B. Sc. Thesis

Design, Implementation and Evaluation of a Self-Tracking-Application for Long COVID Patients

Freie Universität Berlin

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Abstract

Long COVID presents a wide variety of symptoms, making it challenging for patients to understand and manage their condition. Self-reflection enables patients to gain insight into their situation, allowing them to identify patterns and correlations that could help them maintain their well-being. However, effective self-reflection depends on the ability to collect sufficient and relevant data, which can be realized with self-tracking. For long COVID patients, maintaining motivation to consistently track their symptoms can be challenging.

Although numerous self-tracking apps are available, few are specifically tailored to the needs of long COVID patients. This thesis addresses this gap by proposing a design concept for a self-tracking application specifically for long COVID patients.

A Human Centered Design (HCD) approach is employed, gathering firsthand perspectives from patients, integrating these insights into the app design, and evaluating the concept with experts. The findings, the resulting design concept and the evaluation results are presented, providing a foundation for future work in enhancing self-tracking and self-reflection solutions for long COVID patients.

Contents

1. Introduction

COVID-19 is an infectious disease caused by the SARS-CoV-2 coronavirus, its symptoms typically lasting from 1 to 14 days. However, for some individuals, the effects of the virus extend beyond this period, leading to a condition known as long COVID. The World Health Organization (WHO) defines long COVID as "the continuation or development of new symptoms three months after the initial SARS-CoV-2 infection, with these symptoms lasting for at least two months and with no other explanation." This condition can affect individuals regardless of their age or the severity of their initial symptoms [35, 36].

Long COVID is characterized by persistent symptoms such as "fatigue, breathlessness and cognitive dysfunction (for example, confusion, forgetfulness, or a lack of mental focus or clarity)" [35]. Although these conditions are the most common, WHO states that over 200 different symptoms have been reported, significantly impacting the daily life of individuals, making it difficult for them to perform activities such as working or doing household chores [36].

The wide variety of symptoms can make it challenging for patients to understand their condition and maintain their well-being. In this regard, reflection, specifically self-reflection is a way for patients to gain insight about their current situation as well as identify trends and patterns about themselves in the long term [25].

One method with which patients could self-reflect would be by using personal informatics systems to help them collect and explore information about themselves. Li et al. define personal informatics systems as "those that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge" [25]. For example, patients could input various data, such as symptoms they are experiencing, physical activities they have done etc. continuously over an extended period of time, which would then give them the opportunity to observe and analyze their information, helping them gain insight, understand the implications and find correlations between certain actions and symptoms. This type of self-reflection with the support of personal informatics systems provides an advantage over having to rely solely on the memory, as the memory can often be significantly limited due to factors such as forgetfulness, sleep, etc. [25].

However, motivating patients suffering from long COVID to engage in self-tracking for extended periods could be a challenging task.

The APA Dictionary of Psychology defines motivation as "a person's willingness to exert physical or mental effort in pursuit of a goal or outcome" and distinguishes between internal and external motivating factors; intrinsic motivation being "an incentive to engage in a specific activity that derives from pleasure in the activity itself" and extrinsic motivation being "an external incentive to engage in a specific activity, especially motivation arising from the expectation of punishment or reward" [10, 9, 8].

Informed by this situation, this thesis aims to identify strategies to sustain patients' motivation for self-tracking, ultimately leading to increased data collection. The motivation behind this pursuit is based on the idea that more collected data leads to more accurate insights from the data collected.

1.1. Motivation

Self-tracking and reflection is a promising avenue for individuals to better understand their health conditions, and identify correlations between different activities and symptoms in order to generally track and maintain their well-being.

However, for individuals suffering from long COVID, common symptoms such as headaches, joint pain and memory and concentration problems could make self-tracking frustrating. Factors like light and sound, which can easily cause sensitivities, could also make the interaction with electronic devices (e.g., smartphones, tablets) difficult for these individuals.

For example, individuals experiencing severe headaches may not be comfortable being exposed to a bright screen or patients with joint pains may not feel comfortable with larger amounts of typing. In cases like these more suitable methods must be found. For example, a voice recording option or a short survey could be better solutions for these patients. Other patients might be triggered from notification sounds reminding them to keep on top of their tracking or feel overwhelmed if faced with too many questions due to brain fog or fatigue.

The motivation of this thesis is to understand the factors with which individuals suffering from long COVID can be motivated to use self-tracking tools for a longer period of time, resulting in a larger quantity of collected data and thus higher quality results for self-reflection.

1.2. Research goal and question

The goal of this thesis is to provide ways of motivation that help individuals suffering from long COVID continue self-tracking as well as to create a tool in which these methods are implemented. This self-tracking tool will be in the form of a mobile health application tailored to the needs of long COVID patients. With this tool, users will be able to log their symptoms along with other variables such as their activity, diet, etc. throughout their day.

Through the goal of understanding the challenges posed by long COVID and creating a motivating and effective self-tracking tool for patients to support them during their recovery journey, the following research question emerges:

1. How could the design space of a self-tracking app be conceptualized to motivate users suffering from long COVID to log data often and consistently by enhancing their self-tracking experience?

Regarding this question, this project aims to identify and implement ways to motivate patients to track their data for a longer period of time, creating a basis for a better self-reflection experience which could, in turn, allow patients to identify correlations in order to better understand their disease (cause-and-effect[1]) and helping them maintain their well-being.

The research will contribute towards answering this question by providing insights into how to design effective self-tracking applications that can support long-term engagement and motivation, while the thesis itself focuses on creating a user interface that provides a reasonable self-tracking experience, tailored to long COVID patients' needs, motivating them to continue frequently tracking their data.

The visualization of the collected data will not be included in the scope of the thesis, however, can be added in future work to introduce the element of self-reflection. Additionally, the thesis will focus on developing a user interface tailored for patients; however, future work could include interfaces for doctors and other healthcare professionals.

1.3. Research approach and methodology

The thesis followed the Human Centered Design (HCD) approach, prioritizing the requests and requirements of long COVID patients to ensure a result that met their needs both functionally and emotionally. The project was structured around the following phases of HCD: Vision, Analyze, Design for usability, Construct and deploy, Evaluation in context, and Feedback.

In the *Vision* phase, relevant literature was reviewed as preliminary research. This was followed by the *Analyze* phase, which involved analyzing existing apps and conducting user interviews to gather insights into the patient perspective.

In the *Design for usability* phase, a low-fidelity prototype was created based on the insights from the previous phase. Interactive elements were then added to the prototype to achieve a high-fidelity prototype. In the *Construct and Deploy* phase, this prototype was translated into a native mobile app.

In the *Evaluation in context* phase, interviews were conducted with two experts to evaluate the effectiveness of the design concept and identify areas for improvement. Finally, in the *Feedback* phase, the findings and possible future improvements were discussed.

The following sections elaborate on each phase, offering a more detailed explanation of the methods and steps involved.

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[1] "a relationship between actions or events such that one or more are the result of the other or others" [17].

1.3.1. Vision

The Vision phase focused on conducting preliminary literature research to establish a solid foundation for the thesis. The research concentrated on keywords such as personal informatics, self- and health-tracking, and self-reflection, which provided essential insights into the technical and conceptual aspects necessary for the development of the thesis.

1.3.2. Analyze

The Analysis phase focused on understanding the needs of long COVID patients to guide the app design.

A comprehensive app analysis was first conducted, involving the selection and testing of a group of self-tracking apps over several weeks. This evaluation concentrated on usability, features, and data input methods, with a particular focus on how each app handled data input.

Following this, user interviews were conducted to gather direct feedback from individuals suffering from long COVID. The data from these interviews was analyzed thematically to extract relevant insights and requirements for the app design.

1.3.3. Design for usability

The Design phase focused on developing a solution to enhance the data entry process while supporting efficient data collection.

The design was created in Figma and consisted of three main components: an onboarding process, a daily data entry interface, and a settings system. The onboarding process allows users to personalize their tracking by entering frequent symptoms, activities, and other relevant factors. The daily data entry interface facilitates easy recording of data through intuitive controls, such as sliders and a searchable medication database. The settings system enables users to adjust their tracking preferences.

At the end of the Design phase, interactive elements were added to the low-fidelity prototype, resulting in a click dummy ready for implementation and evaluation.

1.3.4. Construct and deploy (Implementation)

The Implementation phase focused on developing the design concept into a native mobile app. The app was built using TypeScript and React Native. Tamagui was used for the UI design, facilitating alignment with design specifications. SQLite was used for local data storage to enhance privacy and ensure compliance with DiGA guidelines.

1.3.5. Evaluation in context

For the Evaluation phase, two expert interviews were conducted to assess the design concept of the app.

The experts interacted with the clickable prototype, completing specific tasks related to the onboarding process, daily data entry, and settings. This provided them with a walkthrough of the app, giving the opportunity to share their feedback throughout the process.

The feedback from these expert interviews was then analyzed, and a final design concept was presented based on their insights.

1.3.6. Feedback

The Feedback phase focused on discussing the findings and exploring possible future improvements.

2. Theoretical Background

The Federal Ministry of Health in Germany (BMG - in German: Bundesministerium für Gesundheit) explains that some individuals may experience significant health issues that persist for weeks, months, or even years, after a SARS-CoV-2 infection and these long-term effects are known as long COVID. They state that long COVID is not a single, uniform disease but rather a range of different long-term health problems, with symptoms that can affect various organ systems, vary greatly in intensity and duration, change over time, and are often difficult to differentiate from other health conditions [15].

It is likely that the amount and diversity of the symptoms associated with long COVID could pose challenges for patients affected by the condition, making it difficult for them to understand their condition and effectively treat its symptoms, likely adding to their experience of feeling overwhelmed and distressed.

The mobile health application created as a part of this thesis aims to help patients keep track of their symptoms by giving them the opportunity to log these easily. The goal is to create an application with which patients collect as much data as possible, whilst creating the opportunity for the application to be improved in further work, allowing patients to self-reflect on this data. The following scenario exemplifies the potential benefits of the proposed mobile health application within this thesis, by providing a contextual understanding of its practical implementation.

> **Scenario:** Patient A has been diagnosed with long COVID after suffering from a long list of symptoms such as shortness of breath, palpitations, muscle pain, fatigue, headaches and brain fog. The symptoms are difficult to keep track of and patient A feels overwhelmed. The goal is to give patient A an application in which they can add and log their symptoms throughout their day. Patient A can wake up and enter the quality of their sleep in the app. They can log the activities they are doing throughout the day, the food they have been eating or the medications they have taken. If they are experiencing a headache in the evening they can log this as well, along with the severity of the headache. The information gathered in the app can later on be made visible for patient A to look back at in the form of various graphs and charts, enabling them to identify possible correlations between activities and symptoms. For example, maybe they do not log any symptoms after walking but they often log a headache after jogging or after taking a certain medication for their headache they are left feeling fatigued. Such correlations could support patient A in forming a lifestyle in which they can maintain their well-being as well as help them express what they are going through, also supporting the communication between them and their healthcare workers.

In the given scenario, the accuracy and reliability of the data that can be visualized is dependent on the patients consistent tracking of their symptoms and activities. It is therefore of great importance to investigate how to motivate patients to sustain their tracking efforts over an extended period of time.

This problem is considered within the research question (see subsection 1.2), aiming to explore means to promote frequent and consistent tracking as well as to identify design principles which will enhance the user experience and make the tracking process as comfortable and user-friendly as possible.

3. Related Work

Li et al. [25] define personal informatics systems as systems "that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge." They state that "effective personal informatics systems help users collect the necessary personal information for insightful reflection." Li et al. conduct a survey with a number of people who already self-tracked in some way and inspect the tools the participants were using, how often they used these tools, different issues they faced and ask them for suggestions to improve the process. As a result Li et al. introduce a "stage-based model of personal informatics" which consists of five stages:

1. the *preparation* stage, where users decide on what information they would like to collect and what tools they will be using;
2. the *collection* stage, where users collect the data;
3. the *integration* stage, where the data is prepared for reflection;
4. the *reflection* stage, where the users review and reflect on their data and
5. the *action* stage, where users can decide what they would like to do with the information they have learned about themselves.

Based on this model, Li et al. note that issues users face in one stage can affect the stages that come afterwards. They also point out the difference between user-driven and system-driven stages and emphasize the importance of the balance between the two. Li et al. also state that personal informatics systems can be either uni-faceted or multi-faceted, depending on how many facets they concentrate on, and note that many of their participants wished to see connections between multiple facets of their lives.

Rooksby et al.'s approach [29] also stems from the previously mentioned field of personal informatics, however, this approach concentrates on lived experiences, which is not mentioned in the work of Li et al. Rooksby et al. conduct interviews with a number of people in order to understand "what people want, do and experience when using personal trackers". They describe their observations by introducing the term "lived informatics" and explain that the term "is meant to mean just that people are using information and finding its meaning in their day-to day-lives". Based on their findings Rooksby et al. note the importance of understanding that people might not always be rational or logical with their tracking choices and that it is therefore important to design technologies so that different trackers can be interwoven. They also note that it is important to remember that personal tracking is "enmeshed with everyday life and people's outlook on their future."

Likewise, Epstein et al. [18] define personal informatics as collecting and reflecting on personal information. They reiterate the term "lived informatics", previously introduced by Rooksby et al., defining this as a type of personal informatics that goes beyond goal-driven tracking and is more a part of everyday life, in which people are driven to track their data out of curiosity and interest. Epstein et al. expand upon prior work, after conducting a number of surveys and interviews with people who self-track data in the areas of physical activity, finances and location in order to understand the reason specific tools are chosen by users, the reason these tools are sometimes changed and the reason users sometimes quit self-tracking, offering a revised model of personal informatics. In this model, Epstein et al. divide Li et al.'s preparation stage into "deciding" and "selecting". Epstein et al. also reiterate the stages of collection, integration, and reflection defined by Li et al. and suggest "tracking and acting", stating the idea that these processes often happen simultaneously. Epstein et al. find that users can be motivated to engage in self-tracking in order to change their behavior, receive rewards or engage in social interaction, or in order to view their data from a different perspective.

Expanding on Li et al.'s [25] preparation stage and Epstein et al.'s [18] selection process, Lee et al. [24] investigate how individuals select self-tracking apps and how technology can facilitate this process. Lee et al. conduct a comprehensive review of personal informatics literature to explore the factors individuals typically consider important when using self-tracking tools. As a result, they identify seven key factors that are considered: data collected, feedback provided, goal-setting capabilities, privacy, social opportunities, style, and convenience. Lee et al. note that the interviews conducted as part of their research confirmed the identified factors, along with further factors such as the reputation of the app, developer support, and cost.

In addition to the aforementioned studies, it is essential to understand the underlying motivations driving individuals' interactions. Edward L. Deci and Richard M. Ryan define motivation as "what 'moves' people to action," and state that theories of motivation focus on what energizes and gives direction to behavior. They explain that various theories of motivation in experimental psychology have tried to predict learning, performance, and behavior change and critique that these theories usually view motivation as a "unitary entity", focusing more on the amount of motivation rather than the different types, qualities, or orientations [30].

Building on this foundation, Deci and Ryan introduce the Self-Determination Theory (SDT), a theory grounded in empirical research that explores human motivation, development, and wellness. SDT distinguishes between different types of motivation—autonomous, controlled, and amotivation—and their roles in predicting performance, relational, and well-being outcomes. The theory also identifies autonomy, competence, and relatedness as three essential psychological needs, stating that the degree to which these needs are fulfilled influences both the type and strength of motivation [30].

By examining different aspects of how individuals collect, reflect on, and use personal information in their lives, as well as the underlying motivations and psychological aspects driving these behaviors, these approaches provide valuable insight into personal informatics as well as into motivation and serve as a guide for this thesis.

4. Methodology

In light of the Human-Centered Design approach, this part of the thesis incorporated the following phases: Analyze, Design, Implementation, and Evaluation.

The Analyze phase aimed to understand the perspective of the patients. The insights gathered in this phase were then used in the Design phase to create a design concept tailored to the requirements of the patients. In the Implementation phase, a native mobile app was developed based on the design concept. Finally, the Evaluation phase focused on gathering expert feedback to refine the design concept.

The following sections will describe these phases, detailing the processes and the methods employed.

4.1. Engaging in the patient perspective

To create a design concept that specifically met the needs of long COVID patients, gaining a deep understanding of their experiences and requirements was essential. This was achieved through two methods of data collection:

1. an *app analysis* of existing apps in this and similar fields and
2. *user interviews* with individuals suffering from long COVID.

4.1.1. Preliminary measures

Before conducting the user interviews, a preliminary app analysis was conducted, with a group of apps that enable the self-tracking of symptoms and further data. This analysis aimed to gain insights into the apps currently used by patients and to understand how these apps handle various aspects of the self-tracking process. Although the initial aim was to choose apps from the digital health applications directory [19] (DiGA – in German: 'Digitale Gesundheitsanwendungen'), it was found that not only were there few to no apps specifically for long COVID in the directory, but most of the apps listed required an access code from one's health insurance. Therefore, the apps were instead selected from the Apple App Store. The keywords used for the search were "long covid", "symptom tracker", and "self-tracking".

During this search, it was found that many apps that appeared in the searches with the keyword "long covid" were, in fact, generalized to work for many different conditions where self-tracking could be beneficial. The limitations of this regarding long COVID patients will be discussed further on in the app analysis.

Ultimately, the following 9 apps were chosen for the app analysis:

- Long-Covid Tagebuch [28]

- INSELhealth - cofit [32]
- Altea Care [26]
- Visible: Long Covid & ME/CFS [34]
- Bearable - Symptom Tracker [12]
- Guava: Health Tracker [22]
- Symptom Tracker° [16]
- Symptom Tracker - OpenCare [23]
- Symptom Tracker [7]

One app that could not be included in the list although it met all the criteria was the Fimo Health App [20]. This app also required an access code from one of its partnering health insurances. Fortunately, insights into its functionalities could be obtained from a patient who had previously used the app.

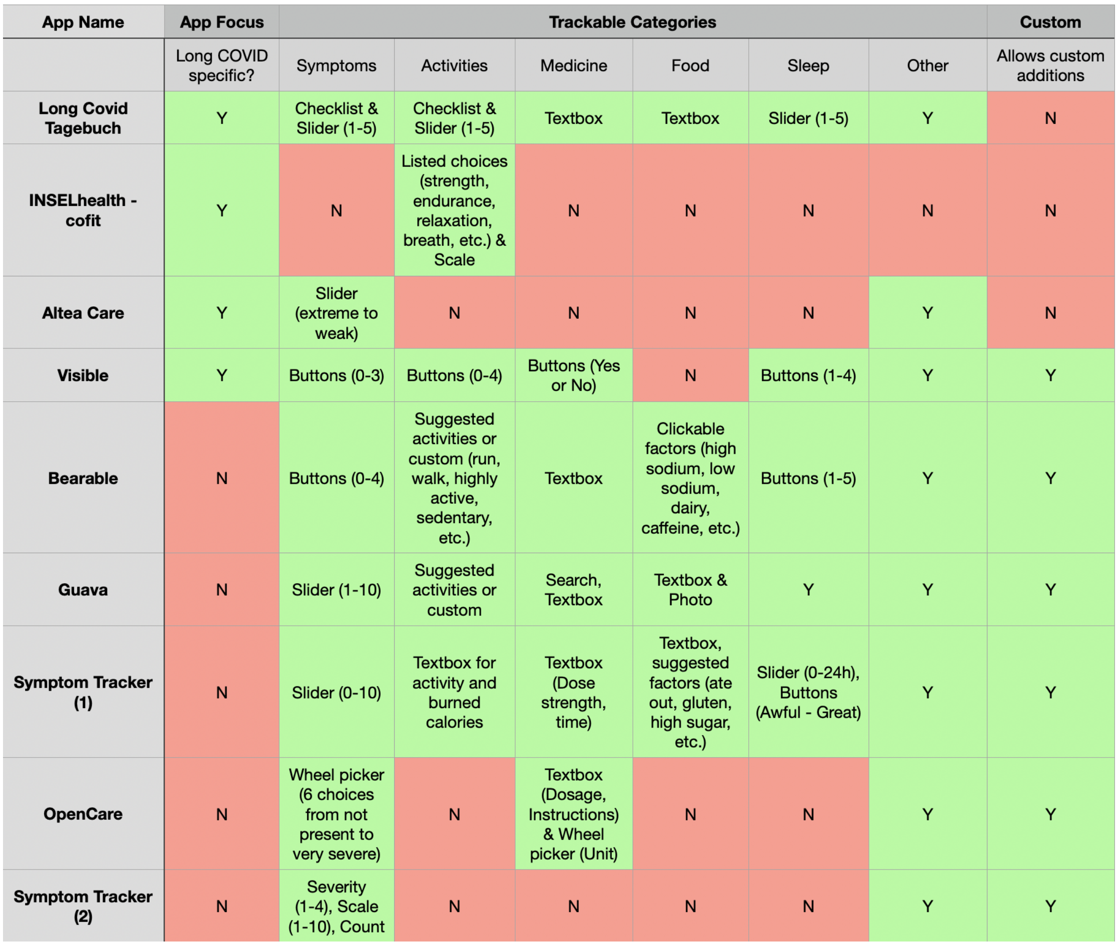
Each app was set up and then tested with a randomized set of symptoms over a period of a few weeks. For apps requiring paid access, testing was limited to the duration of their free trial phases. During this period, the usability, features, and potential issues of the apps were observed, particularly focusing on the data input methods.

While testing the apps, it became clear that the method by which data is collected greatly affects how it can be visualized, with different visualization methods requiring different types of data collection. This interdependence made it important to also analyze the data visualization features of the apps.

During the testing phase, several tables were created for each app. The main table detailed the different factors that the apps tracked, how these factors were categorized and what data entry methods were used to collect the data in each of these categories. Another table displayed the data visualization, and another the pros and cons of certain features as well as notes on the design aspects. These tables were then analyzed and the most important information combined into two main tables, Figure 1 and Figure 2, serving an overview in identifying the various approaches adopted for self-tracking and to support self-management for long COVID patients.

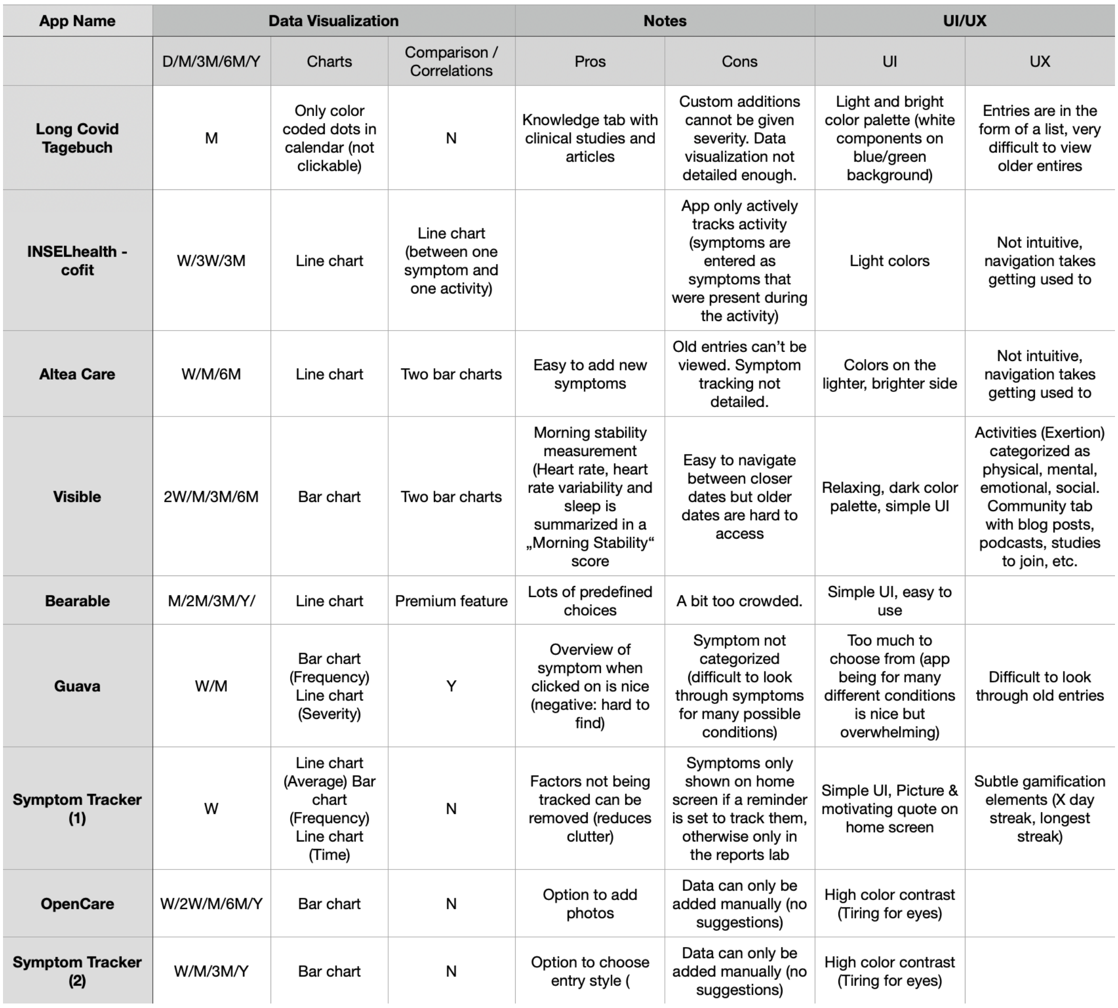
Figure 1 presents a feature matrix, outlining the data entry methods used by different apps. The matrix containing a list of common categories that were tracked over many apps (Trackable Categories), detailing how data is entered for these categories and whether the apps track additional categories beyond those listed. The matrix also shows if custom data entries are possible (Custom).

Figure 2 presents an overview of the data visualization features of the apps, as well as further notes such as certain pros and cons and details about the user interface and user experience (UI/UX).



App Name	App Focus	Trackable Categories						Custom
	Long COVID specific?	Symptoms	Activities	Medicine	Food	Sleep	Other	Allows custom additions
Long Covid Tagebuch	Y	Checklist & Slider (1-5)	Checklist & Slider (1-5)	Textbox	Textbox	Slider (1-5)	Y	N
INSELhealth - cofit	Y	N	Listed choices (strength, endurance, relaxation, breath, etc.) & Scale	N	N	N	N	N
Altea Care	Y	Slider (extreme to weak)	N	N	N	N	Y	N
Visible	Y	Buttons (0-3)	Buttons (0-4)	Buttons (Yes or No)	N	Buttons (1-4)	Y	Y
Bearable	N	Buttons (0-4)	Suggested activities or custom (run, walk, highly active, sedentary, etc.)	Textbox	Clickable factors (high sodium, low sodium, dairy, caffeine, etc.)	Buttons (1-5)	Y	Y
Guava	N	Slider (1-10)	Suggested activities or custom	Search, Textbox	Textbox & Photo	Y	Y	Y
Symptom Tracker (1)	N	Slider (0-10)	Textbox for activity and burned calories	Textbox (Dose strength, time)	Textbox, suggested factors (ate out, gluten, high sugar, etc.)	Slider (0-24h), Buttons (Awful - Great)	Y	Y
OpenCare	N	Wheel picker (6 choices from not present to very severe)	N	Textbox (Dosage, Instructions) & Wheel picker (Unit)	N	N	Y	Y
Symptom Tracker (2)	N	Severity (1-4), Scale (1-10), Count	N	N	N	N	Y	Y

Figure 1: App Analysis: Data Entry



App Name	Data Visualization			Notes		UI/UX	
	D/M/3M/6M/Y	Charts	Comparison / Correlations	Pros	Cons	UI	UX
Long Covid Tagebuch	M	Only color coded dots in calendar (not clickable)	N	Knowledge tab with clinical studies and articles	Custom additions cannot be given severity. Data visualization not detailed enough.	Light and bright color palette (white components on blue/green background)	Entries are in the form of a list, very difficult to view older entires
INSELhealth - cofit	W/3W/3M	Line chart	Line chart (between one symptom and one activity)		App only actively tracks activity (symptoms are entered as symptoms that were present during the activity)	Light colors	Not intuitive, navigation takes getting used to
Altea Care	W/M/6M	Line chart	Two bar charts	Easy to add new symptoms	Old entries can't be viewed. Symptom tracking not detailed.	Colors on the lighter, brighter side	Not intuitive, navigation takes getting used to
Visible	2W/M/3M/6M	Bar chart	Two bar charts	Morning stability measurement (Heart rate, heart rate variability and sleep is summarized in a „Morning Stability“ score	Easy to navigate between closer dates but older dates are hard to access	Relaxing, dark color palette, simple UI	Activities (Exertion) categorized as physical, mental, emotional, social. Community tab with blog posts, podcasts, studies to join, etc.
Bearable	M/2M/3M/Y/	Line chart	Premium feature	Lots of predefined choices	A bit too crowded.	Simple UI, easy to use	
Guava	W/M	Bar chart (Frequency) Line chart (Severity)	Y	Overview of symptom when clicked on is nice (negative: hard to find)	Symptom not categorized (difficult to look through symptoms for many possible conditions)	Too much to choose from (app being for many different conditions is nice but overwhelming)	Difficult to look through old entries
Symptom Tracker (1)	W	Line chart (Average) Bar chart (Frequency) Line chart (Time)	N	Factors not being tracked can be removed (reduces clutter)	Symptoms only shown on home screen if a reminder is set to track them, otherwise only in the reports lab	Simple UI, Picture & motivating quote on home screen	Subtle gamification elements (X day streak, longest streak)
OpenCare	W/2W/M/6M/Y	Bar chart	N	Option to add photos	Data can only be added manually (no suggestions)	High color contrast (Tiring for eyes)	
Symptom Tracker (2)	W/M/3M/Y	Bar chart	N	Option to choose entry style (	Data can only be added manually (no suggestions)	High color contrast (Tiring for eyes)	

Figure 2: App Analysis: Data Visualization and General Factors

The app analysis provided several insights into self-tracking solutions for long COVID patients, as well as more generalized apps with broader target groups. The apps offered a range of factors to track beyond symptoms, including activity, sleep, medications, and food, however, the specific factors varied among apps, with some covering more aspects than others. This highlighted the need to identify which factors are most relevant for long COVID patients.

Many apps appeared visually overwhelming due to the extensive amount of data they aimed to collect or the amount of information presented on a single screen. This raised concern about the optimal amount of information long COVID patients would be comfortable viewing at once. Particularly, apps that were not specifically tailored to long COVID patients often included either a very extensive list of symptoms or no predefined symptoms at all, which could both be overwhelming. Apps that categorized symptoms and allowed custom entries for symptoms that weren't listed generally seemed to offer a more user-friendly experience.

Although several apps featured various graphical representations of the collected data, the depth of visualization seemed generally limited, with most offering only line or bar charts of a single factor at a time. The apps that included data comparison features often presented these as charts placed side-by-side or stacked. The apps that collected data via text boxes seemed to provide fewer options for data visualization, the data entered as free text often not being available in the visualizations. Data entry features allowing users to click on previous entries could enhance usability by facilitating recognition of repeat entries.

Additionally, while many apps allowed users to review data entered in the past, navigation between dates was often rather difficult, typically limited to horizontal scrolling through dates shown at the top of the screen or horizontal or vertical scrolling through entries. Apps that incorporated a calendar for date navigation offered a more user-friendly experience. Lastly, a few of the apps that focused specifically on long COVID provided additional information about the condition, including articles, blog posts, research papers, and podcasts, which could be valuable for users seeking information.

4.1.2. Participant recruitment for user interviews

For the recruitment of interviewees, a multifaceted approach was undertaken with the goal of achieving broad outreach as well as diversity in the participants for a better understanding of the requirements of long COVID patients.

In the first instance, a flyer was created detailing the thesis objectives and the interview process. The flyer included information about the thesis, the research goals, the target participants and their relevance, the interview format, and contact details. The flyer served as a primary communication tool to inform potential participants about the research (see Appendix A).

Then, the NAKOS (Nationale Kontakt- und Informationsstelle zur Anregung und Unterstützung von Selbsthilfegruppen) database [27] was used to identify the self-help groups in Germany that were specifically for individuals suffering from long COVID. The search yielded 228 long COVID self-help groups in Germany, including 14 located in Berlin. All identified groups in Berlin were contacted via email, followed by a random selection of 30 additional groups across Germany. The flyer was attached to the emails to facilitate easy distribution among group members.

Additionally, physical copies of the flyer were placed on information boards across the main campus of Freie Universität Berlin. These boards were selected for their high visibility among diverse university members and visitors.

The flyer was also shared with personal contacts who knew of people suffering from long COVID for further distribution.

Out of 44 self-help groups that were contacted, 13 responses were received, with 10 groups agreeing to share the information with their members. Four individuals from these groups reached out, expressing interest in participating.

Three further individuals, who had been contacted through personal contacts, also expressed interest.

Some interviewees kindly offered to share the flyers with personal contacts or groups they were involved in, during their interviews. These yielded two more individuals who were interested in the interviews.

In the end, the search was concluded with a total of nine individuals who had expressed interest. Despite this initial number, only three interviews were successfully conducted, primarily due to personal circumstances such as health-related issues and scheduling conflicts, as well as a lack of responses from some participants. Additionally, one participant (P4), with whom an interview could not be conducted, provided a comprehensive email addressing the interview questions. This response was considered equivalent to an interview, bringing the total number of participants to four.

4.1.3. Conducting the interviews

Pilot interview Before the first interview was conducted, a pilot interview took place with a volunteer who had not been formally diagnosed with long COVID but experienced potential symptoms. This person was considered a suitable candidate to gain initial insights into the clarity and efficacy of the interview questions.

The pilot interview served as a valuable practice session, ensuring a smoother execution of the subsequent interviews.

User interviews Prior to each interview, participants were given a consent form to confirm their permission for the interviews to be recorded and their feedback to be used in the thesis (see Appendix B).

The interviews were conducted either face-to-face or via telephone, based on the preferences of the participants and the logistical feasibility. All participants demonstrated a high level of openness in their responses to the questions. Each interview lasted approximately one hour and was recorded using the iOS Voice Memos app [11].

The interviews were conducted in a semi-structured format, aiming to balance structure and flexibility. The approach enabled the inclusion of follow-up questions, improving the understanding of the participants' responses while adhering to a structured set of questions (see Appendix C) for easier comparison of the answers.

The interviews covered various topics such as demographic information, the participants' symptoms and how they manage these, their previous and current self-tracking practices, and their requirements from a self-tracking app. Emphasis was especially placed on their specific requests and requirements regarding data entry in the app, as well as the factors to enhance their motivation for regular data tracking.

The following table presents an overview of the user profiles from the interviews, including participants' age, long COVID symptoms, and their current (or past, if not currently self-tracking) self-tracking tools. This data serves as an introduction to the participant group before their requirements are presented.

	Participant P1	**Participant P2**	**Participant P3**	**Participant P4**
Age	60 years old	31 years old	35 years old	Nearly 40
Long COVID since	July 2022	August 2022	October 2022	1.5 years
Symptoms	- Fatigue, - Sleeping problems, - Lack of strength, - Low lung capacity, - Heart pain, - Chest pain, - Joint pain during exertion, - Difficulties concerning short-term memory, - Concentration difficulties, - Comprehension problems, - Headaches	- Fatigue, - Palpitations, - Muscle pain, - Twitching and tingling in the arms and legs, - Headaches	- Fatigue, - Concentration difficulties, - Disorientation, - High pulse (when standing), - Especially after exertion: Cardiovascular problems, Muscle pain, Sleep disturbances, Night sweats	- Fatigue, - PEM (Post-exertional malaise)
Current self-tracking method/tool	Garmin's Connect App [21]	Visible App [34]	currently none (before: Fimo Health [20])	N/A

Table 1: User Profiles

4.1.4. Analyzing the collected data

The audio files from the interviews were transcribed using the Aiko app [31]. For privacy reasons, each transcript was anonymized and assigned an identifier: P1, P2, P3, and P4, enabling individual contributions to be tracked without compromising privacy. The original voice recordings were then deleted in accordance with the consent form given to the participants.

The qualitative data collected was analyzed to derive insights and application requirements relevant to the thesis. In this regard, a thematic analysis, as outlined by Braun and Clarke [14], was attempted.

To begin with the analysis, the formatted and anonymized transcripts were uploaded into MAXQDA [33], an analysis software for qualitative data.

Then, a preliminary set of codes, based on relevant keywords and factors, were decided on and each transcript was reviewed, coding the relevant data segments using these predefined codes. The preliminary set of codes were as follows:

- Physical Barriers
- Psychological Barriers
- Technological Barriers
- Past Tracking Experiences
- Positive Reactions
- Negative Reactions
- Intrinsic Motivation
- Extrinsic Motivation
- Gaining insights from data
- Feature Requests
- Ease of use

After coding all four interviews, the next phase involved organizing the codes into broader categories referred to as themes. This process provided a clearer view of the main patterns and relationships within the data. During this phase, it became apparent that some codes needed to be more specific. As a result, in addition to categorizing the codes into themes, subcategories were created for some codes, leading to the refinement of these codes into more detailed themes. An overview of the finalized code system can be seen in Figure 3.

Once the codes and themes were finalized, various maps were generated in MAXQDA (see Figures 3, 4, 5), offering visual representations of different relationships between the data. These maps supported the analysis process by highlighting different connections and intersections within the data.

Figure 3: Code-Relations-Browser

The code-relations-browser in Figure 3 provides a visual representation of the co-occurrences of codes, allowing for the identification of the codes that are most strongly linked to each other. For example, it is observable that Feature Requests were most linked to Gaining Insights from Data, Ease of Use, Tracking Effort and Support Systems, allowing the following conclusions to be drawn:

- The app must allow users to gain insights from their data (Gaining Insights from Data).
- The app must enable the suitable tracking of various symptoms and other factors, such as activities and medications (Trackable Datasets).
- The app must be easy to use (Ease of Use and Tracking Effort).
- The app must support users in managing their condition (Support Systems).

The strong connection of these factors with Feature Requests indicates that a key motivating factor for users is having all necessary functions integrated within the app in a user-friendly manner.

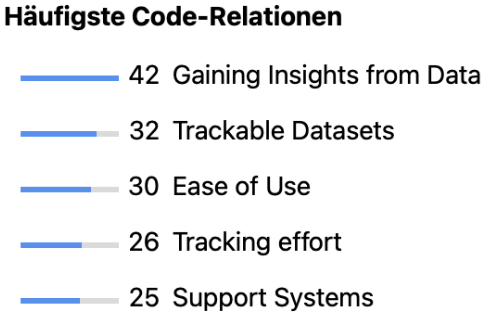


Figure 4: Feature Requests: Most Frequent Code Relations

The visualization of the code relationships in Figure 4 within the theme Feature Requests also supports this conclusion.

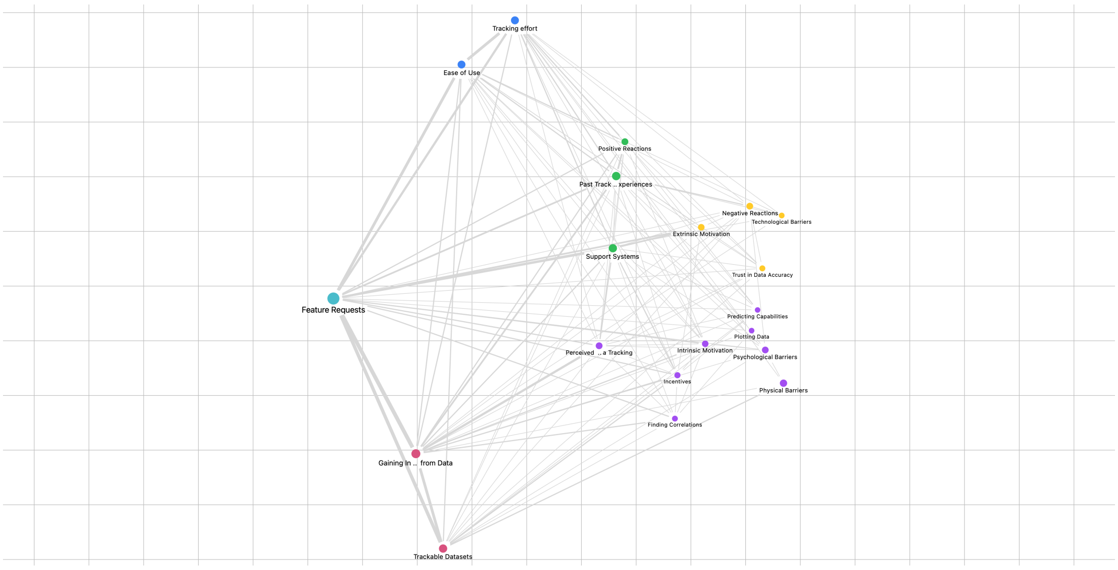


Figure 5: Code Map

The code map in Figure 5 offers an overview of the relationships between different factors, providing useful insights for conclusions. Different themes are shown as nodes, with their size indicating the frequency of their occurrence throughout the data. The connecting lines represent the relationships between the codes. The codes are clustered based on their similarity, revealing color-coded groups that highlight various aspects of the analysis.

For example, the blue cluster at the top of the map includes codes like “Tracking Effort” and “Ease of Use,” focusing on aspects of usability and design. This cluster could be titled “User Experience”. The yellow cluster on the right side of the map includes codes that address negative aspects, such as barriers users mentioned and factors affecting their trust in data. The purple cluster below includes codes that emphasize positive aspects, such as incentives and goals. Together, these two clusters represent the positive and negative factors impacting user behavior and could be titled “Motivation” or “Motivating and De-motivating Factors”. The pink cluster at the bottom of the map focuses on self-tracking and data visualization aspects of the data and could be titled “Goals”.

The code “Feature Requests” stands out as a significant cluster on its own, with the size of the node representing its importance in the research. This cluster is heavily interconnected with all the other clusters, indicating that user requests are influenced by all the aforementioned factors.

Finally, the insights gained from the visualizations were used to gather findings from the interviews and to create a list of functional and non-functional requirements.

4.1.5. Deriving the requirements of the patients

Despite the limited number of participants, this data collection method proved successful in gathering firsthand perspectives from individuals affected by long COVID, allowing the identification of design features and functions that would support them in their self-tracking endeavors.

The following Figure 6 presents a table displaying the factors that the users expressed a desire to track in a self-tracking app, to explore potential causal relationships between their symptoms and the rest of the factors. The table aims to create a weighting system using plus signs (+) to represent the number of users who mentioned each factor. This system was used to prioritize the factors, ensuring that the most frequently mentioned factors were addressed in this thesis. Regarding this, the main factors that were included in the thesis were Symptoms, Activities, Medications & supplements, and Dietary intake. Stress was also added. Tracking of the menstrual cycle was excluded due to the complexity of this factor.

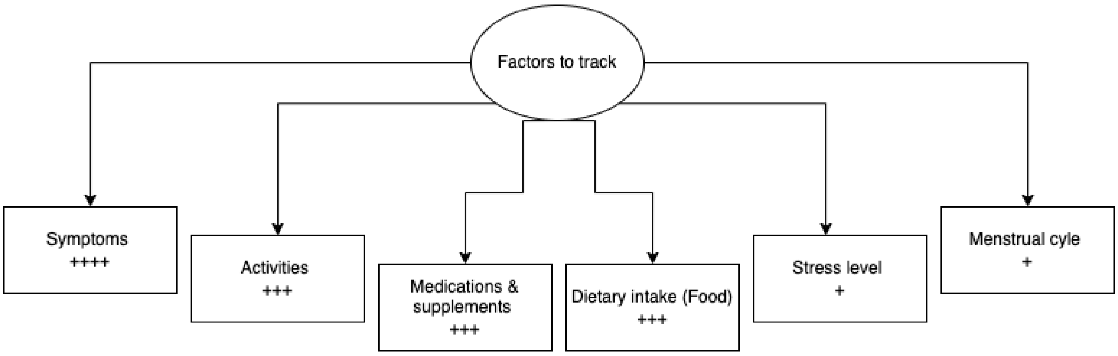


Figure 6: Factors to Track

The following tables 2 & 3 provide an overview of the functional and non-functional requirements derived from the analysis.

ID	Requirement
FR01	Users can choose their symptoms from a list.
FR02	Users can enter custom symptoms.
FR03	Users can enter the severity of the symptom using a scale with enough levels to choose from.
FR04	The severity of each symptom is entered separately (to avoid unnecessary scrolling).
FR05	The next symptom appears immediately after the previous severity is entered (to avoid unnecessary clicks).
FR06	Data from the previous day is available when entering the symptom severity.
FR07	Users can add and remove symptoms they track at any time.
FR08	Users can choose their activities from a list.
FR09	Users can add custom activity options.
FR10	Activities are entered in a way that allows differentiation for data visualization (activities are not entered as free text).
FR11	Users can add and remove activities they track at any time.
FR12	Users can log their medications and supplements.
FR13	Users can add notes to medications/supplements (e.g., reason for taking, effects).
FR14	Users can see start and end dates in data visualization.
FR15	Users can record details about their dietary intake, such as foods or food groups (e.g., foods high in histamine, low-inflammatory foods).
FR16	Users can record stress levels.
FR17	Users can add a note related to their stress levels (e.g., reason).
FR18	Users have the flexibility to choose which factors they want to track.
FR19	Users can mark specific days with an indicator and add notes to highlight that these days should be viewed differently from others.
FR20	Users can use voice dictation for text input where text is required.

Table 2: Functional Requirements

ID	**Requirement**
NFR01	The app is designed to be as simple as possible to use, minimizing complexity in both design and interaction.
NFR02	The app is in dark mode or offers a range of customizable color themes.
NFR03	The app is designed to reduce the amount of typing required, favoring simple clicks where possible.
NFR04	The app avoids unnecessary scrolling and movement.
NFR05	The app provides users with a sense of personalization.
NFR06	The app rewards users for activities and behaviors that contribute positively to their well-being (rather than rewarding potentially counterproductive actions like excessive activity).
NFR07	The app supports users in maintaining a positive outlook.

Table 3: Non-Functional Requirements

These requirements are presented in a detailed manner below. User quotes drawn from the codes identified during the analysis have been incorporated throughout the explanation, offering direct insight into the feedback that shaped the requirements.

The patients highlighted several **functional requirements** for the app, drawing on their previous self-tracking experiences as well as their broader expectations and their needs for such a tool.

Regarding symptom tracking, patients emphasized the need for the app to allow symptom selection from a predefined list (FR01) and provide the option to enter custom symptoms (FR02), allowing typing to be reduced and ensuring that any missing symptoms could be added manually by the patients. When discussing the method for entering symptom severity, all patients who expressed a preference indicated that they would like a severity scale. Some patients also highlighted the importance of having sufficient levels on the scale to accurately reflect the intensity of their symptoms (FR03). P3 noted, *"I would find a scale for selection useful. I think it shouldn't have too few steps. For example, with FimoHealth, at one point it was reduced to five steps, which I found too few. The intervals felt too large to actually see changes, as the changes for me, at least, are not that significant. I think smaller intervals would be better."*

In addition to the severity scale, patients stressed the importance of streamlining symptom data entry to avoid overwhelming them. Several patients mentioned the need to minimize unnecessary scrolling, P3 providing positive feedback on entering symptoms sequentially, stating, *"So it was really like, you were guided through it, you didn't have to do much yourself, and there was always only one thing on the screen at a time, which was not overwhelming"* (FR04). P3 also emphasized the need for the app to automatically proceed to the next symptom after entering the severity of the previous one, minimizing unnecessary clicks (FR05), adding, *"And otherwise, I think there shouldn't be too many clicks. It's enough to just tap the scale and move on. I don't need to confirm it again if it's always just one thing, and it should also be large enough."*

Another requirement was for the app to provide users with the option to view data from the previous day when entering current symptom severity (FR06), aiding users in comparing their current state with the previous day. P2 found this feature beneficial in another app, stating, *"I also always use the 'copy data from yesterday' setting. It helps me see how I felt yesterday and how I feel today in comparison. I then adjust it based on how I feel today. I find this quite useful as a reminder."*

Lastly, patients requested the ability to add or remove symptoms as their condition and tracking needs evolves over time (FR07), P3 explaining, *"But it would also be good if you could gradually adjust the app as your condition changes. For example, if you could remove symptoms you no longer have, so you're not asked about them every day, that would also make it shorter again."*

In terms of tracking activities, patients emphasized the importance of being able to enter activities in a manner that allows for differentiation in data visualization (FR08, FR09, FR10), P3 explaining, *"In the last app, I could only write down what I did during the day in words or click on activities that I did that day, like whether I went for a walk or not. But even then, it didn't work to display this in a chart."*

When tracking medications and supplements, patients highlighted the need to record these entries (FR12) and to add notes regarding their purpose or effects (FR13), P3 remarking, *"Especially with medications and dietary supplements, these are things I'm constantly experimenting with. There are so many recommendations and ideas, and trying everything at once doesn't make sense. That's why I try one thing after another, but you can't remember everything. I would like to be able to store more information about this."* Additionally, patients expressed the desire to see when they had started and ended taking medications or supplements in data visualizations (FR14), P3 exlaining, *"I also had medications in the FimoHealth app, which I found only somewhat useful. It didn't help me much because I couldn't make any notes about the medications, and I also couldn't see the time periods during which I took them in the graphs. That would have been helpful too."*

For dietary intake, many patients expressed interest in recording information about their food consumption, including specific categories such as high-histamine or low-inflammatory foods (FR15). They noted that such details could significantly impact their symptoms and expressed a desire for better insights into these effects, P1 stating, *"... it would be best to also enter what you've eaten, because a lot is related to food... And there are all these mast cell issues and, what are they called, the ones you can't tolerate, like histamine and anti-inflammatory diets, and so on. It would be helpful to know if, for instance, eating a lot of paprika could potentially have an effect,"* and P4 further noting, *"Many of us try out different diets (low histamine, anti-inflammatory) and/or dietary supplements; perhaps there are people who would like to keep track of such experiments."*

Regarding stress, one participant (P3) expressed desire to record stress levels (FR16), stating, *"Yes, stress. Stress might be useful, provided it's not included with the symptoms.*

Perhaps stress could be tracked using a separate scale," additionally suggesting that the ability to add notes related to stress would be beneficial (FR17), explaining, *"... a note would be useful there because there are different types of stress. ... And perhaps to first determine whether all stress is problematic or only certain types, more data collection might be needed."*

In general, patients emphasized the need for flexibility in selecting which factors to track (FR18), P2 expressing, *"I think that would be too much for me, and I'm not sure if the effort would be worth it."* There was also a desire to mark significant days with indicators and add notes to highlight special events (FR19), P3 explaining, *"... for very special events, such as those that led to a crash, I would like to have something like a star or a marker to indicate that it was truly significant."* Lastly, patients highlighted the usefulness of voice dictation for text input (FR20), P1 remarking, *"... enter little text, but especially on the phone, who likes to type? ... Or dictation, I do it quite often now, and I have to say it has gotten quite good."*

When discussing usability, patients highlighted the significance of both visual and functional simplicity in the app. They stated several **non-functional requirements**, including the need for design customization, reduced typing, and minimized scrolling.

Patients expressed the requirement for the app to be as simple as possible to use, minimizing complexity in both design and interaction (NFR01), P2 noting, *"... rather simple and clear,"* when asked about their expectations regarding usability. All patients who were asked expressed a preference for a dark mode, with some suggesting the addition of a range of color themes to choose from (NFR02). P3 stated, *"... one can either individually adjust the color scheme or generally keep it a bit darker."*

Patients also stressed the importance of reducing the amount of typing required by the app, favoring simple clicks where possible (NFR03). Regarding this, P1 stated, *"... it would be easy, if I didn't have to type."* P3 similarly noted, *"... not having to write something every time ... being able to handle much of it just by clicking,"* and added, *"... also not too many clicks, it's enough if you just tap the scale and then it continues right away."*

As previously mentioned during the functional requirements, the need to avoid unnecessary scrolling and movement was expressed (NFR04), P3 suggesting, *"I would leave unnecessary movement out,"* and P4 explaining, *"Animation/movement: Preferably none. Quick movements are a problem. (Quick cuts, shaky things, and similar issues). Another problem: scrolling down quickly (I close my eyes/look away while doing it)."*

During the interviews, it became clear that **motivational factors** such as gamification did not resonate with all the participants. Instead, they were more motivated by an app tailored to their specific needs, which simplified and supported their self-tracking efforts. Many patients highlighted the value of personalization as an important factor in enhancing their experience, alongside positive reinforcement and support for maintaining a positive outlook.

Patients highlighted the need for the app to provide a sense of personalization (NFR05), P2 stating, *"Being reminded that the long-term will give me something, I think that's a good aspect ... I think it has to be done cleverly so that it doesn't get boring. That it should be a bit more personal, so that you know it's not the same thing every day, but the app says, 'Hey, you've already reached 100 days, awesome.'"* Similarly, P3 noted, *"And otherwise, in terms of motivation, especially for the cognitive aspects, as I said, it has to be as simple as possible. Yes. And it cannot be overwhelming, but it still needs to be personally tailored."*

Patients also mentioned that the app could incorporate rewards, emphasizing the need for these rewards to positively contribute to their well-being rather than rewarding potentially counterproductive behaviors, such as excessive activity (NFR06). P3 explained, *"With these apps, there's sometimes the problem that you can't really reward yourself for doing more. For example, you can't reward me like my fitness watch does, for taking more steps today than yesterday. That's not the motivation I need because it would push me beyond my goals, which I actually, I mean push me beyond my limits, which I avoid."*

Additionally, many patients expressed a desire for support in maintaining a positive outlook (NFR07), P3 stating, *"Focusing on something nice is always a good idea, especially with this condition."*

4.2. Designing the prototype

The primary objective of this thesis was to propose a design concept for the data entry aspect of a self-tracking app tailored to the needs of long COVID patients. The design needed to fulfill user requirements to encourage users to consistently track their data, while also serve as an effective data collection tool in order to provide a richer dataset for visualization.

Based on the identified requirements, it was determined that, in addition to the main component of daily data entry, two supplementary components would be essential: an onboarding process and a settings interface. These components were crucial for simplifying and optimizing the daily data entry experience. The onboarding process allows users to input consistent information, including daily symptoms, frequent activities, and medications taken regularly. The settings interface provides the functionality to add or remove tracked data and factors. Integration of the onboarding data and the modifications in the settings into the daily data entry allows for a more efficient and user-friendly data logging experience.

In the proposed design, the app features the following tabs:

- A tab for viewing daily data (referred to as "Home")
- A tab for visualizing data
- A tab for accessing community features such as information and forums

- And a tab for configuring the settings (referred to as “Settings”)

For the scope of this thesis; however, focus was solely set on the design of the data entry, onboarding, and settings components. The other tabs were included as placeholders.

The app prototype was developed using the Figma prototyping tool.

In accordance with the user requirements, a dark mode was implemented. A blend of blues and purples were chosen for the color scheme, avoiding high-contrast colors and instead using pastel shades for lighter tones and muted colors for darker tones to ensure visual comfort.

The following section introduces the app designs in a specific sequence: starting with the onboarding process, followed by daily data entry, and the settings. This order intends to provide a coherent walkthrough of the app, reflecting a typical user journey.

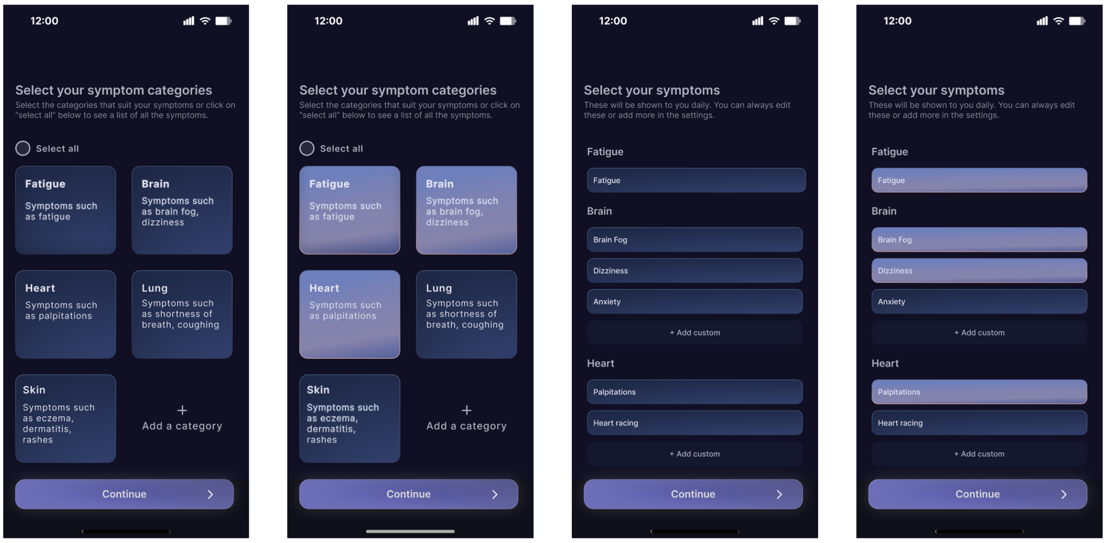
4.2.1. Low-fidelity prototype

Onboarding The onboarding process enables users to personalize their tracking preferences, aiming to tailor the app experience as closely as possible to their individual needs.

In the first step of the onboarding process, users are asked to select their symptoms. This process was divided into two pages during onboarding to minimize user overwhelm.

On the first page, users select categories relevant to their symptoms. This acts as a filter in the next view, removing the symptoms from the categories they did not choose. Additionally, an option to select all categories was included to streamline the process for users who wish to view all available symptom categories.

On the second page, users are presented a list of symptoms from which they can choose their specific symptoms. Custom additions are also possible to both the symptom categories and the symptoms, allowing users to enter options that were not initially listed.


Select your symptom categories

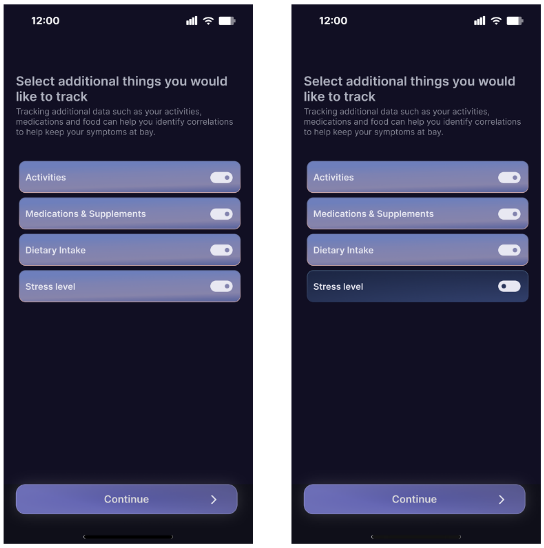
Select the categories that suit your symptoms or click on "select all" below to see a list of all the symptoms.

Select your symptoms

These will be shown to you daily. You can always edit these or add more in the settings.

Figure 7: Onboarding - Symptom Categories & Symptoms

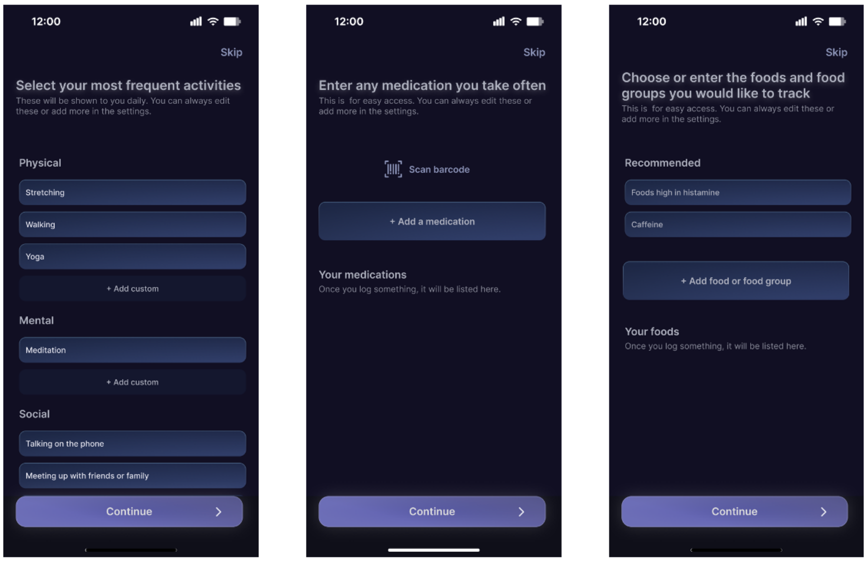
After selecting their symptoms, users are given the option to select which factors they wish to track, allowing them to customize their tracking preferences. Deactivated factors are then hidden from the app interface to reduce clutter. Factors can also be activated and deactivated at any time through the settings, as indicated in the descriptive text.


Select additional things you would like to track

Tracking additional data such as your activities, medications and food can help you identify correlations to help keep your symptoms at bay.

Figure 8: Onboarding - Further Factors

Once users select the factors they wish to track, they are given options to enter details related to these factors, such as frequent activities, medications, or dietary intake options. This functionality aims to further simplify the daily data entry process by allowing users to save options they are likely to enter frequently.


Select your most frequent activities

These will be shown to you daily. You can always edit these or add more in the settings.

Enter any medication you take often

This is for easy access. You can always edit these or add more in the settings.

Your medications

Once you log something, it will be listed here.

Choose or enter the foods and food groups you would like to track

This is for easy access. You can always edit these or add more in the settings.

Your foods

Once you log something, it will be listed here.

Figure 9: Onboarding - Activities, Medications, Dietary Intake

Daily Entry The daily data entry methods were a crucial part of the thesis.

The first factor that was designed was the symptom severity entry. According to the functional requirements, symptoms needed to be recorded individually, with severity levels displayed using a scale. This scale was centrally positioned on the screen with levels arranged vertically to optimize usability. It featured a color gradient from green to red and ranged from 0 to 10, with labels indicating 0 (none), 1 (mild), and 10 (severe).

To ensure clarity and ease of use, the scale levels were presented in distinct boxes, indicating that only whole numbers could be selected and facilitating direct interaction through clickable numbers. A pointer was centrally placed on the scale, allowing users to drag this to the appropriate severity level as an additional option.

In addition, a “Show Previous Result” toggle button was incorporated to enable users to view their most recently entered severity. A progress bar was also included, which advances with each symptom entry to provide visual feedback on how far the users are in tracking their symptoms.

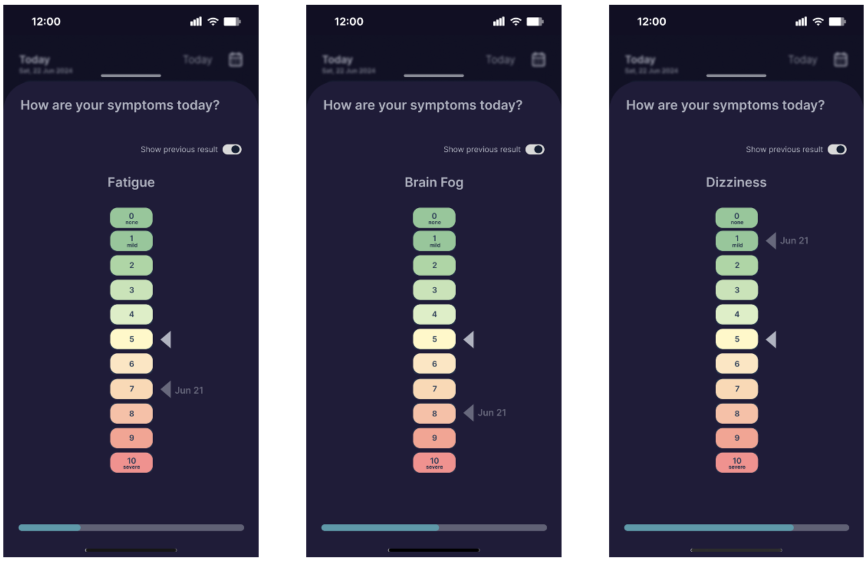
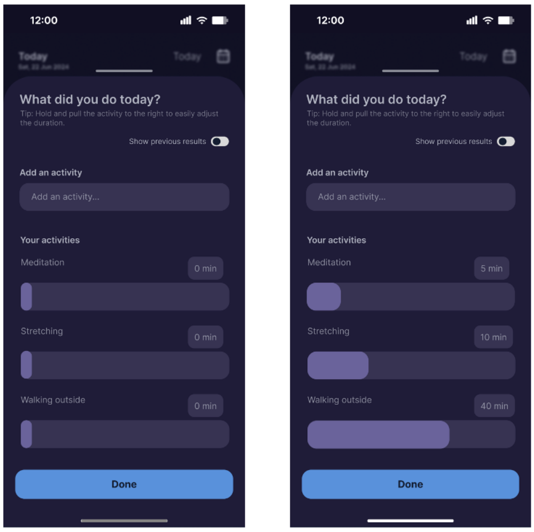


Figure 10: Daily Entry - Symptoms

The next page designed for the data entry was the activity entry interface. On this page, users are presented with a horizontal bar for each activity, which they can drag to the right to adjust the duration of the activity. The selected activities that the users frequently engage in are shown by default, facilitating a quicker data entry experience.

The duration of each activity is displayed above its corresponding bar, dynamically updating as users adjust the scale. This also gives users the option to manually input or modify the duration by clicking on the displayed value.

To accommodate infrequent activities, an option to add custom activities was also incorporated.



What did you do today?

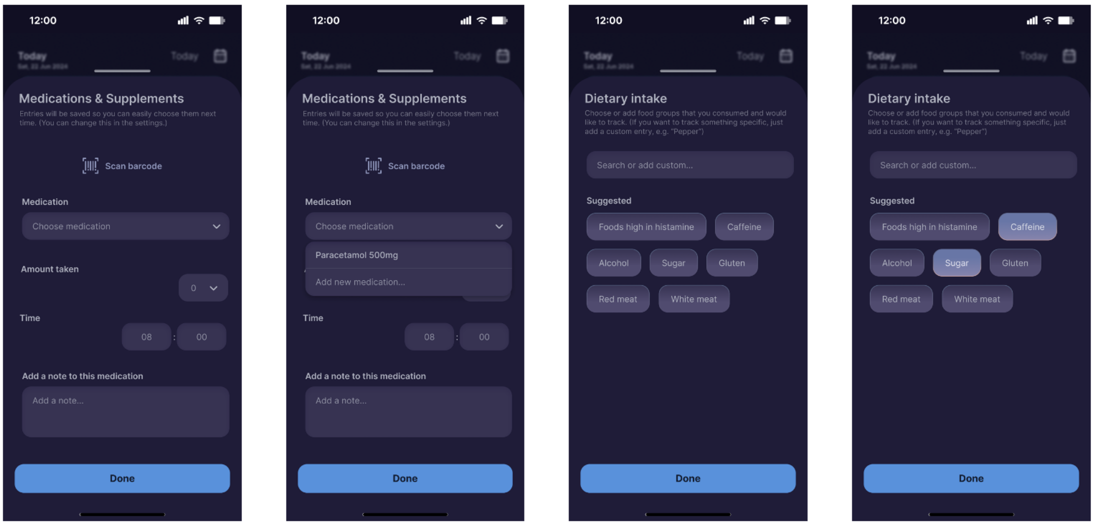
Tip: Hold and pull the activity to the right to easily adjust the duration.

Figure 11: Daily Entry - Activities

The requirements of the medication and supplement entry specified users needed to be able to add medications or supplements along with a note, while also collecting data such as the amount and time for data visualization purposes, all while maintaining simplicity.

Aiming to address these requirements, a search bar was incorporated into the page, enabling users to view previously entered medications and also add new ones. The amount, time, and notes were added as additional fields.

To further simplify the process of entering new medications, a barcode scanning feature was also integrated, allowing users to quickly and easily add medications by scanning their barcodes.



Medications & Supplements

Entries will be saved so you can easily choose them next time. (You can change this in the settings.)

Dietary intake

Choose or add food groups that you consumed and would like to track. (If you want to track something specific, just add a custom entry, e.g. "Pepper")

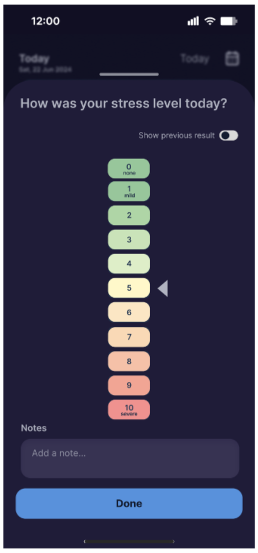
Figure 12: Daily Entry - Medications & supplements, Dietary Intake

Tracking dietary intake involves a broad range of possibilities in regard to what users might want to track, including specific foods (e.g., paprika), food groups (e.g., high-histamine foods, dairy, gluten), or dietary patterns (e.g., vegan, keto).

To simplify this process, users are given the option to enter their own categories. The entries are saved as clickable factors for future selection to minimize repetitive typing and ensure consistency in data entry.

Suggested options are also provided to guide users in selecting what they might want to track.

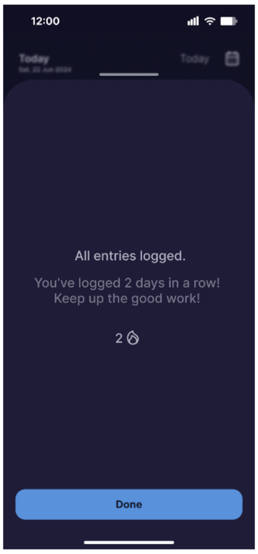
To maintain consistency, the stress level entry was designed using the same scale as the symptom entry. As both involve severity measurements, the goal was to provide users with a familiar entry process, avoiding the need to adapt to a new method.



How was your stress level today?

Figure 13: Daily Entry - Stress level

Upon completing an entry, users are given feedback confirming that the entry has successfully been logged. A personalized message was incorporated into the page, to offer a sense of achievement, similar to earning a badge. This addition aims to introduce motivating elements, such as personalization and subtle gamification, while avoiding unnecessary clutter.



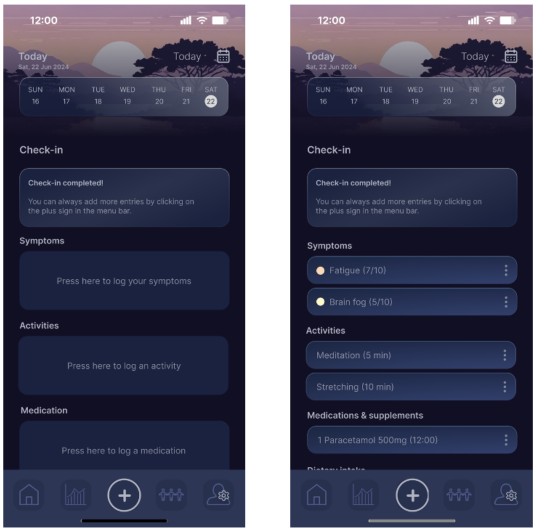
All entries logged.

You've logged 2 days in a row!
Keep up the good work!

Figure 14: Daily Entry Completed

The home screen of the app was designed as a dashboard, where users can enter and view their data. Each tracked factor is displayed individually, however, a check-in component was also included above all factors, allowing users to record all their data in one process, eliminating the need to select each factor separately, if they want to enter all their data at once.

A horizontally scrollable calendar was integrated into this page enabling users to quickly navigate to nearby dates. For accessing older dates, a separate calendar icon was provided. A “Today” button was additionally included to offer an easy way to return to the current day.



Check-in completed!

You can always add more entries by clicking on the plus sign in the menu bar.

Press here to log your symptoms

Press here to log an activity

Press here to log a medication

Fatigue (7/10)

Brain fog (5/10)

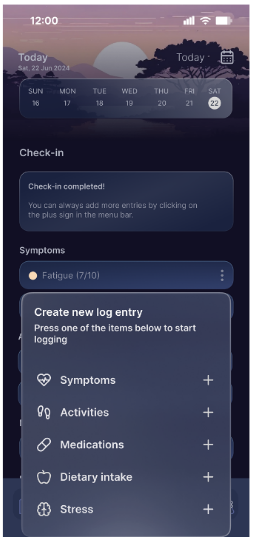
Meditation (5 min)

Stretching (10 min)

1 Paracetamol 500mg (12:00)

Figure 15: Home Screen - Before and After Daily Entry

A feature for quick and accessible data entry throughout the app was integrated into the menu bar via the plus sign.



Check-in completed!

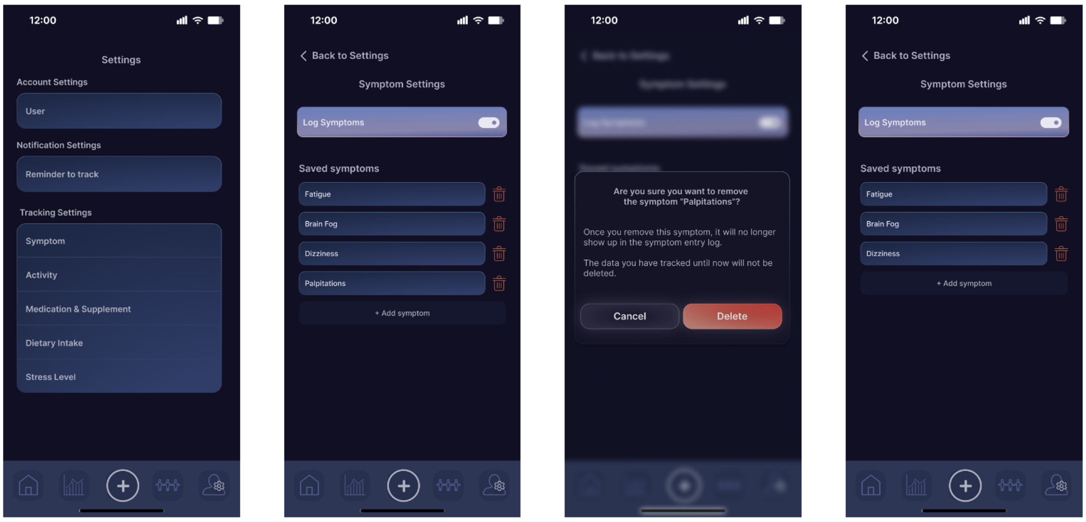
You can always add more entries by clicking on the plus sign in the menu bar.

Create new log entry

Press one of the items below to start logging

Figure 16: Quick Add Menu

Settings The settings allow users to toggle factors on and off and to add or remove entries as needed. For instance, as illustrated in Figure 17, users can remove a symptom they no longer experience in the symptom settings, thereby excluding it from their daily logging from then on.



Are you sure you want to remove the symptom "Palpitations"?

Once you remove this symptom, it will no longer show up in the symptom entry log.

The data you have tracked until now will not be deleted.

Figure 17: Settings and Symptom Settings

4.2.2. High-fidelity prototype

Once the designs were completed, interactions were added to the prototype, resulting in a click dummy which would be used for the expert evaluations.

4.3. Implementation

The app was primarily developed using TypeScript [6], which is compiled to JavaScript. The user interface was built with React Native [3], a framework that integrates the widely-used web technology ReactJS [2] with native UI elements across various platforms. React Native offers the advantage of a single codebase that can be used across multiple platforms, as its components do not rely on platform-specific code. While the implementation for this thesis focused on iOS, this flexibility enables easy transition to other platforms, such as Android and even Watch OS platforms.

To implement the design components, such as styling and interactivity, Tamagui [5] was chosen, due to its extensive range of components, which accelerated the development process and facilitated customization of the user interface to align with specific design systems. The comprehensive configuration file offered by Tamagui allowed for the app's UI to closely match the prototype.

4.3.1. Architecture overview

The following Figure 18 presents an overview of the app architecture. Although Reminders and Data Exporters were not implemented in the scope of the thesis, the architecture overview displays them as modules part of the system, due to their importance to the system as a whole.

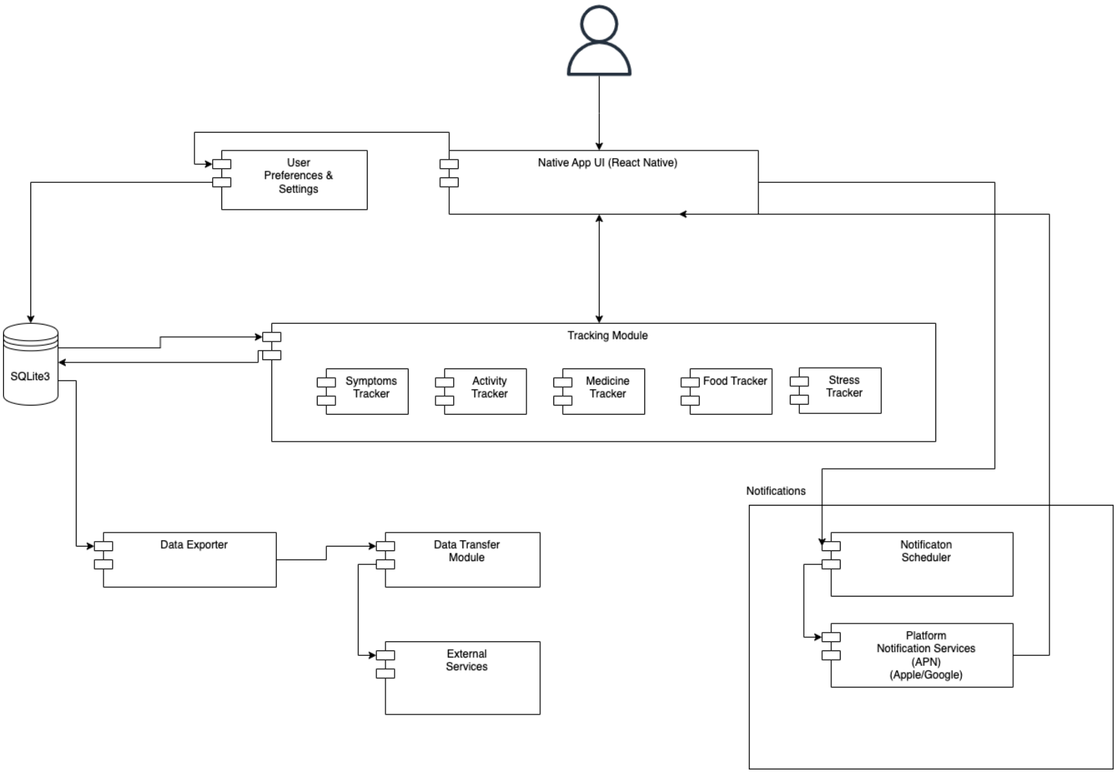


Figure 18: Architecture Overview

Matching the requirements of the DiGA guidelines According to the DiGA guidelines for data privacy [13], the following requirements must be met:

- In order to be successfully listed in the DiGA directory, an app *must create an account for each user. All user data must be linked to this account* and the *users must be able to use a pseudonym. Data that is no longer actively required must be deleted within a grace period* equal to the duration the data was used, or a maximum of 3 months, whichever is shorter. Furthermore, *any data transferred over a network must be end-to-end encrypted.*
- Data exports for DiGA-listed apps *must use interoperable data formats*, *provide an audit trail of exports*, and *inform the user of an export. Exporting data must require user consent*, and the *exported data must be provided in a human-readable format.*
- The service must attempt to *minimize the amount of data collected* and the *collected data must have a purpose that is beneficial to the user.*

In order to assess which technologies were best-suited long-term to match the DiGA guidelines, multiple storage technologies were compared. A summary of the comparison is presented in the following Table 4.

Tech / Features	**Offline first**	**Device sync**	**Private export**	**Data sharing**	**E2E encrypted**	**Structured data**
Filesystem / custom structure	✓, easy to develop	˜, limited, platform reliant	✓	˜, limited, requires documentation	✓, possible	✗, difficult migration
PG	✗	✓, data is centralized	˜, possible but not private	✓, data is centralized	✗	✓
SQLite	✓	˜+, platform reliant	✓	✓, share SQLite files	˜, possible, requires implementation	✓
NoSQL / MongoDB	˜, possible	˜, possible	˜	˜	✗	✗

Table 4: Technology vs. Features Comparison

To ensure data privacy and guarantee that only the data the user actively submits for export is sent, an offline-first data model was selected. This offers multiple benefits:

- Data is stored offline-first, never leaving the device unless explicit consent is given
- The encryption requirements for network transfers are only ever needed for exports, not for every data point collected

Selecting a centralized database storage would have required the server to handle several extra issues to achieve similar goals:

- Row-level security needs to be configured properly so that user data is never sent to the wrong user
- Audit trails for all operations to ensure data never leaks to unauthorized entities
- Strong security configurations on the server to ensure that only authorized entities have access to the database

Additionally, a structured data model (e.g., SQL) was selected to ensure that future data analysis features are built on a robust and well-organized foundation.

Unstructured data storage models could create difficulties migrating data to newer formats, for example, if a user disabled automatic app updates and then switched between multiple major versions. SQL-based databases have dedicated libraries to handle these challenges, which is why DrizzleORM [1] was selected as the data access layer library.

SQLite [4] is an SQL-based database system that stores the entire database in a single file, making the database portable, aiding in easier data sharing.

One of the DiGA requirements state that users **must have** an account. It is necessary to clarify whether a locally stored database tied to the user's device qualifies as an account.

If a central database hosted on a server is required, a minimal authentication database could be employed to store user credentials and the location of their SQLite database. In this case, the centralized app server would store each user database as a separate SQLite file, ensuring that the data of each user is isolated from others.

4.3.2. Data model

The following data model in Figure 19 was designed to offer users several configuration options whilst also making sure that a structured framework was maintained for effective data analysis, as mentioned previously:

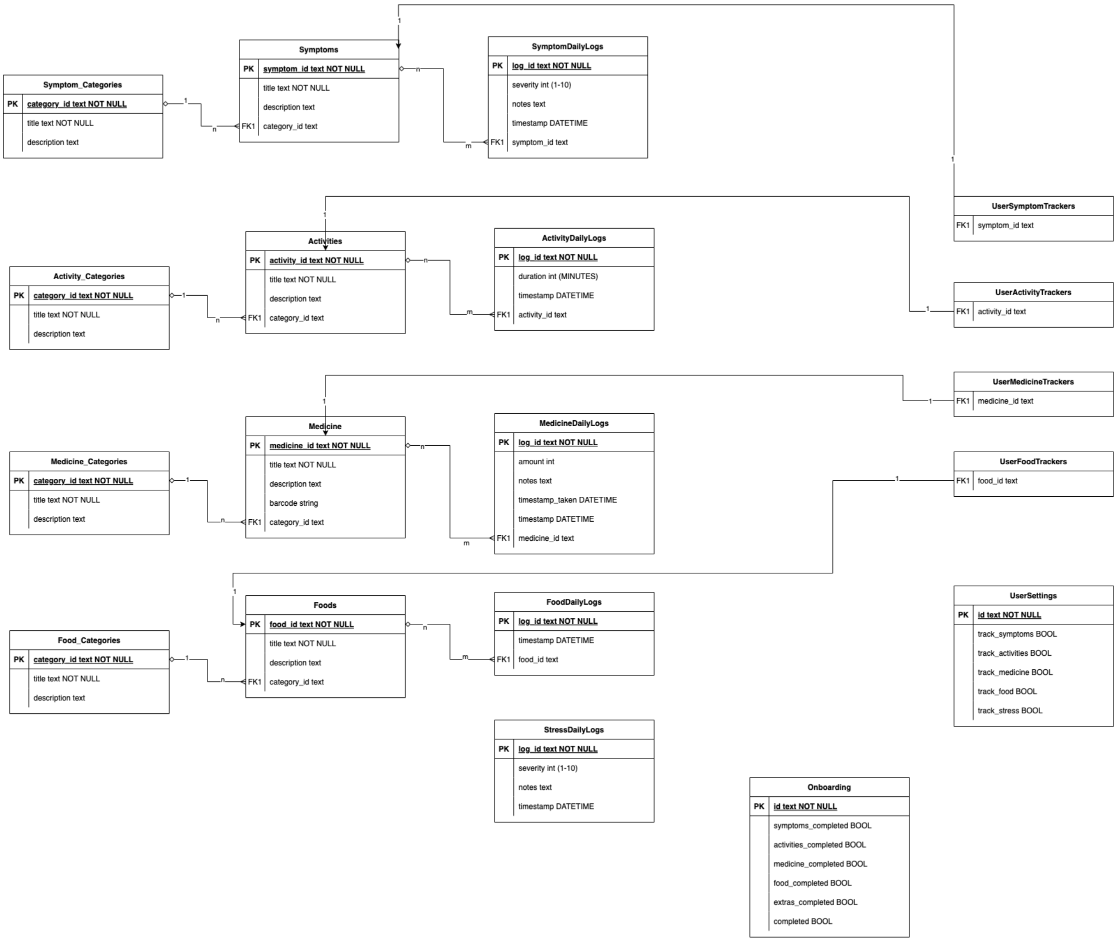


Figure 19: Data Model

The 5 factors that can be tracked in the app are Symptoms, Activities, Medicine & supplements ("Medicine" here), Dietary intake ("Food" here), and Stress. In the data model, these are named SymptomDailyLogs, ActivityDailyLogs, MedicineDailyLogs, FoodDailyLogs, and StressDailyLogs. These factors will be referred to as *trackers*.

With the exception of stress, each tracker has a list of *trackable data points*, which are the options that users can track, and these trackable data points are sorted into categories. The trackable data points are named Symptoms, Activities, Medicine, and Food, and their categories are Symptom_Categories, Activity_Categories, Medicine_Categories, and Food_Categories in the data model.

In the app, users can select trackable data points from a list of predefined options as well as add additional trackable data points to each tracker.

The trackable data points selected by the user are stored in the tables UserSymptomTrackers, UserActivityTrackers, UserMedicineTrackers, and UserFoodTrackers.

If a user wants to disable a tracker (e.g., user does not wish to track medicine), the information is stored in the UserSettings table.

4.3.3. Implementation

Creating an easy-to-use severity slider The severity slider was built as a reusable React component with the following interface:

```
interface SeveritySliderProps {
        value: number;
        onValueChange: (value: number) => void;
        previousValues?: { date: string; value: number }[];
        showPrevious?: boolean;
```

The implementation uses the "react-native-gesture-handler" library for handling gestures and utilizes the device's haptics engine to provide subtle feedback through soft and short vibrations.

Users can either drag the cursor along the severity slider from 0 to 10, or click directly on the slider to select a value.

To capture and react to these input methods, the component is wrapped in the following component:

```
<GestureDetector gesture={pan}>
        <GestureDetector gesture={press}>
                {...component code}
        </GestureDetector>
</GestureDetector>
```

To determine the nearest severity value during a drag or click event, the following algorithm was developed:

```
// determine the nearest value, which is clamped between 0 and 10
// the actual calculation is:
// * y position of the cursor (finger)
// * divided by the size of each severity box + gap between two boxes
const nearest = Math.min(
        Math.max(0, Math.floor(drag.y / (size + gap))),
        10
      );

// only if the value has actually changed, give the user feedback about
   it
if (nearest !== currentValue) {
  currentValue = nearest;
  // value Position is used to display the arrows along the value
```

```
  valuePosition = withClamp(
    { min: 0, max: 10 * totalHeight },
    withSpring(nearest * totalHeight)
  );

  // if the value has changed, a soft haptic feedback is called
  Haptics.impactAsync(Haptics.ImpactFeedbackStyle.Soft);
}
```

This effectively allowed to dynamically adjust the size of the severity boxes, depending on the amount of space available on the screen, whilst maintaining functionality.

If previous values should be shown, an array of previous values can be passed to the component.

Implementing an activity slider The activity slider features a different layout: it includes a horizontal slider for input and a numerical input box above it, allowing users to also specify a value in minutes.

This component has a different interface due to its additional configuration options:

```
type HorizontalSliderWithInputProps = {
  // the current value as a percentage of the maximum value (0-100)
        value?: number | undefined;
  onValueChange: (value: number | undefined) => void;
  // is called specifically if the numerical input was changed
  onInputValueChange?: (value: number | undefined) => void;
  // a suffix to display for numerical input field (usually "min", but
      could be "hours")
  suffix?: string;
  // the label to display above the slider
  label?: string;
  // a function that converts the % value back to a readable value for
      the user
  // e.g. 50% of 120 mins max -> (50) => "60"
  valueToText?: (value: number) => string;
  // a function that can be called to determine at any given value if the
       haptics
  // engine should be called
  // can be used e.g. to vibrate every 10 minute steps
  // (value) => value % 10 === 0
  shouldVibrate?: (value: number) => boolean;
}
```

The implementation is similar to the severity slider, however, the algorithm is slightly different:

```
// given a width (current value) and a total width of the slider, determine the
// percentage value (0 - 1)
const widthToValue = (w: number, pw: number) => {
    return Math.min(1, Math.max(0, w / pw));
  };

const value = widthToValue(drag.x, totalBarWidth);
const pValue = Math.round(value * 100);

if (shouldVibrate(pValue)) {
  Haptics.impactAsync(Haptics.ImpactFeedbackStyle.Soft);
}
```

The final “MinutesSlider” was implemented as follows:

```
const MinutesSlider = ({
  value,
  onValueChange,
  max = 120,
  min = 0,
  label,
}: {
  value: number | undefined;
  onValueChange: (value: number | undefined) => void;
  max?: number;
  min?: number;
  label?: string;
}) => {
  const clamped = Math.min(Math.max(min, value ?? min), max);
  const val = clamped ? (clamped / max) * 100 : 0;

  const percentageToMinute = (percentage: number) => {
    return Math.round((percentage / 100) * max);
  };

  return (
    <HorizontalSlider
      value={val}
      onValueChange={(next) => {
        if (next === undefined) {
          return onValueChange(undefined);
        }
        onValueChange((next / 100) * max);
      }}
      onInputValueChange={(next) => {
        if (next === undefined) {
          return onValueChange(undefined);
        }
        onValueChange(Math.min(max, Math.max(min, next)));
      }}
      shouldVibrate={(v) => percentageToMinute(v) % 10 === 0}
```

```
      suffix={"min"}
      label={label}
      valueToText={(v) => `${percentageToMinute(v)}`}
    />
  );
};
```

Reusing components The implementation of generic input methods helped accelerate the development of the screens. For example, the activity UI employs the slider to capture user input and directly writes the value to the database:

```
export default function LogActivity() {
  const startOfToday = DateTime.now().startOf("day");
  const { data: activities } = useLiveQuery(
    db.query.userActivities.findMany({
      with: {
        activity: {
          with: {
            logs: {
              where: gte(activityDailyLog.date, startOfToday.toJSDate()),
            },
          },
        },
      },
    })
  );

  return (
    <KeyboardView
      h="100%"
      flex={1}
      flexDirection="column"
      behavior="padding"
      borderTopEndRadius={40}
      borderTopStartRadius={40}
      backgroundColor="$background"
    >
          <View p={32} h="100%" flexDirection="column" flex={1} zIndex
            ={0}>
            <View
              w="100%"
              position="relative"
              flexGrow={0}
              flexShrink={0}
            >
              <TouchableOpacity
                style={{
                  position: "absolute",
                  top: 0,
                  right: 0,
```

```
                  opacity: 0.5,
                  zIndex: 10,
                }}
                onPress={() => {
                  router.back();
                }}
              >
                <X size={24} color={"#B0B3C2"} />
              </TouchableOpacity>
              <Text fontSize={"$8"} fontWeight={"600"} color="$textSecondary">
                What did you do today?
              </Text>
              <Text fontSize={"$6"} fontWeight={"400"} color="$textMuted">
                Tip: Hold and pull the activity to the right to easily adjust
                the duration or enter the duration manually.
              </Text>
            </View>
            <ScrollView
              w="100%"
              maxHeight={"75%"}
              flexGrow={1}
              mt={20}
              backgroundColor={"$background"}
              borderRadius={20}
            >
              <View h={200} py={20}>
                <View flexDirection="row" my={2} justifyContent="space-between">
                  <Text
                    fontSize={"$6"}
                    fontWeight={"500"}
                    color="$textSecondary"
                  >
                    Add an activity
                  </Text>
                  <OpenInfoSheet />
                </View>
                <Input
                  placeholder="Activity..."
                  backgroundColor={"rgba(57, 50, 85, 1)"}
                  h={42}
                  mb={12}
                />
                <Text fontSize={"$6"} fontWeight={"500"} color="$textSecondary">
                  Your activities
                </Text>
                <View flexDirection="column" gap={6}>
                  {activities?.map((userActivity) => {
                    return (
                      <MinutesDragSlider
```

```
                        value={userActivity.activity?.logs[0]?.value ?? undefined}
                        onValueChange={async (value) => {
                          if (userActivity.activity?.logs[0]) {
                            await db.update(activityDailyLog).set({
                              value: value,
                            }).where(eq(
                              activityDailyLog.activityId, userActivity.activityId!
                            ))
                          } else {
                            await db.insert(activityDailyLog).values({
                              id: `${userActivity.activityId}-${DateTime.now().toISO()}`,
                              value: value!,
                              activityId: userActivity.activityId!,
                              date: DateTime.now().toJSDate(),
                            });
                          }
                        }}
                        min={0}
                        max={120}
                        label={userActivity.activity?.title ?? "Activity"}
                      />
                    );
                  })}
                </View>
              </View>
            </ScrollView>
            <View
              mt={10}
              flexGrow={0}
              flexShrink={0}
              w="100%"
              px={32}
              flexDirection="column"
              gap={8}
            >
              <Button rightIcon={<ChevronRight size={24} color={"#fff"} />}>
                Continue
              </Button>
            </View>
          </View>
    </KeyboardView>
  );
}
```

The implementation of the app was not completed, leaving certain features for future development. However, the components that were implemented aim to provide a foundation for further development. The link to the Git repository is provided in Appendix G and a screen recording of a walkthrough of the implemented app is available in Appendix H.

4.4. Evaluation

4.4.1. Preliminary measures

For the evaluation, an expert interview was conducted where two participants were invited to observe and evaluate the design concept. To maintain anonymity, the experts will be referred to as E1 and E2.

E1 is an assistant professor with a background in movement sciences and currently works primarily on citizen science projects, where patient expertise is integrated into research. The current research E1 is involved in, mainly focuses on fatigue and self-management in individuals with chronic conditions, making this expert an ideal candidate for an expert interview. E2 is a junior researcher at an impact lab specializing in personalized health technologies. E2 focuses on developing health technologies that support individuals with chronic diseases, particularly through self-management. Currently, E2 is working on a project aimed at developing technology to support individuals with chronic lung conditions in self-management.

4.4.2. Study procedure

The interviews were conducted and recorded using the online conference software Webex. During the interviews, the clickable Figma prototype was shared with the experts, who then shared their screens, allowing the observation of their interactions with the app. The interviews followed a semi-structured format, with specific tasks (see Appendix D) to complete within the prototype (see Appendix E) whilst also allowing follow-up questions to gain deeper insights into the experts' feedback.

The tasks aimed to simulate the experience of a long COVID patient using the app for the first time, beginning with the onboarding process, followed by the entry of symptoms and additional factors for the current day, and concluding with a brief exploration of the user settings.

4.4.3. Data analysis

The expert interviews were transcribed using the Aiko app [31]. The qualitative data was then analyzed using a method similar to the thematic analysis approach adopted for the user interviews. The data was organized by the tasks that the experts were given, which were treated as themes. The information from each interview was then combined to provide a comprehensive overview of the expert feedback on the various features of the app. The results of this analysis are presented in the subsequent section.

4.4.4. Results of the evaluation

The feedback of the two experts will be presented in the sequence of the app walkthrough to maintain coherence and clarity.

The first screen of the prototype was the home screen in its pre-onboarding state. E2 appreciated the concise welcoming text, noting that excessively lengthy text can diminish user motivation. Additionally, E2 praised the color scheme, expressing that it avoids conflicts and excessive brightness.

When **selecting symptom categories** on the first screen of the onboarding process, E2 appreciated the colors of the buttons changing upon selection but suggested enhancing intuitiveness by adding icons or symbols to the categories.

When **selecting symptoms** in the next screen, E2 appreciated the option to add custom symptoms but questioned why additions were not possible for the “fatigue” category.

When **selecting further factors** to track, E1 identified an issue with the title “Select additional things you would like to track”, stating that the title suggested an action contrary to what users needed to perform on the page, which was deselecting pre-selected options if they did not wish to track these. After explaining that this design decision had been made to encourage users to track more factors, E1 recommended changing the title to better reflect the expected user interaction. After also experiencing difficulty realizing that factors were selected by default and needed to be deselected, E2 likewise recommended ensuring coherence between titles and expected actions but additionally expressed concern that having all factors pre-selected might overwhelm some patients. E2 also questioned whether users would understand the use of toggle buttons and suggested exploring alternative buttons to enhance intuitiveness. After deselecting the factor “stress level”, E2 appreciated the color change, noting that it now clearly indicated the factor had been deselected.

When **selecting activities** to track, E2 appreciated that the suggested activities were tailored to the needs of long COVID patients, focusing on low-intensity rather than high-intensity exercises, noting that this could subconsciously motivate patients to try out some of these activities for symptom management.

When **entering medications and supplements**, E2 appreciated the use of the barcode scanner.

In the final section of the onboarding process, when **selecting dietary intake factors**, E1 noted that it could be beneficial to provide users with information on why certain foods or food groups had been suggested, recommending that users could either find this information directly on the page or have the option to access additional sources. E2 suggested implementing a barcode scanner for scanning foods, similar to the one used for medications and supplements. E2 also noted that the term ‘dietary intake’ should be added to this page for clarity.

Once the onboarding was completed, the experts were asked about how they expected to enter data. Both experts stated the expectation to enter data by clicking on the separate factors (e.g., Symptoms, Activities, Medications, etc.), which is one of the correct methods. Despite some uncertainty, E2 also correctly identified the option to add symptoms, activities, etc., using the plus button in the menu. However, neither one of the experts recognized the “daily check-in” option, which allows all factors to be entered consecutively, aiming to simplify data entry for users who wish to log all data at once. E2 also mentioned expecting to answer a few questions as part of the check-in. After clarification, E1 suggested enhancing the design to make the feature more prominent and intuitive and E2 suggested adding a tip to better explain the function.

Both experts encountered difficulty recognizing that the current page was the home page. While examining the home page, E2 also proposed integrating data from smartwatches to streamline data entry for data such as daily activities.

Next, the experts were asked to log their data for the current day.

When **logging the severity of their symptoms**, both experts appreciated the design of the severity scale and its color gradient. E1 additionally highlighted the utility of the 0 to 10 numbering system and the labels ranging from “none” to “severe”. E1 expressed the expectation to enter whole numbers and that selecting a value would display the next symptom, both of which were confirmed. E2 found the arrow confusing, stating that users could mistake this for a pre-entered value and emphasized the need for some kind of feedback to confirm the entered value. E2 also suggested using a different color for symptom names, noting that they blend into the page, potentially causing users to overlook the transition to the next symptom. Both experts appreciated the option to view data from the previous entry, E1 explaining that many users compare their current condition to the previous day. E1 appreciated that each symptom was entered sequentially, stating that this avoided clutter, adding that the progress bar served as an effective motivational tool by allowing users to see how far they were in the data entry process. Additionally, E1 recommended adding a back button to allow users to easily return to the previous page during the data entry process, noting that swiping right to navigate back might not be intuitive for users of all age groups. E1 also suggested considering enabling multiple symptom entries per day to capture varying severities.

When **logging activities**, E1 quickly recognized the adjustable sliders and the option to manually enter the duration, and E2 noted the benefit of the given tip, suggesting that the fact that the minutes could also be entered manually should be added in the tip. E2 also noted that it was unclear why there was the option to add another activity after the activities had been added in the onboarding. This prompted the idea of adding an info button. E1 expressed concern about horizontal scrolling potentially triggering discomfort for patients sensitive to scrolling. Although the assumption during the design phase was that horizontal scrolling would be less problematic than vertical scrolling, as the only moving element is the slider itself, which should strain the eyes less, this requires validation through user testing. A potential solution that could also be considered in future work would be to incorporate a setting that allows users to further minimize movement within the app.

When **logging medications and supplements**, E2 appreciated the inclusion of supplements, noting their importance for some patients and E1 appreciated the barcode scanning feature. E1 expressed concern about the inconvenience of logging medications individually, particularly for users who wished to log multiple daily medications and suggested implementing a pre-filled list with the option to remove individual medications. However, it was also mentioned that incorporating the option for users to input the amount and time of each medication, if required, could present a challenge within this design suggestion. Regarding the issue of having to log medications individually, E2 agreed that manual entry can be time-consuming and demotivating and suggested allowing users to group medications to streamline the process.

When **logging the options for dietary intake**, E1 appreciated the feature suggesting various factors to track, allowing users to monitor a wide range of options. E1 noted that this approach could also benefit future research, particularly given the limited understanding of factors influencing long COVID.

E2 appreciated the personalized message displayed after the entries had been completed, explaining that it effectively employed behavior change techniques and added a subtle element of gamification. E1 stated that the primary motivation for self-tracking is intrinsic.

When asked to **add stress levels back as a factor to log**, E1 initially found it challenging to understand that this was incorporated into the user settings. E2 contemplated between the plus button in the menu and the user settings but ultimately navigated to the user settings. E2 did however later appreciate the use of icons in the menu that opened through the plus button.

After logging the stress level, E1 suggested positioning this underneath the symptoms on the home page, since stress is closely related to the symptoms.

After seeing the user settings in the previous task, when asked to **remove a symptom** that no longer affects the patient, E1 found the process of removing a symptom straightforward. E2 first attempted to click on the three dots next to the symptoms on the home screen, but since this functionality was not implemented in the prototype, E2 then navigated to the user settings and successfully removed the symptom. E1 appreciated the popup message, noting that it effectively addressed concerns about whether the data associated with the symptom would also be deleted upon its removal, but suggested changing the terminology of “deleting a symptom” to avoid confusion.

While discussing further features of the app, E1 advised against integrating a social function (the “Community” tab) within the app, highlighting findings from previous research indicating that users tend to prefer self-tracking apps to be separate from social apps. E1 also emphasized the importance of community forums requiring moderation and expressed concerns about potential user demotivation from negative posts. Instead, an “Information” tab was discussed for future work, to provide users with beneficial information.

When asked about thoughts on the community tab, E2 noted that a network could be beneficial for users, also recognizing that some individuals have a need to share their stories and receive support, though this might not appeal to everyone. E2 suggested including an option to deactivate the community function, allowing each user to decide for themselves, and also suggested limiting certain functions to prevent misuse.

4.4.5. Final design concept

The expert evaluations yielded a valuable list of improvements for the design concept. Several of these suggestions were incorporated into the final design, however, due to constraints such as limited time and resources (e.g., for user testing), some improvements were deferred to future work.

In the **symptom category selection** section of the onboarding process, icons were added to the categories to improve intuitiveness.

In the **symptom selection** section, the option to add custom symptoms was also added under the category ‘Fatigue.’

In the **further factor selection** section, the initial state of the factors was changed from pre-selected to not selected to ensure coherence between the title and the expected user actions. An alternative approach would have been to modify the title from “Select the additional factors you would like to track” to “Deselect the additional factors you do not wish to track,” however, the decision was made to maintain the overall consistency of the onboarding process and ensure that the format was consistent with the other questions that prompt users to “select” factors.

In the **dietary intake** factors selection section, an ‘info’ button was added to explain why certain foods or food groups are suggested. Additionally, a barcode scanner was integrated to facilitate easier input of food items, and the term ‘dietary intake’ was included in the section title for better context.

The design of the ‘Check-in’ box on the **home page** was enhanced to align with the other factor entry buttons, aiming to increase its visibility and indicate that it is interactive. Furthermore, the text within the box was updated to provide clearer guidance on its functionality, making it more intuitive for users.

In the **symptom entry** section of the daily log, the color of the symptom names was improved to enhance visibility.

In the **activity entry** section, an explanation that users can manually enter the time by clicking on the time field was added to the tip. Additionally, an ‘info’ button was placed next to the option to add an activity, to explain the intention behind this option, which is to allow and promote users to record one-time or infrequent activities.

The **medication and supplement entry** section was redesigned to allow users to log multiple entries simultaneously. In response to expert feedback, a pre-filled list was implemented, enabling users to quickly select and remove medications that were not taken on a given day.

'Back' buttons were added **throughout the app** to improve user experience in terms of navigation, allowing users to return to previous screens easily.

Additionally, the terminology 'delete a symptom' was changed to 'stop tracking a symptom' in the **symptom settings**.

The final design concept, incorporating the aforementioned improvements, is presented in the following Figures 20, 21 and 22. The improved clickable prototype can be found in Appendix F.

Select your symptom categories
Select the categories that suit your symptoms or click on "select all" below to see a list of all the symptoms.

Select your symptoms
These will be shown to you daily. You can always edit these or add more in the settings.

Select additional factors you would like to track
Tracking additional data such as your activities, medications and food can help you identify correlations to help keep your symptoms at bay.

Select your most frequent activities
These will be shown to you daily. You can always edit these or add more in the settings.

Enter any medication or supplement you take often
This is for easy access. You can always edit these or add more in the settings.

Add a medication or supplement
Name: Paracetamol 500mg
Note: Write a note here...

Your medications
Once you log something, it will be listed here.

Choose or enter the foods and food groups you would like to track
This is for easy access. You can always edit these or add more in the settings.

Your foods
Once you log something, it will be listed here.

Onboarding complete!
You can change all settings in the "User Settings" tab in the menu.

Figure 20: Final Design Concept: Onboarding

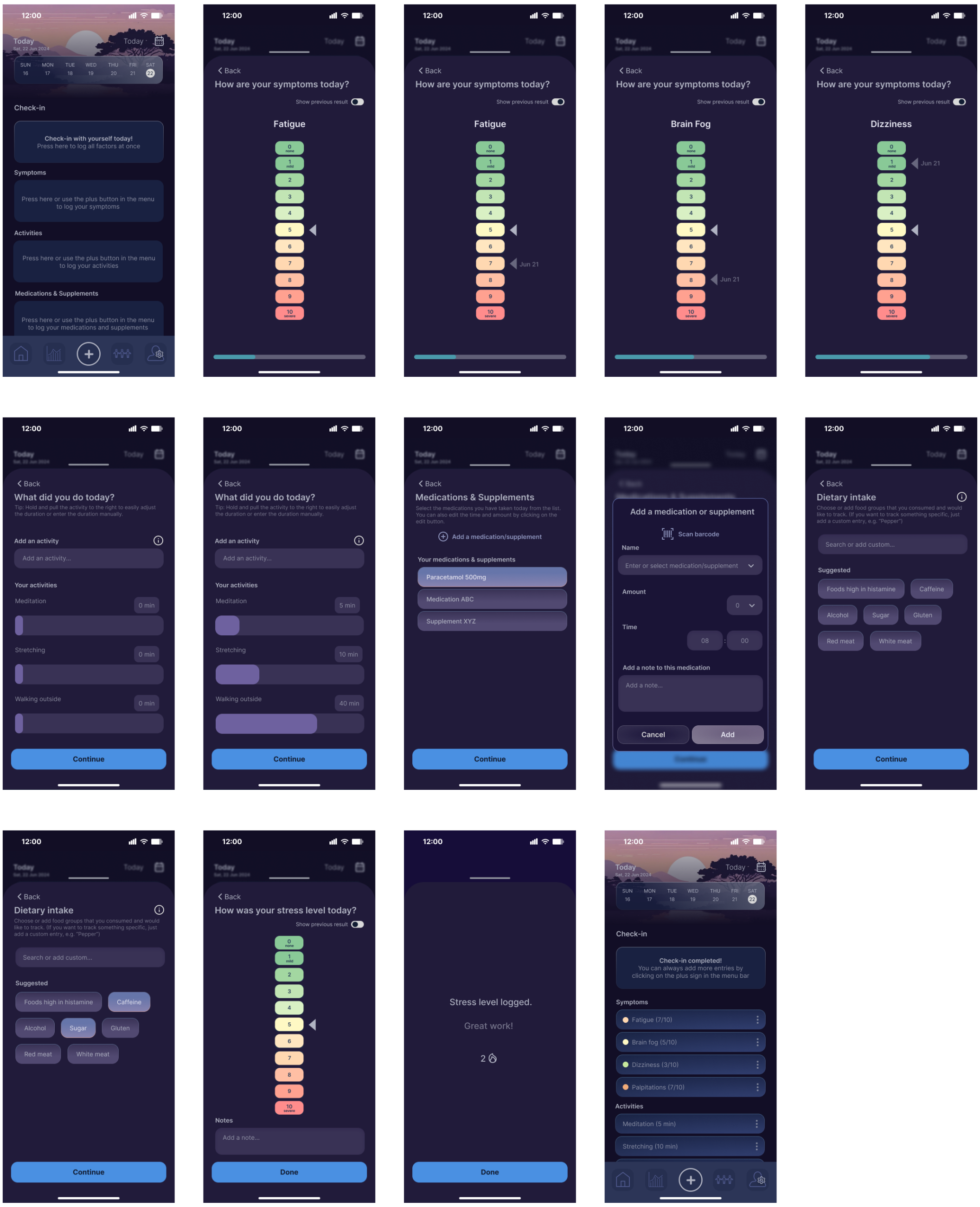
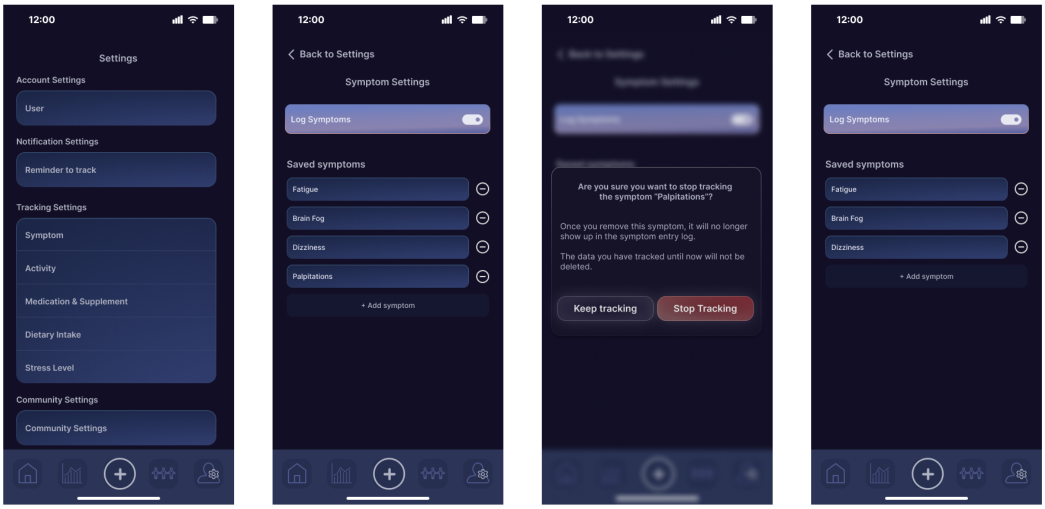


Figure 21: Final Design Concept: Daily Data Entry



Are you sure you want to stop tracking the symptom "Palpitations"?

Once you remove this symptom, it will no longer show up in the symptom entry log.

The data you have tracked until now will not be deleted.

Figure 22: Final Design Concept: Settings

5. Discussion

5.1. Results of the thesis

This thesis aimed to develop a design concept for a self-tracking mobile health application tailored to the needs of long COVID patients, with the objective of motivating sustained self-tracking and facilitating the collection of comprehensive data. The resulting design concept, presented in section 4.4.5, incorporates a range of features and components specifically selected to address the unique requirements of patients suffering from this condition.

Key findings integrated into the design concept include:

- **Minimizing visual clutter:** The app should emphasize a clean and simple interface, ensuring that patients are not overwhelmed by visual elements.
- **Simplified interaction:** The design should minimize the need for text entry and instead, rely on click-based interactions wherever possible. For instances where text entry is necessary, features such as speech-to-text and dictation functions can be included to further ease the process.
- **Visual appeal and accessibility:** The app should be designed to be visually appealing while avoiding bright, high-contrast colors that could cause discomfort.
- **Customization possibility:** The app should provide customization options to allow users to tailor the types and depth of data they track according to their individual needs and preferences.

A significant insight from the study is that the motivation for long COVID patients is primarily driven by the overall suitability and usability of the app. While subtle elements of gamification and other motivational features can contribute, the main emphasis should be on creating a seamless, effective user experience that facilitates an easy self-tracking journey. The app should provide a functional and efficient tool that meets patients' needs without causing frustration or them to feel overwhelmed. It is safe to say that the motivation of long COVID patients is largely intrinsic, and can be enhanced by the app's ability to offer meaningful insights regarding their condition.

5.2. Limitations

One of the challenges faced early in the research phase was the scarcity of research focusing on the design and motivational needs of users, especially those with chronic conditions such as long COVID and ME/CFS. This limited the ability to make research-backed design choices and forced the choices to rely heavily on the requirements derived from the interviews with patients.

The user interviews were limited to four patients, despite a month-long recruitment effort. This was largely due to the complexity of managing their many symptoms. All of the patients who showed interest in the interviews suffered from fatigue and therefore needed to pace their day, or sometimes even week carefully, to participate in such an interview. Further factors such as extended response times from participants and the need for significant recovery periods before and after medical appointments further complicated the interview process.

While the interviews proved successful in gathering a lot of feedback and this feedback showed consistency regarding the requirements, insights gained from a larger and more diverse group, with a broader range of participants, especially including those with varying levels of technical affinity, could have been even more comprehensive.

In addition to this, iterative user testing during the design phase would have been beneficial, however, this was not possible due to the lack of time and the aforementioned issues of planning such interviews with long COVID patients.

Usability tests after expert evaluations would have also been beneficial. For example, feedback from one expert suggested that pre-selecting all factors in the factor selection section of the onboarding process might overwhelm some patients, although the intention behind this design choice was to encourage users to track more factors. This could have been easily identified in a usability test. Concerns regarding the intuitiveness of toggle buttons or horizontal scrolling potentially causing discomfort for patients sensitive to such interactions could have also been looked into in usability tests.

During the expert evaluation, it became apparent that the design of the medications page, which required logging each medication individually, might not be suitable for patients who take multiple medications throughout the day. The requirement to facilitate the entry of multiple medications while capturing details such as the time, amount taken, and notes for each medication (rather than each instance) presented a significant design challenge. Although a preliminary solution for logging multiple medications was integrated into the final design concept, it was not possible to refine the page adequately due to time constraints.

A further limitation due to time constraints and complexity was the implementation of the design concept. While part of the design concept was implemented, as detailed in the Implementation section (see 4.3.3), the app could not be fully developed. However, the Git repository for the project is provided in that section, allowing for continued development in the future.

5.3. Future work

Building on the insights from this thesis as well as the faced limitations, several areas present opportunities for the refinement and future development of the app.

As mentioned in the limitations section, the design concept for the daily medication entry requires further development. One expert suggested a pre-filled list of medications with the option to remove individual items, which was incorporated in the final designs. Another expert suggested allowing users to group medications (e.g., by administration time) to facilitate data entry. Further work is needed here to find a design solution that allows for the tracking of enough variables without being overwhelming.

The design concept could also be expanded to support multiple symptom entries within a single day, enabling users to capture variations in severity. This would provide a more in-depth understanding of symptom fluctuations. To enable this even further, the further factors could also be expanded with details such as timestaps, enabling users who wish to enter this detailed data to see clearly, when what symptom was bad and what factors were logged at similar times, possibly affecting it. It is important to note however, that this too would have to be designed in such a way that users are given the option but are not obliged to enter their factors in such complexity, as it was seen in the user interviews that although some users are interested in entering very detailed data, some find this overwhelming or unnecessary.

Small nuances that could improve the user experience could also be explored and added in future work. For example, in the expert interviews, one expert suggested repositioning the “Stress level” factor underneath “Symptoms” on the home page, noting the close relationship between stress and symptoms. This prompted the idea of allowing users to reorder factors according to their preferences. Implementing such nuances of customizability would also need to be done in a manner that is both simple and intuitive, to avoid visual clutter while enhancing user control over the interface.

As the onboarding process was added to the scope of this thesis to streamline data entry, the app could be further enhanced with a feature tour. This additional component would introduce users to the app’s key features and layout, potentially simplifying their initial interaction and improving overall user experience.

Future work could explore the integration of smart devices, such as smartwatches, to incorporate automatically tracked data, which could also streamline the data entry process of some factors. However, it is important to note that ensuring users retain sufficient control over modifying this data would be crucial to avoid overwhelm.

Further work could also explore the patients’ perspective on a community tab. Although not within the scope of this thesis, the interviews involved discussions about its potential integration and revealed mixed opinions. While some users expressed a desire for a community feature for patients to share experiences and receive support, others preferred keeping self-tracking separate from social interactions. Concerns about moderation and the risk of negative posts discouraging users were also highlighted in the interviews with experts. Future iterations could consider allowing users to deactivate the community function. An “Information” tab offering valuable resources, could also replace the community tab.

The most significant opportunity for future work lies in the data visualization aspect. The project's focus on understanding factors for motivation for long COVID patients and designing a concept to support their sustained self-tracking practices was aimed at ensuring the collection of sufficient data for meaningful self-reflection. Achieving this goal relies on the development of effective data visualization solutions. Future work should address the visualization of individual factors in depth, while also exploring methods to compare and combine different data points to help patients gain a deeper understanding of their condition and identify correlations, ultimately aiding in better management and self-reflection.

6. Conclusion

Long COVID, an extension of the SARS-CoV-2 coronavirus infection, is characterized by the persistence or emergence of symptoms lasting at least two months after the initial illness. With over 200 identified symptoms, this condition significantly impacts patients' quality of life [36]. The vast array of symptoms complicates the process of understanding and managing the condition.

Self-reflection is essential for patients with long COVID as it offers the possibility for them to gain insights and identify patterns about their condition over time [25]. However, effective self-reflection depends on the ability to collect sufficient and relevant data, which can be realized with self-tracking.

While numerous self-tracking apps exist, few are tailored specifically to the needs of long COVID patients, leading to potential difficulties and demotivation in maintaining self-tracking practices.

This thesis addressed this gap by developing a design concept for a self-tracking app customized to the needs of long COVID patients. The study found that usability and relevance are crucial motivators for these patients. Consequently, the proposed design emphasizes a clean interface, simplified interactions, visual comfort, and customization options, while also incorporating personalized encouragement and positive reinforcement.

Limitations faced during the study included a small participant sample and time constraints affecting the testing and evaluation of the design concept by potential users.

Future development of the design concept should focus on refining medication tracking, expanding symptom tracking capabilities, and integrating data from smart devices to streamline data entry. Additionally, exploring community features could further enhance user experience.

The most significant opportunity for future work lies in studying the data visualization needs of long COVID patients and integrating these insights into the app, providing a comprehensive tool that supports patients in managing their condition effectively.

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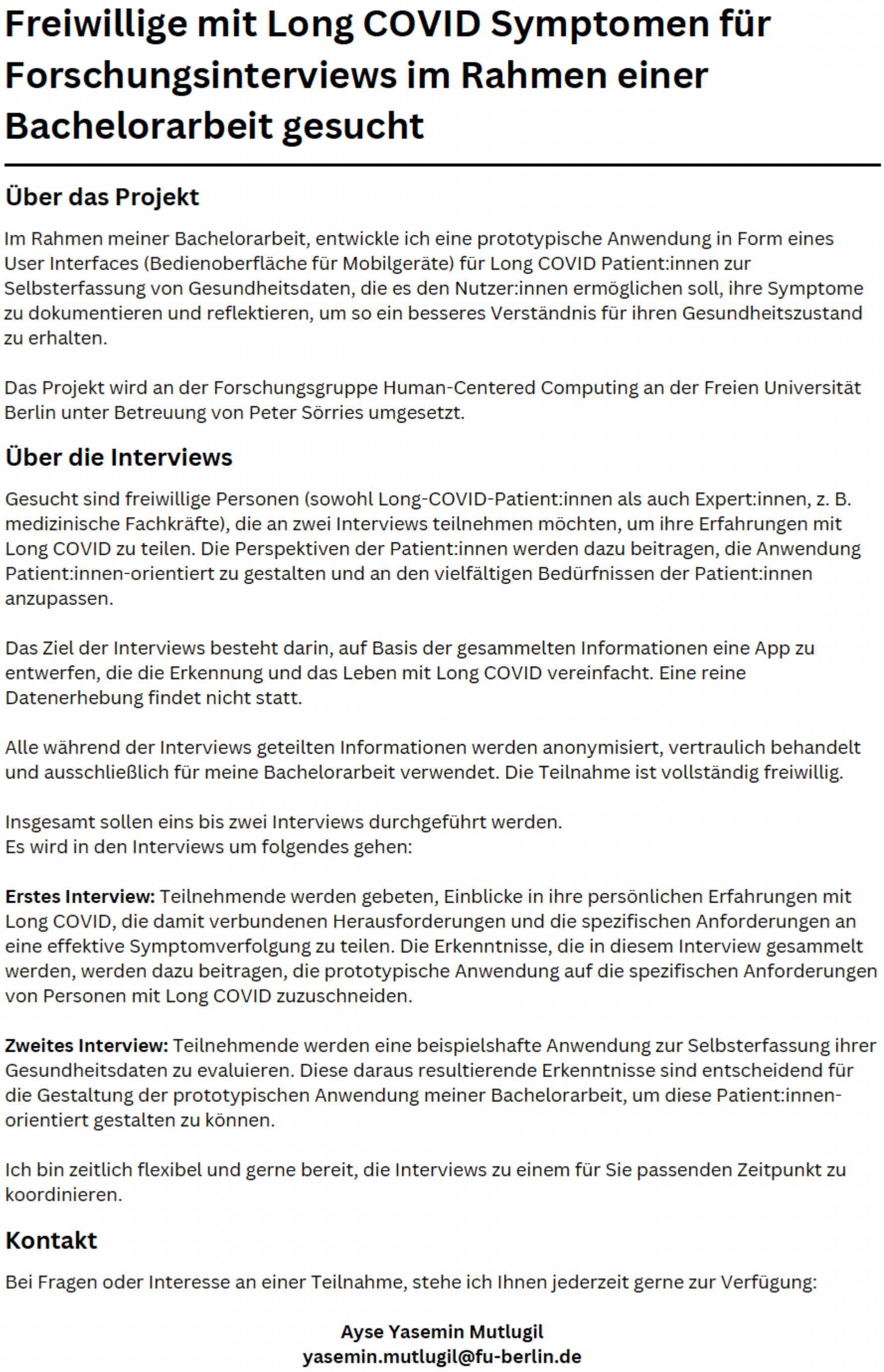
Appendix

A. Interview flyers



Freiwillige mit Long COVID Symptomen für Forschungsinterviews im Rahmen einer Bachelorarbeit gesucht

Über das Projekt

Im Rahmen meiner Bachelorarbeit, entwickle ich eine prototypische Anwendung in Form eines User Interfaces (Bedienoberfläche für Mobilgeräte) für Long COVID Patient:innen zur Selbsterfassung von Gesundheitsdaten, die es den Nutzer:innen ermöglichen soll, ihre Symptome zu dokumentieren und reflektieren, um so ein besseres Verständnis für ihren Gesundheitszustand zu erhalten.

Das Projekt wird an der Forschungsgruppe Human-Centered Computing an der Freien Universität Berlin unter Betreuung von Peter Sörries umgesetzt.

Über die Interviews

Gesucht sind freiwillige Personen (sowohl Long-COVID-Patient:innen als auch Expert:innen, z. B. medizinische Fachkräfte), die an zwei Interviews teilnehmen möchten, um ihre Erfahrungen mit Long COVID zu teilen. Die Perspektiven der Patient:innen werden dazu beitragen, die Anwendung Patient:innen-orientiert zu gestalten und an den vielfältigen Bedürfnissen der Patient:innen anzupassen.

Das Ziel der Interviews besteht darin, auf Basis der gesammelten Informationen eine App zu entwerfen, die die Erkennung und das Leben mit Long COVID vereinfacht. Eine reine Datenerhebung findet nicht statt.

Alle während der Interviews geteilten Informationen werden anonymisiert, vertraulich behandelt und ausschließlich für meine Bachelorarbeit verwendet. Die Teilnahme ist vollständig freiwillig.

Insgesamt sollen eins bis zwei Interviews durchgeführt werden.
Es wird in den Interviews um folgendes gehen:

Erstes Interview: Teilnehmende werden gebeten, Einblicke in ihre persönlichen Erfahrungen mit Long COVID, die damit verbundenen Herausforderungen und die spezifischen Anforderungen an eine effektive Symptomverfolgung zu teilen. Die Erkenntnisse, die in diesem Interview gesammelt werden, werden dazu beitragen, die prototypische Anwendung auf die spezifischen Anforderungen von Personen mit Long COVID zuzuschneiden.

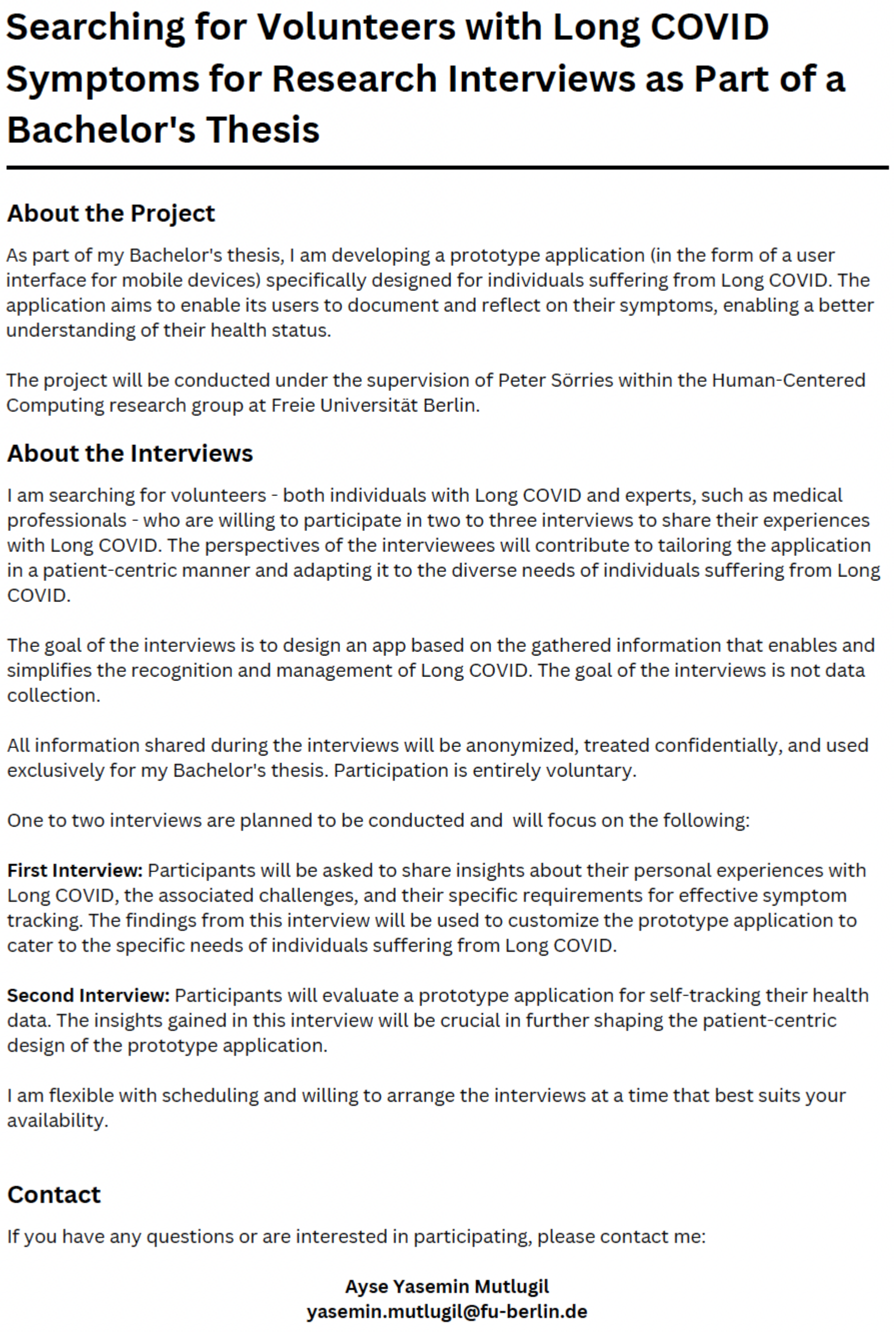
Zweites Interview: Teilnehmende werden eine beispielshafte Anwendung zur Selbsterfassung ihrer Gesundheitsdaten zu evaluieren. Diese daraus resultierende Erkenntnisse sind entscheidend für die Gestaltung der prototypischen Anwendung meiner Bachelorarbeit, um diese Patient:innen-orientiert gestalten zu können.

Ich bin zeitlich flexibel und gerne bereit, die Interviews zu einem für Sie passenden Zeitpunkt zu koordinieren.

Kontakt

Bei Fragen oder Interesse an einer Teilnahme, stehe ich Ihnen jederzeit gerne zur Verfügung:

Ayse Yasemin Mutlugil
yasemin.mutlugil@fu-berlin.de



Searching for Volunteers with Long COVID Symptoms for Research Interviews as Part of a Bachelor's Thesis

About the Project

As part of my Bachelor's thesis, I am developing a prototype application (in the form of a user interface for mobile devices) specifically designed for individuals suffering from Long COVID. The application aims to enable its users to document and reflect on their symptoms, enabling a better understanding of their health status.

The project will be conducted under the supervision of Peter Sörries within the Human-Centered Computing research group at Freie Universität Berlin.

About the Interviews

I am searching for volunteers - both individuals with Long COVID and experts, such as medical professionals - who are willing to participate in two to three interviews to share their experiences with Long COVID. The perspectives of the interviewees will contribute to tailoring the application in a patient-centric manner and adapting it to the diverse needs of individuals suffering from Long COVID.

The goal of the interviews is to design an app based on the gathered information that enables and simplifies the recognition and management of Long COVID. The goal of the interviews is not data collection.

All information shared during the interviews will be anonymized, treated confidentially, and used exclusively for my Bachelor's thesis. Participation is entirely voluntary.

One to two interviews are planned to be conducted and will focus on the following:

First Interview: Participants will be asked to share insights about their personal experiences with Long COVID, the associated challenges, and their specific requirements for effective symptom tracking. The findings from this interview will be used to customize the prototype application to cater to the specific needs of individuals suffering from Long COVID.

Second Interview: Participants will evaluate a prototype application for self-tracking their health data. The insights gained in this interview will be crucial in further shaping the patient-centric design of the prototype application.

I am flexible with scheduling and willing to arrange the interviews at a time that best suits your availability.

Contact

If you have any questions or are interested in participating, please contact me:

Ayse Yasemin Mutlugil
yasemin.mutlugil@fu-berlin.de

B. Consent form

Information und Einverständniserklärung
Erhebung, Verarbeitung und Übermittlung von personenbezogenen Daten

1. Grundlegende Informationen

Name der/des Teilnehmenden:	______________________________
Datum:	______________________________
Ort:	______________________________
Titel der Forschung:	**Design, Implementation and Evaluation of a Self-Tracking-Application for Long COVID Patients**
Untersuchende/r Forscher:innen:	Ayse Yasemin Mutlugil

Vielen Dank, dass Sie zugestimmt haben, an der oben genannten Forschung teilzunehmen. Forschungsethik und Datenschutzbestimmungen (d. h. DSGVO[1]) erfordern, dass die Teilnehmenden ausdrücklich zustimmen, aufgezeichnet zu werden und wie die erhobenen Informationen verwendet werden. Diese Informations- und Einwilligungserklärung ist notwendig, damit wir sicherstellen können, dass Sie den Zweck Ihrer Teilnahme verstehen und mit den Bedingungen Ihrer Teilnahme einverstanden sind. Ihre Einwilligung stellt gemäß Art. 6 Abs. 1 lit. a DSGVO die Rechtsgrundlage für die Datenverarbeitungsprozesse im Zuge der Forschung dar.

2. Hintergrund
Hintergrund dieser Forschung ist es, die Motivation von Long-COVID-Patient:innen bezüglich der Datenerhebung zu untersuchen. Ziel ist es, ein Konzept für eine Self-Tracking-App zu entwickeln, die Patient:innen unterstützt, ihre Symptome besser zu verstehen und zu managen.

3. Ablauf
Die Forschung findet in einem Zeitraum von ca. 3 Monaten statt. Der Ablauf der Evaluation erfolgt mittels semi-strukturierter Interviews und der Analyse der gesammelten Informationen. Falls notwendig, werden Bilder und ggf. Videos von den Forscher:innen gemacht. Mit Ihrer Teilnahme werden keine Risiken erwartet, aber Sie haben das Recht, eine Aufnahme jederzeit abzubrechen oder von der Forschung zurückzutreten. Es kann sein, dass Nachfragen zur weiteren Klärung erforderlich sind. Wenn dies der Fall ist, werden wir Sie per E-Mail kontaktieren, um dies zu erbitten.

3. Datenverwertung und -veröffentlichung
Elemente des digitalen Dokuments dürfen in anonymisierter Form direkt oder indirekt in meiner Abschlussarbeit zitiert und angezeigt werden.

4. Entschädigung
Sie werden für die Teilnahme an dieser Forschung nicht entlohnt.

5. Vertraulichkeit
Ihre Daten werden vertraulich behandelt. Der Zugang zu Ihren Daten (Transkripte) wird auf mich (Untersuchende/r Forscher:innen) beschränkt sein. Wir werden einzelne Namen stets anonymisieren.

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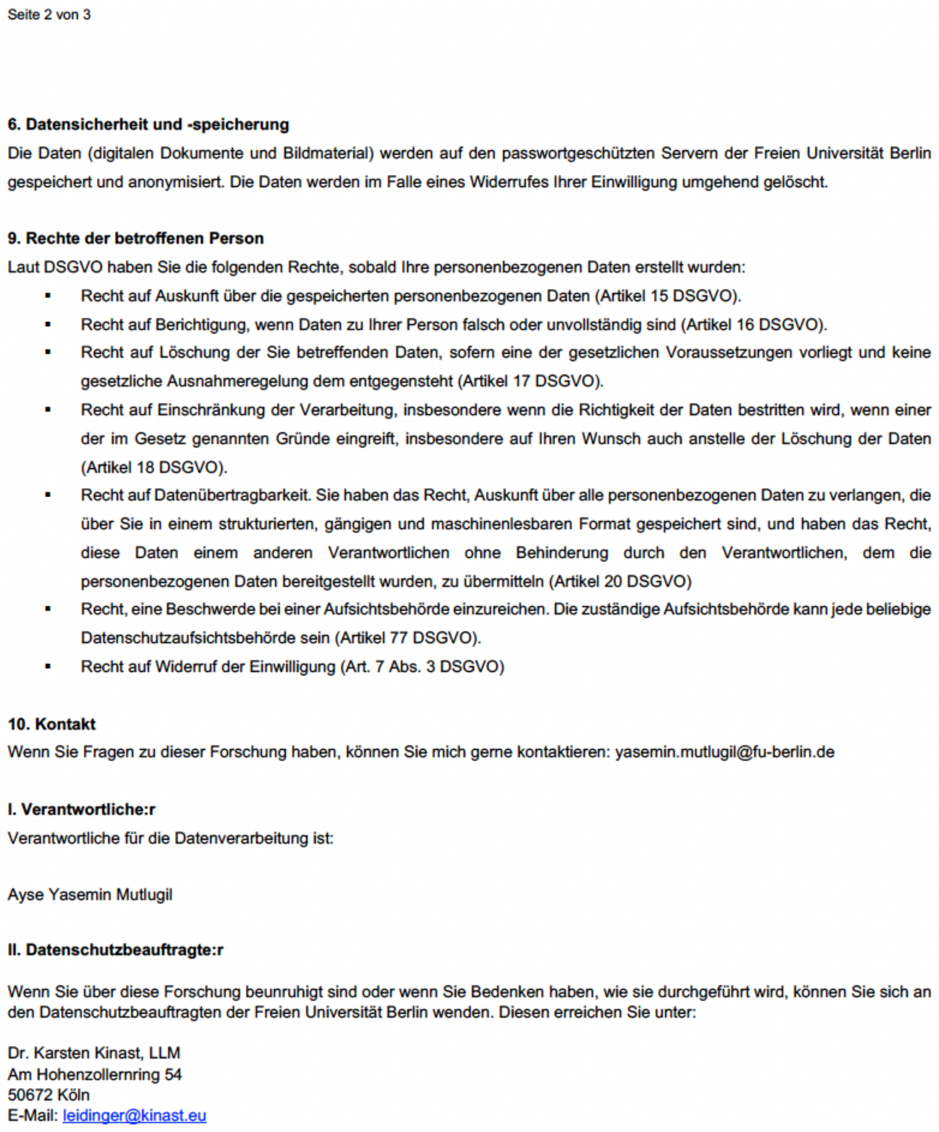
[1] Weitere Informationen zur DSGVO finden Sie unter: https://dsgvo-gesetz.de/



6. Datensicherheit und -speicherung

Die Daten (digitalen Dokumente und Bildmaterial) werden auf den passwortgeschützten Servern der Freien Universität Berlin gespeichert und anonymisiert. Die Daten werden im Falle eines Widerrufes Ihrer Einwilligung umgehend gelöscht.

9. Rechte der betroffenen Person

Laut DSGVO haben Sie die folgenden Rechte, sobald Ihre personenbezogenen Daten erstellt wurden:

- Recht auf Auskunft über die gespeicherten personenbezogenen Daten (Artikel 15 DSGVO).
- Recht auf Berichtigung, wenn Daten zu Ihrer Person falsch oder unvollständig sind (Artikel 16 DSGVO).
- Recht auf Löschung der Sie betreffenden Daten, sofern eine der gesetzlichen Voraussetzungen vorliegt und keine gesetzliche Ausnahmeregelung dem entgegensteht (Artikel 17 DSGVO).
- Recht auf Einschränkung der Verarbeitung, insbesondere wenn die Richtigkeit der Daten bestritten wird, wenn einer der im Gesetz genannten Gründe eingreift, insbesondere auf Ihren Wunsch auch anstelle der Löschung der Daten (Artikel 18 DSGVO).
- Recht auf Datenübertragbarkeit. Sie haben das Recht, Auskunft über alle personenbezogenen Daten zu verlangen, die über Sie in einem strukturierten, gängigen und maschinenlesbaren Format gespeichert sind, und haben das Recht, diese Daten einem anderen Verantwortlichen ohne Behinderung durch den Verantwortlichen, dem die personenbezogenen Daten bereitgestellt wurden, zu übermitteln (Artikel 20 DSGVO)
- Recht, eine Beschwerde bei einer Aufsichtsbehörde einzureichen. Die zuständige Aufsichtsbehörde kann jede beliebige Datenschutzaufsichtsbehörde sein (Artikel 77 DSGVO).
- Recht auf Widerruf der Einwilligung (Art. 7 Abs. 3 DSGVO)

10. Kontakt

Wenn Sie Fragen zu dieser Forschung haben, können Sie mich gerne kontaktieren: yasemin.mutlugil@fu-berlin.de

I. Verantwortliche:r

Verantwortliche für die Datenverarbeitung ist:

Ayse Yasemin Mutlugil

II. Datenschutzbeauftragte:r

Wenn Sie über diese Forschung beunruhigt sind oder wenn Sie Bedenken haben, wie sie durchgeführt wird, können Sie sich an den Datenschutzbeauftragten der Freien Universität Berlin wenden. Diesen erreichen Sie unter:

Dr. Karsten Kinast, LLM
Am Hohenzollernring 54
50672 Köln
E-Mail: leidinger@kinast.eu

Einverständniserklärung

Mit meiner Unterschrift erkläre ich mich damit einverstanden, an dieser Forschung gemäß den Bedingungen des Informationsblattes (Seiten 1-2 dieses Dokuments), teilzunehmen.

Im Einzelnen willige ich in die folgenden Verarbeitungsvorgänge im Zuge dieser Forschung ein:

☐ Anfertigung von Bild- und Videoaufnahmen während der Forschung.

☐ Anonymisierte Nutzung der Transkripte für meine Abschlussarbeit

Diese Einwilligungserklärung wird auf freiwilliger Basis erteilt und kann jederzeit formlos mit Wirkung für die Zukunft gegenüber Ayse Yasemin Mutlugil widerrufen werden, ohne dass dies nachteilige Folgen hätte.

____

Unterschrift der/des Teilnehmenden

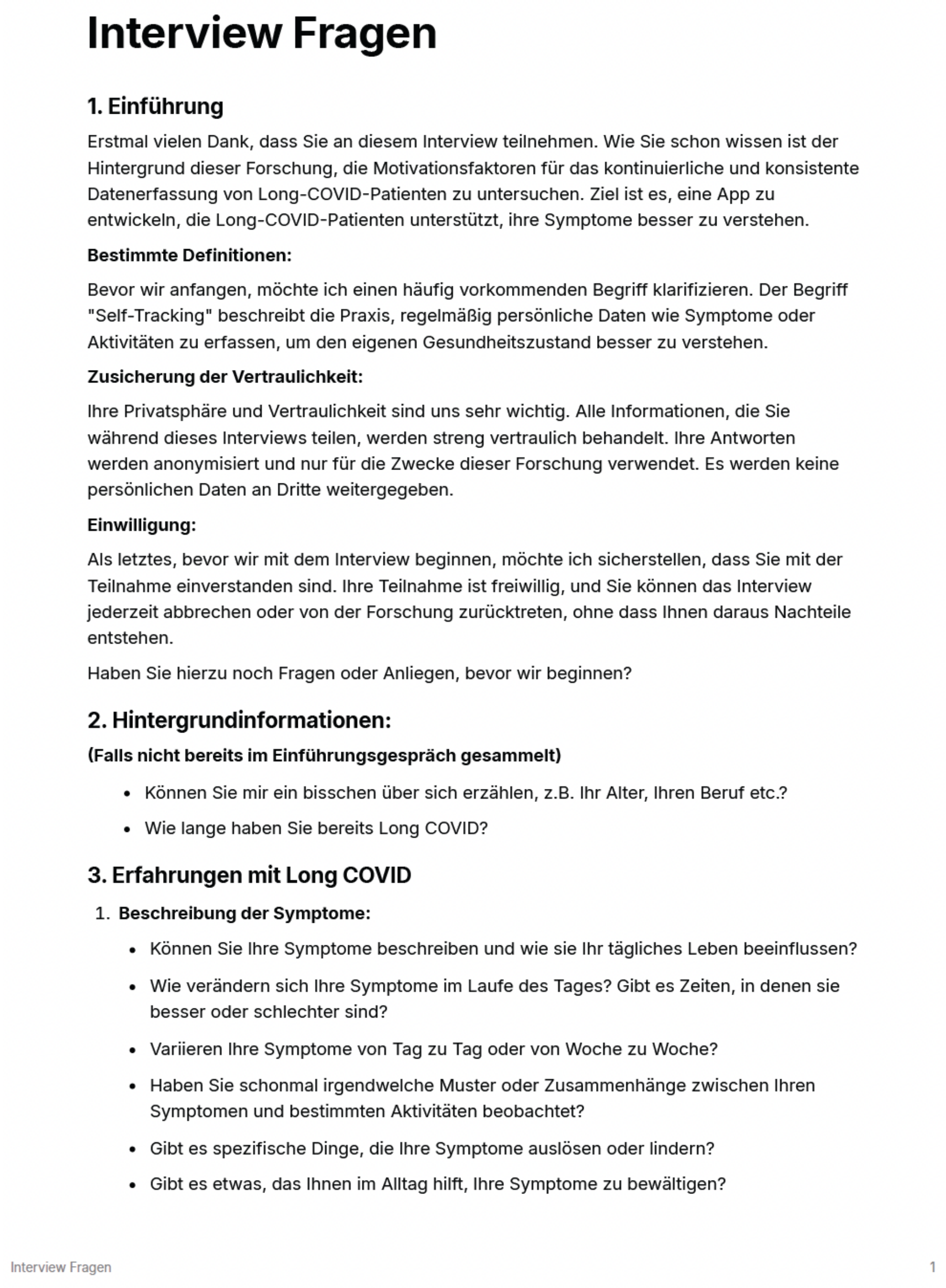
____

Unterschrift der/des Forschenden

__________________, ___________________

Ort, Datum

C. User interview questions



Interview Fragen

1. Einführung

Erstmal vielen Dank, dass Sie an diesem Interview teilnehmen. Wie Sie schon wissen ist der Hintergrund dieser Forschung, die Motivationsfaktoren für das kontinuierliche und konsistente Datenerfassung von Long-COVID-Patienten zu untersuchen. Ziel ist es, eine App zu entwickeln, die Long-COVID-Patienten unterstützt, ihre Symptome besser zu verstehen.

Bestimmte Definitionen:

Bevor wir anfangen, möchte ich einen häufig vorkommenden Begriff klarifizieren. Der Begriff "Self-Tracking" beschreibt die Praxis, regelmäßig persönliche Daten wie Symptome oder Aktivitäten zu erfassen, um den eigenen Gesundheitszustand besser zu verstehen.

Zusicherung der Vertraulichkeit:

Ihre Privatsphäre und Vertraulichkeit sind uns sehr wichtig. Alle Informationen, die Sie während dieses Interviews teilen, werden streng vertraulich behandelt. Ihre Antworten werden anonymisiert und nur für die Zwecke dieser Forschung verwendet. Es werden keine persönlichen Daten an Dritte weitergegeben.

Einwilligung:

Als letztes, bevor wir mit dem Interview beginnen, möchte ich sicherstellen, dass Sie mit der Teilnahme einverstanden sind. Ihre Teilnahme ist freiwillig, und Sie können das Interview jederzeit abbrechen oder von der Forschung zurücktreten, ohne dass Ihnen daraus Nachteile entstehen.

Haben Sie hierzu noch Fragen oder Anliegen, bevor wir beginnen?

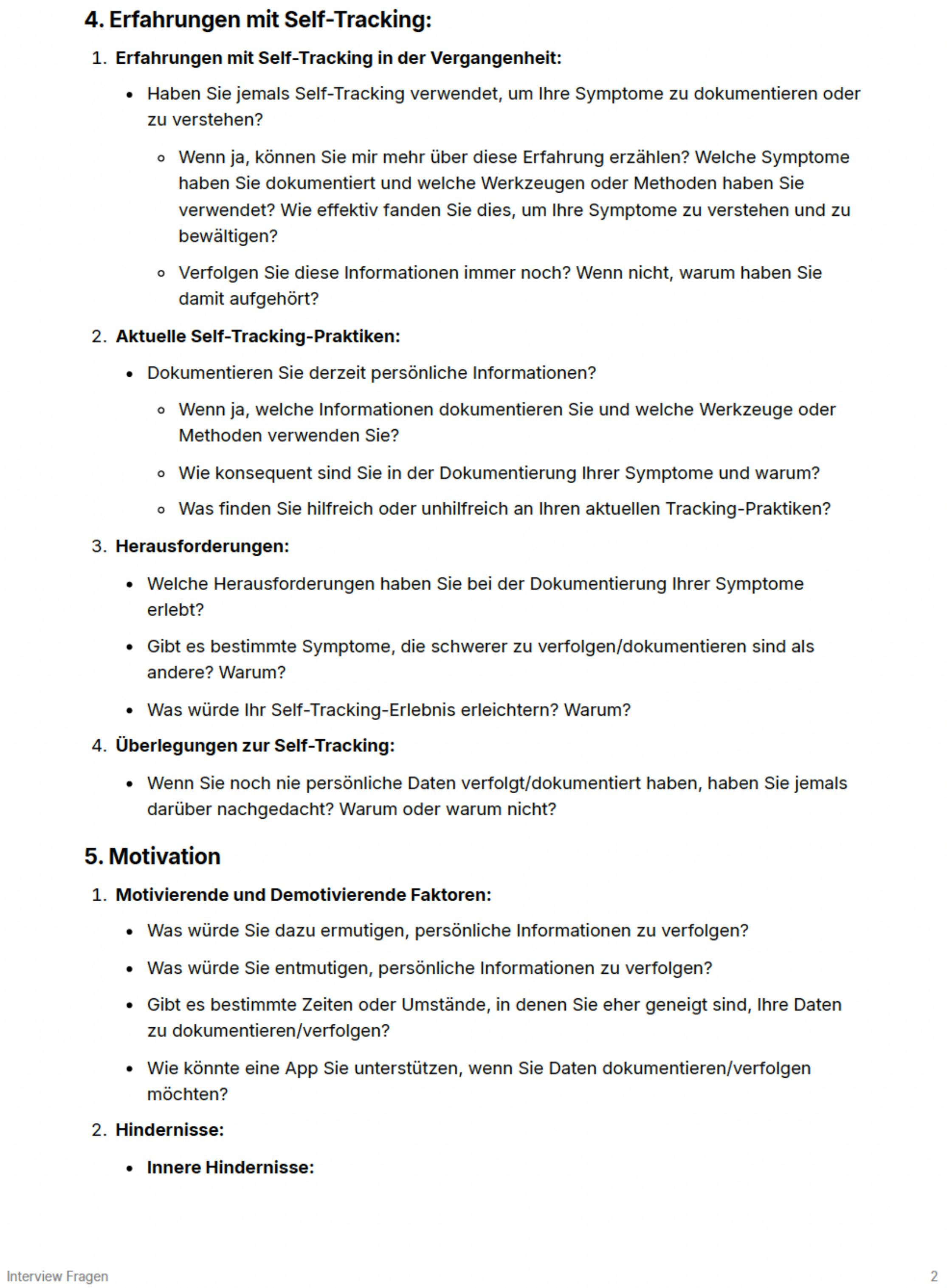
2. Hintergrundinformationen:

(Falls nicht bereits im Einführungsgespräch gesammelt)

- Können Sie mir ein bisschen über sich erzählen, z.B. Ihr Alter, Ihren Beruf etc.?
- Wie lange haben Sie bereits Long COVID?

3. Erfahrungen mit Long COVID

1. **Beschreibung der Symptome:**
    - Können Sie Ihre Symptome beschreiben und wie sie Ihr tägliches Leben beeinflussen?
    - Wie verändern sich Ihre Symptome im Laufe des Tages? Gibt es Zeiten, in denen sie besser oder schlechter sind?
    - Variieren Ihre Symptome von Tag zu Tag oder von Woche zu Woche?
    - Haben Sie schonmal irgendwelche Muster oder Zusammenhänge zwischen Ihren Symptomen und bestimmten Aktivitäten beobachtet?
    - Gibt es spezifische Dinge, die Ihre Symptome auslösen oder lindern?
    - Gibt es etwas, das Ihnen im Alltag hilft, Ihre Symptome zu bewältigen?

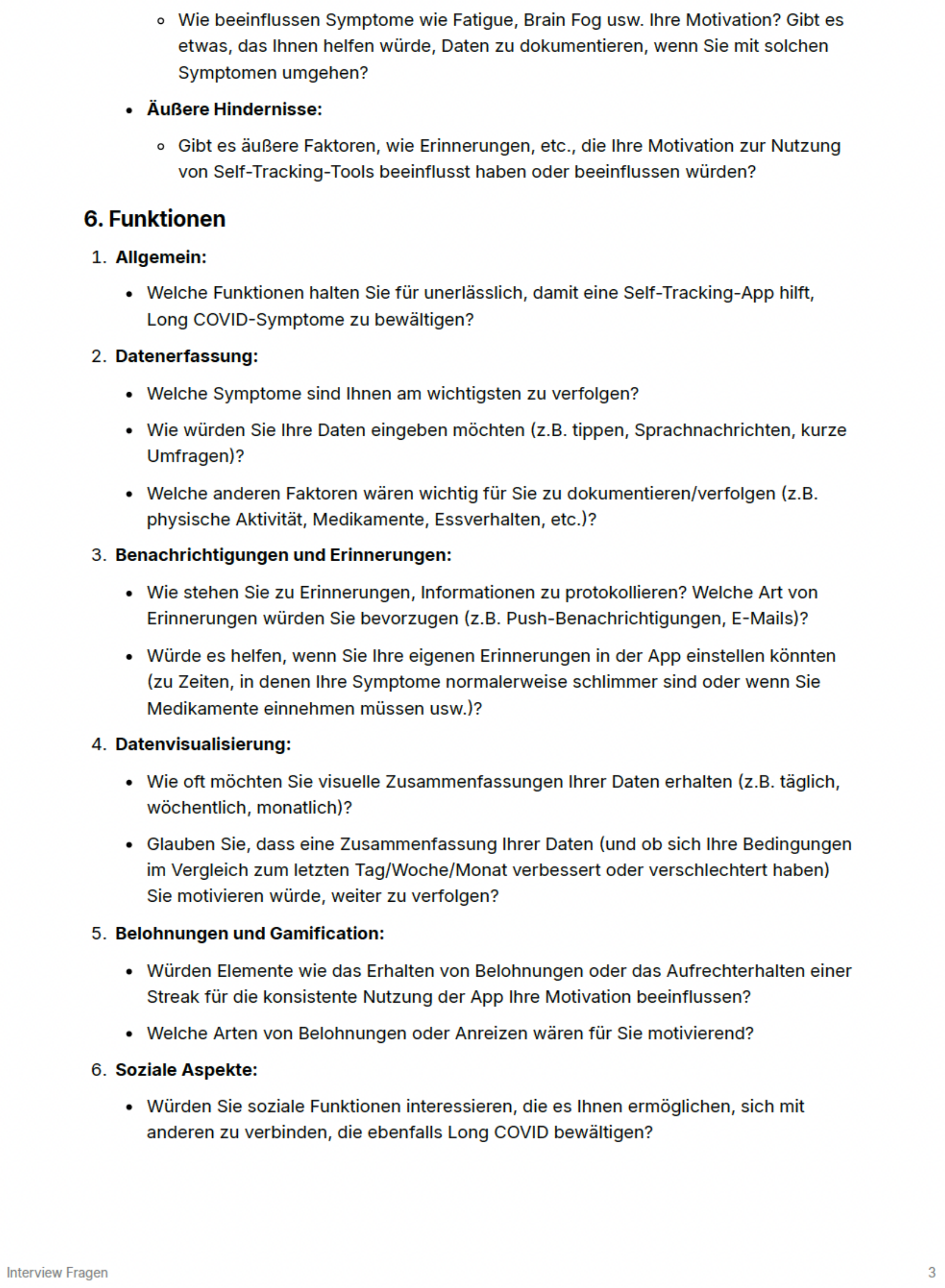


4. Erfahrungen mit Self-Tracking:

1. **Erfahrungen mit Self-Tracking in der Vergangenheit:**
    - Haben Sie jemals Self-Tracking verwendet, um Ihre Symptome zu dokumentieren oder zu verstehen?
        - Wenn ja, können Sie mir mehr über diese Erfahrung erzählen? Welche Symptome haben Sie dokumentiert und welche Werkzeugen oder Methoden haben Sie verwendet? Wie effektiv fanden Sie dies, um Ihre Symptome zu verstehen und zu bewältigen?
        - Verfolgen Sie diese Informationen immer noch? Wenn nicht, warum haben Sie damit aufgehört?
2. **Aktuelle Self-Tracking-Praktiken:**
    - Dokumentieren Sie derzeit persönliche Informationen?
        - Wenn ja, welche Informationen dokumentieren Sie und welche Werkzeuge oder Methoden verwenden Sie?
        - Wie konsequent sind Sie in der Dokumentierung Ihrer Symptome und warum?
        - Was finden Sie hilfreich oder unhilfreich an Ihren aktuellen Tracking-Praktiken?
3. **Herausforderungen:**
    - Welche Herausforderungen haben Sie bei der Dokumentierung Ihrer Symptome erlebt?
    - Gibt es bestimmte Symptome, die schwerer zu verfolgen/dokumentieren sind als andere? Warum?
    - Was würde Ihr Self-Tracking-Erlebnis erleichtern? Warum?
4. **Überlegungen zur Self-Tracking:**
    - Wenn Sie noch nie persönliche Daten verfolgt/dokumentiert haben, haben Sie jemals darüber nachgedacht? Warum oder warum nicht?

5. Motivation

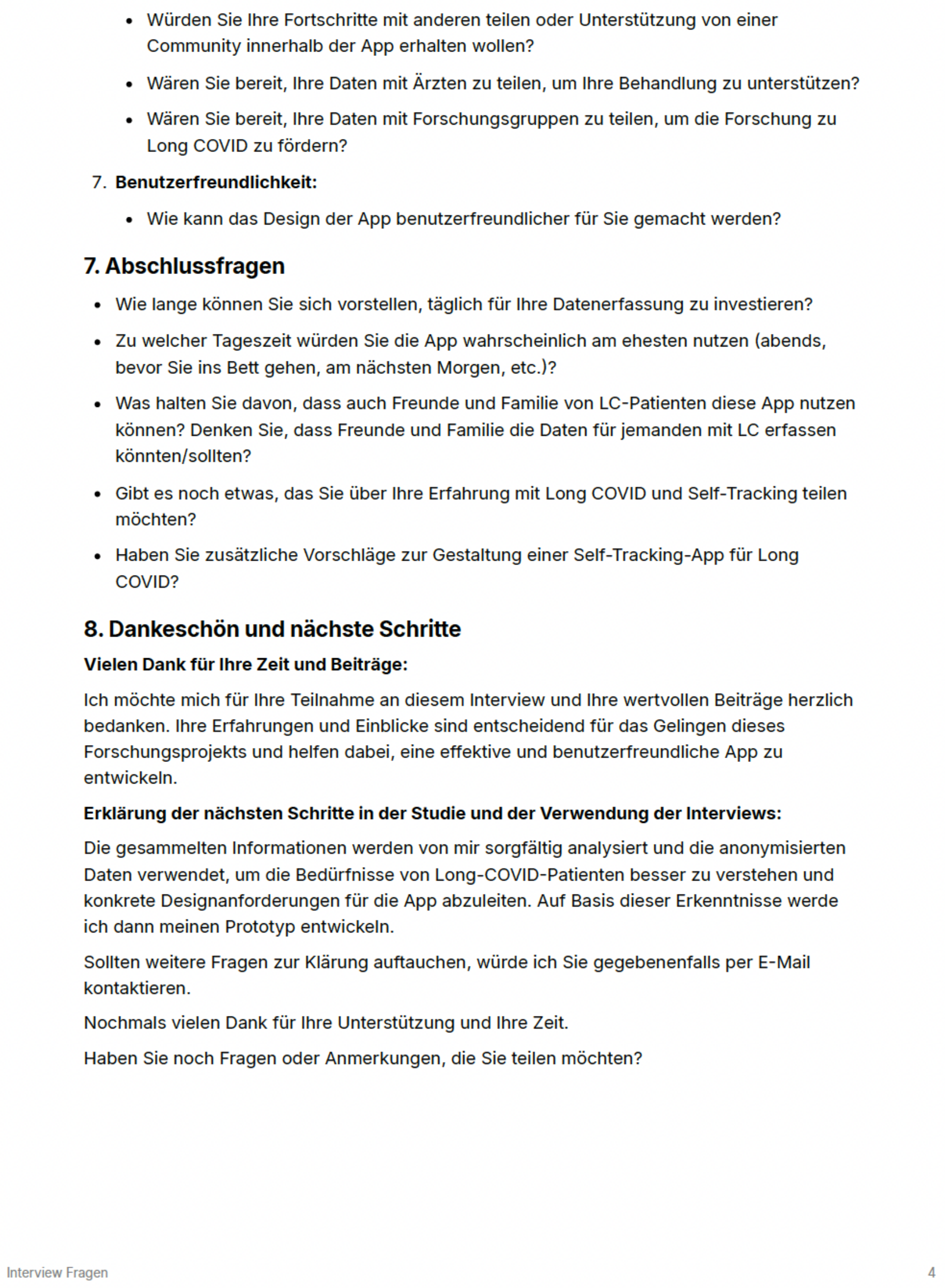
1. **Motivierende und Demotivierende Faktoren:**
    - Was würde Sie dazu ermutigen, persönliche Informationen zu verfolgen?
    - Was würde Sie entmutigen, persönliche Informationen zu verfolgen?
    - Gibt es bestimmte Zeiten oder Umstände, in denen Sie eher geneigt sind, Ihre Daten zu dokumentieren/verfolgen?
    - Wie könnte eine App Sie unterstützen, wenn Sie Daten dokumentieren/verfolgen möchten?
2. **Hindernisse:**
    - **Innere Hindernisse:**



  - Wie beeinflussen Symptome wie Fatigue, Brain Fog usw. Ihre Motivation? Gibt es etwas, das Ihnen helfen würde, Daten zu dokumentieren, wenn Sie mit solchen Symptomen umgehen?
- **Äußere Hindernisse:**
  - Gibt es äußere Faktoren, wie Erinnerungen, etc., die Ihre Motivation zur Nutzung von Self-Tracking-Tools beeinflusst haben oder beeinflussen würden?

6. Funktionen

1. **Allgemein:**
   - Welche Funktionen halten Sie für unerlässlich, damit eine Self-Tracking-App hilft, Long COVID-Symptome zu bewältigen?
2. **Datenerfassung:**
   - Welche Symptome sind Ihnen am wichtigsten zu verfolgen?
   - Wie würden Sie Ihre Daten eingeben möchten (z.B. tippen, Sprachnachrichten, kurze Umfragen)?
   - Welche anderen Faktoren wären wichtig für Sie zu dokumentieren/verfolgen (z.B. physische Aktivität, Medikamente, Essverhalten, etc.)?
3. **Benachrichtigungen und Erinnerungen:**
   - Wie stehen Sie zu Erinnerungen, Informationen zu protokollieren? Welche Art von Erinnerungen würden Sie bevorzugen (z.B. Push-Benachrichtigungen, E-Mails)?
   - Würde es helfen, wenn Sie Ihre eigenen Erinnerungen in der App einstellen könnten (zu Zeiten, in denen Ihre Symptome normalerweise schlimmer sind oder wenn Sie Medikamente einnehmen müssen usw.)?
4. **Datenvisualisierung:**
   - Wie oft möchten Sie visuelle Zusammenfassungen Ihrer Daten erhalten (z.B. täglich, wöchentlich, monatlich)?
   - Glauben Sie, dass eine Zusammenfassung Ihrer Daten (und ob sich Ihre Bedingungen im Vergleich zum letzten Tag/Woche/Monat verbessert oder verschlechtert haben) Sie motivieren würde, weiter zu verfolgen?
5. **Belohnungen und Gamification:**
   - Würden Elemente wie das Erhalten von Belohnungen oder das Aufrechterhalten einer Streak für die konsistente Nutzung der App Ihre Motivation beeinflussen?
   - Welche Arten von Belohnungen oder Anreizen wären für Sie motivierend?
6. **Soziale Aspekte:**
   - Würden Sie soziale Funktionen interessieren, die es Ihnen ermöglichen, sich mit anderen zu verbinden, die ebenfalls Long COVID bewältigen?



  - Würden Sie Ihre Fortschritte mit anderen teilen oder Unterstützung von einer Community innerhalb der App erhalten wollen?
  - Wären Sie bereit, Ihre Daten mit Ärzten zu teilen, um Ihre Behandlung zu unterstützen?
  - Wären Sie bereit, Ihre Daten mit Forschungsgruppen zu teilen, um die Forschung zu Long COVID zu fördern?

7. **Benutzerfreundlichkeit:**
    - Wie kann das Design der App benutzerfreundlicher für Sie gemacht werden?

7. Abschlussfragen

- Wie lange können Sie sich vorstellen, täglich für Ihre Datenerfassung zu investieren?
- Zu welcher Tageszeit würden Sie die App wahrscheinlich am ehesten nutzen (abends, bevor Sie ins Bett gehen, am nächsten Morgen, etc.)?
- Was halten Sie davon, dass auch Freunde und Familie von LC-Patienten diese App nutzen können? Denken Sie, dass Freunde und Familie die Daten für jemanden mit LC erfassen könnten/sollten?
- Gibt es noch etwas, das Sie über Ihre Erfahrung mit Long COVID und Self-Tracking teilen möchten?
- Haben Sie zusätzliche Vorschläge zur Gestaltung einer Self-Tracking-App für Long COVID?

8. Dankeschön und nächste Schritte

Vielen Dank für Ihre Zeit und Beiträge:

Ich möchte mich für Ihre Teilnahme an diesem Interview und Ihre wertvollen Beiträge herzlich bedanken. Ihre Erfahrungen und Einblicke sind entscheidend für das Gelingen dieses Forschungsprojekts und helfen dabei, eine effektive und benutzerfreundliche App zu entwickeln.

Erklärung der nächsten Schritte in der Studie und der Verwendung der Interviews:

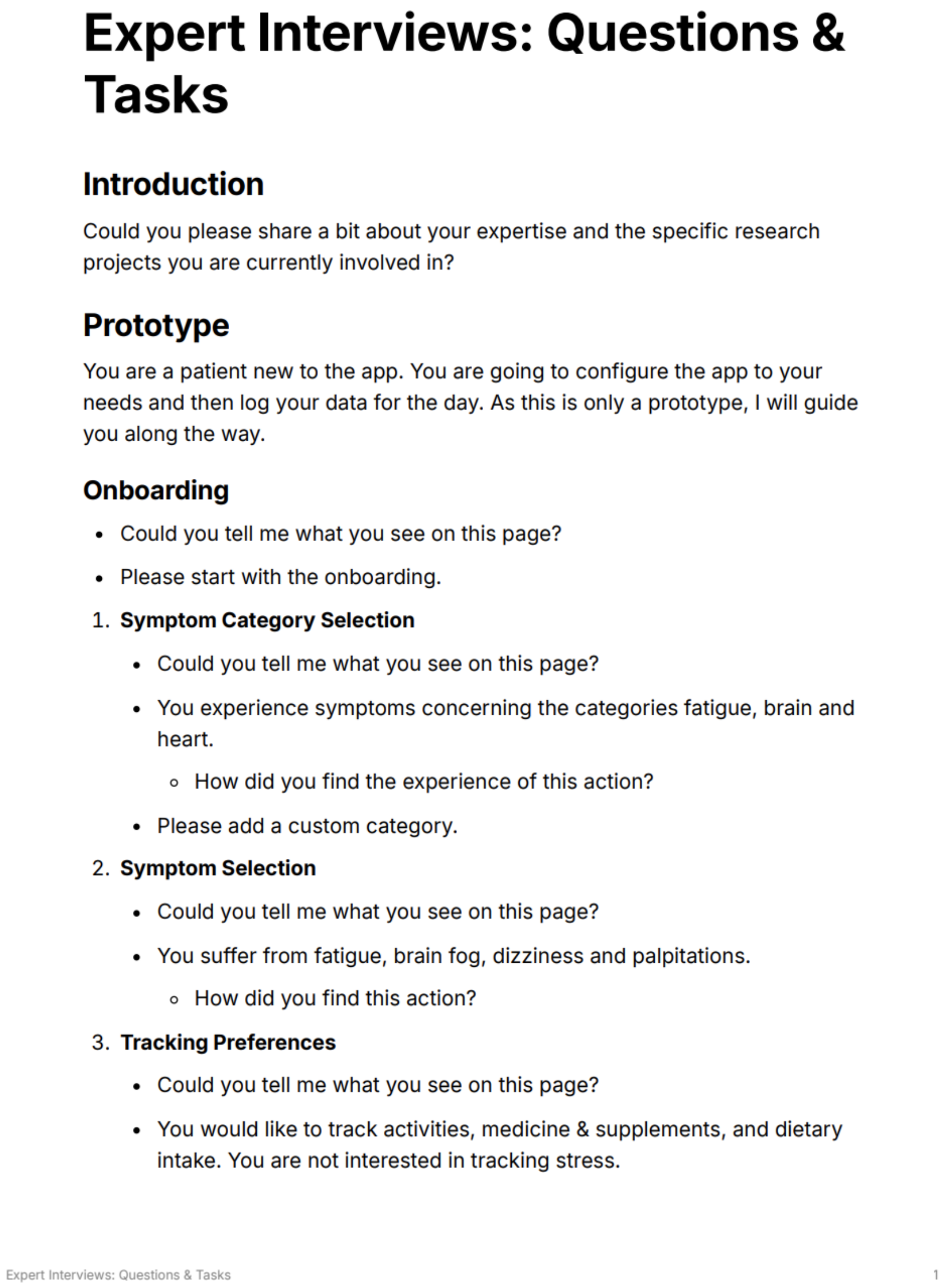
Die gesammelten Informationen werden von mir sorgfältig analysiert und die anonymisierten Daten verwendet, um die Bedürfnisse von Long-COVID-Patienten besser zu verstehen und konkrete Designanforderungen für die App abzuleiten. Auf Basis dieser Erkenntnisse werde ich dann meinen Prototyp entwickeln.

Sollten weitere Fragen zur Klärung auftauchen, würde ich Sie gegebenenfalls per E-Mail kontaktieren.

Nochmals vielen Dank für Ihre Unterstützung und Ihre Zeit.

Haben Sie noch Fragen oder Anmerkungen, die Sie teilen möchten?

D. Expert interview questions & tasks



Expert Interviews: Questions & Tasks

Introduction

Could you please share a bit about your expertise and the specific research projects you are currently involved in?

Prototype

You are a patient new to the app. You are going to configure the app to your needs and then log your data for the day. As this is only a prototype, I will guide you along the way.

Onboarding

- Could you tell me what you see on this page?
- Please start with the onboarding.

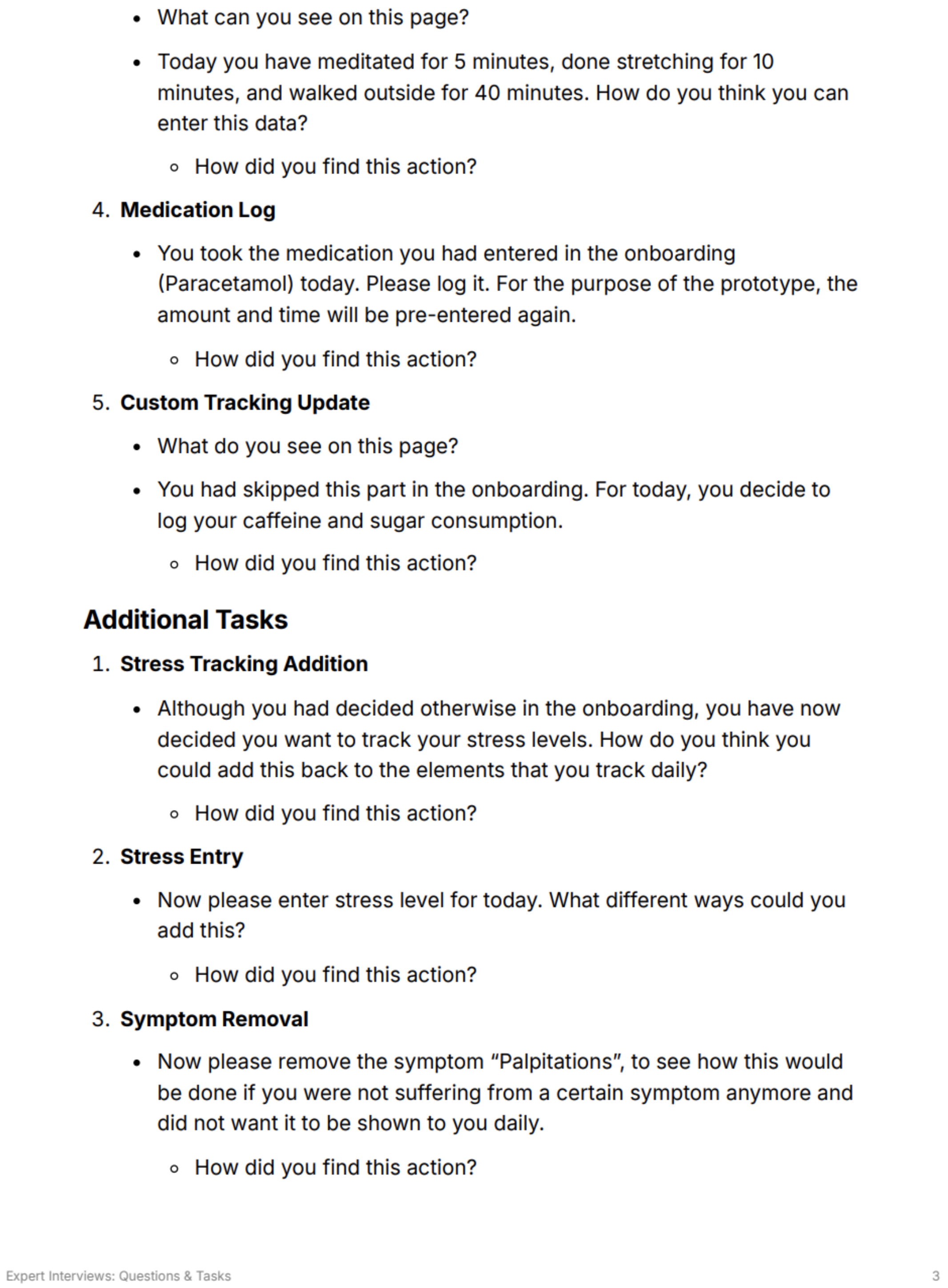
1. **Symptom Category Selection**
    - Could you tell me what you see on this page?
    - You experience symptoms concerning the categories fatigue, brain and heart.
        - How did you find the experience of this action?
    - Please add a custom category.
2. **Symptom Selection**
    - Could you tell me what you see on this page?
    - You suffer from fatigue, brain fog, dizziness and palpitations.
        - How did you find this action?
3. **Tracking Preferences**
    - Could you tell me what you see on this page?
    - You would like to track activities, medicine & supplements, and dietary intake. You are not interested in tracking stress.

        - How did you find this action?

4. **Activity Selection**
    - Could you tell me what you see on this page?
    - To manage your symptoms you often do stretching and meditation. You also go out for walks. Please choose these and continue.
        - How did you find this action?
5. **Medication Input**
    - Could you tell me what you see on this page?
    - Now you want to enter the medication you take the most often. For the purpose of the prototype, the data will already be filled out once you choose to add a medication.
        - How did you find this action?
6. **Custom Tracking Decision**
    - Could you tell me what you see on this page?
        - You are not sure what to track here yet so you don't choose anything. (You will come back to this later.)

Daily Check-in

1. **Initial Data Entry**
    - Could you tell me what you see on this page?
    - Now that you have completed the onboarding, you would like to enter your data for the first time. Without clicking anywhere yet, how do you think you could do this?
2. **Symptom Entry Process**
    - You are now expected to log the severity of your first symptom, how do you think this works? What do you expect to happen here?
    - Although you haven't tracked before, please toggle the option to view the entry from the previous day to see how this would be displayed.
    - Now enter your symptom severities, please.
        - How did you find this action?
3. **Activity Entry**



- What can you see on this page?
- Today you have meditated for 5 minutes, done stretching for 10 minutes, and walked outside for 40 minutes. How do you think you can enter this data?
    - How did you find this action?

4. **Medication Log**
    - You took the medication you had entered in the onboarding (Paracetamol) today. Please log it. For the purpose of the prototype, the amount and time will be pre-entered again.
        - How did you find this action?
5. **Custom Tracking Update**
    - What do you see on this page?
    - You had skipped this part in the onboarding. For today, you decide to log your caffeine and sugar consumption.
        - How did you find this action?

Additional Tasks

1. **Stress Tracking Addition**
    - Although you had decided otherwise in the onboarding, you have now decided you want to track your stress levels. How do you think you could add this back to the elements that you track daily?
        - How did you find this action?
2. **Stress Entry**
    - Now please enter stress level for today. What different ways could you add this?
        - How did you find this action?
3. **Symptom Removal**
    - Now please remove the symptom “Palpitations”, to see how this would be done if you were not suffering from a certain symptom anymore and did not want it to be shown to you daily.
        - How did you find this action?

Wrap-up Questions

1. **Overall App Evaluation**
    - How would you evaluate your overall experience with the app?
2. **Challenges and Difficulties**
    - Were there any specific features or tasks that you found challenging or confusing?
3. **Positive Feedback and Highlights**
    - Can you identify any particular aspects of the app that you found particularly effective or enjoyable?
4. **Final**
    - Is there anything you would like to add?

E. Interactive prototype used for expert interviews

Click here to view the interactive prototype used for the expert interviews

F. Improved interactive prototype

Click here to view the improved interactive prototype

G. Git repository

https://git.imp.fu-berlin.de/ayseyasem96/bachelor-thesis

H. Screen recording of the resulting app

https://box.fu-berlin.de/s/LAo66Dy3fEpSDB6