are:

- participant - anyone who has given consent to participate in the evaluation of the research survey.
- researcher - anyone who has been given access to the website which provides the anonymised results collected from the enrolled participants.

The user stories in 3.2will be prioritised based on the**MoSCoW** technique.Table 3.1 provides the key to the prioritisation technique.

Must-have	This category consists of initiatives that are "musts" for the application. They represent non-negotiable needs for the application.
Should-have	They are essential for the application, but they are not vital. If left out, the application still functions. However, the initiatives may add significant value.
Could-have	These initiatives are not necessary to the core function of the application.
Won't-have	This category contains functionalities which will not be included in a specific release, time frame or prioritised in the future. Their absence is not detrimental to the functionality of the final product.

Table 3.1: *MoSCoW Key*

User Stories	**Priority**
As a participant, I want to be able to register on the app.	Must-have
As a participant, I want to be able to update my profile information at any point.	Could-have
As a participant, I want to be able to answer a series of questions about myself so I can partake in the survey.	Must-have
As a participant, I want to be able to receive notifications so I know when it is time to complete a survey at any point.	Could-have
As a participant, I want to be able to withdraw from the survey.	Must-have
As a participant, I want to be able to complete a consent form that will authorise the use of my responses for the intended purpose.	Must-have
As a participant, I want to manually input the answers for the survey.	Must-have
As a participant, I want to easily access, understand, and control my data privacy within the app.	Must-have
As a participant, I want to get regular updates regarding the research.	Should-have
As a researcher, I want to visualise the summarised data.	Must-have
As a researcher, I want to filter and search based on specific criteria (Demographic).	Should-have

Table 3.2: *User Stories*

3.4 Non-Functional Requirements

Requirement	Description	Priority
Security and Privacy	Ensuring the security and privacy of participant data. This includes encryption of data during transmission and storage, secure user authentication, and compliance with data protection regulations.	Must-have
Scalability	Managing a potentially large number of participants as the research progresses. This would ensure that the infrastructure can scale to accommodate participant engagement.	Should-have
Usability	Having an intuitive and user-friendly interface to ensure ease of use for participants. This involves clear navigation, simple language, and easy accessibility of features.	Must-have
Compatibility	The application should be compatible with a range of iOS versions. This would ensure accessibility for a diverse participant group.	Should-have
Compliance with Research Ethics	The application must adhere to ethical standards in research,including obtaining informed consent from participants and ensuring the anonymity and confidentiality of collected data.	Must-have

Table 3.3: *Non-Functional Requirements*

3.5 Risk Analysis

As part of the project, a comprehensive risk analysis will be conducted. The findings are detailed in the risk register which can be found in **Appendix A Risk Register**. The risk register lists potential project risks. It is a tool that has facilitated anticipating potential challenges and formulate appropriate mitigation strategies. As a part of the risk analysis, the risk register will be revisited multiple times to ensure new risks identified are taken into consideration.

3.6 Data Protection Regulations

Data protection is yet another crucial factor that must be taken into account when considering the requirements.The healthcare sector traditionally processes large amounts of personal data. Nowadays, medical practice increasingly uses information technologies, such as smartphone applications ('apps') and wearable devices (e.g. smart watches, smart soles), for treatment plans and information collection. There are some applications that are developed specifically for a) the healthcare sector b) the general public to keep track of their health c) research purposes. Within the European Union (EU), the processing of personal data collected by these technologies is regulated by the General Data Protection Regulation (GDPR) .The GDPR entered into force on 25 May 2018. The GDPR provides controllers and processors with obligations and data subjects with rights. For any application, it is necessary for the application developers/providers to formulate privacy policies to determine whether they are in line with each other and with the GDPR [34]. In addition to this, the EU commission has a Privacy code of conduct on mobile health apps. The current draft of the Code consists of practical guidance for app developers on data protection principles while developing mobile health apps. The Code addresses notably the following topics like user consent, purpose limitation, privacy, advertisements on mobile applications, data transfers etc [35].

3.7 Evaluation

Conducting thorough evaluation is essential for any system. Considering it's importance, a comprehensive range of evaluations will be conducted to guarantee the functionality of MindPath.

- **Unit testing** will be conducted to validate individual components and the functionality of the system.
- **Integration testing** will be conducted to verify the seamless integration of components and modules within MindPath.
- **System testing** will be conducted to assess the overall functionality and the performance of the integrated system.
- **User Evaluation** will be conducted to gain insights are gained into aspects such as the survey content, app navigation, website content, and website features. The user evaluation of the system would involve human participants and would require an ethics approval. This has been sought from the University of Sheffield. The ethics approval letter can be found in **Appendix D Ethics Application Approval Letter**, and the supporting documents can be found in **Appendices E and F**.
- **Acceptance Testing** will be conducted to determine if the system meets the predefined requirements.
- **Cross-Device Testing** will be performed to ensure that the iOS app works consistently across different devices.

Chapter 4

Technology Survey and Analysis

This section will include insights on software, tools, and relevant tech skills in the context of this project. This would include comparing and analysing different tools and technologies. This information will be instrumental in guiding the project by providing a clear understanding of the technological landscape.

4.1 Software Development Lifecycles (SDLC)

The Software Development Life Cycle (SDLC) refers to a methodology with clearly defined processes for creating high-quality software [36]. There are multiple software development life cycle models that exist. They can be put in three categories – sequential, incremental and evolutionary [37]. They all define similar stages, such as analysis, requirements elicitation, development, testing and maintenance. The main difference is how and when these models are used.

Sequential Models: Sequential Models in software development follow a linear approach, wherein the system is systematically constructed in a step-by-step manner. The model features well-defined and successive phases with no overlaps. The outcome of each phase serves as the input for the subsequent phase [38]. One of the major drawbacks of following this model is that it is not flexible and has no communication with the stakeholders during these phases making it impossible to receive feedback and make alterations [39]. The waterfall model is an example of a sequential model. The waterfall was the first method and was introduced back in 1970 [40]. It has the same sequential approach where the model's flow can be compared to a waterfall, which moves from higher to lower points before arriving at its destination. In conclusion, the sequential model's drawbacks are unsuitable for smaller teams/projects and evolving projects.

Iterative Models: Iterative and incremental software development is an approach characterised by a gradual enhancement of features and a cyclic release and upgrade pattern. The process begins with planning and progresses through iterative development cycles, incorporating continuous user feedback and incrementally adding features. Each cycle concludes with the deployment of the finalised software. Additionally, iterative development involves revisiting and improving parts of the system based on user feedback, allowing for the mod-

ification of targets for subsequent deliverables. Even though the requirements can be easily implemented, the approach still required extensive documentation [41].

4.2 Agile

The Agile methodology (an iterative model) is a project management approach that involves breaking the project into phases and emphasises continuous collaboration and improvement. The team/developer follows a cycle of planning, executing, and evaluating [42]. Agile methodology is well-suited for this project due to its adaptability and responsiveness. Unlike the Sequential Model, which follows a rigid, linear progression, Agile allows for continuous adjustments and iterations. Agile's emphasis on iterative development, frequent user feedback, and incremental feature additions aligns perfectly with the dynamic nature of this project.

4.3 Swift

Swift is an open-source programming language, announced by Apple in 2014 [43]. Until then, Objective-C mostly was used for iOS development. Both languages are inherent to the iOS platform. However, Swift offers significant advantages.

Swift is faster: Swift is faster than most programming languages. It is almost 2.6x faster than objective C and 8.4x faster than Python which gives a seamless experience to the developers [44].

Swift is easier to use: Objective-C builds on the complex syntax of C, while Swift opts for a more English-like syntax. Swift also shares similarities with modern programming languages such as Python and Ruby.

Open Source: Swift is an openly developed programming language with source code, a bug tracker, forums, and regular builds accessible at Swift.org. The open source nature of swift means that it has a large community surrounding its use that opens to collaboration and newer ideas. It also makes it even more customizable as per the needs [45].

4.4 SwiftUI

Introduced in 2019, SwiftUI is a front-end framework that enables the creation of user interfaces through a declarative approach [46]. Due to its inherently declarative approach, generating a text label with the text "Hello World" is straightforward, requiring only the code Text("Hello World"). Before SwiftUI, developers primarily used the UIKit framework and Storyboards to create user interfaces [47]. Layouts were either programmatically defined or arranged on a canvas (Storyboard) and connected to code using outlets. UIKit required careful constraint-setting for each element to ensure proper display on various screen sizes and orientations. For building an iOS application, SwiftUI can be considered as the better option. SwiftUI, built on top of UIKit, handles the technical complexities, enabling developers to focus on crafting user-friendly interfaces. SwiftUI promotes reusability and allows custom views to be easily extracted and reused.

4.5 Development Environment

The system will be developed on MacBook Air 15' (2023) with a M2 chip , 16 GB of RAM, 10 Core GPU and 512 GB SSD. The operating system is macOS Ventura 13.2. The iOS app will be tested on iPhone 12 and iPhone 13 Pro, both running iOS 17. The project will be developed using XCode 15 (2023). Additionally, Visual Studio Code will be used for developing the website.

4.5.1 XCode

Xcode, is a macOS integrated development environment (IDE) created by Apple. It allows you to develop applications for iOS, macOS, watchOS, and tvOS. It equips developers with the necessary tools for testing, analysing, optimising, and submitting apps to the App Store. Xcode also includes a simulator for testing applications across various devices and environments [48].
In September 2023, Apple released XCode 15. Xcode 15 introduced a host of new features aimed at enhancing productivity and performance. These include improvements to code completion and Xcode Previews, the introduction of a test navigator and test report for streamlined testing, and a simplified distribution process. Other notable improvements include better navigation, more efficient source control management, and improved debugging capabilities [48].

4.6 Database

Selecting an appropriate database is a critical aspect of any software project. Several key factors were taken into account to determine the most suitable database for the system MindPath. These factors will depend on the functionalities of the system.

- The system should operate on a cloud-based database. This will simplify the overall process by eliminating the need for a local setup and maintaining it. Real-time updates will be a crucial aspect of the system , employing a cloud-based database would guarantee this.
- NoSQL databases are known for their scalability and flexibility, making them ideal for handling large data volumes. Since the system would potentially handle large data volumes, a NoSQL database can be the most efficient choice.
- For a NoSQL database, the choice will be between two of the leading options - Google Firebase and MongoDB Atlas.
- MongoDB Atlas and Google Firebase are the two choices that embody all the key factors. Table 4.1 provides a comparative study between

With Google Firebase and MongoDB being the two main contenders for the database choice, the final decision was based on the results of a decision matrix in Table 4.2.

Key:
Score for each Criteria: 1-5 (1= lowest and 5 = highest)
Weighted Score = Score of each criteria * Weight of each criteria

Criteria	MongoDB Atlas[49]	Google Firebase [50]
Type	It is a document-oriented database.	It is a web and mobile app platform.
Use Cases	It is often used for big data and high-performance applications due to its ability to handle large amounts of unstructured data.	It is typically used for small apps that require real-time data. It's particularly useful for applications that need instant updates, like chat apps or live game scores.
Hosting	It can be hosted on-premise or cloud.	It is a cloud-only platform.
Querying	It had extensive support for querying - allows you to perform extensive calculations.	It has more limited querying capabilities, but it's designed to be simple and straightforward to use.
Scalability	Easily allows you to handle growing data volumes.	It offers instant scalability across devices.
Security	Robust Security Measures.	Robust Security Measures.

Table 4.1: *Comparative Study between MongoDB and Google Firebase*

Criteria	**Weight**	**MongoDB**		**Google Firebase**	
		Score	Weighted Score	Score	Weighted Score
Familiarity	2	5	10	3	6
Ease of Use	2	3	6	4	8
Real-time updates	5	3	15	4	20
Scalability	4	5	20	3	12
Security	5	5	25	5	25
Total			**76**		**71**

Table 4.2: *Decision Matrix for Databases*

4.7 MERN stack

The MERN stack is a powerful technology stack that combines MongoDB, Express.js, React, and Node.js [51].

- MongoDB: Aa a NoSQL database, MongoDB provides a flexible document model that is ideal for handling large volumes and diverse types of data. This is essential for the iOS application's data storage and retrieval requirements.
- Express.js: As a back-end web application framework running on top of Node.js, Express.js simplifies the routing and middleware setup. This ensures efficient server-side logic implementation.
- React: Used for building the front-end, React's component-based architecture facilitates the development of a dynamic user interface with efficient data management and stateful interactions.

- Node.js: This JavaScript runtime environment executes JavaScript code server-side, enabling a lightweight, efficient, and scalable back-end architecture. This complements the real-time data processing requirements of the system.

4.8 Data Visualisation with Chart.js and Plotly

For the data visualisation on the website, the two visualisation tools that can be considered are: Chart.js and Plotly.js [52].

- **Chart.js:** Known for its simplicity and flexibility, it can be used to create interactive charts and graphs. It is particularly useful for rendering straightforward visualisations like line charts, bar charts, and pie charts.
- **Plotly.js:** This offers advanced visualisation capabilities, including 3D models and multi-dimensional data plots. This library can be useful for its extensive range of options and its ability to handle more complex visual requirements.

4.9 Accessibility: iOS application and Website

iOS Application: iOS provides multiple in-buit accessibility features which can be used system wide[53]. When it comes to making an inclusive design, Apple's Human Interface Guidelines gave an in-depth review of all the best practices[54]. Most of these practices can easily be implemented while developing the application using SwiftUI. Testing for the accessibility will be performed manually, using Xcode's environment overrides and accessibility inspector.

Website: The website will be developed by following the Web Content Accessibility Guidelines (WCAG) developed by the World Wide Web Consortium (W3C). It defines four principles - perceivable, operable, understandable, and robust – each one containing 12-13 guidelines [55]. The website will incorporate some of the best practices like using semantic tags, responsive text and maintaining good colour contrast ratios.

Chapter 5

Design

This chapter outlines how MindPath has been designed. It explains the architectural choices that validates MindPath's functionality. It also covers how the system components (the iOS App and Website) have been designed and how they interact to provide a seamless user experience.

5.1 System Design

MindPath consists of an iOS application and a website. The system design for MindPath was to designed to streamlined process for survey administration and data visualisation. Figure 5.1 gives a visual understanding of the data flow across the different components of MindPath. The points listed below give an overview of how each different component of MindPath is designed.

- **Database Integration:** Both the iOS app and the website connect directly to the MongoDB Atlas cloud database. This setup ensures unified data flow and robust data management across components. Additionally, the use of technologies and frameworks like SwiftRealm and the MERN stack support the project's needs for scalability and complex data visualisations.
- **iOS Application:** Developed using SwiftUI, the iOS app offers a user-friendly interface across all Apple platforms. It integrates ResearchKit to utilise its functionalities. The backend connection to a MongoDB Atlas cloud database through SwiftRealm enables efficient data management and seamless data synchronisation within the app's ecosystem.
- **Website:** The website is built using the MERN stack (MongoDB Atlas, Express.js, React.js, and Node.js). It features advanced data visualisation tools such as Chart.js and Plotly.js that provide interactive and visually engaging information.

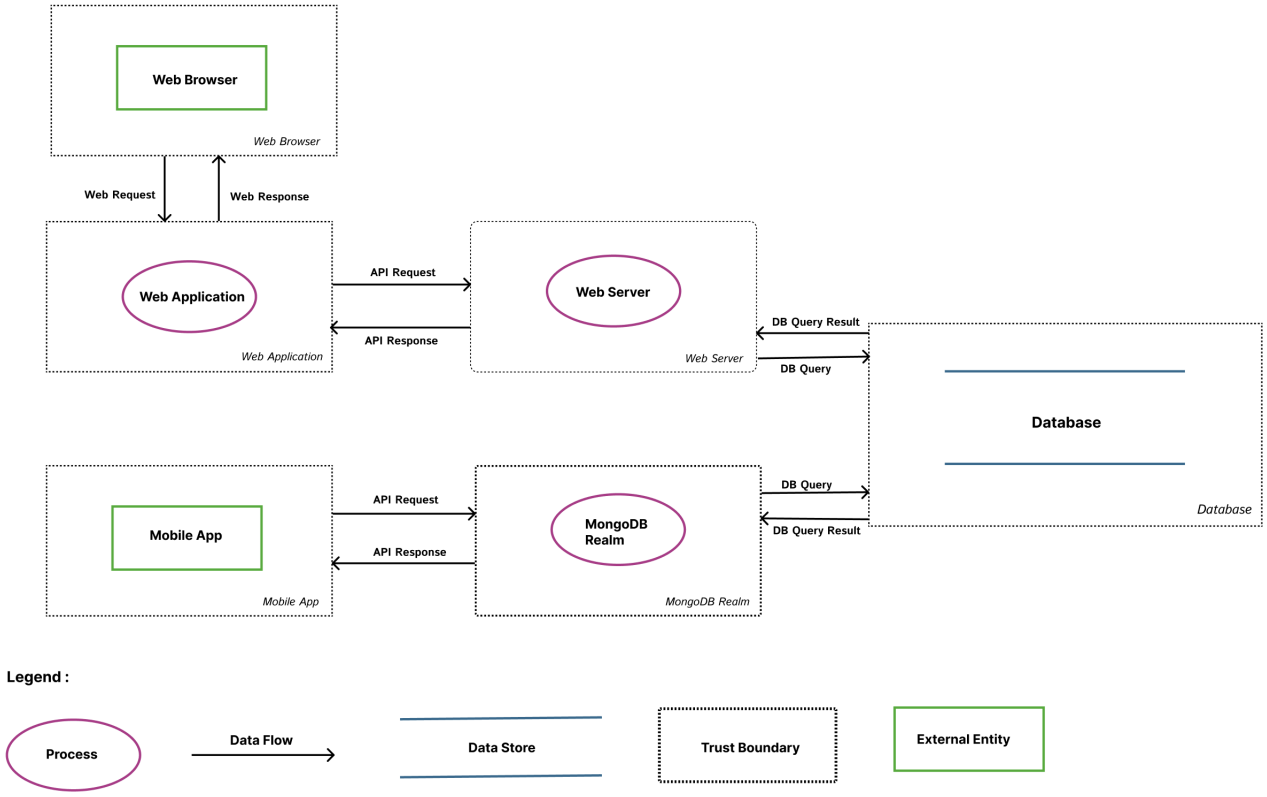


Figure 5.1: *MindPath Data Flow Diagram*

5.2 Database Design

The tables in figure 5.2 represents the database design of the system. It consists of 2 tables: *SurveyData* and *SurveyAnswers*.

- In MongoDB Atlas, data is stored in documents and collections. This is similar to the Document Object Model (DOM) in web development, where data is structured in a tree-like format like in Figure 5.3. The DOM's hierarchical structure is a good analogy for how MongoDB Atlas organises data into documents and collections. Figure 5.4 provides an example of the structure of a document within such a collection.

- The database is intentionally designed with simplicity and scalability in mind. It consisting of two collections: *SurveyData* and *SurveyAnswers*. The *SurveyData* collection

holds individual records with fields for age, occupation, and an array of **ObjectIDs** . These **ObjectIDs** reference the *SurveyAnswers* collection. This array links multiple survey answers to a single participant's data, exemplifying a one-to-many relationship. Each document within the *SurveyAnswers* collection holds a unique **ObjectID** and **questionId** that correlates to the identifier used in the actual survey and the corresponding **answer**. This design ensures that every entry in the collection is directly linked to a specific survey question. This separation ensures that the answers can be managed independently of the survey data.

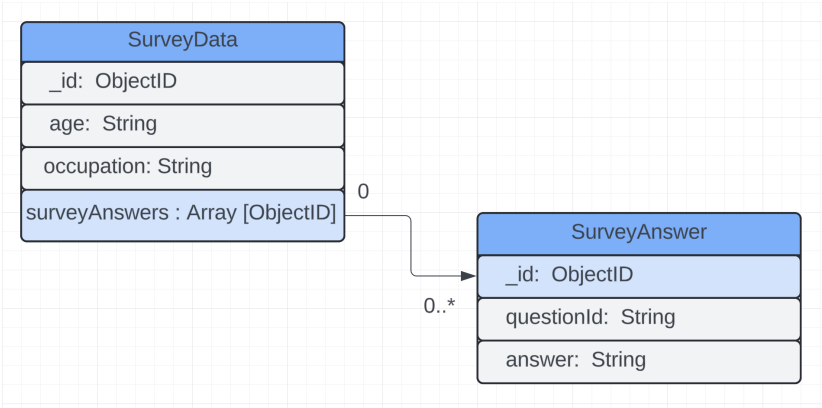


Figure 5.2: *Database Design*

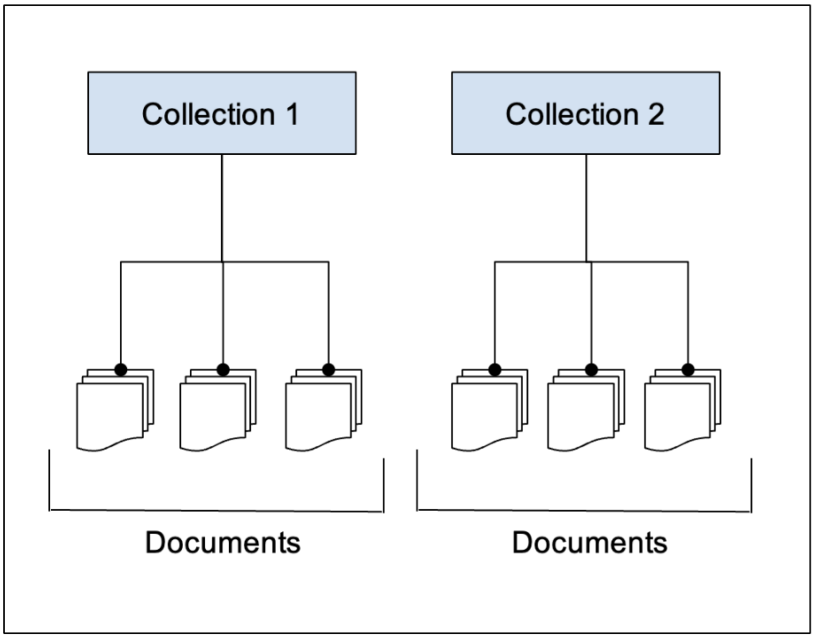


Figure 5.3: *DOM Tree Structure [56]*

Figure 5.4: *DOM tree-like Structure Example [57]*

- This database structure allows to restructure the collected survey answers without impacting the participant's survey data. Additionally, it simplifies the process of participants skipping questions as it won't store null or placeholder values for unanswered questions. Instead, it only stores the answers provided, which makes for a more efficient and clean data storage strategy.
- Overall, the design choices have been made to accommodate the system's requirements for a database that is dynamic to handle a variety of survey types and questions and is flexible to allow participants to fill in the surveys without the constraints of a rigid schema.

5.3 Data Communication Infrastructure

This infrastructure forms the framework that enables different system components of MindPath to communicate and exchange data. It ensures that the services are cohesive, responsive, and scalable. This section discusses how APIs facilitate communication in the system and highlights the key data exchange endpoints. It also covers the integration of RealmSwift and how it is used to ensure that the iOS app works with MongoDB Atlas.

5.3.1 API and API Endpoints

APIs enable integration and communication between different systems. An API may comprise multiple endpoints that facilitate access to various resources. These endpoints are identified by URLs (Uniform Resource Locators), serving as their unique addresses. Communication occurs through RESTful (Representational State Transfer) APIs, wherein requests are handled via HTTP protocols that support methods such as POST, GET, PUT, PATCH, and DELETE. The architecture in Table 5.1 allows the website to interact seamlessly with its backend through specified endpoints.

Endpoint	Method	Desscription
/survey-data	GET	This is the raw form of data that the website gets from the database
/heat-map	GET	Specific to heatmap
/all-data	GET	provides the data in a compressed form

Table 5.1: *API Endpoints*

A RESTful API utilises web standards such as HTTP to facilitate communication between components using methods such as GET, POST, PUT, and DELETE for data operations. In an architecture like MindPath's website where a React.js frontend works with an Express.js backend, the React.js application makes HTTP requests to manipulate and retrieve data, and the backend responds in JSON format. This setup enables the frontend to dynamically update its interface without reloading the page.

5.3.2 RealmSwift

RealmSwift is a tool specifically designed for developers using Swift, to interact with the Realm database. [58]. Recommended by MongoDB Atlas for use in SwiftUI applications, RealmSwift offers an efficient way to manage data interactions and synchronisation. Unlike traditional databases or standard URL APIs, Realm provides a streamlined approach with minimal setup. This improves app performance through real-time capabilities and effective data synchronisation. RealmSwift was used in MindPath to facilitate seamless interaction with MongoDB Atlas. Figure 5.5 visually represents how RealmSwift works with MongoDB.

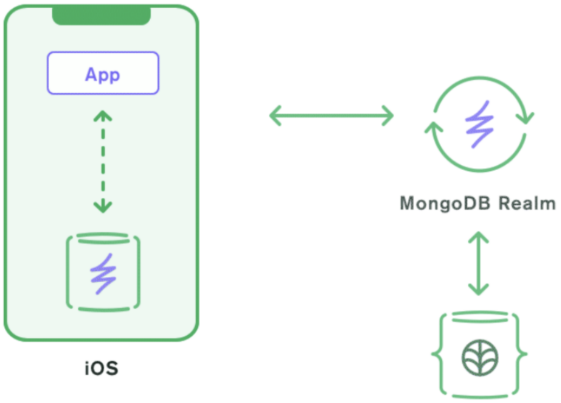


Figure 5.5: *RealmSwift and MongoDB Atlas [59]*

5.4 iOS Application Design

This section provides an overview of the technologies and methods used in designing the iOS application. Each of the components highlighted below plays a crucial role in shaping the app, making it the comprehensive tool that it is.

5.4.1 SwiftUI and UIKit

The iOS application "MindPath" is built using SwiftUI. SwiftUI uses a straightforward approach where developers specify what the UI should look like, and the framework handles the rest. This made it easier to use and less prone to errors. In contrast, UIKit, although powerful, requires more code and can be cumbersome, especially with complex interfaces. SwiftUI streamlines development across Apple platforms, reduces repetitive code, and supports live previews for quicker adjustments.

5.4.2 MVVM with SwiftUI

MindPath utilises the Model-View-ViewModel (MVVM) architectural pattern [60]. It integrates seamlessly with SwiftUI's structure. MVVM separates the app's data (Model), its presentation (View), and the logic (ViewModel). This separation facilitates easier debugging and testing, improving overall code quality. In combination with SwiftUI, MVVM enables efficient data binding and state management. This ensures that UI components are dynamically updated in response to data changes.

5.4.3 ResearchKit Integration

The integration of ResearchKit into the application's design was a strategic decision aimed at leveraging Apple's open-source framework to facilitate medical research and gather valuable health data from users. This framework allows creating detailed surveys within the app. By utilising ResearchKit, the application taps into a set of tools designed specifically for research. This enables the app it to conduct studies with a level of precision and user engagement that was previously challenging to achieve.

5.4.4 Integrated ResearchKit Components

ResearchKit offers an array of components crucial for the design and functionality of research applications. For "MindPath," certain components stood out as particularly beneficial. This ensured that the app operates effectively and fulfills its intended purpose.

- **ORKOrderedTask:** In ResearchKit, a survey is considered as ORKOrderedTask that has a collection of step objects. Each step object handles a specific question in the survey, such as "How many hours is your screentime?" or "How many hours did you sleep last night?".
- **ORKInstructionStep:** These are used to guide users through the survey or study. They are not a part of the actual survey but are used in the onboarding proces. They ensure users are well-informed about the tasks they will perform.

- **ORKQuestionStep and ORKAnswerFormat:** The ORKQuestionStep is used to define a single question within a survey. The ORKAnswerFormat accompanies the ORKQuestionStep and specifies the type of response that is allowed for the question. It controls how users can answer a question—whether they can enter text, select from multiple choices, or pick a date.

- **ORKResult:** ResearchKit provides multiple methods for storing results. In addiotion to this, it also offers diverse options for app users to respond to questions. This includes multiple-choice questions (MCQs) or scale answer types, where responses can range from 0 to 10. ResearchKit facilitates the analysis of this data to extract insights pertinent to the research goals by efficiently handling and storing the outcomes of survey tasks and various data collection within the app.

5.4.5 Structuring Surveys with ResearchKit Components

The survey in the application utilises the ResearchKit components to effectively gather detailed and accurate information from users. The integration of instruction steps guides the user through the survey. This ensured clarity and consistency in the data collection process. The tasks in the survey are designed to probe various aspects of the participant's health and wellness. This is done by utilising a mix of MCQs and scale answers. This structured approach improves the user experience and ensures the data collected is valuable to be used for research.

5.4.6 Survey Questions

The structure of the survey questions within the app was thoughtfully executed. This was done by taking into consideration the various components of ResearchKit. The process begins with an instruction step, where participants are provided with detailed information about the survey and what their participation entails. This introductory phase is crucial as it includes essential information about the survey itself and the consent process, ensuring participants are fully informed before proceeding. Following the instruction step, the survey transitions into a series of steps. Here, participants engage with the questions and respond through a mix of multiple-choice questions (MCQs) and scale answer types.

5.4.7 Survey Question Structure

The survey questions were structured to efficiently collect information. Each question follows a specific pattern:

- Each question in the survey targets specific areas of the participant's lifestyle. For example, the question might be "How is your sleep pattern?"

- It then delves into the implications of these areas on the participant's mental health. It asks about the consequences of their sleep patterns on their overall mental well-being.

This approach is advantageous for several reasons. Firstly, it ensures a systematic collection of data. By initially establishing a baseline of the user's habits or conditions and subsequently inquiring about their effects, the survey can draw direct interactions between various lifestyle

factors and mental health. This method provides a clearer understanding of how specific factors contribute to the overall mental health of the individuals. The survey format has been designed to be straightforward to ensures that the core objectives of the survey are met.

5.4.8 Content for the Survey Questions

The content of the survey questions for "MindPath," was designed in a way that it serves its purpose and aligns with the goal of the survey. Formulating these questions was guided by a comprehensive approach that focused on capturing a wide array of data. This required a deep dive into considering demographics and lifestyle parameters. The aim was to create an informative survey that could provide meaningful insights.

- **Demographic Approach:** The survey starts with demographic questions based on age and occupation. This approach is underpinned by the understanding that different life stages can significantly influence one's mental health and lifestyle.

  For the answer options to the age question, the age categories of **18-24, 25-34, 35-44, 45-54, 55-64, and 65 and over** were chosen as each category represents crucial life phases.

  1. **18-24:** early adulthood, often involves significant life changes such as starting university or entering the work life)
  2. **25-34:** establishing career paths, possibly starting families
  3. **35-44:** mid-career, possibly with growing family responsibilities
  4. **45-54:** often at peak career positions, dealing with teenage children or ageing parents
  5. **55-64:** approaching or entering early retirement
  6. **65 and over:** retirement, focusing on health, and possibly dealing with significant lifestyle changes

  For the answer options to the occupation question, the occupation options of **Stay at Home, Student, Professional, Unemployed, and Other** were chosen. These roles encompass varying levels of stress, responsibility, and societal engagement.

  1. **Stay at Home:** Captures those dedicating their time to managing household duties and/or caring for family members.

2. **Student:** Includes individuals primarily engaged in academic studies, from primary to higher education.
3. **Professional:** Encompasses individuals working professionals.
4. **Unemployed:** Represents those currently not working but available for and seeking employment.
5. **Other:** Allows respondents who do not fit into the predefined categories to classify themselves.

- **Lifestyle Parameters:** Following the demographic foundation, the survey questions move towards question related to specific lifestyle parameters.

  1. **Physical Activity Levels:** Understanding a participant's engagement level and frequency of physical activities offers insights into their mood and stress management practices.
  2. **Sleep Patterns:** By examining sleep quality and duration, the survey seeks to uncover potential connection between sleep/rest and mental health. Sleep irregularities can both signal and aggravate mental health issues.
  3. **Nutritional Habits:** This section evaluates dietary choices. This recognises the role that a nutritious diet play in regulating mood and cognitive fucntion, thereby influencing overall mental well-being.
  4. **Social Interactions:** Assessing the quality and quantity of social interactions helps gauge the support network's strength and its effects on mental health.
  5. **Profession:** Exploring the nature of an individual's occupation and its related stressors or satisfactions allows for an understanding of how work impacts mental health.

The survey's structured approach of beginning with broad demographic information and progressing through detailed questions about lifestyle is designed to elicit a comprehensive understanding of the topic. This structure ensures that MindPath collects relevant, diverse, and meaningful data. This would facilitate a thorough analysis the interaction between mental health and lifestyle factors across different demographic segments.

5.4.9 Wireframes: iOS App

The iOS application wireframes visually represents the design of the app in two main categories: *a) Onboarding:* it showcases the initial steps for the participants and *b) Survey:* it showcases the steps when a participant is completing the survey. Figure 5.6 presents the onboarding mockups, and Figure 5.7 presents the survey mockups.

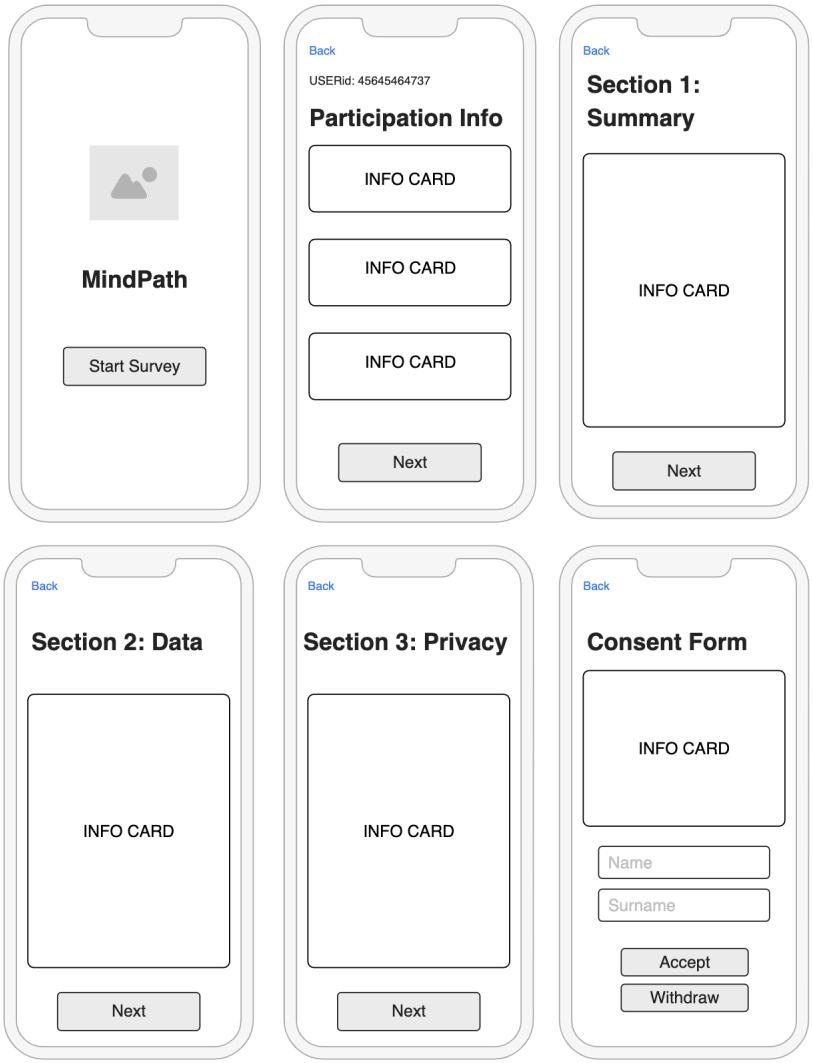


Figure 5.6: *iOS App Onboarding*

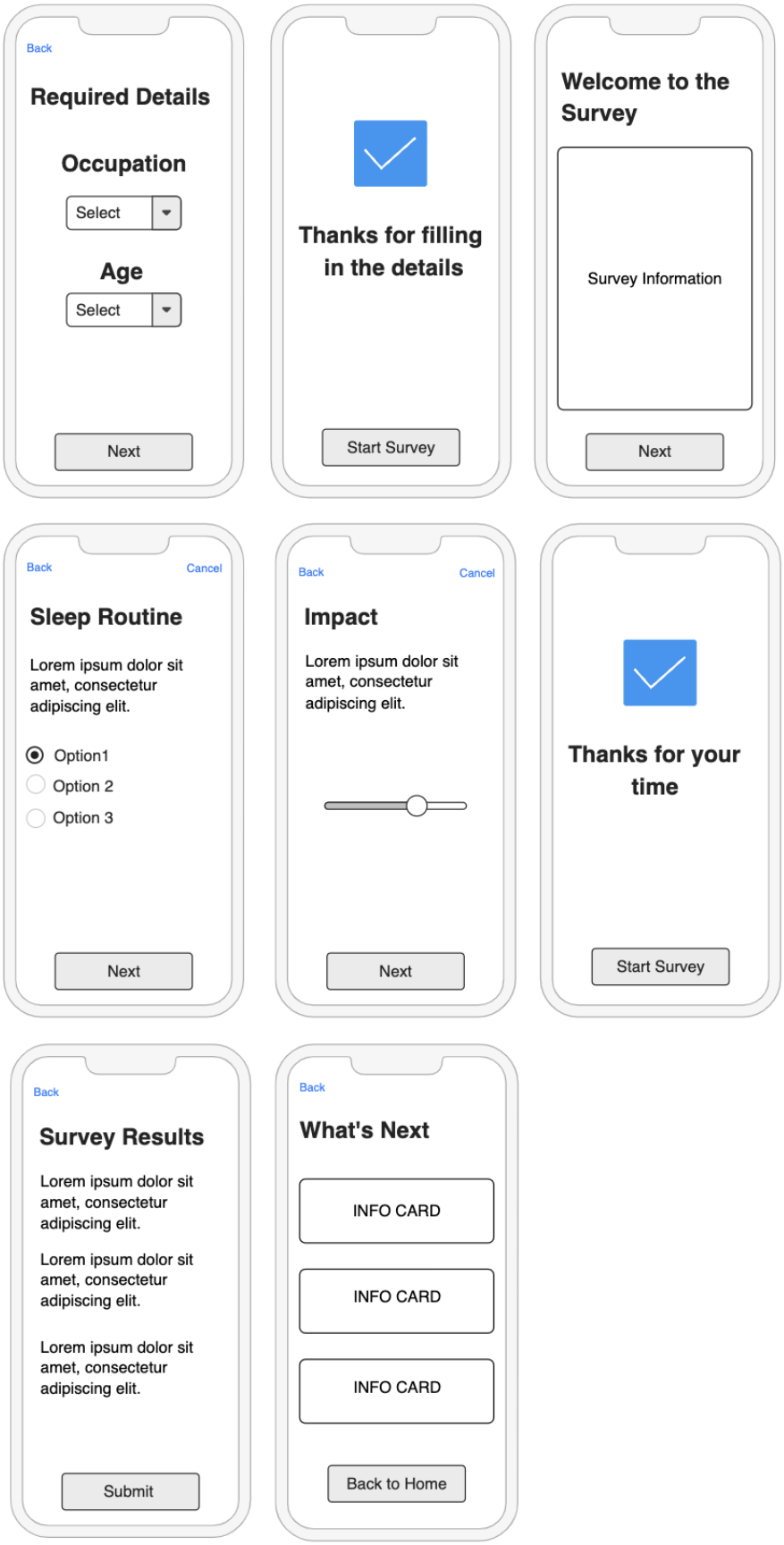


Figure 5.7: *iOS App Survey*

5.5 Website Design

This section provides an overview of the technologies and methods used in designing the Website. Each of the components highlighted below plays a crucial role in shaping the website, making it the comprehensive tool that it is. The website adopted the MERN stack to fulfill its requirements. Understanding and utilising the components of the MERN stack was crucial in the design of the website. Adopting these technologies allows seamless interaction between the database, server, and the frontend components.

5.5.1 Design Architecture

Although the website does not explicitly follow the Model-View-Controller (MVC) architectural pattern, the integration of MERN stack components lends itself to an MVC-like framework. Figure 5.8 gives a visual representation of this architecture. In this architecture:

- MongoDB Atlas acts as the Model and is responsible for data management and storage.
- Express.js functions as the Controller. It manages the application's logic and facilitates data transfer between the frontend and the database.
- React.js serves as the View. It presents the data in a user-friendly format using interactive visualisations.

This synergy allows for seamless data flow within the application. From data storage and management with MongoDB Atlas to processing and handling server-side requests with Express.js and Node.js to producing the dynamic presentation of data on the web frontend via React.js.

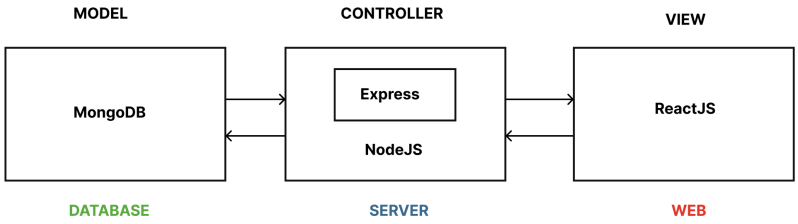


Figure 5.8: *MERN Stack*

5.5.2 Frontend Design

The frontend for the MindPath website has been designed by adopting the design practices used for a React.js website. This design uses a component-based architecture, has a modular and efficient approach. Each element including the navigation bar, data graphs, and information cards, are encapsulated within distinct components. This allows reusability and simplifies the development process. React.js also has features like states and effects that can be vital to ensure dynamic functionality of the interface. States manage component-specific data for real-time updates and ensures a smooth visualisation experience. Effects

are managed through the *useEffect* hook. They handle operations like API calls and DOM manipulations and help in keeping the interface responsive and current.

As illustrated in the Figure 5.9, by following a component-based approach, each webpage is a distinct component composed of finer, interconnected subcomponents. This structure not only makes the design robust but also streamlines the development process by allowing for individual components to be reused. The hierarchical representation in the image underscores the ease of managing and updating website features independently.

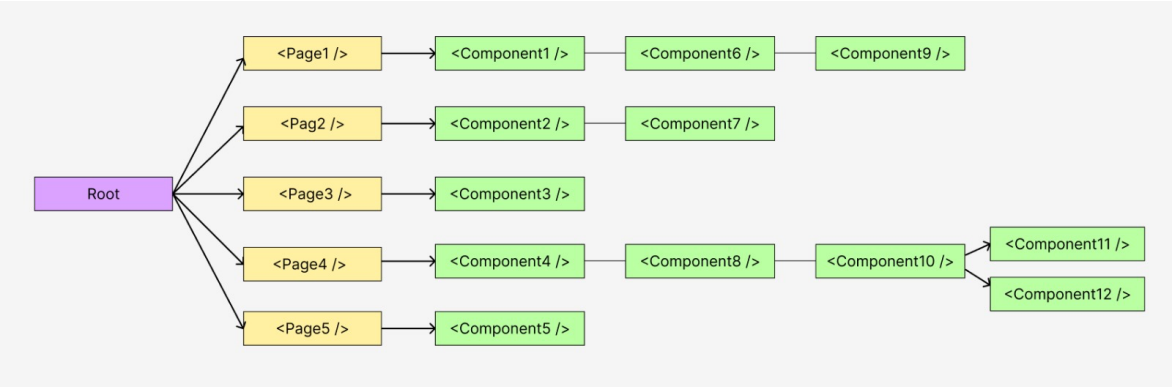


Figure 5.9: *Component Based Architecture*

5.5.3 Visualising Data

The primary goal of the website is to facilitate the analysis of survey data collected via the iOS app by employing various data visualisation techniques. To address the diverse needs of data analysis, it was necessary to understand and design techniques that would enable researchers to assess data from multiple angles and identify trends or anomalies. Considering the the requirements above, listed below are the four ways the data will be visualised.

- **Demographic Breakdown**: Utilising bar charts, line charts, and pie charts (implemented via ChartJS), this visualisation technique segments data according to demographic variables such as age or occupation. This approach helps in identifying demographic patterns or disparities in the data.

- **Individual Factor Analysis**: Scatter plots are used to display the relationship between individual lifestyle factors (like physical activity levels or sleep hours) and their reported impacts on mental health. This form of visualisation is particularly effective in highlighting variances, trends, and offers a granular view of collected data.

- **Correlation Heatmap**: The heatmap can be used to visualises the strength of relationships between various factors, such as physical activity, sleep patterns, and professional stress, and their interaction with mental health. This visualisation highlights

which factors are most strongly or weakly related to mental health.

- **Comparative Analysis**: A radar chart compares multiple factors simultaneously to evaluate their relative on mental health. This multi-axial approach allows researchers to assess which lifestyle factors are perceived as most and least impactful and offers insights into the aggregate influence of different lifestyle factors.

5.5.4 Wireframes : Website

These wireframes in Figure 5.10 represent two main pages of the website. The first page is like a portal and initial orientation for the users. The other pages represent how the visualisations would be displayed.

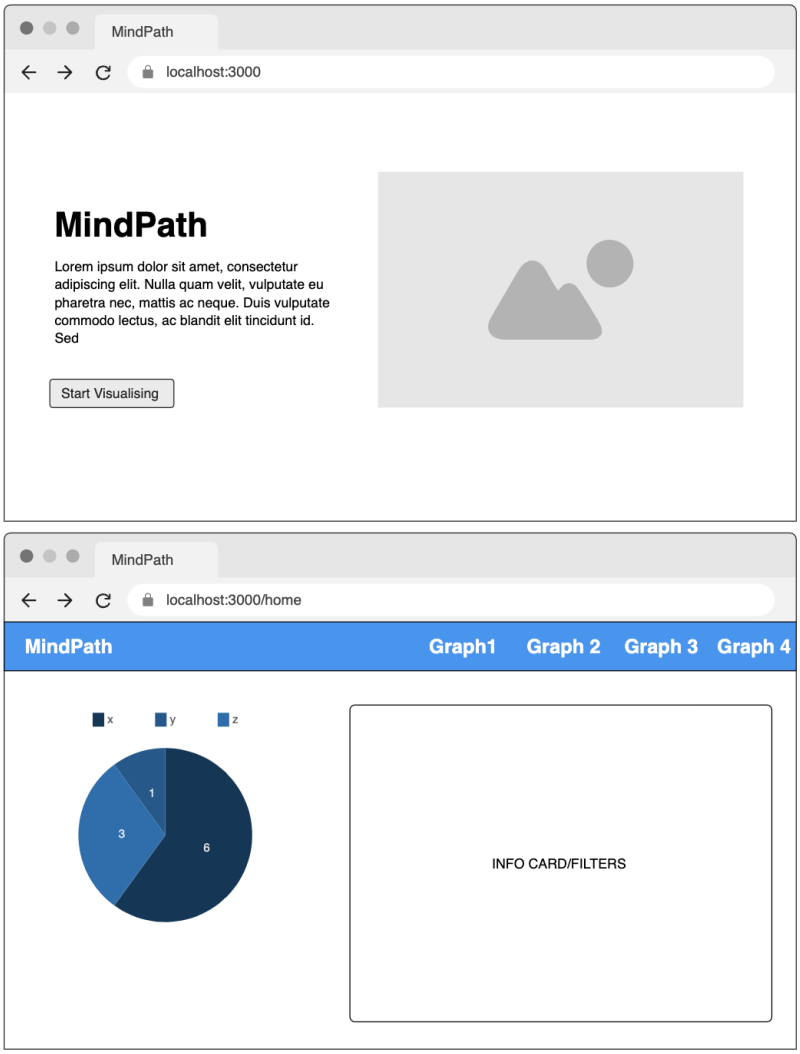


Figure 5.10: *Website Onboarding*

5.6 User Experience for MindPath

The user experience (UX) for MindPath has been designed to ensure a cohesive and intuitive user interface. This section will outline the design rationale applied to MindPath.

- **Color Scheme and Fonts**: MindPath uses a consistent colour scheme centered around the shade 00b4d8 (Blue) and uses Apple's built-in fonts.
- **Logo**: The MindPath logo is designed to represent the app and its purpose. It has been designed using the SF Symbols Library [61].
- **Navigation and Flow**: The layout is designed for ease of navigation with a clear and logical structure, guiding users through various sections and functionalities without confusion. Strategic use of symbols and icons supports a sensible flow.
- **Accessibility**: High-contrast colors and Apple's accessibility features allow adjustments for text size and colour settings.
- **Data Visualisation**: To cater to the website's emphasis on data visualisation, a broader colour palette is used for the graphs and charts to ensure they are distinct and clear.

Chapter 6

Implementation and Testing

6.1 Agile Approach

The project has been implemented and tested by following an agile approach. Adopting this approach improved the development and testing for MindPath. The implementation was systematically divided into four key sprints:

- MongoDB Atlas Setup and Schema Configuration: This initial phase was critical for establishing an efficient data structure that ensures data management and retrieval capabilities that would support the functionality of the components developed in the subsequent sprints.
- iOS Application: The second sprint focused on developing the iOS application. This involved utilising multiple iteration cycles to incorporate continuous feedback, optimise functionality, and improve user experience.
- Website: This sprint involved the development of the website. It had several iterations to refine the interface and ensure seamless integration with the backend services.
- Integration: This involved the integration or connecting of all the components developed in the three sprints.
- Each phase was executed in such a way that it allowed to incorporate any changes at any point during development and testing.

6.2 iOS Application

The development phase involved multiple iterations focused on incremental feature development and testing. Started by setting up the application framework , followed by basic view integration, ResearchKit integration, and using RealmSwift for data management. Each iteration underwent thorough testing before being integrated into the broader system. This structured approach ensured all components operated seamlessly together. The following sections highlight the features implemented in the iOS application.

6.2.1 Onboarding Experience

1. On launching MindPath for the first time, the participants are presented with a welcome page. Refer to Figure 6.1.

2. The participants are then navigated to the Application Information page. On this page, users are assigned a unique and anonymous User ID. Refer to Figure 6.1. This page provides an overview of the app through a series of steps.

Figure 6.1: *Welcome Page and Participation Information*

3. This stage of the iOS App consists of 3 sections. Figure 6.2 shows how these sections give the participants information about the what the survey is about, how will the data be handled and app's commitment to user privacy.

   Summary: This section allows the participants to learn about the the purpose of the app.

   Data: This section details the participant's contribution to the research by providing data on lifestyle choices and how it will used to explore the link between lifestyle and mental health.

   Privacy: This section emphasises the app's commitment towards user privacy and details how data is kept anonymous and secure throughout the research process.

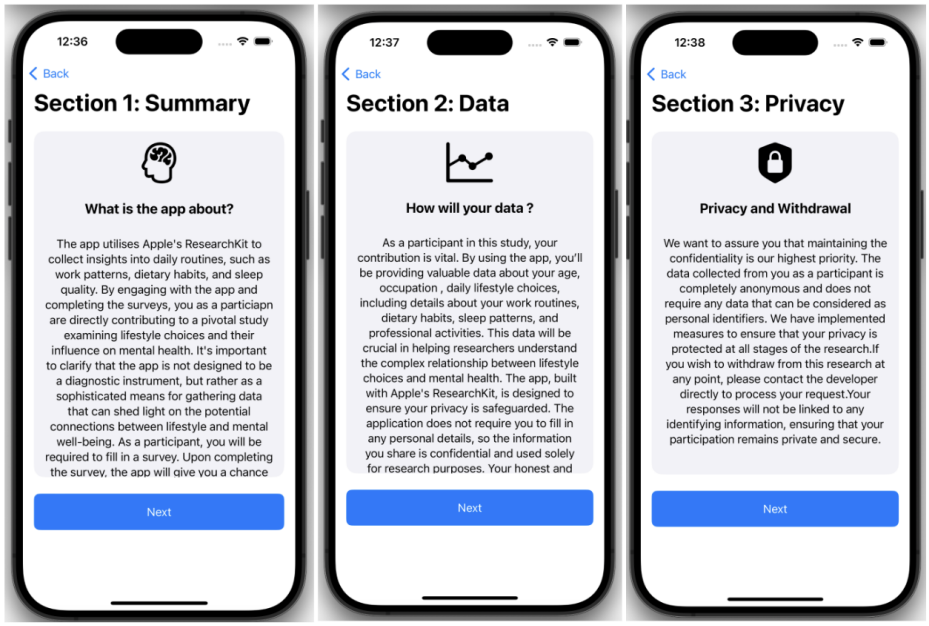


Figure 6.2: *Summary, Data and Privacy*

4. In the Consent section, the participants are asked to provide their informed consent. This section requires users to enter their full name and offers an option to download a PDF version of their signed consent. Figure 6.3 gives an overview of the entire process. An example of the signed consent form can be found in **Appendix I iOS App Consent Form**

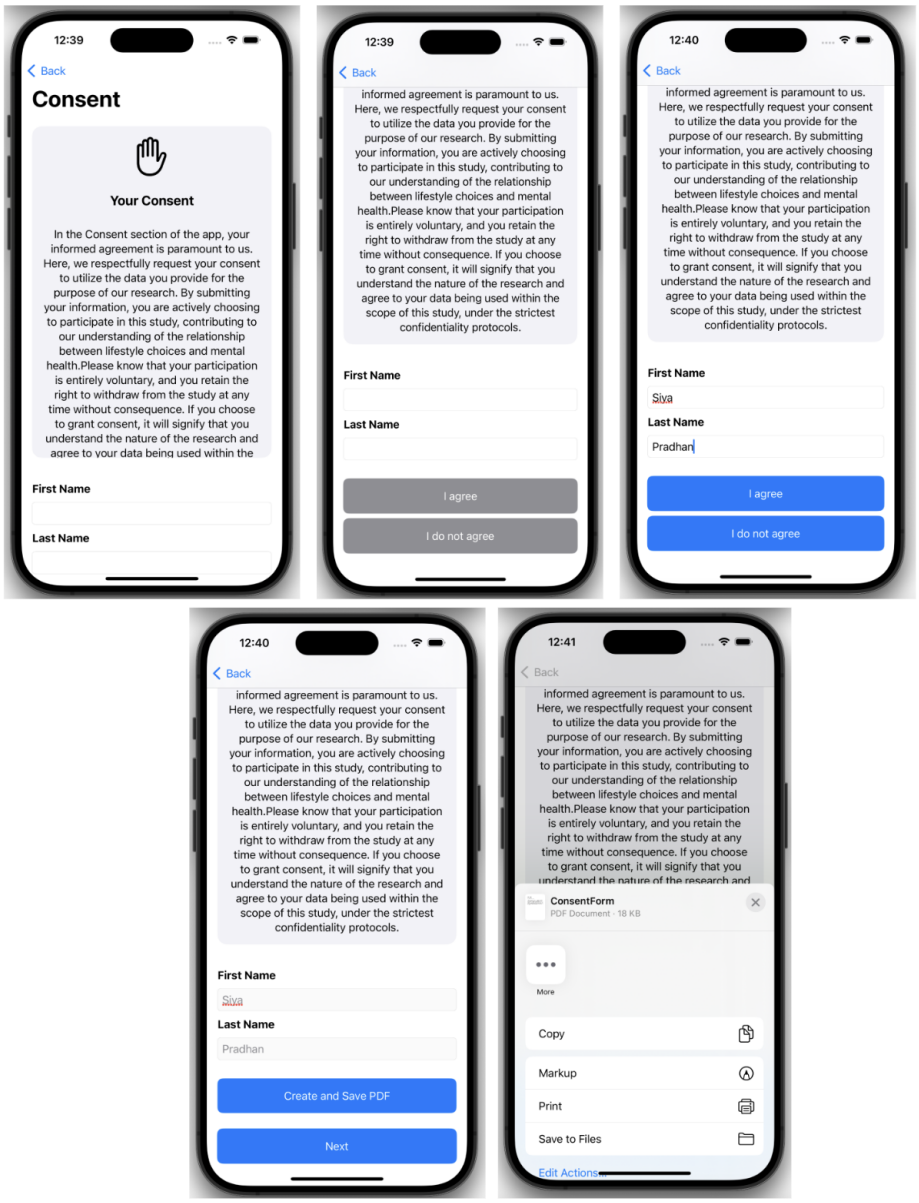


Figure 6.3: *Consent*

5. Once participants have completed the consent process, they progress to the final stage of onboarding where they are required to enter personal details. This step, titled "Required Details," prompts participants to provide information such as their occupation and age range. Figure 6.4 shows how the participant would enter the details.

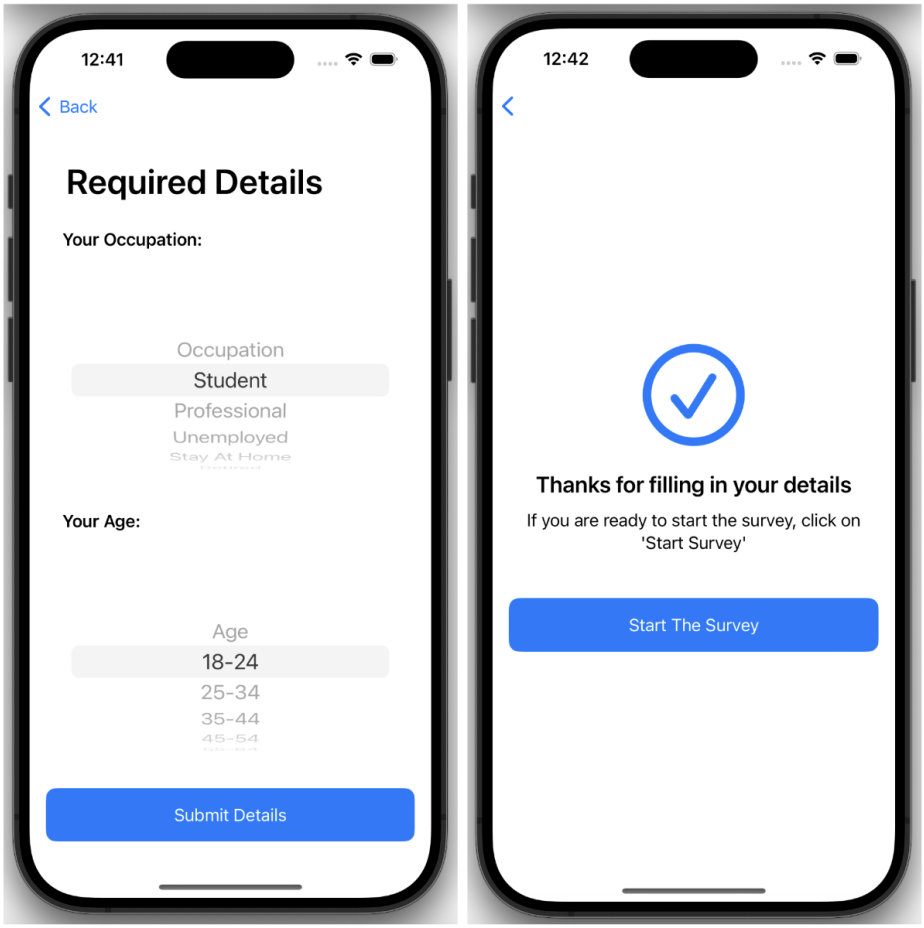


Figure 6.4: *Required Details*

6.2.2 ResearchKit

The ResearchKit integration is in an important part of MindPath. In order for the participants to participate in the research, two conditions must be fulfilled:

- The participant has given their consent;
- They have filled in the required details.

On successully completing the onboarding process, the participants are then presented with the survey. ResearchKit's survey tasks are not directly compatible with Swift Views and require the use of UIKit's UIViewController structure for execution. To facilitate this within a Swift environment, a separate file is used. This file acts as a bridge as it manages the execution of ResearchKit's survey tasks and the collection of results within the app. This then initiates the survey, manages the participant's interaction, and captures the results as a list of *ORKResult* objects, which are then seamlessly fed back into the main application workflow.

The participant journey through the survey is systematically structured as follows:

1. The survey begins with a modal presentation and momentarily shifts away from the main app flow. This transition signals the start of the survey. This is where participants are briefed with an introductory screen that outlines what to expect, the nature of the questions, and the survey format.

2. Participants then proceed to the question series within the survey. Throughout this process, ResearchKit ensures user autonomy by providing a "cancel" option at each step. This allows the participants to exit the survey at any time prior to submission.

3. After completing the questions, the survey ends with a completion step. This signifies the end of the survey. It thanks the participant for their contribution, and then returns to the main application flow.

To implement the participant journey, the entire survey is considered an *ORKOrderedTask* within ResearchKit. The ResearchKit framework conceptualises the survey as an *ORKOrderedTask*. This task model represents a sequence of steps performed in a specific order, collecting data in a consistent and structured manner. It includes instructions, questions, and completion statements to guide participants through the survey.

These individual components collectively form the ResearchKit Survey as seen in Figure 6.5 and 6.6.

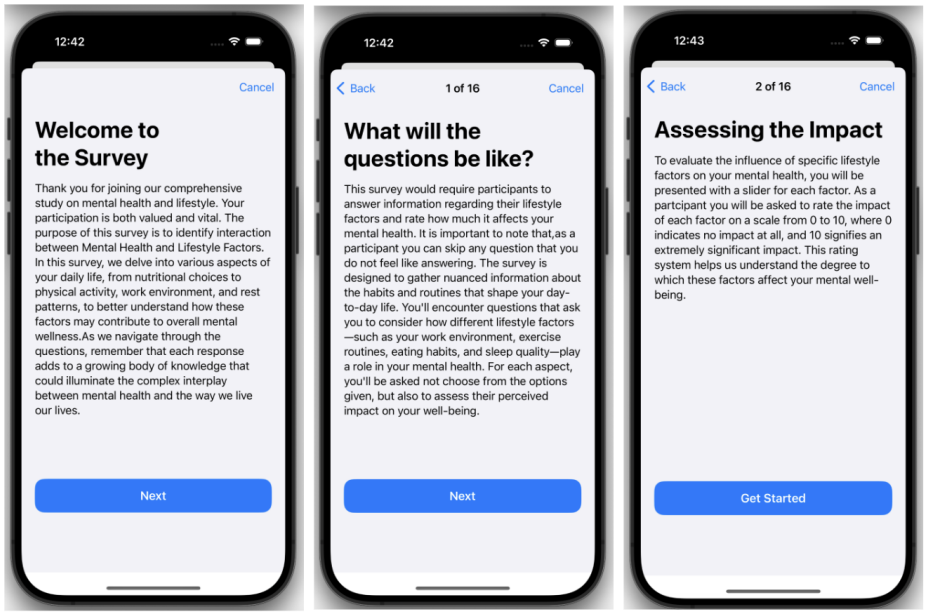


Figure 6.5: *ResearchKit Survey*

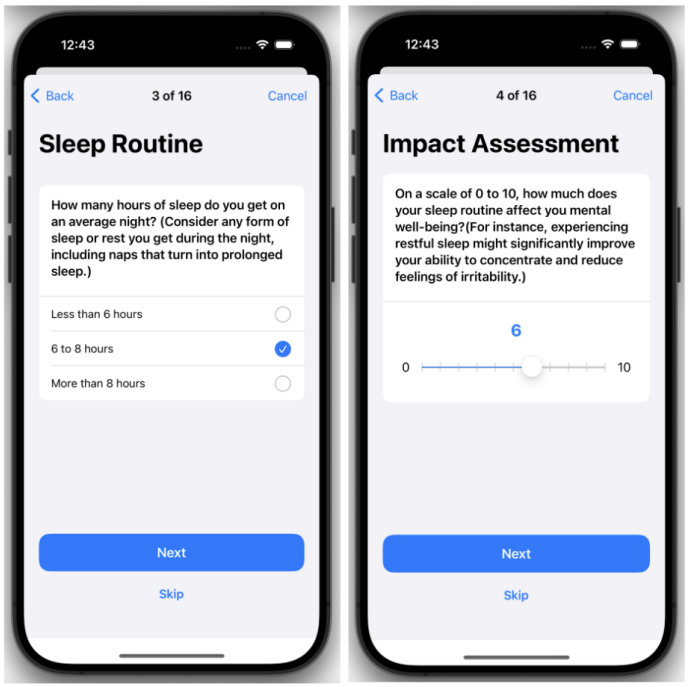


Figure 6.6: *Researchkit Survey Questions*

6.2.3 Reviewing Results and Next Steps

After completing the survey, the participants can review their answers before submission. Once they submit the survey, they are directed to a page that outlines the next steps. This features cards with messages that acknowledge their contribution and guides them with further engagement with the subject. Figure 6.7 gives an overview of the whole process. The last information card "Resources for Mental Health" contains a hyperlink that directs users to the *verywellmind* website [62]. Here the participants can review and understand about the importance of mental health.

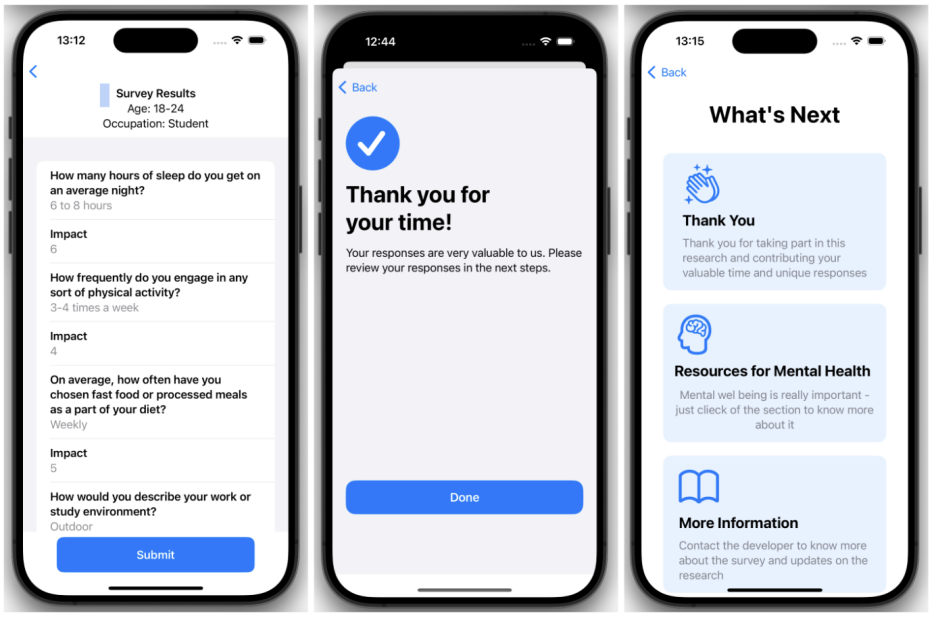


Figure 6.7: *Review Answers*

6.3 Website

The development phase consisted of multiple iterations. The initial iterations focused on setting up the React application, backend services, establishing client connections to MongoDB, and developing key API endpoints. Subsequent iterations added data manipulation features and chart tools. Each iteration underwent thorough testing to ensure component functionality. The final iterations refined UI elements and added pages like the landing page. The following sections showcase the features implemented in the website.

6.3.1 Onboarding Experience

1. Mandatory Privacy Policy: The website requires researchers to agree to its privacy policy before using the site. Figure 6.8 and 6.9 [1] represents the onboarding process. The privacy policy document can be found in **Appendix H Website Privacy Policy**.This is an essential step where they must agree to the website's data handling and privacy practices.

2. Streamlined Access to Data Visualisation: The welcome page serves as a streamlined gateway that guides the researchers directly to the visualisations.

3. Intuitive Navigation Interface: After acknowledging the privacy policy, the researchers are then directed to a default visualisation page. This presents them with one of four data visualisation methods. The top section of this page features a navigation bar which enables seamless transition between different visualisation formats.

[1] The illustration on the welcome page has been adopted and modified from https://freeillustrations.xyz/

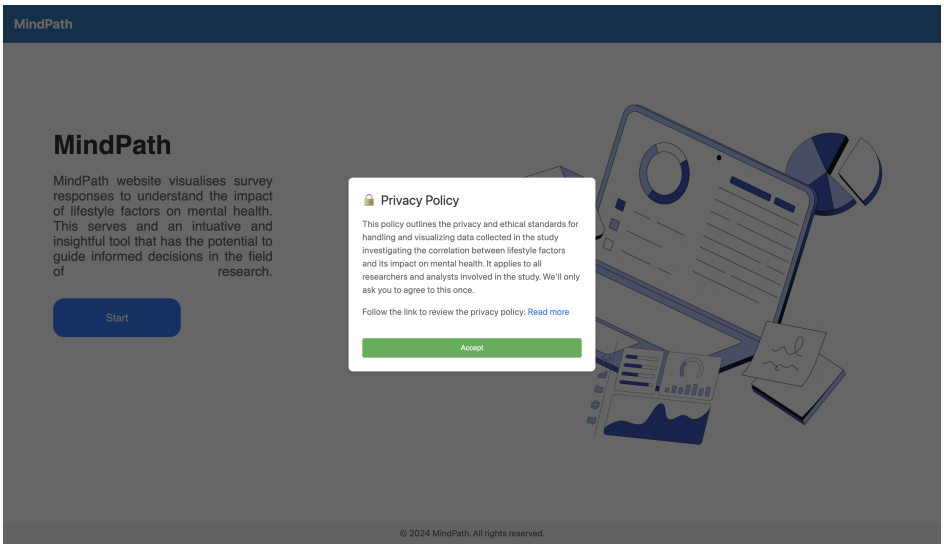


Figure 6.8: *Website Privacy Policy*

Figure 6.9: *Website Welcome Page*

6.3.2 Visualisations

After completing the onboarding process, the researchers are presented with four types of visualisations. Each one of them providing a distinct method for analysing the responses.

1. **Demographic Breakdown Plot:**

   - The Demographic Breakdown Plot helps researchers examine survey responses and understand the relevance of specific questions across demographic groups. Using filters like age and profession, they can analyse data selectively. Once they

select the appropriate option from the filters, they are provided with the number of responses and the average impact for the question they have selected. This is presented in the form bar, line, and pie chart. Figure 6.10 provides a visual representation of the page layout.

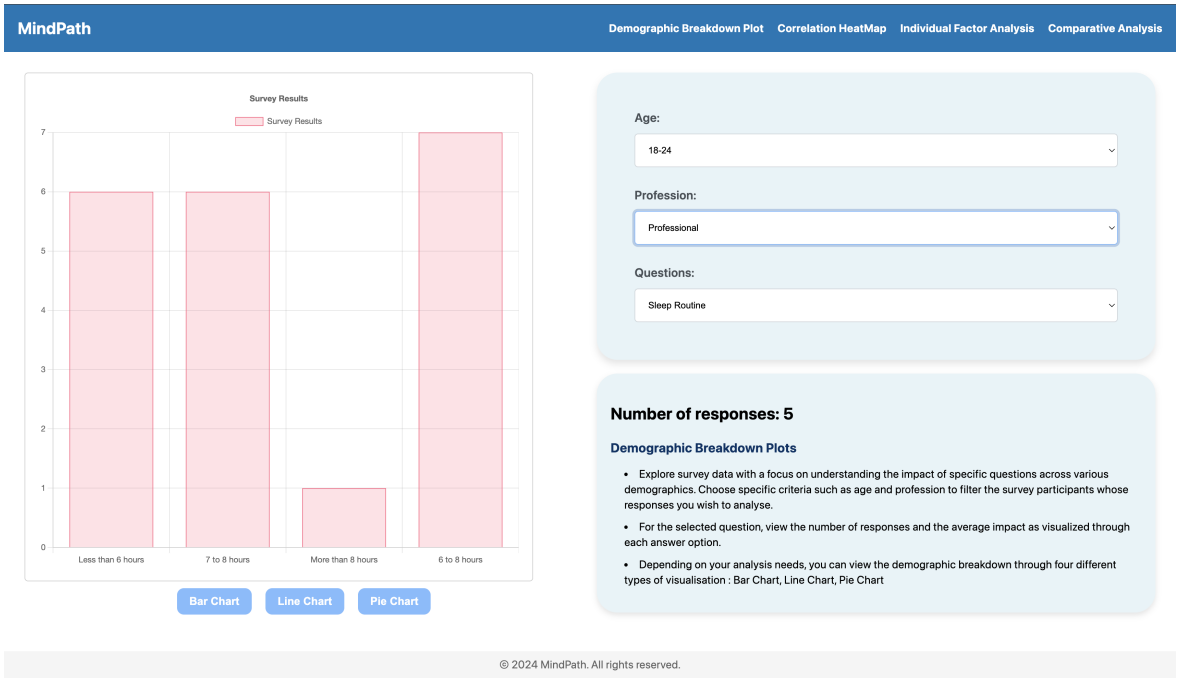


Figure 6.10: *Demographic Breakdown Plot*

- The Demographic Breakdown Plot is implemented to dynamically display various chart types based on user-selected filters. Figure 6.11 represents how the functionality is achieved through a central *UnifiedChart* component. This handles the rendering of bar, line, and pie charts using *Chart.js*.
- When specific options are selected from the filter, the component fetches the appropriate data from the server using the fetch utility, *fetchSurveyData*. The data is then parsed to match *Chart.js* data structures. State hooks within *UnifiedChart* manage the chart rendering, with *useEffect* triggering a re-fetch of data when filter values change. The chart type dynamically adjusts based on selection (Bar, Line, or Pie), while *Chart.js* configurations control responsiveness, aspect ratio, and settings for scales and legends.

```
// Export the chart components
export const BarChart = (props) => <UnifiedChart {...props} type="Bar" />;
export const LineChart = (props) => <UnifiedChart {...props} type="Line" />;
export const PieChart = (props) => <UnifiedChart {...props} type="Pie" />;
```

Figure 6.11: *UnifiedChart to Render different charts*

2. **Correlation Heatmap:**

   - The Correlation Heatmap allows the researhcers understand the average impact score of each question against the respective responses. This allows the researchers to analyse which factors have the strongest and weakest relations (based on colour intensity)with mental health. Additionally, they can utilise the interactive elements of the heatmap to hover over specific data points. Figure 6.12 provides a visual representation of the page layout.

Figure 6.12: *Correlation Heatmap*

   - Researchers can also compare the results across different questions directly within the heatmap to identify unique patterns and correlations that may exist between lifestyle habits and mental health outcomes
   - As shown in Figure 6.13, the *HeatMap* component initiates a data fetching process in the *useEffect* hook and which calls the API to retrieve survey data. Once fetched, the data undergoes transformation to align with the structure required by *Plotly*'s heatmap. This transformation involves mapping survey questions to the y-axis, responses to the x-axis, and average impact scores as the z-values. The transformation logic ensures that each response aligns correctly across the

matrix, filling in with null where data is not available to maintain integrity in the visualization layout.

```
14  useEffect(() => {
15    // Fetch data from the API
16    fetch('http://localhost:3030/heatmap')
17      .then(response => response.json())
18      .then(data => {
19        // Once data is fetched, transform it
20        const transformedData = transformData(data);
21        setHeatmapData(transformedData);
22      })
23      .catch(error => console.error("Failed to fetch heatmap data:", error));
24  }, []);
```

Figure 6.13: *Using useEffect to get data from API*

3. **Individual Factor Analysis:**

   - This allows the researchers to map the individual responses regarding each lifestyle factor against the corresponding impacts. This method allows the researchers to reveal underlying trends and deviations. For each factor being analysed, the researchers can assess both the volume of responses and the average impact score. This dual-perspective approach reveals the prevalence of the factor's influence as well as its intensity. Figure 6.14 provides a visual representation of the page layout.

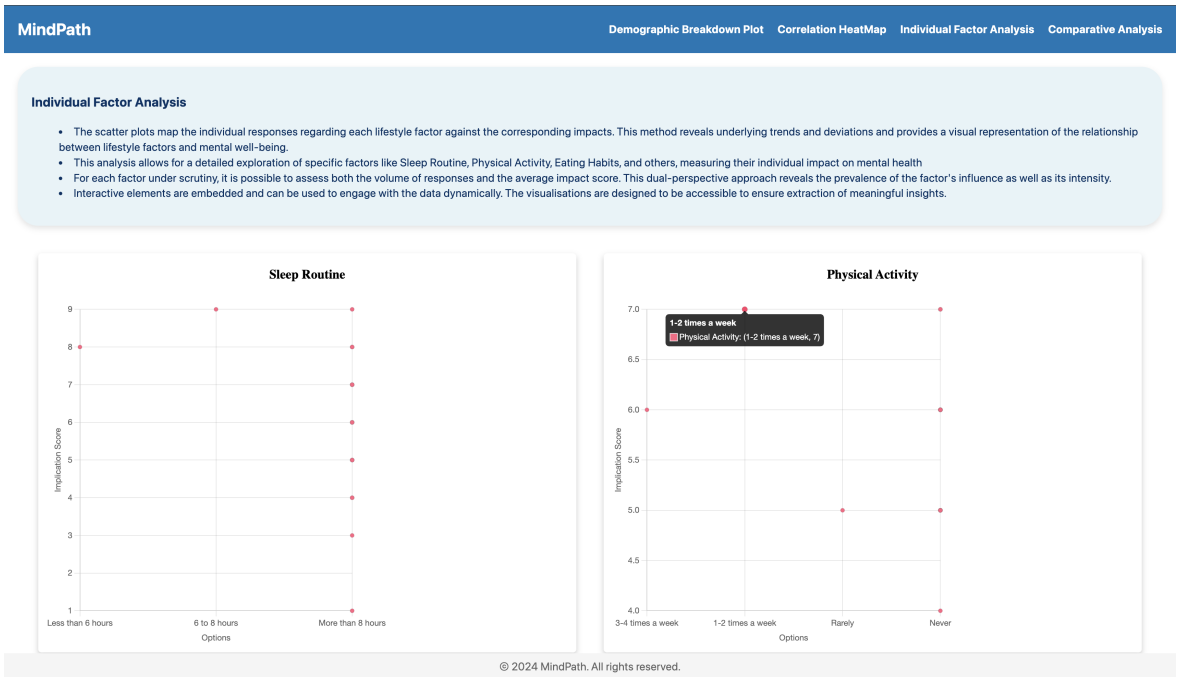


Figure 6.14: *Individual Factor Analysis*

   - The *ScatterPlot* component fetches the necessary data using a fetch function. Once the data is retrived, a transformation function *processDataForQuestion* (refer to code snippet in Figure 6.15) structures the data into a format suitable for plotting. This function maps responses to their respective questions, converting categorical response data into numerical indices. These then serve as the x-values in the scatter plot, while the impact scores are used as y-values.

```
29  const processDataForQuestion = (data, questionId) => {
30    return data.map(item => {
31      const answerKey = `MultipleChoiceQuestionStep${questionId}`;
32      const scoreKey = `ScaleQuestionStep${questionId}`;
33      const answer = item.surveyAnswers[answerKey];
34      const yValue = parseInt(item.surveyAnswers[scoreKey], 10) || 0;
35
36      // Find the index of the answer in the options array to use as a numeric value
37      const xValue = options[questionId].indexOf(answer);
38
39      return { x: xValue, y: yValue };
40    }).filter(point => point.x > 0 && point.y > 0);
41  };
42
43  const Chart = ({data, question, questionId }) => {
44    const labels = options[questionId];
45
46    const chartData = {
47      labels,
48      datasets: [{
49        label: question,
50        data: data,
51        backgroundColor: 'rgba(255, 99, 132, 1)',
52      }],
53    };
54
55  >   const chartOptions = {…
78    };
79
80    return (
81      <div style={{ width: '500px', height: '500px' }}>
82        {/* Canvas element explicitly sized; chart inherits this size */}
83        <Scatter data={chartData} options={chartOptions} width={100} height={100} />
84      </div>
85    );
86  };
```

Figure 6.15: *Data formatting using ProcessDataForQuestion*

4. **Comparative Analysis:**

   - This visualisation utilises a radar plot to identify the average implication scores for each question category. This allows researchers to compare the relative effects of these factors side-by-side on a multi-axial layout. This format helps identify which factors consistently have greater or lesser mean impacts. Figure 6.16 provides a visual representation of the page layout and illustrates the functionality of the visualisation.
   - This visualisation uses *Chart.js* with the *Radar* chart component. *RadarPlot* component begins by fetching aggregated survey data from a specified API endpoint. Once the data is retrieved, it undergoes a processing step where average implication scores for each lifestyle factor are calculated. Figure 6.17 shows how this

is handled by the *calculateAverageImplications* function. It compiles scores from responses, computes averages, and prepares the dataset for visualisation. This process ensures that the radar chart reflects accurate and meaningful metrics.

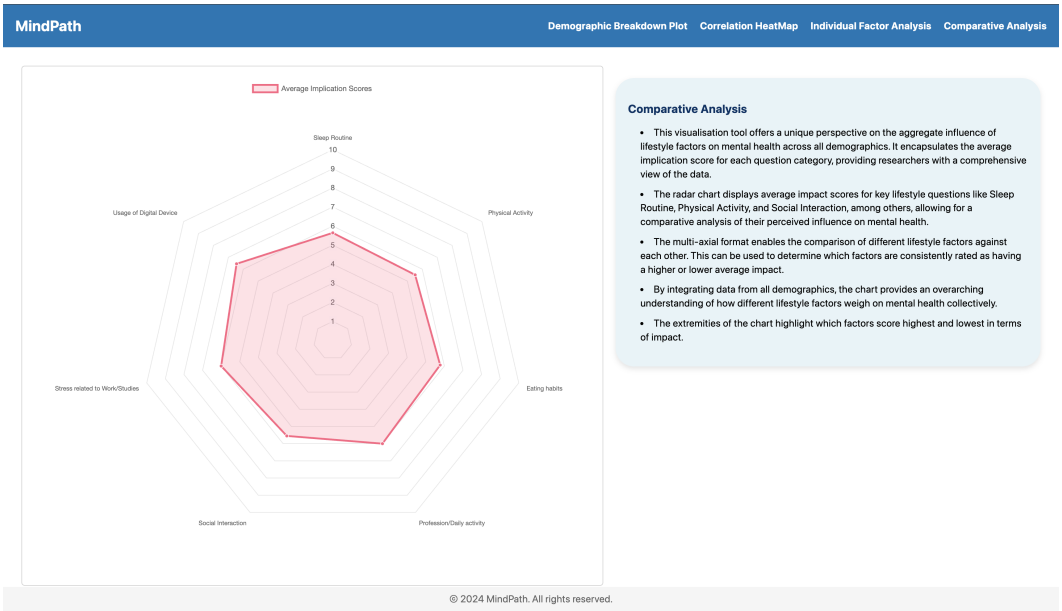


Figure 6.16: *Radar Plot*

```
45  const calculateAverageImplications = (data) => {
46      // Initialize an object to store total scores and counts for each question
47      const totals = Object.keys(questions).reduce((acc, questionId) => {
48        acc[questionId] = { total: 0, count: 0 };
49        return acc;
50      }, {});
51
52      // Aggregate the total scores and counts for each question
53      data.forEach(item => {
54        Object.keys(questions).forEach(questionId => {
55          const scoreKey = `ScaleQuestionStep${questionId}`;
56          const score = parseInt(item.surveyAnswers[scoreKey], 10);
57          if (!isNaN(score)) { // Ensure the score is a number
58            totals[questionId].total += score;
59            totals[questionId].count += 1;
60          }
61        });
62      });
63
64      // Calculate the average score for each question and round it
65      const averages = Object.keys(totals).map(questionId => {
66        if (totals[questionId].count === 0) return 0; // Avoid division by zero
67        return totals[questionId].total / totals[questionId].count;
68      });
69
70      return averages;
71    };
```

Figure 6.17: *Calculating Average Implications using calculateAverageImplications*

6.3.3 Data Manipulation Across Visualisations

Data manipulation is an essential process in for the website. It transforms raw data fetched from the database into structured formats and makes it suitable for various visualisation tools. This transformation ensures that the data is readable, accessible, and tailored to the specific requirements of different chart types. All the visualisations described above employ these manipulation techniques to get the appropriate results.

The data manipulation process starts with fetching raw data from the backend server, typically via RESTful API calls. Once the data is received, it undergoes several transformation steps to match the data structure and aggregation levels required by the different visualisation components (e.g., Bar, Line, Pie, Scatter, and Radar charts).

- **Normalisation**: Filters out irrelevant information to keep only key data points (e.g., *fetchData* functions in Radar and Scatter Plot components).
- **Categorisation and Indexing**: Groups responses based on predefined categories like age or profession (e.g., *processDataForQuestion* function maps answers to numeric indices).

- **Aggregation**: Calculates sums or averages for data points. For example, the *calculateAverageImplications* function in the Radar Chart computes average scores across demographic segments.
- **Sorting and Ordering**: Sequences data logically for visual clarity, crucial for bar and line charts.
- **Advanced Data Grouping and Structuring**: The *processAndTransformData* function groups data entries by identifiers and distinguishes between multiple-choice and scale questions, enabling detailed analysis and insightful visual representations.

6.3.4 Routing

Routing in the dashboard was implemented using the *'react-router-dom'* library. The main configuration is encapsulated within the 'App' component, which employs the 'BrowserRouter' to wrap the application. This setup uses the HTML5 history API and ensures that the browser's URL is in sync with the user interface.

```
frontend > src > JS App.js > ...
1  import React from "react";
2  import { BrowserRouter as Router, Route, Routes } from "react-router-dom";
3  import Home from "./pages/Home";
4  import HeatMap from "./pages/Heatmap";
5  import ScatterPlot from "./pages/ScatterPlot";
6  import About from "./pages/About";
7  import RadarPlot from "./pages/RadarPlot";
8
9
10 export default function App() {
11   return (
12     <Router>
13       <Routes>
14         <Route path="/" element={<About />} />
15         <Route path="/home" element={<Home />} />
16         <Route path="/heatmap" element={<HeatMap />} />
17         <Route path="/scatter-plot" element={<ScatterPlot />} />
18         <Route path="/radar-plot" element={<RadarPlot />} />
19         <Route path="/about" element={<About />} />
20         <Route path="*" element={<div>Not Found</div>} />
21       </Routes>
22     </Router>
23   );
24 }
```

Figure 6.18: *Routing /frontend/src/App.js*

As seen in Figure 6.18, within the BrowserRouter, a Routes component houses all individual Route components. Each 'Route' defines a mapping from a URL path to a corresponding React component that renders the appropriate view:

- The root path '/' directs to the 'About' component with introductory content.
- The */home* route loads the 'Home; component, the application's main entry point.

- The paths */heatmap, /scatter-plot, /radar-plot* links to 'HeatMap', 'ScatterPlot', and 'RadarPlot', each displaying specific data visualisations.
- A generic fallback route (*) captures unspecified paths and displays a "Not Found" message.

This configuration ensures seamless navigation while maintaining clean and organised code. Using *react-router-dom* provides a flexible structure for expanding the number of routes and components.

6.3.5 Component Based Architecture

The MindPath website adopts a component-based architecture. It is a strategic design choice that structures the user interface into independent and reusable modules known as components. This approach enables each component to operate autonomously. A structure example of how this works for the frontend the website can be seen in figures 6.19 and 6.20.

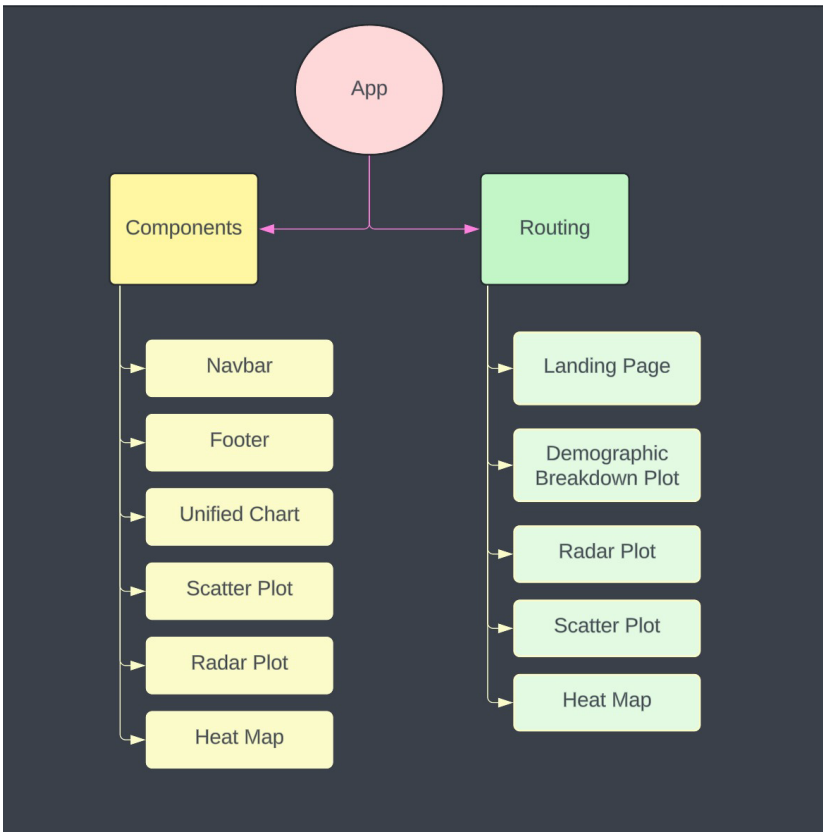


Figure 6.19: *Component Structure*

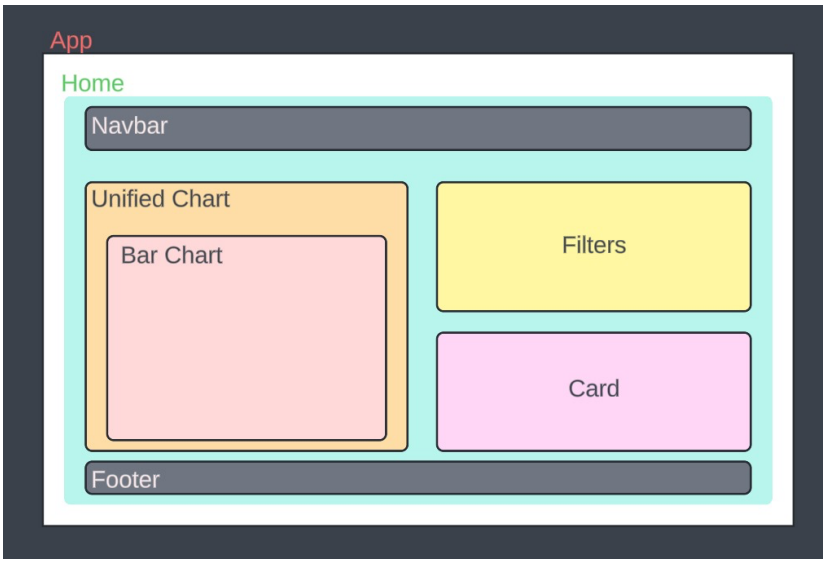


Figure 6.20: *Website Component Structure*

6.4 Networking Layer

The networking layer is a critical component of MindPath. It handles data transfer using RealmSwift and URL API Endpoints. It operates transparently and ensures seamless data communication between the client and server. Its design supports robust data management and dynamic content delivery. It's important to explain how it's been implemented, as its proper functioning is essential for a smooth user experience.

6.4.1 RealmSwift

The iOS application includes RealmSwift in its networking layer to facilitate data transmission to MongoDB Atlas. RealmSwift acts as an intermediary that manages local persistence while seamlessly synchronising with the remote database.

The *SurveyData* and *SurveyAnswer* classes are defined using RealmSwift's Object model (as shown in Figures 6.21 and 6.22), providing a schema for the survey data that will be stored locally and synced to MongoDB Atlas. The Object model enables the application to handle data as objects, which simplifies the process of data manipulation and transmission.

When survey results are collected within the app, each result is instantiated as a *SurveyAnswer* object and is appended to a S*urveyData* object representing the entire survey. These objects are then saved to Realm's mobile database on the device and forwarded to MongoDB Atlas. This is done using *saveSurveyData()*, refer to Figure 6.23.

To ensure up-to-date data on MongoDB Atlas, RealmSwift uses a subscription-based model, which listens for changes to the local database. When a change is detected, such as the addition of a new survey response, it triggers synchronisation with the cloud database. This

```
8  import RealmSwift
9
10 class SurveyAnswer: Object, ObjectKeyIdentifiable {
11     @Persisted(primaryKey: true) var _id: ObjectId
12     @Persisted var questionId: String = "" // This will be "q1", "q2", etc.
13     @Persisted var answer: String = ""     // This will be "a1", "a2", etc.
14
15     convenience init(questionId: String, answer: String) {
16         self.init()
17         self.questionId = questionId
18         self.answer = answer
19     }
20 }
```

Figure 6.21: *surveyAnswer Model*

```
8  import RealmSwift
9
10 class SurveyData: Object, ObjectKeyIdentifiable {
11     @Persisted(primaryKey: true) var _id: ObjectId
12     @Persisted var occupation = ""
13     @Persisted var age = ""
14     @Persisted var surveyAnswers = List<SurveyAnswer>() // A list to store question-answer pairs
15
16     convenience init(occupation: String, age: String, surveyAnswers: List<SurveyAnswer>) {
17         self.init()
18         self.occupation = occupation
19         self.age = age
20         self.surveyAnswers.append(objectsIn: surveyAnswers)
21     }
22 }
```

Figure 6.22: *surveyData Model*

```
213     private func saveSurveyData(_ surveyAnswers: [SurveyAnswer]) {
214             let newSurveyData = SurveyData()
215             newSurveyData.occupation = occupation
216             newSurveyData.age = age
217             for surveyAnswer in surveyAnswers {
218                 $surveyAnswers.append(surveyAnswer) // Append survey answers to observed results
219                 newSurveyData.surveyAnswers.append(surveyAnswer)
220             }
221
222             $surveyData.append(newSurveyData)
223         }
224
```

Figure 6.23: *saveSurveyAnswers function*

ensures that data is consistently mirrored between the local store and MongoDB Atlas.

6.4.2 URL API Endpoints

The URL API endpoints are an essential aspect of the website's implementation. These endpoints are the juncture at which the client-side application requests and receives data from the server. This enables dynamic data retrieval without reloading the page.

The backend server, made with Node.js and Express.js, offers a suite of RESTful endpoints. Each of these endpoints serve a distinct function in data operations. For instance, as seen in Figure 6.24, the */survey-data* endpoint is designed to handle queries for specific survey data. It does this by taking parameters such as age, occupation, and question IDs to fetch tailored data sets. The query parameters in the URL allow the server to filter and return data based on user requirements.

The */heatmap* endpoint aggregates and transforms survey data to compute average implication scores. By processing complex data on the server side, the endpoint offloads the computational burden from the client and delivers ready-to-use data for visualisation.

Similarly, the */all-data* endpoint is a comprehensive data access point that provides an all-inclusive dataset for the frontend. This endpoint's implementation showcases the ability to perform complex database operations, like joining documents from different collections and reshaping the data. This allows it to conform to the frontend's expected structure.

```
166  app.get('/survey-data', async (req, res) => {
167      const { age, occupation, questionIDs } = req.query;
168      if (!age || !occupation || !questionIDs) {
169          return res.status(400).send('Age, occupation, and questionIDs must be specified.');
170      }
171
172      try {
173          await client.connect();
174          const data = await fetchSurveyDataWithAnswers("dissertaion_data", "SurveyData", "SurveyAnswer", age, occupation, questionIDs);
175          res.json(data);
176      } catch (error) {
177          console.error(error);
178          res.status(500).send('An error occurred while fetching data.');
179      } finally {
180          await client.close();
181      }
182  });
183
184 > app.get('/heatmap', async (req, res) => {…
194  });
195
196
197 > app.get('/all-data', async (req, res) => {…
205  });
206
207
208  app.listen(port, () => {
209      console.log(`Server listening at http://localhost:${port}`);
210  });
```

Figure 6.24: *Routes /backend/app.js*

In the API endpoint implementation for the website, "async/await" is used to manage asynchronous operations effectively. This syntax allows for clear, concise handling of operations that may otherwise lead to delays.The implementation of these API endpoints exemplifies a clean, well-documented, and maintainable approach that adheres to the REST principles. By

making sure that the data handling is done by the server, the endpoints allow the frontend to remain lightweight and responsive.

6.5 Testing

Software testing is an essential component of software development that ensures the system meets its intended specifications and user requirements. The V-Model is key framework in software testing. It illustrates how various testing levels correspond with different stages of software development. This model provides a clear guideline for determining the appropriate types of testing to be conducted on the system [63].

6.5.1 System and Integration Testing

MindPath comprises multiple interconnected components. Integration testing is a critical phase in the development process. Its main aim is to verify the seamless interaction between these disparate system components. This testing ensures that data flows correctly across the system, from the database through backend services to the frontend interface. In case of MindPath, the backend plays an important role in this architecture as it retrieves data from MongoDB Atlas using URL APIs, processes this data, and then delivers it to the frontend. To verify the reliability of this, several tests were conducted using Postman. These tests evaluated the backend's ability to accurately handle HTTP requests and provide precise data responses.

6.5.2 API Endpoint Specifications and Test Results

Listed below are the detailed descriptions of some API endpoints along with the tests conducted to validate their functionality:

1. **Demographic Breakdown Plot API**

   - **Endpoint Description:** This endpoint ensures including three essential parameters: Age, Occupation, and QuestionIDs. It is designed to fetch and render data specifically for the Demographic Breakdown Plot.
   - **Test Outcome: Successful Request and Response** When provided with the correct parameters, the API successfully returns the expected data, structured specifically for plotting. This demonstrates the system's effective request handling capabilities. Figure 6.25 illustrates the API's robust error handling by showing the response when required parameters are missing. Additionally, Figure 6.26 depicts successful data retrieval when all parameters are supplied, highlighting the system's reliability in delivering accurate responses

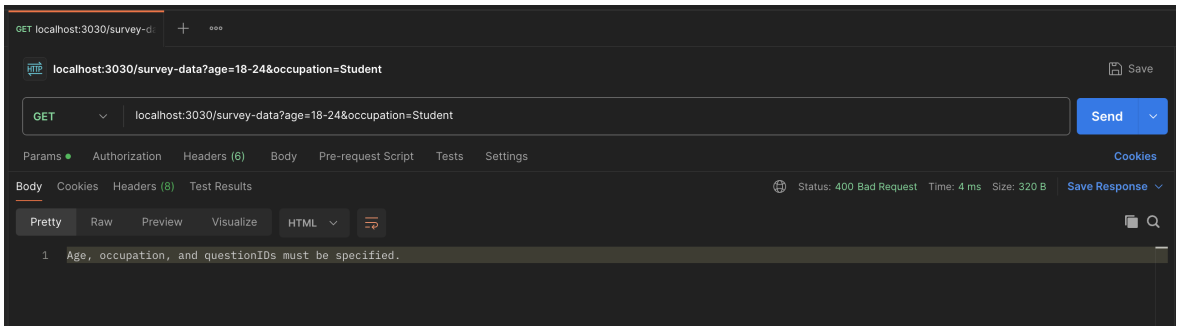


Figure 6.25: *API Response for Incomplete Parameters*

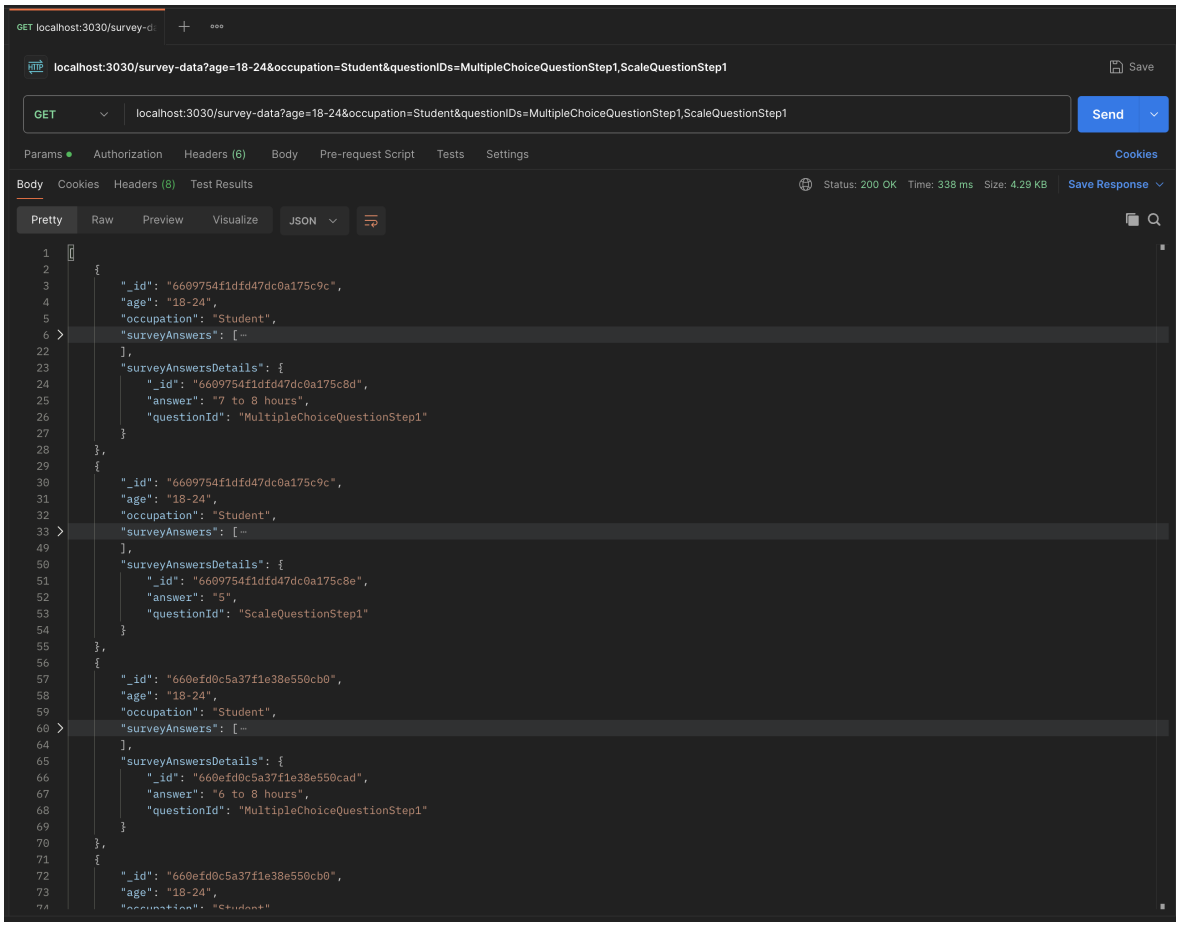


Figure 6.26: *Successful Data Retrieval for Demographic Breakdown Plot*

2. **All-Data Endpoint**

   - **Endpoint Description:** The */all-data* endpoint is responsible for providing a comprehensive JSON-formatted response that encompasses all requisite data elements as required by the frontend for rendering.
   - **Test Outcome:** Figure 6.27 shows the JSON output from the */all-data* endpoint.

This shows the system's capability to deliver comprehensive data responses in the required format.

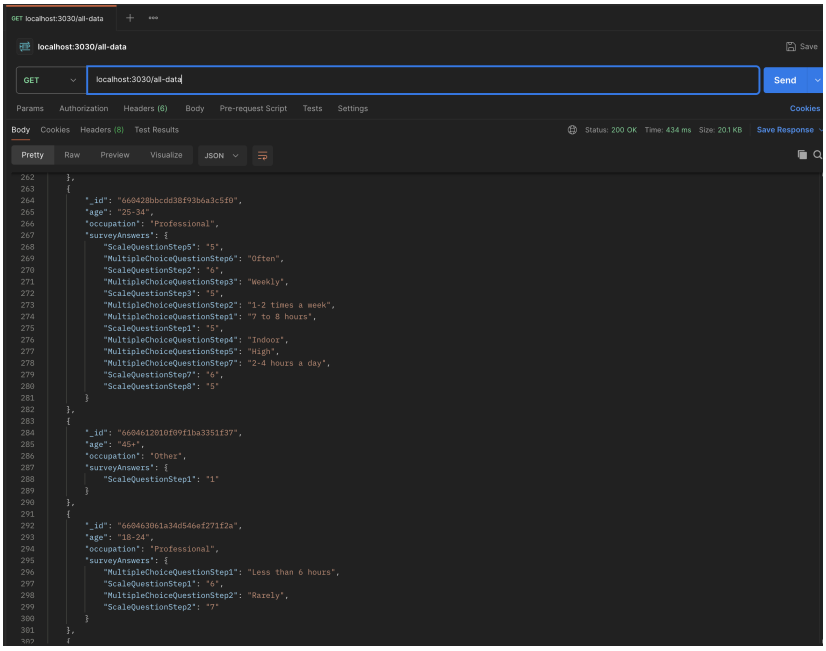


Figure 6.27: *JSON Response from /all-data Endpoint*

These system integration tests conducted using Postman validate that the MindPath's backend processes and responds to API requests accurately and efficiently. The test results confirm the backend's ability in handling errors and its capability to meet the data requirements of the frontend components.

6.5.3 Acceptance Testing

Acceptance testing evaluates whether the system's functionality aligns with the agreed-upon user requirements. It is crucial for ensuring that each function operates as expected. To facilitate effective acceptance testing, each user story is equipped with detailed acceptance criteria. These criteria are designed to be testable, clear, concise, and user-friendly. The complete list of all tests can be found in **Appendix C Acceptance Testing**.

Table 6.1 gives a detailed example of the testing conducted for a user story. The acceptance criteria for each story has been formulated in a such a way that it outlines the sequence of steps a participant would typically follow to successfully complete the task of providing consent.

Story	**Acceptance Criteria**	**Status**
As a participant, I want to be able to complete a consent form that will authorise the use of my responses for the intended purpose.	1. Open MindPath 2. Navigate to the Consent Form. 3. Fill out the Consent Form. 4. Submit and Download my completed Consent Form.	Implemented

Table 6.1: *Example User Story with Acceptance Criteria*

6.5.4 Usability Testing

Usability testing is a method of testing the functionality of a website, app, or other digital product by observing real users as they attempt to complete tasks on it [64]. While conducting this testing, the users will be assigned a series of tasks to execute. Their interactions with the MindPath were observed and documented. The data is then analysed to identify potential areas within the system that may require refinement. For instance, if a user found it hard to navigate to different parts of the system, it may indicate a need to streamline the process.

The user testing for the MindPath was carried out as part of a thorough user evaluation. During this evaluation, participants interacted with the system to provide feedback on various features. The detailed analysis of the evaluation can be found in **Section 7.3 User Evaluation**.

The evaluation of the research component of the dissertation, which involves assessing the effectiveness of the questions asked in the app, was not conducted due to certain constraints. Although extensive research has ensured these questions are effective for their intended purposes, there remains an opportunity to evaluate the questions by a professional in the future updates of the system.

6.5.5 Cross-device Testing

Cross-device testing ensures that an application works well on different devices.The cross-device testing was conducted using the Xcode simulator as it offers a wide range of devices to choose from. For testing MindPath, the selection included the iPhone 15 Pro (latest model) and the iPhone SE 3rd generation (a relatively older model). This approach ensured that the app's compatibility and performance were evaluated across a broad spectrum of models. Figure 6.28 and Figure 6.29 shows the app being tested simultaneously on both the iPhone 15 Pro and the iPhone SE (3rd generation) to highlight differences in user experience and functionality.

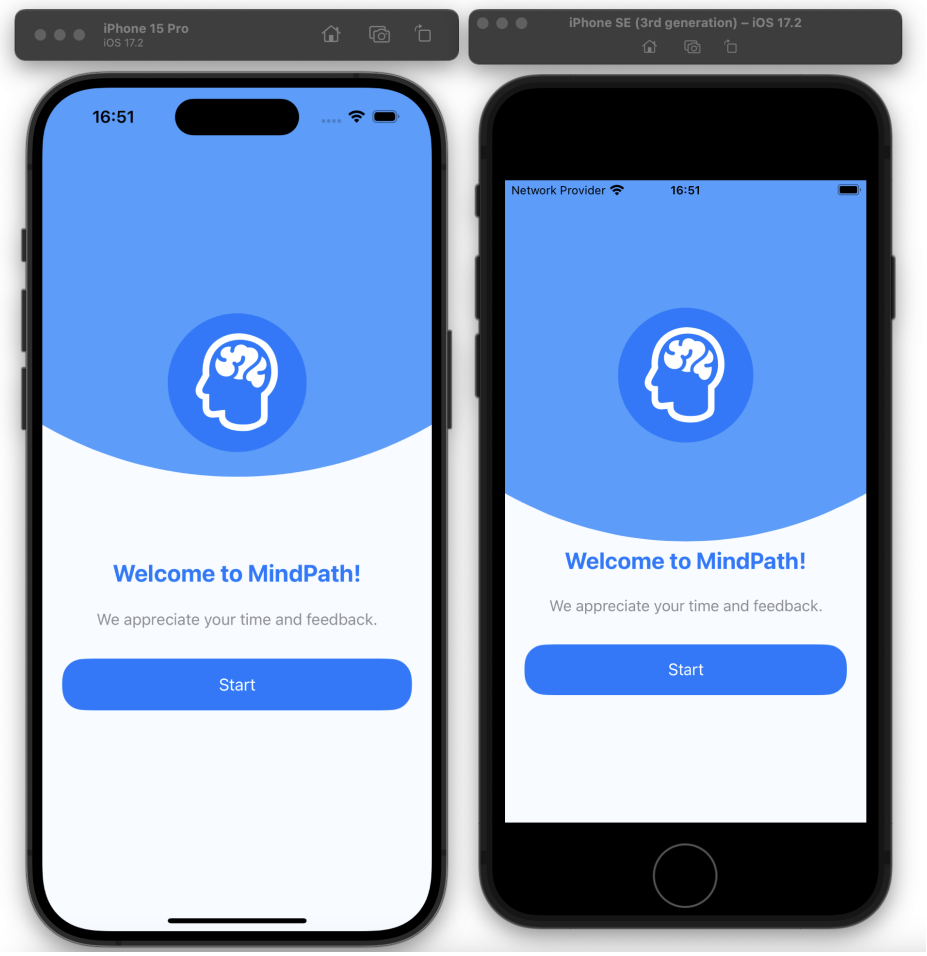


Figure 6.28: *MindPath on iPhone 15 pro and iPhone SE*

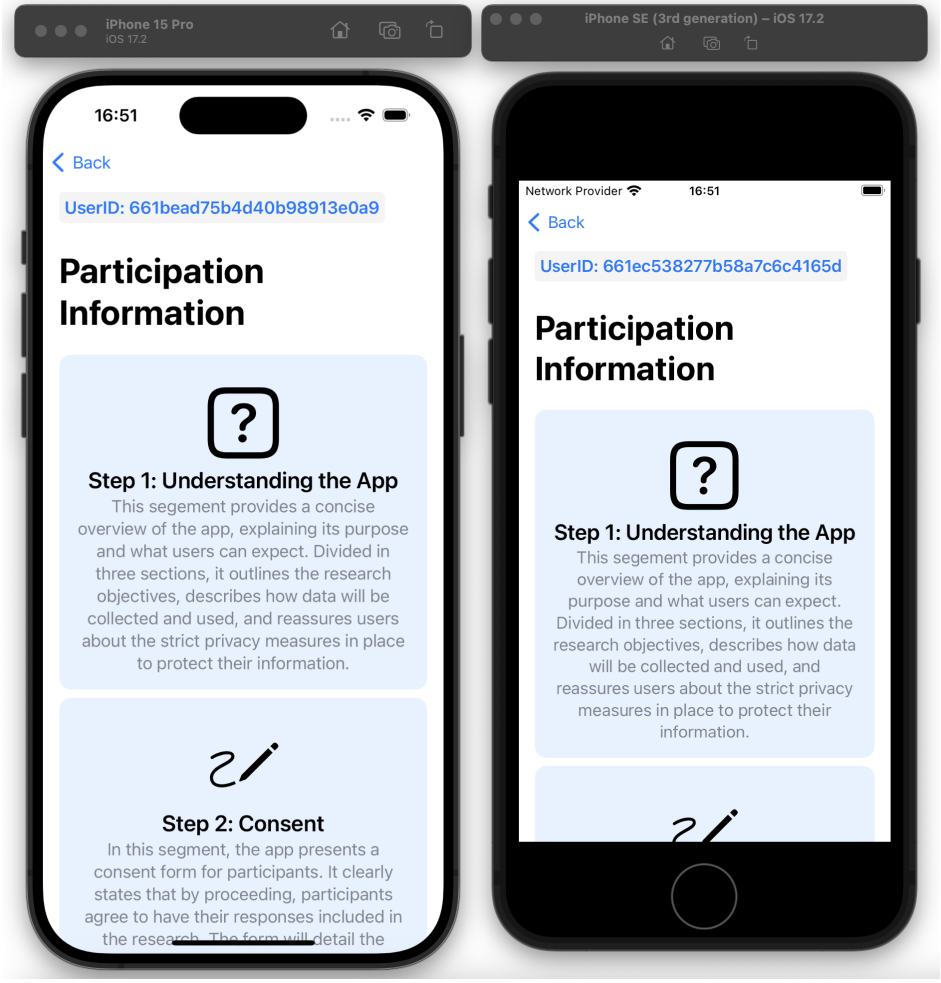


Figure 6.29: *Participation Information on iPhone 15 pro and iPhone SE*

6.5.6 Unit Testing

The units test target the smallest testable parts of the software. The primary goal of unit testing is to validate that every small unit of the software performs as designed. This type of testing ensures that the code behaves correctly before it is integrated with other parts of the application.

Testing Frameworks and Environments

- **iOS Application Testing:** For the iOS app, unit tests were conducted using the XCTest framework. It is a tool integrated within Xcode that creates and manages unit tests for iOS applications. XCTest allows developers to test functionalities in isolation, check the correctness of logic under various conditions, and measure performance metrics [65].

- **Website Frontend Testing:** The website's frontend components are tested using Jest alongside the React Testing Library. Jest provides a comprehensive testing framework

with built-in test runners and assertion capabilities, while React Testing Library offers utilities to test components in a manner that simulates real user interactions.

Examples of Unit Tests

Unit testing in MindPath encompasses both backend logic and user interface components. This ensurred comprehensive coverage of the entire system.

- **ReactJS Component Testing:** The test suite for the Demographic Breakdown Plot page verifies that the component renders correctly, responds to user inputs, and accurately reflects state changes. Figure 6.30 files shows a section of test suite made for this page.
- **iOS Application Testing:** Tests within the iOS environment focus on how responsive the app is to user interactions, data handling, and how it performs under typical usage scenarios. Figure 6.31 shows two test cases made for the testing the landing page.

frontend > src > pages > JS Home.test.js > ...

```
1  import React from "react";
2  import { render, screen, fireEvent } from "@testing-library/react";
3  import Home from "./Home";
4  import { BrowserRouter } from 'react-router-dom';
5
6  const renderWithRouter = (component) => {
7    return { ...render(<BrowserRouter>{component}</BrowserRouter>) }
8  }
9
10 describe("Home Component", () => {
11   it("renders the Home component with default values", () => {
12     renderWithRouter(<Home />);
13     expect(screen.getByText("MindPath")).toBeInTheDocument();
14     expect(screen.getByText("Demographic Breakdown Plot")).toBeInTheDocument();
15   });
16
17   it("should toggle privacy notice", () => {
18     renderWithRouter(<Home />);
19     const closeButton = screen.getByText('×');
20     fireEvent.click(closeButton);
21     expect(screen.queryByText("In accordance with GDPR")).not.toBeInTheDocument();
22   });
23
24   it("handles state changes for filters", () => {
25     renderWithRouter(<Home />);
26     const selectAge = screen.getByLabelText('Age');
27     fireEvent.change(selectAge, { target: { value: '25-30' } });
28     expect(selectAge.value).toBe('25-30');
29   });
30 });
```

Figure 6.30: *ReactJS Home Test File*

```
func testSuccessfulLoginFlow() {
    let app = XCUIApplication()
    let startButton = app.buttons["Start"]

    // Assume the start button triggers the login and then navigates
    startButton.tap()

    // Assuming there's a label or text that appears only after login
    let welcomeText = app.staticTexts["Welcome to MindPath!"]
    XCTAssertTrue(welcomeText.exists)
}

func testNavigationFromContentViewToInformationView() {
    let app = XCUIApplication()

    let startButton = app.buttons["Start"]

    XCTAssertTrue(startButton.exists, "Start button should exist on ContentView")

    startButton.tap()

    // Wait for the transition if needed
    let exists = NSPredicate(format: "exists == true")
    let informationTitle = app.staticTexts["Participation Information"]

    expectation(for: exists, evaluatedWith: informationTitle, handler: nil)
    waitForExpectations(timeout: 5)  // Adjust timeout

    // Check that the InformationView is displayed after tapping 'Start'
    XCTAssertTrue(informationTitle.exists, "InformationView should be displayed after tapping Start")
}
```

Figure 6.31: *iOS Testing*

Chapter 7

Results and Discussions

This chapter assesses the project's accomplishments and outlines potential future directions. It revisits the initial requirements and emphasises their dynamic adaptation through the agile methodology. The chapter also discusses the successful aspects of the project and the challenges faced. The user evaluation in this section focuses on getting insights for potential improvements and ideas for future iterations. Finally, the chapter outlines future work, including technical improvements, feature expansions and setting the stage for further research.

7.1 Revisiting Requirements

Revisiting the requirements is a crucial aspect to consider when discussing the results of the project. It serves as a fundamental metric for evaluating project progression and achievement of the stipulated goals. This analysis not only indicates the implementation status of each requirement but also highlights how the project has evolved over its course.

During the development phase, the project requirements underwent numerous modifications. The adoption of an agile and iterative approach provided the necessary flexibility to adapt to evolving project requirements. These modification included - adding user stories and altering some pre-existing user stories to meet the project's objectives. Unfortunately, due to time constraints, certain user stories could not be implemented. Alternatively, the new user stories seemed more appropriate within the project's context and the constraints of the available time frame.

7.1.1 Modified User Stories

Table 7.1 presents the original project requirements, any modifications made, and their implementation status.

Original User Story	Modified User Story	Status
As a participant, I want to be able to register on the app.	As a new participant, I want to able to start the survey by adding details regarding my age and occupation.	Implemented
As a participant, I want to be able to update my profile information at any point.	-	Not Implemented
As a participant, I want to be able to answer a series of questions about myself so I can partake in the survey.	-	Implemented
As a participant, I want to be able to receive notifications so I know when it is time to complete a survey at any point.	-	Not Implemented
As a participant, I want to be able to withdraw from the survey.	As a participant, I want to able to withdraw from the survey at any point by contacting the developer.	Implemented
As a participant, I want to be able to complete a consent form that will authorise the use of my responses for the intended purpose.	-	Implemented
As a participant, I want to manually input the answers for the survey.	-	Implemented
As a participant, I want to easily access, understand, and control my data privacy within the app.	-	Implemented
As a participant, I want to get regular updates regarding the research.	As a participant, I want to get regular updates regarding the research by contacting the developer.	Implemented
As a researcher, I want to visualise the summarised data.	-	Implemented
As a researcher, I want to filter and search based on specific demographic criteria .	-	Implemented

Table 7.1: *Modified User Stories and Implementation Status*

7.1.2 Additional/New User Stories

Table 7.2 presents the additional/new requirements in the form of user stories.

User Stories	Status
As a participant, I should be able to view my unique user ID.	Implemented
As a participant, I want to able to read and understand the participant information.	Implemented
As a participant, I want to be able to be able to download my completed consent form .	Implemented
As a participant, before starting the survey, I should understand the survey questions' content and the appropriate way to answer them.	Implemented
As a participant, while filling out the survey, I should have the option to cancel the survey at any point.	Implemented
As a participant, when filling out the survey, I want to be able to skip questions.	Implemented
As a participant, after finishing the survey, I want to be able to review my answers before submitting.	Implemented
As a researcher, I want to be able to read and understand the privacy policy before visualising the summarised data.	Implemented
As a researcher, I want to access varied graphical data representation methods to analyse the summarised data.	Implemented
As a researcher, I want to be able to comprehend the various visualisations by reviewing the informational cards displayed on the page.	Implemented

Table 7.2: *New User Stories and Implementation Status*

The complete list of user stories can be found in**Appendix B User Stories**. The list is a compilation of the modified user stories, additional/new user stories and their implementation status.

7.2 Implemented Features

The project has successfully achieved its main objectives by developing an iOS app and a website, collectively known as the MindPath. MindPath is specifically designed to explore the interactions between mental health and lifestyle factors. It is crucial to discuss these features in detail as part of the results section because they form the foundation of MindPath . Without these integrated features, the system would not function as intended. The sections below detail the features that have been successfully incorporated into the iOS application and the website. A complete video demonstration of the MindPath and its features can be found in **Appendix J Demonstration Video for MindPath**.

7.2.1 iOS Application

These implemented features are crucial as they form the backbone of the application. They ensure efficient interaction, secure data handling, and are compliant with accessibility requirements. Table 7.3 provides a list of the implemented features, a brief description and status for each.

Feature	**Description**	**Status**
ResearchKit Integration	Utilised the diverse tools provided by ResearchKit to develop an interactive and informative survey experience.	Implemented
Custom Consent Form	Implemented to compensate for the deprecated module in the new version of ResearchKit. This has been done to enhance compliance and participant understanding.	Implemented
Anonymous User ID	Implemented to safeguard user privacy. This feature ensures that all participant data collected through the app is stored and processed without using any personal identifiers.	Implemented
Accessible User Interface	Designed with accessibility in mind, the interface accommodates users with various disabilities and ensures that the app can be used by a wide demographic.	Implemented
RealmSwift Integration	Utilised RealmSwift to manage databases efficiently. This feature supports offline data entry, storing data locally and syncing when internet connectivity is restored.	Implemented

Table 7.3: *iOS App Features*

7.2.2 Website

These implemented features are essential, as they form the backbone of the website. These features have been designed to improve data interaction, management, and visualisation. They are essential for ensuring that the website functions by providing secure, accessible, and reliable data processing capabilities. Table 7.4 rovides the list of implemented features, brief description and status for each.

Feature	Description	Status
MongoDB URL API	Served as a key for managing database interactions securely and efficiently. This API supported robust data handling.	Implemented
Express Server Setup	Utilised the Express framework to streamline server management, routing, and middleware configuration. This setup ensured the website's back end operates efficiently, handling requests and serving responses without delays.	Implemented
Multiple Routes Setup	This enhanced the website's structural and navigational framework and improving overall user experience.	Implemented
Visualisation Tools	Integrated ChartJS and Plotly to provide dynamic and interactive visualisations. These tools enabled exploring data through a variety of graphical representations.	Implemented
Privacy Policy	Implemented a privacy policy that clearly outlines how user data is collected, used, and protected. This transparency is vital for building trust with the participants and ensuring compliance with regulations in place.	Implemented

Table 7.4: *Website Features*

7.3 User Evaluation

The main aim of the user evaluation was to assess the functionality and quality of MindPath, and gather insights on desired features for future iterations. The user evaluation was conducted using Google Forms. It was made available to the to participants once they completed their evaluation. A total of 25 participants engaged in this evaluation. Before participating, they were provided with an information sheet and a consent form. This documentation clearly outlined purpose of the evaluation, how the collected responses would be used, and the process for withdrawal. Initially, the survey was designed exclusively for evaluating the iOS app. For the website, the initial idea was to have the website's content and visualisations evaluated by a professional in this field. However, due to certain difficulties faced in the process, the strategy was revised. The survey was then modified to encompass questions on the website's functionality and desired features for the future iterations. This adjustment enabled collecting valuable user feedback on overall functionality and user experience. Although the respondents were not professionals, obtaining an external and non-technical perspective proved to be extremely beneficial. The survey questions were designed to assess key aspects such as navigation, technical issues encountered, relevance of the content, additional features, and ideas for future iterations. The results for the user evaluation can be found in **Appendix**

G User Evaluation

7.3.1 iOS App

For the iOS app, the users were required navigate through the app. This included onboarding, filling out the consent form, and completing the survey.

- **Participant Involvement:** All 25 participants completed the evaluation.
- **User-Friendly Design:** A majority (60%) *strongly agreed* that the app's design is user-friendly. This indicated a positive reception towards the app's interface.
- **Navigation:** The responses showed that 44% found the navigation *easy*, while 52% found it *very easy*. This highlighted the app's navigational efficiency.
- **Functionality and Performance:** Most participants (84%) did not encounter significant issues with the app's functionality or performance. Some participants (16%) experienced minor difficulties. However, they did not affect the functionality of the app. This indicated that the app is robust and efficient in terms of functionality and performance.
- **Relevance of Survey Questions:** Over half of the participants (52%) found the survey questions very relevant to their lifestyle and mental well-being. This demonstrated that the research and thought invested in formulating the questions were indeed effective and useful.
- **Engagement and Additional Elements:** The feedback suggested that gamification (48%) and More comprehensive tracking and feedback of the surveys (48%) could significantly enhance user engagement and satisfaction.
- **Future Iterations:** Looking forward, 52% of users expressed a preference for integrating HealthKit to make the surveys more engaging adn effcient.
- **Overall Satisfaction:** From the limited responses for this question, users appreciated the app's UI and suggested adding more incentives like gamification to increase user engagement.

7.3.2 Website

For evaluation of the website, the users were required to navigate through the pages of the website. This involved exploring different types of visualisations and engaging with the interactive elements of the charts.

- **Participant Engagement:** All 25 participants completed the evaluation of the website.
- **Design User-Friendliness:** 60% of the participants rated the design of the website as user-friendly and easy to navigate. This indicated a generally positive user interface experience.

- **Ease of Navigation:** The majority of users (56%) found the website easy to navigate. This highlighted the website's navigational efficiency.
- **Functionality and Performance:** A significant majority (88%) reported no issues with the website's functionality or performance. This showcased the technical stability of the website.
- **Content and Visualisations:** Most participants (76%) found the visualisations and content of the website to be effective and user-friendly. This affirmed the quality and accessibility of the informational graphics.
- **Future Iterations:** For future iterations, 52% favored adding more options for data visualisations. This indicating a desire for deeper interaction and more varied data presentation.
- **Overall Satisfaction:** The qualitative feedback suggested that the visualisations and the diverse methods of data presentation are the key strengths of the website.

7.3.3 Conclusion

Overall, the user evaluation was designed to encompass all critical aspects of the system. This ensured a comprehensive coverage of potential areas for improvement.The survey questions were strategically formulated to ascertain the effectiveness of existing features and identify opportunities for future enhancements. This evaluation served as a crucial indicator in understanding how well the system aligns with the requirements.

7.4 Limitations and Constraints

This section highlights the challenges encountered during the implementation of the project. It is crucial to address these challenges in the results section as they have substantially impacted the outcomes.The project encountered several challenges; however, this section will only address those that had a significant impact on the project. Some of these challenges were encountered during the implementation phase and others may potentially become restrictions in the future.

7.4.1 MongoDB Atlas

MongoDB Atlas has proven to be an effective database management solution for MindPath. It provided robust support for the system's needs. However, it still presented certain limitations that have impacted the development phase and has the potential to have impact in the future.

- **Intermittent Server Errors:** MongoDB Atlas constantly generated internal server errors. This disrupted the connection between iOS App and the database. The error occurs randomly and unpredictably. When it does happen, it prevents the display of real-time data. On doing some research, it was found that this issue is commonly associated with AWS cloud services. Although not a constraint, it definitely does pose as a limitation.

- **Dynamic IP Address Registration:** The development phase utilised a locally hosted website and required frequent IP address updates due to network changes. For security reasons, MongoDB Atlas allows connections only from pre-approved IP addresses. As a result, every new IP address must be manually added every time anyone wants to visualise the data. In the future, securing a static IP address or purchasing a domain may be necessary to stabilise access and reduce maintenance overhead.

- **Storage and Connection Limitations:** The free version of MongoDB Atlas permits only up to 5GB of data storage and supports limited simultaneous connections. Currently, the data collected from surveys totals less than 10MB. However, as plans to scale and distribute the app more broadly progress, upgrading to a paid version will be essential to accommodate increased data storage needs.

7.4.2 ResearchKit Consent Module

ResearchKit has been an integral component of MindPath; however, certain issues with its implementation may pose restrictions in the future. Specifically, the standard consent modules were deprecated and could not be used. To address this challenge, a custom consent module was developed. The design and development of this was based on the observations that the primary function of a consent module is to allow participants to acknowledge the information, sign to give their consent, and have the option to download the document. This solution effectively replicates these essential functions. While this custom module currently meets the project's needs, the eventual publication of the app will likely necessitate the implementation of a more formal module or the development of a robust alternative to meet publishing standards. If not addressed, the existing solution may be considered insufficient.

7.5 Further Work

This section outlines potential future work for the project. This includes a) initiatives/features that were planned initially but not executed due to various constraints and b) additional initiatives/features that are of interest for further development. The additional initiatives/features discussed in this section were selected based on how would they enhance the app's value and the preferences expressed by users during the user evaluation. These considerations aim to guide the next phases of the project. This not only ensures continuous improvement but also adapts to evolving requirements and opportunities.

7.5.1 Notifications

The feature outlined in the user story, "As a participant, I want to be able to receive notifications so I know when it is time to complete a survey," was not implemented due to time constraints. Nonetheless, this feature remains a crucial requirement for future versions of the project. Enabling notifications will allow participants to receive timely updates about potential new surveys and important research developments. Successfully implementing this feature would enhancing user engagement.

7.5.2 Participant Accounts

The feature outlined in the user story, "As a participant, I want to be able to update my profile information at any point," was not implemented due to time constraints. Integrating this functionality in future iterations is essential. This would enable them to view their survey history and update personal information as needed. Successfully implementing this feature would enhance user autonomy, ensure data accuracy, and improve overall app engagement.

7.5.3 Gamification

Gamification involves incorporating game elements into non-game settings, such as websites, online communities or learning management systems. The objective is to motivate users to engage more deeply, fostering collaboration, interaction, and sharing [66].In the user evaluation, many participants identified gamification as one of the key features that could be implemented in the future iterations. In general,gamification in such app has the ability to transforms routine tasks into fun activities [67]. Whether implemented in the iOS app or on the website, introducing the concept of gamification has the potential to substantially boost user participation and engagement. On the website, gamification can help researchers in better understanding and analysing content. For the app, it can help participants more clearly grasp the purpose of the system, encouraging greater overall involvement.

7.5.4 Additional Filter for Demographic Breakdown Plot

Based on user evaluations, over half of the respondents suggested adding more filters to the demographic breakdown plot. In response to this feedback, expanding the range of filters has been included in the further work section. This enhancement will help researchers better understand how lifestyle factors are linked to mental health. By introducing additional filters, the analysis has the potential to become more comprehensive. Furthermore, it might also pave wave for clearer insights into how different aspects of lifestyle affect mental health in various groups. This can lead to more effective interventions and research outcomes.

7.5.5 Integrating HelathKit and Utilising Wearable Technologies

Currently, MindPath effectively utilises the different features of ResearchKit and has been successful at fulfilling its requirements. HealthKit is a framework that provides a central repository for health and fitness data on iPhone and Apple Watch [68]. With the user's permission, apps can communicate with the HealthKit access and share this data. The potential integration of HealthKit could significantly increase the overall value of the system in terms of functionality and user engagement. This integration is achievable with minimal additional development because of the compatibility between the two frameworks. Many ResearchKit apps already use HealthKit to gather more comprehensive information about their users [69]. For example, monitoring heart rate during step tests can augment the data collected for research purposes.

In addition to the HealthKit integration, the development of a companion app for the Apple Watch could significantly expand MindPath's reach and functionality. As of 2020, with global user base of over 100 million [70], this addition would enable users to monitor various lifestyle

factors directly from their wrist and facilitate continuous data collection. The integration of the Apple Watch would ensure a seamless flow of health data between the device and the application. This setup would empower users with real-time insights into their physical activity, heart rate, and other health metrics. Together, these integrations would not only improve the quality of the data collected but also enhance user engagement and app reliability.

7.5.6 More research into questions

The current survey questions that are used in the MindPath app are already well researched. However there is substantial scope for further enhancement.

Continued research into the content of survey questions can be crucial for enhancing the accuracy and value of the responses collected. By researching more into the subject matter and refining the questions, it would be possible to formulate queries that yield more useful and significant insights when answered and analysed. This not only improves the quality of data but also ensures its relevance for research purposes. Simultaneously, making changes to the way the questions are presented and answered can significantly boost respondent engagement. Incorporating interactive elements like drag-and-drop rankings or scenario-based queries can revitalise the survey experience. To successfully implement these interactive features, integrating the frameworks discussed in the previous section will be crucial.

By leveraging these methodologies and features, the surveys can be designed to be both more engaging and precise. This integration would not only enhance the quality of responses but also ensure that the data collection process remains robust and adaptable to future technological advancements.

Chapter 8

Conclusion

Mental health encompasses our emotional, psychological, and social well-being. It influences how we think, feel, and act. It's vital in our life because it affects how we handle stress, relate to others, and make choices in our daily lives. A positive mental state enables us to cope with life's challenges, realise our potential, and contribute meaningfully to our communities. Mental health is more than just the absence of mental disorders; it's about thriving and flourishing in various aspects of life. Prioritising mental health is crucial in today's world as it significantly impacts our overall well-being and quality of life.

Lifestyle factors encompass a range of habits and choices that individuals make in their daily lives, including diet, exercise, sleep patterns, stress management, and social interactions. Adopting a healthy lifestyle can profoundly impact mental health by improving cognitive function, boosting mood, reducing stress levels, and promoting overall well-being. Regular physical activity, balanced nutrition, quality sleep, and effective stress management techniques are all essential components of a healthy lifestyle that contribute to mental wellness. By incorporating these lifestyle factors into our daily routines, we can enhance our resilience, improve our mood, and possibly reduce the risk of mental health disorders.

While there has been significant progress in the development of mental health apps, the focus has predominantly been on emotional well-being. Despite the increasing recognition of the importance of lifestyle factors in mental health, there still remains a gap in understanding the full extent of this interaction. As technology continues to advance, there is an opportunity to develop more comprehensive mental health apps.

MindPath was developed with the aim to address the growing interest in mental health and to fill in the identified gaps in existing research tools. MindPath can be considered as something that has a research-based approach to mental health and focuses on comprehensive well-being. The main objective of MindPath is to leverage technology to make research more accessible and to simplify the analysis process. It is a system that includes an iOS application and a website designed to facilitate data visualisation. The iOS app features surveys created using Apple's ResearchKit and gathers all the essential data. Meanwhile, the website is developed to simplify the interpretation and analysis of the collected data. Together, these components aim to explore a key question: "How much do lifestyle choices affect one's mental

health?”.

MindPath has made significant progress in its aim to uncover the extent of interaction between mental health and lifestyle factors. The app has successfully met its key objectives by providing interactive survey experiences. MindPath ensures data security through the use of custom consent forms and privacy measures like anonymous user IDs. Meanwhile, the website supports this with efficient backend operations, user-friendly navigation and utilises efficient tools for database management and server efficiency. Both the app and website have been successful at fulfilling their objectives.

Evaluation is a crucial aspect of any project. It serves as a comprehensive test of the system's functionality. MindPath underwent various types of testing to ensure optimal performance. In addition to this, an extensive user evaluation was conducted to evalute the usability of MindPath. The evaluation was designed with questions that addressed all key aspects of the system. This made it easy to assess how well it met its intended requirements. The feedback from this process was overall positive, with participants appreciating the concept and expressing keen interest in the project's future developments.

Throughout the development process, several limitations and constraints were discovered. Despite these challenges, MindPath's foundational achievements have laid a strong groundwork for ongoing research and future improvements. These experiences have not only tested the resilience of the platform but also highlighted areas for improvement, ensuring that MindPath continues to evolve as a robust tool in mental health research.

Moving forward, several avenues for future work have been identified to enhance the capabilities and value of MindPath. These include implementing features such as notifications for survey updates, participant accounts for data management, and gamification elements to foster user engagement. Additionally, expanding filters for demographic breakdown plots and integrating HealthKit and Apple Watch functionality offer opportunities to enrich data collection, data analysis and user experience. Continued research into survey questions and incorporating interactive elements can further improve data accuracy and participant engagement. In conclusion, at this stage, MindPath represents as a satisfactory development in the study of mental health. It merges methods of scientific research with technological innovation to explore interaction of lifestyle choices with mental health. As the platform evolves, it will continue to offer valuable insights and will drive forward the understanding of mental health in the modern world.

Bibliography

[1] J. Firth, M. Solmi, R. E. Wootton, D. Vancampfort, F. B. Schuch, E. Hoare, S. Gilbody, J. Torous, S. B. Teasdale, S. E. Jackson, L. Smith, M. Eaton, F. N. Jacka, N. Veronese, W. Marx, G. Ashdown-Franks, D. Siskind, J. Sarris, S. Rosenbaum, A. F. Carvalho, and B. Stubbs, "A meta-review of "lifestyle psychiatry": The role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders," *World Psychiatry*, vol. 19, pp. 360–380, 2020. DOI: 10.1002/wps.20773. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7491615/.

[2] *Wellness app revenue and usage statistics (2023)*, Business of Apps. [Online]. Available: https://www.businessofapps.com/data/wellness-app-market/#:~:text=There%20are%20estimated%20to%20be.

[3] Apple, *Researchkit*, researchkit.org. [Online]. Available: https://researchkit.org/ (visited on 11/05/2023).

[4] W. H. Organization, *Mental health*, World Health Organization, Jun. 2022. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response.

[5] B. A. LMHC, *Why is mental health important?* Talkspace, Nov. 2021. [Online]. Available: https://www.talkspace.com/blog/why-is-mental-health-important/#:~:text=Positive%20mental%20health%20is%20crucial.

[6] D. H. Barlow and V. M. Durand, *Abnormal psychology : an integrative approach*. Cengage Learning, 2015.

[7] J. Bertolote, "The roots of the concept of mental health," *World Psychiatry : Official Journal of the World Psychiatric Association (WPA)*, vol. 7, pp. 113–6, Jun. 2008. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2408392/ (visited on 11/05/2023).

[8] I. G. Farreras, *History of mental illness*, Noba, 2023. [Online]. Available: https://nobaproject.com/modules/history-of-mental-illness (visited on 11/06/2023).

[9] U. Health, *Healthy lifestyles, healthy outlook*, ucsfhealth.org. [Online]. Available: https://www.ucsfhealth.org/education/healthy-lifestyles-healthy-outlook (visited on 11/06/2023).

[10] tutor2u, *Lifestyle factors — topics*, tutor2u, Aug. 2020. [Online]. Available: https://www.tutor2u.net/hsc/topics/lifestyle-factors (visited on 11/05/2023).

[11] *British nutrition foundation*, 2021. [Online]. Available: https://www.nutrition.org.uk/news/2021/ (visited on 11/07/2023).

[12] L. Maaß, M. Freye, C.-C. Pan, H.-H. Dassow, J. Niess, and T. Jahnel, "The definitions of health apps and medical apps from the perspective of public health and law: Qualitative analysis of an interdisciplinary literature overview," *JMIR mHealth and uHealth*, vol. 10, e37980, Oct. 2022. DOI: 10.2196/37980.

[13] E. Anthes, "Mental health: There's an app for that," *Nature*, vol. 532, pp. 20–23, Apr. 2016. DOI: 10.1038/532020a.

[14] Statista, *Global: Number of smartphone users 2013-2028*, Statista, Jul. 2023. [Online]. Available: https://www.statista.com/forecasts/1143723/smartphone-users-in-the-world#:~:text=After%20the%20fifth%20consecutive%20increasing (visited on 11/05/2023).

[15] Business of Apps, *Number of active iphone units worldwide 2022*, Statista, May 2023. [Online]. Available: https://www.statista.com/statistics/1337745/active-apple-iphone-units-worldwide/#:~:text=In%202022%2C%20the%20number%20of (visited on 11/05/2023).

[16] E. Ozdalga, A. Ozdalga, and N. Ahuja, "The smartphone in medicine: A review of current and potential use among physicians and students," *Journal of Medical Internet Research*, vol. 14, e128, Sep. 2012. DOI: 10.2196/jmir.1994. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3510747/ (visited on 11/05/2023).

[17] Apple, *Researchkit*, researchkit.org. [Online]. Available: http://researchkit.org/ (visited on 11/05/2023).

[18] L. Bührmann, L. Bührmann, T. V. Daele, A. Rinn, N. A. J. D. Witte, D. Lehr, J. J. Aardoom, J. J. Aardoom, J. J. Aardoom, L. Loheide-Niesmann, L. Loheide-Niesmann, J. Smit, H. Riper, H. Riper, and H. Riper, "The feasibility of using apple's researchkit for recruitment and data collection: Considerations for mental health research," *Frontiers in Digital Health*, vol. 4, Nov. 2022. DOI: 10.3389/fdgth.2022.978749. [Online]. Available: https://doaj.org/article/ecb63ed6da174fd58eeaa330829a2c4c (visited on 11/07/2022).

[19] TheVerge, *Apple actives devices 2023*, Statista, Feb. 2023. [Online]. Available: https://www.statista.com/statistics/1383887/number-of-apple-active-devices/#:~:text=In%202016%2C%20Apple%20reached%20one (visited on 11/07/2023).

[20] Apple, *Informedconsent document*, researchkit.org, 2018. [Online]. Available: https://researchkit.org/docs/docs/InformedConsent/InformedConsent.html (visited on 11/05/2023).

[21] ——, *Creatingsurveys document*, researchkit.org, 2018. [Online]. Available: https://researchkit.org/docs/docs/Survey/CreatingSurveys.html (visited on 11/05/2023).

[22] ——, *Activetasks document*, researchkit.org, 2018. [Online]. Available: http://researchkit.org/docs/docs/ActiveTasks/ActiveTasks.html (visited on 11/05/2023).

[23] ——, *Apple advances health apps with carekit*, Apple Newsroom, Mar. 2016. [Online]. Available: https://www.apple.com/newsroom/2016/03/21Apple-Advances-Health-Apps-with-CareKit/ (visited on 11/07/2023).

[24] CareKit, *Carekit : Apple developer*, developer.apple.com, 2023. [Online]. Available: https://developer.apple.com/carekit/ (visited on 11/10/2023).

[25] Apple, *Checkcovid*, App Store, Feb. 2021. [Online]. Available: https://apps.apple.com/us/app/checkcovid/id1504328584 (visited on 11/2023).

[26] L. Bührmann, L. Bührmann, T. V. Daele, A. Rinn, N. A. J. D. Witte, D. Lehr, J. J. Aardoom, J. J. Aardoom, J. J. Aardoom, L. Loheide-Niesmann, L. Loheide-Niesmann, J. Smit, H. Riper, H. Riper, and H. Riper, "The feasibility of using apple's researchkit for recruitment and data collection: Considerations for mental health research," *Frontiers in Digital Health*, vol. 4, Nov. 2022. DOI: 10.3389/fdgth.2022.978749. [Online]. Available: https://doaj.org/article/ecb63ed6da174fd58eeaa330829a2c4c (visited on 11/2023).

[27] H. L. Egger, G. Dawson, J. Hashemi, K. L. H. Carpenter, S. Espinosa, K. Campbell, S. Brotkin, J. Schaich-Borg, Q. Qiu, M. Tepper, J. P. Baker, R. A. Bloomfield, and G. Sapiro, "Automatic emotion and attention analysis of young children at home: A researchkit autism feasibility study," *npj Digital Medicine*, vol. 1, Jun. 2018. DOI: 10.1038/s41746-018-0024-6. [Online]. Available: https://www.nature.com/articles/s41746-018-0024-6 (visited on 11/2023).

[28] B. Byrom, and, *Google scholar*, scholar.google.com, Feb. 2017. [Online]. Available: https://scholar.google.com/scholar?q=Byrom+B+Simpson+L+Lee+J+Flood+E+Cassedy+C+Gadala-Maria+A++Applicability+of+apple+research+kit+to+deliver+cognitive+testing+in+clinical+trials:+results+of+a+pilot+study+.++ISPOR+22nd+Annual+international+meeting+.

[29] Medicines and Healthcare Products Regulatory Agency (MHRA), *An introductory guide to the medical device regulation (mdr) and the in vitro diagnostic medical device regulation (ivdr)*, assets.publishing.service.gov.uk. (visited on 11/2023).

[30] Medicines and Healthcare products Regulatory Agency, *Guidance on class 1 medical devices*, GOV.UK, Oct. 2016. [Online]. Available: https://www.gov.uk/government/collections/guidance-on-class-1-medical-devices (visited on 11/2023).

[31] *The medical devices regulations 2002*, Legislation.gov.uk, 2011. [Online]. Available: https://www.legislation.gov.uk/uksi/2002/618/contents/made (visited on 11/2023).

[32] D. Grainger, *Guidance: Medical device stand-alone software including apps (including ivdmds) v1.10f*, Medicines and Healthcare products Regulatory Agency. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1168485/Medical_device_stand-alone_software_including_apps__including_IVDMDs_.pdf.

[33] University of New South Wales, *Overview of the dass and its uses*. [Online]. Available: https://www2.psy.unsw.edu.au/dass/over.htm (visited on 11/2023).

[34] T. Mulder, *Health apps, their privacy policies and the gdpr*, papers.ssrn.com, Jun. 2019. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506805 (visited on 11/2023).

[35] E. Commission, *Privacy on mobile health apps — shaping europe's digital future*, digital-strategy.ec.europa.eu. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/privacy-mobile-health-apps (visited on 11/2023).

[36] A. Altvater, *What is sdlc? understand the software development life cycle*, Stackify, Mar. 2023. [Online]. Available: https://stackify.com/what-is-sdlc/ (visited on 11/2023).

[37] Wallin, *Software development lifecycle models the basic types*, 2001. (visited on 11/2023).

[38] GitHub, *Understanding the sdlc: Software development lifecycle explained*, GitHub Resources. [Online]. Available: https://resources.github.com/software-development/what-is-sdlc/ (visited on 11/2023).

[39] JavaPoint, *Advantages and disadvantages of sdlc - javatpoint*, www.javatpoint.com. [Online]. Available: https://www.javatpoint.com/advantages-and-disadvantages-of-sdlc#:~:text=Making%20adjustments%20to%20the%20product (visited on 11/25/2023).

[40] D. Hughey, *The traditional waterfall approach*, www.umsl.edu, 2009. [Online]. Available: https://www.umsl.edu/~hugheyd/is6840/waterfall.html#:~:text=The%20Waterfall%20approach%20to%20systems (visited on 11/2023).

[41] T. Solod, *Software development life cycle models: Choosing a way to get things done*, Blog - Mind Studios, Jan. 2020. [Online]. Available: https://themindstudios.com/blog/software-development-life-cycle-models/ (visited on 11/2023).

[42] Atlassian, *Agile best practices and tutorials — atlassian*, Atlassian, 2019. [Online]. Available: https://www.atlassian.com/agile (visited on 11/2023).

[43] Apple, *Swift - apple developer*, Apple, 2019. [Online]. Available: https://developer.apple.com/swift/ (visited on 11/2023).

[44] ——, *Swift apple developer*, developer.apple.com. [Online]. Available: https://developer.apple.com/swift/#objective-c (visited on 11/2023).

[45] ——, *Swift - apple developer*, Apple, 2020. [Online]. Available: https://developer.apple.com/swift/#open-source (visited on 11/2023).

[46] ——, *Xcode - swiftui- apple developer*, developer.apple.com. [Online]. Available: https://developer.apple.com/xcode/swiftui/ (visited on 11/2023).

[47] ——, *Uikit — apple developer documentation*, Apple, 2020. [Online]. Available: https://developer.apple.com/documentation/uikit (visited on 11/2023).

[48] ——, *Xcode - apple developer*, Apple, 2018. [Online]. Available: https://developer.apple.com/xcode/ (visited on 11/2023).

[49] MongoDB, *The most popular database for modern apps*, MongoDB, 2019. [Online]. Available: https://www.mongodb.com/ (visited on 11/2023).

[50] Google, *Firebase*, Firebase, 2023. [Online]. Available: https://firebase.google.com/ (visited on 11/2023).

[51] *What is the mern stack?* Oracle.com, 2024. [Online]. Available: https://www.oracle.com/uk/database/mern-stack/#:~:text=The%20MERN%20stack%20is%20a (visited on 05/04/2024).

[52] R. Percy, *Comparing the most popular javascript charting libraries*, LogRocket Blog, Jan. 2023. [Online]. Available: `https://blog.logrocket.com/comparing-most-popular-javascript-charting-libraries/` (visited on 05/04/2024).

[53] Apple, *Get started with accessibility features on iphone*, Apple Support. [Online]. Available: `https://support.apple.com/en-gb/guide/iphone/iph3e2e4367/ios` (visited on 11/2023).

[54] ——, *Human interface guidelines - design - apple developer*, Apple, 2019. [Online]. Available: `https://developer.apple.com/design/human-interface-guidelines/` (visited on 11/2023).

[55] W3C, *Standards - w3c*, W3.org, 2019. [Online]. Available: `https://www.w3.org/standards/` (visited on 11/2023).

[56] , *Understanding mongodb document model: A quick guide — geopits*, www.geopits.com, Aug. 2023. [Online]. Available: `https://www.geopits.com/blog/guide-to-mongodb-document-model.html` (visited on 05/07/2024).

[57] ——, *Data model design — mongodb manual*, https://github.com/mongodb/docs/blob/v3.0/source/core/model-design.txt. [Online]. Available: `https://www.mongodb.com/docs/v3.0/core/data-model-design/` (visited on 05/07/2024).

[58] ——, *Realm/realm-swift*, GitHub, Mar. 2022. [Online]. Available: `https://github.com/realm/realm-swift` (visited on 05/05/2024).

[59] ——, *Increase app responsiveness with mongodb realm mobile database and aws wavelength — aws open source blog*, aws.amazon.com, Jun. 2022. [Online]. Available: `https://aws.amazon.com/blogs/opensource/increase-app-responsiveness-with-mongodb-realm-mobile-database-and-aws-wavelength/` (visited on 05/07/2024).

[60] michaelstonis, *Model-view-viewmodel*, learn.microsoft.com, Apr. 2022. [Online]. Available: `https://learn.microsoft.com/en-us/dotnet/architecture/maui/mvvm` (visited on 05/05/2024).

[61] , *Sf symbols*, Apple Developer. [Online]. Available: `https://developer.apple.com/sf-symbols/#:~:text=With%20over%205%2C000%20symbols%2C%20SF` (visited on 05/07/2024).

[62] E. Plumptre, *The importance of mental health*, Verywell Mind, Feb. 2023. [Online]. Available: `https://www.verywellmind.com/the-importance-of-mental-health-for-wellbeing-5207938` (visited on 05/06/2024).

[63] D. Kumar, *Software engineering — sdlc v-model - geeksforgeeks*, GeeksforGeeks, Feb. 2019. [Online]. Available: `https://www.geeksforgeeks.org/software-engineering-sdlc-v-model/` (visited on 05/04/2024).

[64] hotjar, *Usability testing 101: What it is what it's not (2020 guide)*, Hotjar, 2020. [Online]. Available: `https://www.hotjar.com/usability-testing/` (visited on 05/07/2024).

[65] , *Apple developer documentation*, developer.apple.com. [Online]. Available: `https://developer.apple.com/documentation/xctest`.

[66] B. Worldwide, *What is gamification?* BI WORLDWIDE, 2022. [Online]. Available: https://www.biworldwide.com/gamification/what-is-gamification/ (visited on 05/06/2024).

[67] V. Struk, *Exploring the impact of gamification in healthcare*, Relevant Software, Aug. 2023. [Online]. Available: https://relevant.software/blog/gamification-in-healthcare/ (visited on 05/06/2024).

[68] Apple, *Healthkit — apple developer documentation*, developer.apple.com, 2024. [Online]. Available: https://developer.apple.com/documentation/healthkit (visited on 05/06/2024).

[69] N. Horton, *Introductions: Healthkit, researchkit and carekit*, Medium, Apr. 2020. [Online]. Available: https://medium.com/kinandcartacreated/introductions-healthkit-researchkit-and-carekit-d72e2ac9ce2 (visited on 05/06/2024).

[70] F. Laricchia, *Apple watch users worldwide 2020*, Statista, Apr. 2022. [Online]. Available: https://www.statista.com/statistics/1221051/apple-watch-users-worldwide/ (visited on 05/06/2024).

Appendices

Appendix A

Risk Register

Key:

Likelihood (L)	Description
5	Very likely/imminent - certain to happen.
4	Probable - a strong possibility of it happening
3	Possible - it may have happened before
2	Unlikely - could happen but unusual
1	Rare - highly unlikely to occur

Impact (I)	Guide Description
5	Catastrophic:non-functional system
4	Major - significant changes to the system
3	Moderate - moderate changes to the system
2	Minor - minor changes to the system
1	Very minor - very minor changes to the system or requirements.

		Impact (I)				
		1	2	3	4	5
Likelihood (L)	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Risk Rating (RR)	Action
High Risk	Stop the task/activity until controls can be put into place to reduce the risk to an acceptable level.
Medium Risk	Determine if further precautions are required to reduce risk to as low as is reasonably practicable.
Low Risk	No further action, keep under review.

Figure A.1: *Risk Analysis Key*

Risks	**Consequences**	**Risk Rating**			**Control Measures**	**Residual Risk**		
		L	**I**	**RR**		**L**	**I**	**RR**
Inadequately defined requirements	Can lead to missing core features and can result in an unsuccessful project.	4	5	20	Ensure that the requirements are well-defined. Following an iterative development that will allow to incorporate alterations at any stage.	2	1	2
Lack of on-time feedback from the supervisor	Can potentially impact the quality of the project.	3	4	12	Submitting drafts at least a week before the deadline. Setting up regular meetings with the supervisor.	1	2	2
Insufficient time to complete the project	Can potentially lead to a missing deadlines or having a unfinished product	5	5	25	Prioritise requirements Regularly working on the project and keeping the supervisor updated Use a Gantt chart to track progress	3	4	12
Issues with SDK or IDE	Can lead to a delay in the development stage	4	5	20	Checking version compatibilities Using the most upto-to-date versions - this would make sure that bug fixes are applied immediately.	3	4	12
Inability to assess the project's usability	This could potentially undermine confidence in the project's suitability for its intended purpose	4	5	20	Having a verifiable acceptance criteria for these requirements.	2	2	4
Unfamiliarity with a frameworks/tools	This can potentially lead to extra time being spent on learning these skills rather than actually developing the product	4	5	20	Using relatively familiar frameworks/tools. Scheduling enough time to learn new tools/frameworks	3	4	12
Delay in applying for the ethics approval	This may lead to extra work (making a second application) and can also lead to delay in testing	4	4	16	Starting the ethics application as soon as possible	2	2	4
Project not getting approved on the App Store	This would lead to a potential delay in testing	3	5	15	Being well acquainted with the App Store Review Guidelines	2	5	10

Figure A.2: *Risk Register*

Appendix B

User Stories

Table B.1: *Combined User Stories and Implementation Status*

User Story	Status
As a participant, I want to be able to start the survey by adding details regarding my age and occupation.	Implemented
As a participant, I want to able to read and understand the participant information.	Implemented
As a participant, I should be able to view my unique user ID.	Implemented
As a participant, I want to easily access, understand, and control my data privacy within the app.	Implemented
As a participant, I want to be able to complete a consent form that will authorise the use of my responses for the intended purpose.	Implemented
As a participant, I want to be able to download my completed consent form.	Implemented
As a participant, I want to be able to answer a series of questions about myself so I can partake in the survey.	Implemented
As a participant, before starting the survey, I should understand the survey questions' content and the appropriate way to answer them.	Implemented
As a participant, I want to manually input the answers for the survey.	Implemented
As a participant, while filling out the survey, I should have the option to cancel the survey at any point.	Implemented
As a participant, when filling out the survey, I want to be able to skip questions.	Implemented
As a participant, after finishing the survey, I want to be able to review my answers before submitting.	Implemented
As a participant, I want to able to withdraw from the survey at any point by contacting the developer.	Implemented
As a participant, I want to get regular updates regarding the research by contacting the developer.	Implemented
As a participant, I want to be able to update my profile information at any point.	Not Implemented

Continued on next page

Table B.1 – continued from previous page

User Story	Status
As a participant, I want to be able to receive notifications so I know when it is time to complete a survey.	Not Implemented
As a researcher, I want to be able to read and understand the privacy policy before visualising the summarised data.	Implemented
As a researcher, I want to visualise the summarised data.	Implemented
As a researcher, I want to filter and search based on specific demographic criteria.	Implemented
As a researcher, I want to access varied graphical data representation methods to analyse the summarised data.	Implemented
As a researcher, I want to be able to comprehend the various visualisations by reviewing the informational cards displayed on the page.	Implemented

Appendix C

Acceptance Testing

Table C.1: *Example User Story with Acceptance Criteria*

Story	Acceptance Criteria	Status
As a participant, I want to be able to start the survey by adding details regarding my age and occupation.	1. Open MindPath App 2. Navigate through the information. 3. Fill out details. 4. Start the survey.	Implemented
As a participant, I want to able to read and understand the participant information.	1. Open MindPath App 2. Navigate to the Participation Information Page. 3. Read and Understand the participation information.	Implemented
As a participant, I should be able to view my unique user ID.	1. Open MindPath App 2. Navigate to the Participation Information Page 3. View the unique user ID at the top of the page.	Implemented

Continued on next page

Table C.1 – continued from previous page

Story	Acceptance Criteria	Status
As a participant, I want to easily access, understand, and control my data privacy within the app.	1. Open MindPath App 2. Navigate to the Information Sections. 3. Read and understand the given information	Implemented
As a participant, I want to be able to complete a consent form that will authorize the use of my responses for the intended purpose.	1. Open MindPath App 2. Navigate to the Consent Form. 3. Fill out the Consent Form.	Implemented
As a participant, I want to be able to download my completed consent form.	1. Open MindPath App 2. Navigate to the Consent Form. 3. Fill out the Consent Form. 4. Submit and Download the completed Consent Form.	Implemented
As a participant, I want to be able to answer a series of questions about myself so I can partake in the survey.	1. Open MindPath App 2. Navigate to the Survey 3. Fill out the Survey. 4. Review Survey Answers. 5. Submit Survey.	Implemented

Continued on next page

Table C.1 – continued from previous page

Story	Acceptance Criteria	Status
As a participant, before starting the survey, I should understand the survey questions' content and the appropriate way to answer them.	1. Open MindPath App 2. Navigate to the Survey Information. 3. Read and Understand the Survey Information.	Implemented
As a participant, I want to manually input the answers for the survey.	1. Open MindPath App 2. Navigate to the Survey Questions. 3. Manually fill in the Survey Questions.	Implemented
As a participant, while filling out the survey, I should have the option to cancel the survey at any point.	1. Open MindPath App 2. Navigate to the Survey. 3. Start Filling Out the Survey. 4. Cancel the Survey by clicking on the cross.	Implemented
As a participant, when filling out the survey, I want to be able to skip questions.	1. Open MindPath App 2. Navigate to the Survey. 3. Start Filling Out the Survey. 4. Skip any question by clicking on "Skip".	Implemented
As a participant, after finishing the survey, I want to be able to review my answers before submitting.	1. Open MindPath App 2. Navigate to the Survey. 3. Complete the Survey. 4. Review the Survey Answers.	Implemented

Continued on next page

Table C.1 – continued from previous page

Story	Acceptance Criteria	Status
As a participant, I want to able to withdraw from the survey at any point by contacting the developer.	1. Exit from the Survey. 2. Navigate to the the Home Page. 3. Contact the developer to withdraw from the Survey.	Implemented
As a participant, I want to get regular updates regarding the research by contacting the developer.	1. Open MindPath App 2. Navigate through the app. 3. Read through the next steps to get more information about updates.	Implemented
As a researcher, I want to be able to read and understand the privacy policy before visualising the summarised data.	1. Open MindPath Website 2. Read the Privacy Policy. 3. Review and Accept the Privacy Policy.	Implemented
As a researcher, I want to visualise the summarised data	1. Open MindPath Website 2. Navigate through the different pages. 3. Visualise the summarised data.	Implemented
As a researcher, I want to filter and search based on specific demographic criteria .	1. Open MindPath Website 2. Navigate to the Demographic Breakdown Plot. 3. Filter and Search based on specific demographic criteria.	Implemented

Continued on next page

Table C.1 – continued from previous page

Story	Acceptance Criteria	Status
As a researcher, I want to access varied graphical data representation methods to analyse the summarised data	1. Open MindPath Website 2. Navigate through the different pages. 3. View and Analyse the different graphical data representation methods.	Implemented
As a researcher, I want to be able to comprehend the various visualisations by reviewing the informational cards displayed on the page.	1. Open MindPath Website 2. Navigate through the different pages. 3. View the different graphical data representation methods. 4. Read the informational cards displayed on each page.	Implemented

Appendix D

Ethics Application Approval Letter

NOTE: the letter contains the project's old title. An amendment was made to the application.The amendment proposed several changes, including a change of the project title. The approved modifications are documented in Figure D.2, which includes a screenshot confirming their approval.

The University Of Sheffield.

Downloaded: 05/05/2024
Approved: 26/03/2024

Siya Pradhan
Registration number: 200337568
Computer Science
Programme: BEng Software Engineering

Dear Siya

PROJECT TITLE: A ResearchKit App to Study the Interaction Between Mental Health and Lifestyle Factors
APPLICATION: Reference Number 058570

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 26/03/2024 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 058570 (form submission date: 15/03/2024); (expected project end date: 25/05/2024).
- Participant information sheet 1134281 version 3 (15/03/2024).
- Participant consent form 1134279 version 1 (03/03/2024).

The following amendments to this application have been approved:

- Amendment approved: 19/04/2024

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Max Rowlands
Ethics Administrator
Computer Science

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Figure D.1: *Ethics Application Approval Letter*

Amendments for "A ResearchKit App to Study the Interaction Between Mental Health and Lifestyle Factors"

Decision on Amendment - Complete (Submitted on 19/04/2024)

Decision
Approved

Feedback

✖ Cancel

Figure D.2: *Approved Amendment*

Appendix E

Information Sheet

Information Sheet

Project Title - MindPath: Leveraging iOS and Web Platforms to Study the Interaction Between Mental Health and Lifestyle Factors

Invitation:

You are being invited to take part in a research project. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

Introduction:

The purpose is to study the Interaction Between Mental Health and Lifestyle Factors using Apple's ResearchKit. ResearchKit is an open-source framework designed to facilitate the creation of applications for medical research purposes. This would include an iOS application and a website. The central aim of the application is to gather empirical data on various aspects of daily life such as work, diet, sleep patterns, and professional activities, with a strong emphasis on maintaining the anonymity and protection of participant data.

The aim of the website is to provide a dynamic and visually engaging platform for the visualization and analysis of the empirical data collected on various aspects of daily life, such as work, diet, sleep patterns, and professional activities. This platform facilitates a comprehensive review of the data, enhancing the understanding of the impact of lifestyle choices on mental health while ensuring the anonymity and protection of participant data.

This approach allows for a practical examination of the question, "To what extent do lifestyle choices influence mental health?"

It is crucial to note that this application and website are not intended to diagnose mental health conditions. Instead, their purpose is to provide valuable insights and contribute to the growing body of academic and medical research investigating the potential link between lifestyle choices and mental health. The application will prompt participants to register and input data by responding to a survey on diverse lifestyle factors. Follow-up questions will ask participants to assess the impact of each factor on their mental well-being.

The anonymised data compiled from these surveys will be made accessible on a corresponding web application, which serves as a dynamic and visually appealing resource for researchers. This platform is designed to facilitate a comprehensive analysis and foster a more profound understanding of the role that lifestyle factors may play in mental health.

In summary, the study will deliver a novel tool for collecting and analysing real-world data, aiming to enrich the conversation and exploration of how daily choices can affect mental health, thereby supporting the advancement of related academic and medical research.

Figure E.1: *Information Sheet*

The study is being conducted by Siya Pradhan, a student of The Department of Computer Science at the University of Sheffield.

Why have I been chosen?

You have been chosen to participate in this study because you fulfill the specific criteria we've set to ensure a responsible and ethical approach to our research. The criteria include being an adult and not having any pre-existing mental health conditions. These guidelines have been put in place to safeguard the well-being of all participants and to uphold the integrity of the research. It is important

to us that the research is conducted in a manner that is considerate of the participants' mental health and overall safety.

Do I have to take part?

No, your participation in this project is entirely voluntary. You can also stop at any time during the process and even ask for any data already collected to be deleted or not used afterwards except for in the case where the research has already been published or in the case where the data has already been anonymised and included in a larger dataset.

If you wish to stop at any time during testing, simply let the researcher Siya Pradhan know via email.

Please note that that by choosing to participate in this research, this will not create a legally binding agreement, nor is it intended to create an employment relationship between you and the University of Sheffield

Participation in the iOS Application and Website Research Study for Lifestyle and Mental Health

As a participant in this research study, your involvement will contribute to the development of an iOS application and Website aimed at understanding the impact of lifestyle choices on mental health. Here are the details on what your participation entails:

Initial Survey on Lifestyle Choices (on the App):

1. You will be asked to enter some details and use the application.
2. The application will prompt you to complete a survey on various lifestyle factors such as sleep quality, working environment, diet, and other daily activities.
3. For each factor, you will have to rate its perceived impact on your mental well-being.

Navigating through different features (on the Website):

Figure E.2: *Information Sheet*

1. You will be asked to interact with the website to evaluate its functionality.

Testing and Feedback on the Application and Website:

1. You will interact with the iOS application, which will gather and summarise your responses.
2. Your feedback on the application and website's usability, survey questions, and overall experience will be solicited through another set of questionnaires.
3. This feedback will be essential for refining the application and enhancing its effectiveness for future users.

Contribution to Research:

1. The anonymised data from your participation will be displayed on a web application.
2. Researchers will use this data to explore the potential links between lifestyle choices and mental health, aiming to provide valuable insights into this critical area of study.

Time Commitment:

- Evaluating the app and website will take up to 20 minutes.
- The feedback survey may take up to 10 minutes.
- Further interaction with the application and website may take more time. However, we encourage you to proceed at a comfortable pace to ensure the accuracy and reliability of the data collected.

As a participant, you will play a vital role in the creation of a tool that seeks to shed light on the complex relationship between lifestyle choices and mental health, thereby contributing to academic and medical advancements in the field.

What are the possible disadvantages and risks of taking part?

There are no anticipated disadvantages, risks, or discomforts associated with participating in this research project. Participants have been carefully chosen based on specific criteria that exclude individuals with pre-existing mental health conditions to ensure the integrity and safety of the research.

While there are no known risks related to the participation in this study, it is important to note that this application is not a diagnostic tool and is intended solely for research purposes. If you have any health conditions or other concerns that you believe may affect your ability to use the application, such as conditions that impact screen interaction or data entry, please inform the researcher prior to participation.

Figure E.3: *Information Sheet*

Procedure, as administered by the Department of Computer Science.

What if something goes wrong and I wish to complain about the research or report a concern or incident?

If you wish to make a complaint about any aspect of the research, please contact Siya Pradhan in the first instance at **sbpradhan1@sheffield.ac.uk**. If you feel that your complaint has not been handled satisfactorily, or your complaint is about the researcher themselves, please contact Dr Mari- Cruz Villa-Uriol or Professor Heidi Christensen.

If you have concerns about potential exploitation, abuse or harm resulting from your involvement in this project, please contact Professor Heidi Christensen and/or the Secretary to the UREC (Lindsay Unwin; l.v.unwin@sheffield.ac.uk).
If your complaint relates to how your personal data has been handled, information about how to raise a complaint can be found in the University's Privacy Notice: https://www.sheffield.ac.uk/govern/data- protection/privacy/general

Contact for Further Information:

If you have any further questions about the research or wish to obtain more information about the study, please contact:

Siya Pradhan (Lead Researcher): **sbpradhan1@sheffield.ac.uk**

Dr Mari-Cruz Villa-Uriol (Research Supervisor): **m.villa-uriol@sheffield.ac.uk**

Professor Heidi Christensen (Head of Department for Computer Science):

heidi.christensen@sheffield.ac.uk

Figure E.4: *Information Sheet*

Appendix F

Consent Form

Consent Form

A ResearchKit App to Study the Interaction Between Mental Health and Lifestyle Factors Consent Form		
Taking Part in the Project	**YES**	**NO**
I have read and understood the project information sheet dated 02/03/2024, or the project has been fully explained to me. (If you will answer No to this question please do not proceed with this consent form until you are fully aware of what your participation in the project will mean.)	☐	☐
I have been given the opportunity to ask questions about the project.	☐	☐
I agree to take part in the project. I understand that taking part in the project will include suing the application and answering a series of questions.	☐	☐
I understand that by choosing to participate as a volunteer in this research, this does not create a legally binding agreement nor is it intended to create an employment relationship with the University of Sheffield.	☐	☐
I understand that my taking part is voluntary and that I can withdraw from the study at any time; I do not have to give any reasons for why I no longer want to take part and there will be no adverse consequences if I choose to withdraw.	☐	☐
I understand that by participating in this study I will not receive any compensation for the participation. Participation is voluntary and there will be no adverse consequences if you choose to withdraw.	☐	☐
How my information will be used during and after the project		
I understand that personal information such as my personal details such as name, phone number, address and email address etc. will **not** be collected via the research. All information that is collected will be stored temporarily on a University of Sheffield Google Drive in line with the requirements of the UK data protection legislation and will be permanently destroyed within 3 months of the successful completion of the project. Date will be deleted before or on the date: 08/08/2024.	☐	☐
So that the information you provide can be used legally by the researchers	☐	☐
I agree to assign the copyright I hold in any materials generated as part of this project to The University of Sheffield.	☐	☐

Name of the Participant: **Signature:** **Date:**

Name of the Researcher: **Signature:** **Date:**

Project contact details for further information:

Name:	Role	Email
Siya B Pradhan	Lead Researcher	sbpradhan1@sheffield.ac.uk
Maria-Cruz Villa-Uriol	Academic Supervisor	m.villa-uriol@sheffield.ac.uk
Heidi Christensen	Head of Department	heidi.christensen@sheffield.ac.uk

Figure F.1: *Consent Form*

Appendix G

User Evaluation

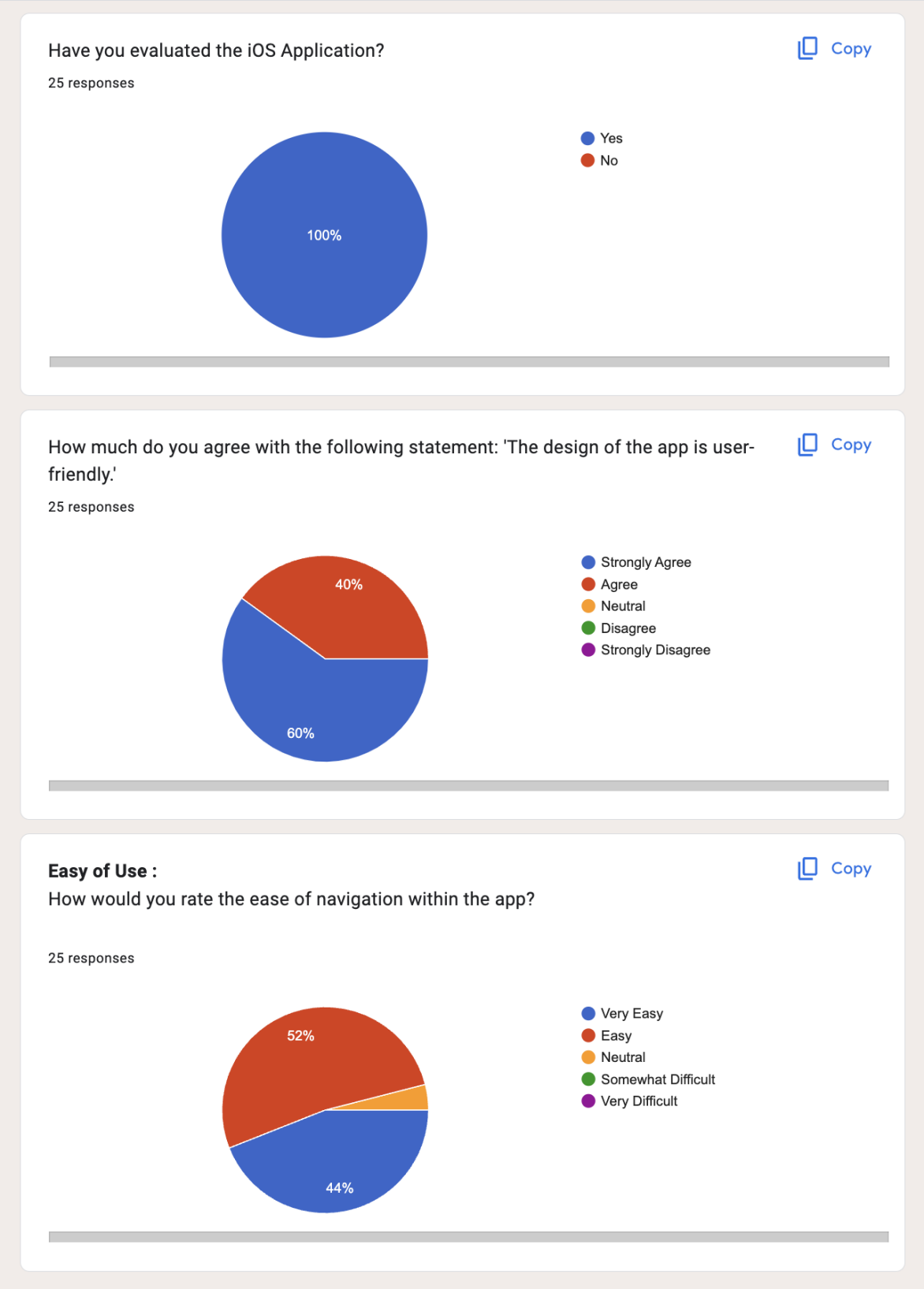


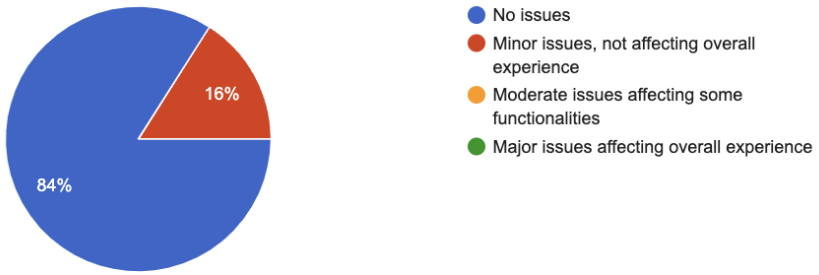
Figure G.1: *iOS App User Evaluation*

Functionality and Performance:

Copy

Did you encounter any issues with the app's functionality or performance?

25 responses

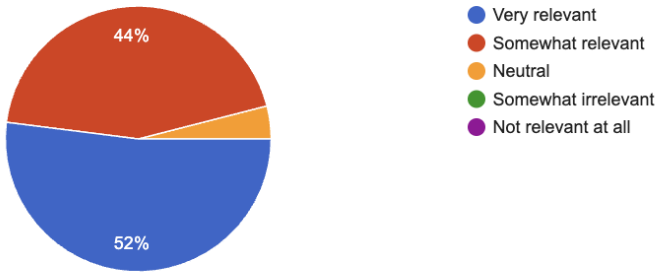


Content and Survey Design:

Copy

Were the survey questions relevant to your lifestyle and their impact on your mental well- being?

25 responses



Engagement and Continuity:

Copy

What changes or additional elements could make you more likely to use the app regularly or recommend it to others?

25 responses

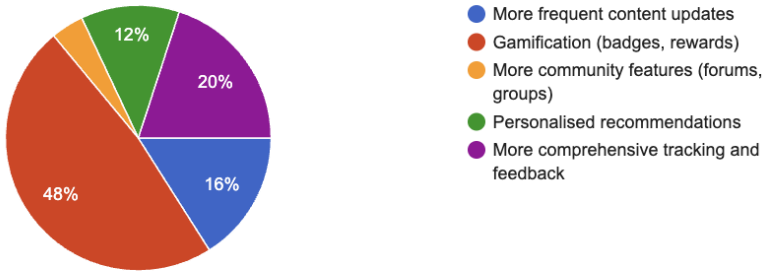


Figure G.2: *iOS App User Evaluation*

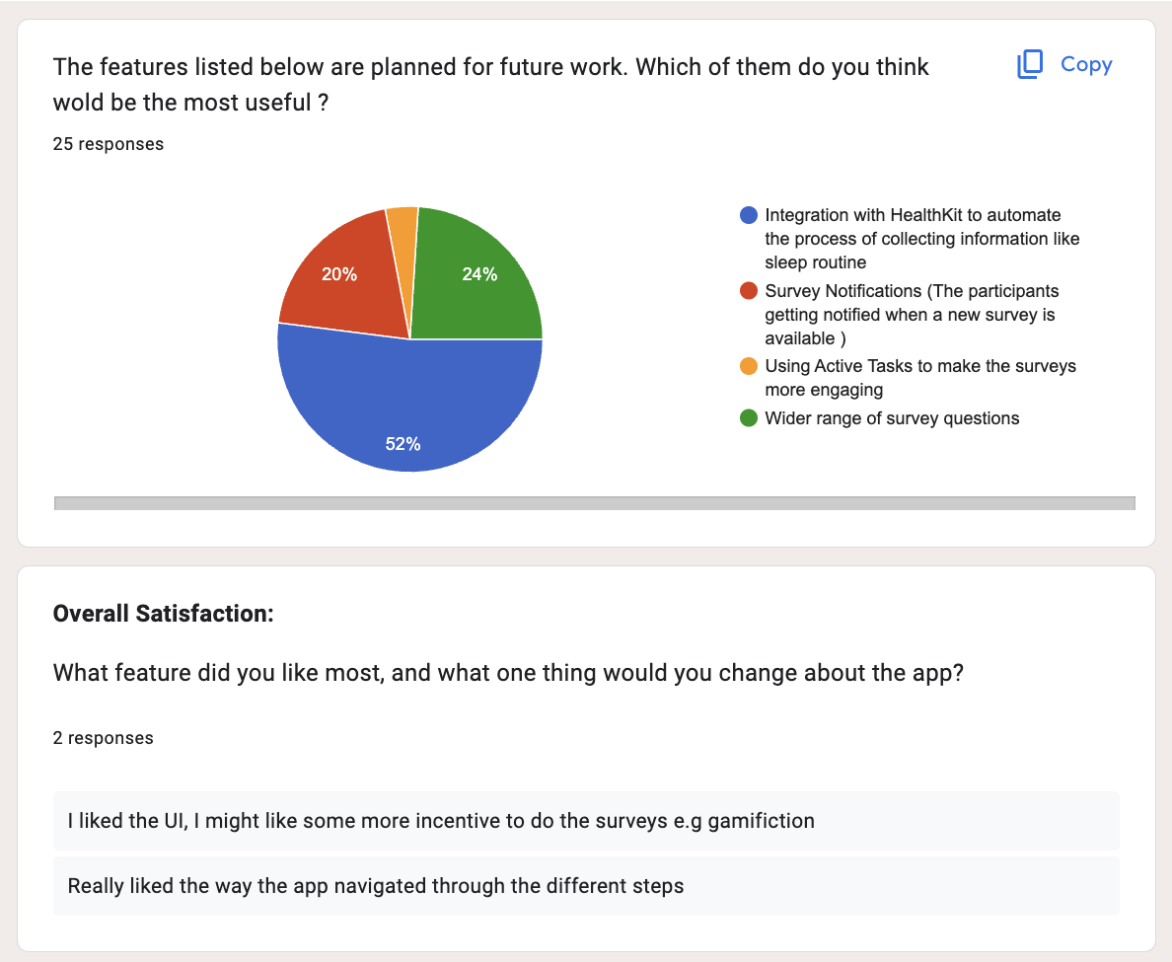


Figure G.3: *iOS App User Evaluation*

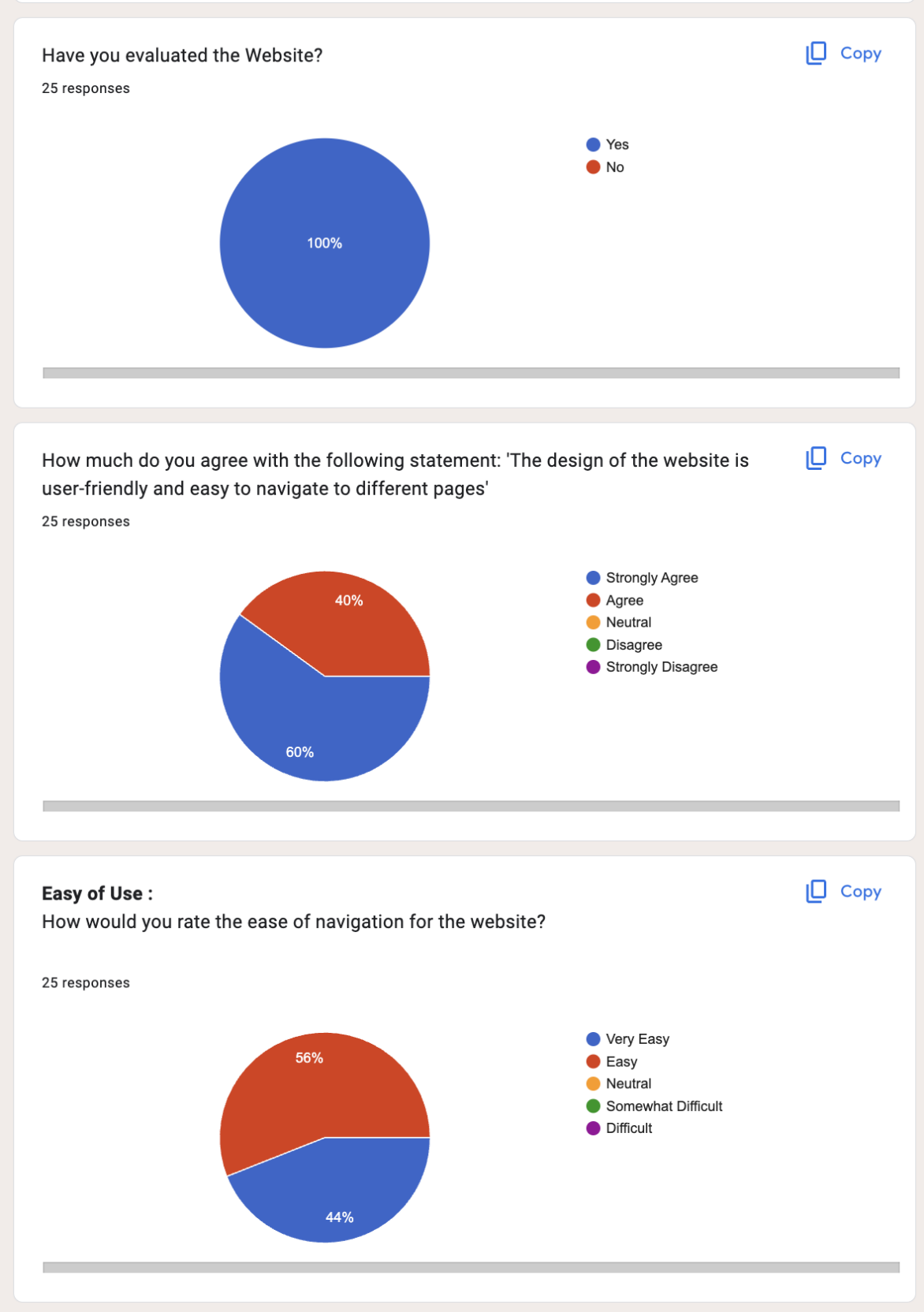


Figure G.4: *Website User Evaluation*

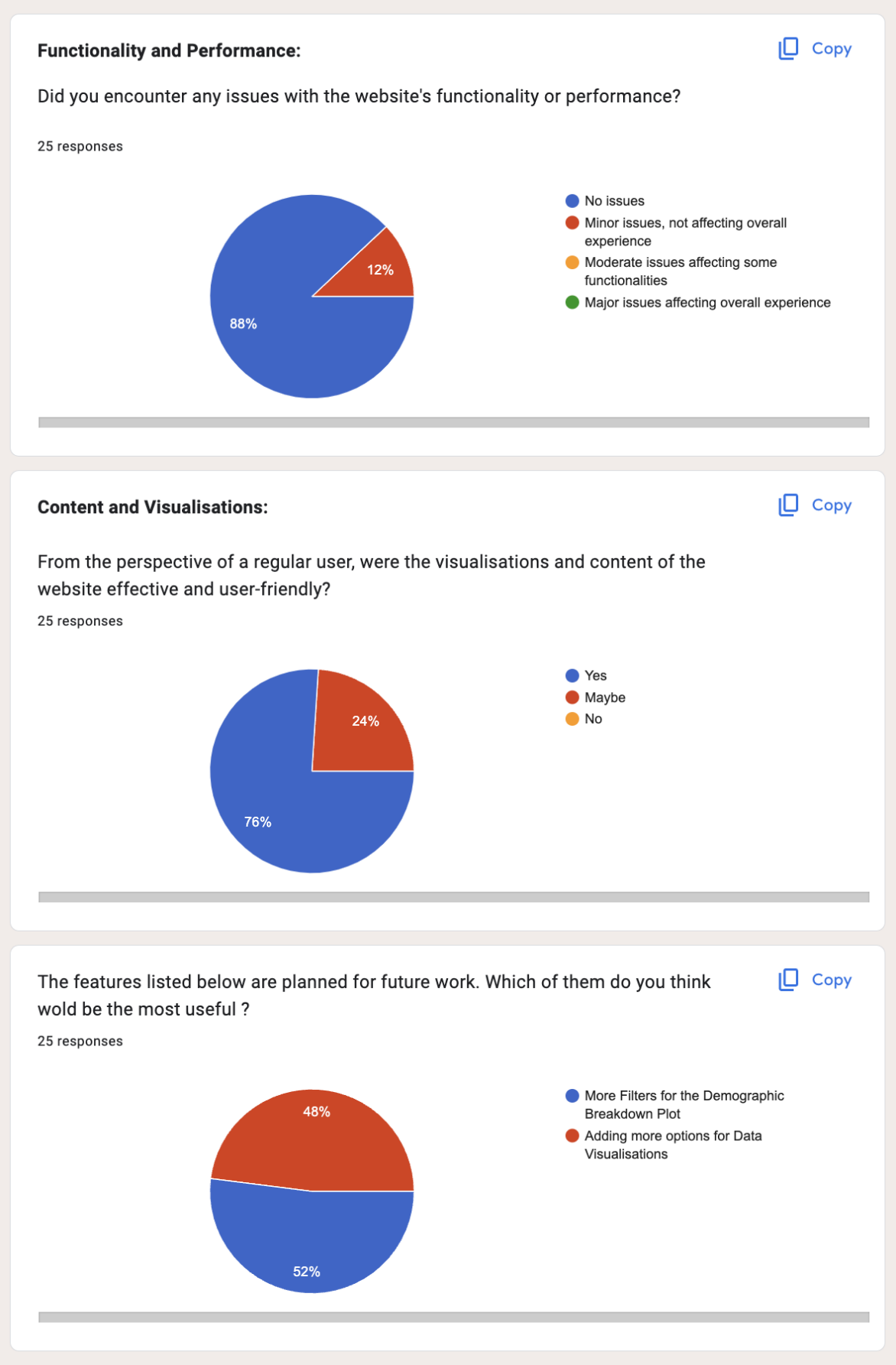


Figure G.5: *Website User Evaluation*

Overall Satisfaction:

What feature did you like most, and what one thing would you change about the wesbite?

2 responses

I liked the option of viewing the data in various different ways (e.g pie chart, graph), I wouldn't make any changes

The visualisations were really informative, even though not a researcher or in the medical field - - still was quite intrigued by the different types of visualisations

Figure G.6: *Website User Evaluation*

Final Remarks:

Is there anything else you'd like to share about your experience that was not covered in the previous questions?

1 response

The UI was very nice for participants to use, it was very clear how my data would be used and the app and website was very accessible. It would be nice if participants have more incentive to fill in the surveys on the app by allowing them how their responses are contributing to the research or gamification of surveys but apart from that it was very clear and easy to use.

Figure G.7: *Final Remarks*

Appendix H

Website Privacy Policy

MindPath Website Privacy Policy

Purpose and Scope

This policy outlines the privacy and ethical standards for handling and visualising data collected in the study investigating the correlation between lifestyle factors and its impact on mental health. It applies to all researchers and analysts involved in the study.

Data Collection and Use

Data collected from participants through the iOS application will be used exclusively for research purposes. This includes demographic information (age and occupation) and lifestyle factors in the form of survey responses.

Anonymity and Confidentiality

No personal information is collected during the survey. Direct identifiers are removed to prevent any possibility of tracing data back to individual participants.

Data Security

Robust security measures are in place to protect data integrity and confidentiality. This includes encryption, secure data transfer, and access controls to prevent unauthorised data access.

Access to Data

Only authorised researchers have access to the anonymised dataset. Access is granted following a review process that ensures compliance with this privacy policy.

Data Sharing and Publication

Findings from the study may be shared or published, provided they do not include any identifiable information. All shared data will be in aggregate form or sufficiently anonymised.

Participant Rights

Participants have the right to withdraw from the study, request deletion of their data, and inquire about data usage. These rights are respected and facilitated by the research team without any penalty to the participant.

Figure H.1: *MindPath Website Privacy Policy*

Ethical Considerations

Researchers agree to uphold the highest ethical standards in their work, including respect for participant privacy, data accuracy, and integrity in analysis and reporting.

Compliance

This research complies with applicable laws and regulations regarding data protection and privacy, ensuring that all data handling practices meet legal standards.

Contact Information

For questions or concerns regarding data privacy, please contact the developer – sbpradhan1@sheffield.ac.uk

Figure H.2: *MindPath Website Privacy Policy*

Appendix I

iOS App Consent Form

Consent Form

Name: Siya Pradhan
Date: 2024-05-05 3:21:47 PM +0000

By signing this consent form, I voluntarily consent to participate in this research survey. I understand that I will be asked to provide details such as my age and occupation. Following this, I will complete a survey that inquires about various lifestyle factors. I hereby agree to provide accurate and truthful responses to the questions posed. I grant the researchers and their affiliates full permission to use my responses for the purposes of this study, which include analysis, publication, and the formulation of health-related insights. I acknowledge that my participation is entirely voluntary, that I may withdraw at any time by contacting the developer, and that my anonymity and confidentiality will be maintained according to the study protocol.

Figure I.1: *MindPath iOS App Signed Consent Form*

Appendix J

Demonstration Video for MindPath

The two links listed below are demonstration videos of MindPath (iOS App and Website). The demonstration videos can be used to understand the user journey for the iOS application and the website. These resources are designed to provide a clear understanding of how the system functions. The demonstration videos are available to anyone with a link and a University of Sheffield email account.

- **iOS App Link** : iOS App Demonstration Video
- **Website Link**: Website Demonstration Video