Personalised Health Monitoring and Decision Support Based on Artificial Intelligence and Holistic Health Records

D2.8 – User Centric Design I

WP2 Requirements, State of the Art Analysis and User Scenarios in iHelp

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Executive summary

This deliverable reports the results achieved by the first half of Task 2.4 – "User Centred Design". The task aims to ensure that the interfaces produced by iHelp are perceived as enjoyable, easy to understand and effective by the different groups of potential users. It also aims to ensure iHelp software development process is aligned with the requirements for medical devices, and that users are motivated to stick with the system for long enough to change their behaviour, bring about long-term health benefits and thus reduce their risk of developing pancreatic cancer.

A major complication in achieving this objective is the AI-based nature of the iHelp software functionality, which creates problems with user comprehension of software actions and trust into AI-derived recommendations. To address this, the deliverable reviews the state of art in health systems personalisation and Artificial Intelligence, including techniques for reach interactions, attracting and retaining attention.

The software developed by iHelp is categorised as medical device Class IIa, which means that the software design process will need to embrace Usability Engineering Principles, and carefully consider the background of target users, and the context in which they will use the system, such as brightness, noise, etc. The background of target users is made explicit through the technique of personas. We are fully aligned with the stipulated focus on usability requirements, using techniques such as wireframing, use case models and descriptions for the user-facing use cases. We create and evaluate the first draft of wireframe models of key interface screens.

This work leads to the first set of user development guidelines, which are split along interfaces specialised for each different persona: a mobile interface for individuals and patients using the system, and desktop interfaces for the model builders, health professionals, policy makers and administrators. The guidelines are based on sound theoretical principles and state-of-practice techniques. The most important are the guidelines regarding the mobile interfaces for individuals/patients using the system to manage their health. These include the following:

Personalisation and interactivity – the interface addressing the end user (individual) in our system should be personalised to their circumstances and context. This personalisation should extend to the messages and communication style from the system to the user, if we wish for the system to be impactful and change behaviour in a significant and meaningful manner. A particular paradigm we will be exploring in this direction is the "coaching" dialogue based on personalised model of the specific individual.

Arousing and retaining attention using techniques structured around the Fogg Behavioural Model, including bright colours, low barriers to opening the app, and personalised gamification features, especially in the individual-facing interfaces. In establishing the proposed colour schema, for example, we try to balance the principles of attracting and keeping attention on one side, and the health-care related theme of our application, which suggested more pastel-like and less aggressive colour schema. The results are illustrated in the proposed templates for desktop interface and mobile device interface.

User-centric design process to drive the development of our interfaces. These should be prototyped in an iterative manner with the active participation of our pilot participants at first, then followed by representatives of all target stakeholder groups. This process has started with this deliverable and will

complete with the user-oriented usability evaluation conducted in WP7. The definition of evaluation criteria is left for the second deliverable of T2.4, D2.9 due to be released in M20 (August 2022).

1 Introduction and objectives

1.1 Scope

This deliverable is the first official output of Task 2.4 - "User Centered Design", responsible for ensuring the interfaces produced by iHelp are perceived as enjoyable, easy to understand and effective by the different groups of potential users. We present the first stage of our work focusing on iHelp components with user interfaces. We review the state of art in health systems personalisation and AI, define key user groups and their characteristics, provide a set of use case models and use case descriptions for user-facing use cases, and create and evaluate the first draft of wireframe models of key interface screens. We also provide the first set of user development guidelines. The definition of evaluation criteria is left for the second deliverable of T2.4, D2.9 due to be released in M20 (August 2022).

1.2 Aim and Objectives

The aim of this deliverable is to ensure the iHelp software is user-friendly, tuned to the needs of different types of users, and encouraging continuous use to bring about long-term health benefits. A major complication in achieving this objective is the AI-based nature of the iHelp software functionality, which creates problems with user comprehension of software actions and trust into AI-derived recommendations. The following objectives are designed to help in achieving this aim:

- Review state of art in AI-driven user personalisation and user-centric software development.
- Identify main user groups and describe them using personas.
- Identify and describe the main user-facing use-cases of the system.
- Develop low-fidelity wireframe interfaces to stimulate discussion with end users.
- Evaluate the extent to which these interfaces fit the needs of the different pilots and their users.
- Provide initial guidelines for software development for user-facing iHelp modules and functionality.

1.3 Approach

The results presented in this deliverable are driven by user-centric design, task-based design and personalised healthcare delivery principles.

We start by identifying key user groups, the ways in which they will interact with iHelp to create value, and the functionality they expect to use in order to derive value for themselves. These key episodes of interaction are mapped to components with user interface and corresponding use cases. Wireframe diagrams are then developed for each key screen of each use case and used to gain feedback from end users.

1.4 Contents of this deliverable

The next section focuses on the theories relevant to our designs and deliberations: user-centric design, task-based design of IS and personalised healthcare delivery. We then proceed to exemplify the key stakeholder groups and their characteristics with a specification of a list of personas. Section 5 then presents the scenarios of each persona interacting with the system as a general Use Case Model. Section 6 details the main use cases and presents the wireframe designs of key screens in each scenario. Section 0 reports on the feedback received by our pilot users on the wireframes presented to them. Section 8 provides general guidelines for constructing the user interfaces of iHelp including recommended colour scheme. Finally, Section 9 provides a brief summary of this deliverable and planning the next stage of work, looking forward to the contents of D2.9, the concluding deliverable of T2.4.

2 Interaction with other tasks and WPs

The T2.4 - "User Centred Design" focuses on defining and applying a user centred design process and design thinking methodology to provide the user-centred design principles that will guide the design and development activities in the iHelp project. The user centred design process serves two key purposes in the iHelp project, a) it involves users in the design and development activities taking place within the WP4 and WP5 of the iHelp project, b) it provides the necessary and timely guidelines to technology developers, allowing them to tune the technical components with the needs and expectations of the target users.

We work together with T2.1 to capture key requirements and use cases, and with T2.2 to identify which components of iHelp will be user-facing. We also work with WP5 to define properties of the user interface which make the delivery of personalised advice and monitoring functionally effective and enjoyable, ensuring continuous use by target user groups. The user development guidelines, use cases and wireframes serve as a starting point for most development tasks (those who interact directly with users, and those that produce content shown to the users of the system). Finally, the evaluation KPIs defined during the second half of T2.4 and described in D2.9 would serve as a basis for the user-centred evaluation of the iHelp system conducted in WP7. Each of these interactions is reviewed in detail below.

2.1 Relationship with other tasks within WP2

The user centred design process and design thinking methodology developed in T2.4 complements the activities carried out in other WP2 tasks, such as elaboration of user requirements with regards to user interaction and user interface design aspects (in T2.1); and translation of user needs in terms of technical/functional or non-technical/non-functional specifications (in T2.3) of the solutions developed in technical work packages of the project. In this respect, the work carried out in T2.4 and reported in this deliverable provides the vital user perspective that complement the requirements and specifications activities carried out in the different tasks of WP2.

2.1.1 User-relevant requirements from T2.1

The user/pilot and technical requirements for the iHelp project are gathered in task T2.1. The gathered requirements are organised, analysed, and documented in deliverable D2.1. The user or pilot requirements are documented in the form of scenarios that detail the objectives, actors, pre/post conditions, process dialogue and where the scenario applies within the context of a pilot level interaction diagram. The interaction diagrams for each pilot provides an overview of the different actors and their interactions with the iHelp components. Moreover, the deliverable D2.1 elaborates the functionalities of the iHelp platform and their mapping with user requirements.

This deliverable provides a complementary approach to typical requirements gathering process, particularly highlighting the user-facing functionalities in the iHelp platform and introducing fine-tuning in their specifications to make them more relevant for target user needs and preferences. Thus, ensuring that the technical developments are not only usable but also effective in terms of their intended purpose. For example, the following functionalities in the iHelp platform are highly relevant to be considered in the user centred design process:

- Secondary Data Extraction and Interoperability (as elaborated in the Section 4.3 – D2.1). This functionality relies on different types of (mobile and wearable) interfaces develop in the iHelp project to gather data about the following health related aspects: physical activity, diet, lifestyle aspects, heart information, sleep information, body signals, symptoms, medication, patient enrolment, scheduled questionnaire, psychological information, and user experience.

- Clinical Decision Support Suite with Visual Analytic Tools (as elaborated in Section 4.7 – D2.1). This functionality provides different interfaces to provide users with the data querying, analytic, dashboard building and data visualisation capabilities.
- Delivery Mechanism for Personalised Healthcare and Real-time Feedback (as elaborated in Section 4.11 – D2.1). This functionality uses the mobile application developed in the iHelp project to provide feedback to the users on relevant risk factors, allows goal setting for relevant risk factors, provides messages and conversational coaching, tracking user interactions and visualise health related data.
- Social Analytics for the Study of Societal Factors and Policy Making (as elaborated in Section 4.12 – D2.1). This functionality provides a visual interface that allows users to analyse the different topics of discussion on the social media platforms. The visual interface allow provides monitoring and alerting functionality, allowing users to track the emergence and propagation of different topics of discussion on the social media platforms.

Monitoring, Alerting, Feedback and Evaluation Mechanisms (as elaborated in Section 4.13 – D2.1). This functionality enables the monitoring of personalised advice, alerts for the targeted recommendations, definition and monitoring of personalised treatment plans, as well as monitoring of personalised health conditions and early symptoms.

2.1.2 Sequence of user-facing system actions and activity diagrams in T2.2

T2.2 uses activity diagrams to describe the sequence of actions in each use case defined in the system, while T2.4 takes a complementary approach by focusing on the interactions between different types of users and the system at the point of different user-facing use cases. However, the two views into the desired functionality of the system are related and an effort has been made to align these two different perspectives.

2.2 Relationship with WP5

The user centred design process is particularly important for the activities carried out in WP5, particularly in the context of the following 2 tasks:

- T5.3 - "Delivery Mechanism for Personalised Healthcare and Real-Time Feedback"
    - This task develops the mobile application that provides the real-time monitoring and decision support capability to the individuals in our pilots. The interface of the mobile application needs to be designed in line with user needs and preferences to support multi-modal dialogues and engaging experiences for the target users. This is where the user centred design process will be applied to ensure effective delivery and monitoring – as described in Section 3.
- T5.4 - "Social Analytics for the Study of Societal Factors and Policy Making"
    - This task develops the social media analysis tool that allows the users (such as decision/policy makers) to analyse the emergence and propagation of different threads of discussion concerning specific topics. The information gathered from the social media platforms is analysed and visualised to provide insight into the societal trends with regards

to specific topics of interests or policies, and social perception and feedback on certain policies. The interface of the social media analysis solution will need to present the data analysis in such a way that makes it easy to understand for the (non-technical) target users, allowing them to study various aspects of the gathered data and use in their own processes that focus on the design of new policies of evaluation of existing ones.

2.3 Relationship with WP7

The user centred design and end-user development techniques developed in T2.4 will become part of the impact assessment of the iHelp project – to be carried out in WP7. The usability aspects of the iHelp platform will be assessed in nearly all tasks of the WP7 to provide a holistic view on the usefulness and usability of the developed solutions. However, a specific task T7.2 - "Usability Evaluation of the iHelp Solution" is specifically focusing on evaluating the user centred design and usability techniques designed and implemented in the context of technology solutions. T7.2 will be guided by the useability guidelines stipulated in this deliverable, and by the Usability KPIs / Metrics defined by T2.4 in the forthcoming deliverable D2.9.

3 Background

3.1 Artificial Intelligence and Personalization of Healthcare Services

3.1.1 Three Types of Artificial Intelligence

Huang and Rust (2018) define Artificial Intelligence (AI) as a source of innovation in services achieved by enabling machines to exhibit aspects of Human Intelligence (HI) (H., R., 18). The unique characteristic of AI is that it enables technologies (e.g., decision management such as recommender systems, machine/deep learning platforms, graphical and language processing platforms) to learn from experience (e.g., available data), adjust to new inputs, connect with users, and undertake human-like tasks (H., R., 21). There are three main types of AI: "mechanical", "thinking", and most advanced, "feeling" AI (H., R., M., 19), (H., R., 21).

The early developments in AI allowed those platforms to perform mechanical tasks, tasks that did not require a huge degree of learning and adaptation and relied on simple, standardized, mechanic rules (e.g., job automation by service robots, (C., M., P., 16), (H., R., 18), (H., R., 21). In majority of cases and industries, AI tends to be higher than just "mechanical" AI (H., R., M., 19). The more advanced level of AI is "thinking" AI, which allows for more advanced tasks guided by analytical algorithms and rules (H., R., 18). This type of AI can learn and adapt to environment based on the availability of user data, which enables AI algorithms to be finetuned to user needs. Examples of "thinking" AI include marketing analytics (W., K., 16), programmatic advertising (C., X., D., + 19), or recommender systems (J., R., T., + 16), (Z., R., J., 19). The main feature of "thinking" AI is that it allows personalization (Huang, Rust and Maksimovic 2019; Huang and Rust 2021). For instance, companies such as Google, Amazon, Facebook, and Netflix personalize their offers using recommender systems, which profile individuals into homogeneous segments and offer products or advice estimated to fit the needs of a specific segment, thus more likely to stick with a potential user (J., R., T., + 16), (X., R., F., + 16), (Z., R., J., 19). These systems deploy existing user data in profiling, are able to learn based on incoming consumer data, and have the proven ability to successfully encourage engagement, use or purchase behaviors (P., T., G., 14), (J., R., T., + 16). The most advanced type of AI is "feeling" AI, which enables machines to learn and adapt in an empathetic way based on experience (Huang and Rust 2018; 2021). This type of AI requires the most advanced inputs (i.e., data, algorithms), which allow to account for user emotions and allows to establish a bond between a machine (e.g., an app) and the user (H., R., 21). This research work concludes that in the mainstream research "feeling" AI is most advanced, but its potential is yet to be realized; "thinking" AI is the focus of mainstream research and applications (H., R., 21). Unfortunately, AI in healthcare seems to be lacking behind the mainstream research and applications.

3.1.2 Advancing AI in Healthcare

Among various touchpoints that are widely available to individuals and could contribute to provision of transformative services, mobile health apps have received most attention from both practitioners and academics because of their potential to facilitate behavior change and drive healthier lifestyles (BLA, 19), (C., X., D., + 19), (T., A., B., + 19), (DA, J., C., + 20), (VZ., C., 20). Regardless the identified potential for those devices to transform individual life and wellbeing, user engagement with such touchpoints, especially on a long-term basis remains low, with some evidence that many users stop using those apps two weeks after download (C., D., S., + 19), (T., A., B., + 19).

Withing iHelp project, we aim to deploy advanced profiling based on capturing some of the most relevant psychological factors that could impact on individuals making healthier choices. Grounding this work in psychological factors, such as health beliefs (entity or incremental), goal orientation, user journey and a range of various demographic and behavioral messages (N., K., K., 15), we aim to profile potential users, and offer advice (e.g., recommendations, feedback, etc.) that will be tailored to their specific needs and behaviours, as illustrated in Figure 1 below.

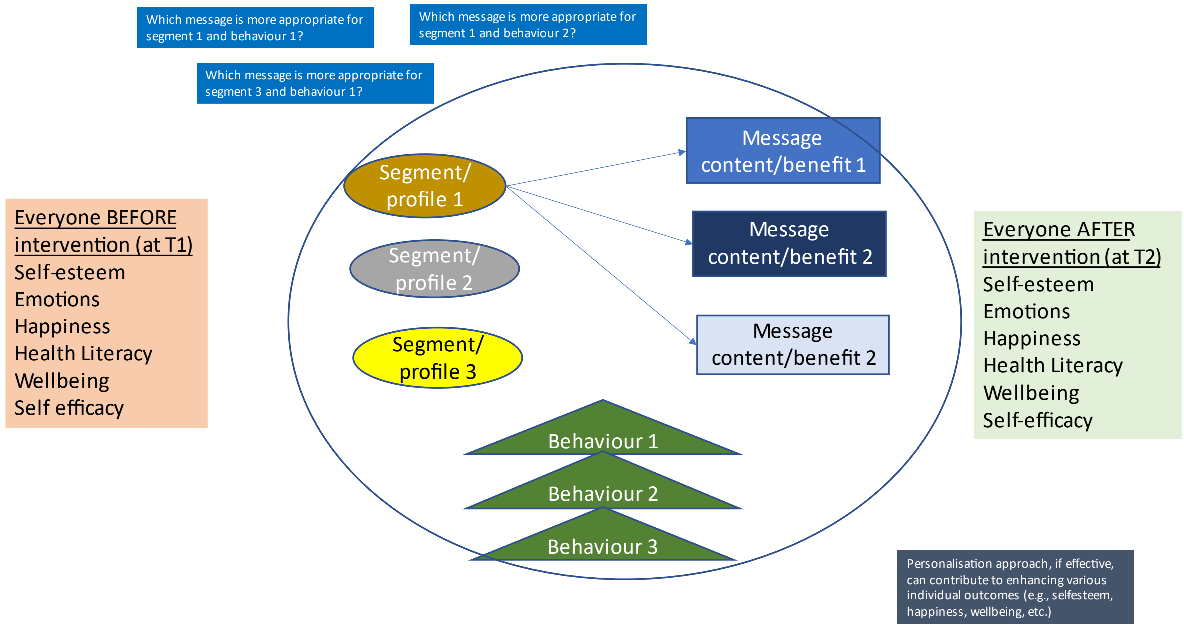

Figure 1: Proposed Personalization Framework.

3.2 Personalised Advice Delivery and Monitoring

In D2.1 – "State of the Art and Requirement Analysis", submitted during M6, of the iHelp project we have identified three mechanisms to deliver personalized advice and real-time feedback in the domain of mobile phone applications: (1) Data visualisation, (2) Feedback messages and nudges, and (3) Conversational coaching. In this section we provide an overview of state-of-the-art interfaces for each one of these mechanisms within the health and wellness domains. Additionally, we provide an overview of different front-end options for monitoring through self-reporting.

3.2.1 Data visualisation

Data visualisation consists of simply showing information to the user in the form of graphs, pie charts or other visualizations. In this sub-section we will describe several ways to provide data visualization.

The first distinction that can be made is between data visualization that uniquely provide feedback (i.e., reports to the user exactly what was measured) and the one that integrates coaching elements (i.e., it includes advice to be followed based on the data measured). Figure 2 exemplifies the distinction between feedback and coaching in data visualization, looking at physical activity monitoring. While the image on the left uniquely provides feedback – by informing the user that they have taken 785 steps today until the present moment, the image on the right includes coaching – by informing the user that they have done 3620 out of the 6000 steps planned for today.

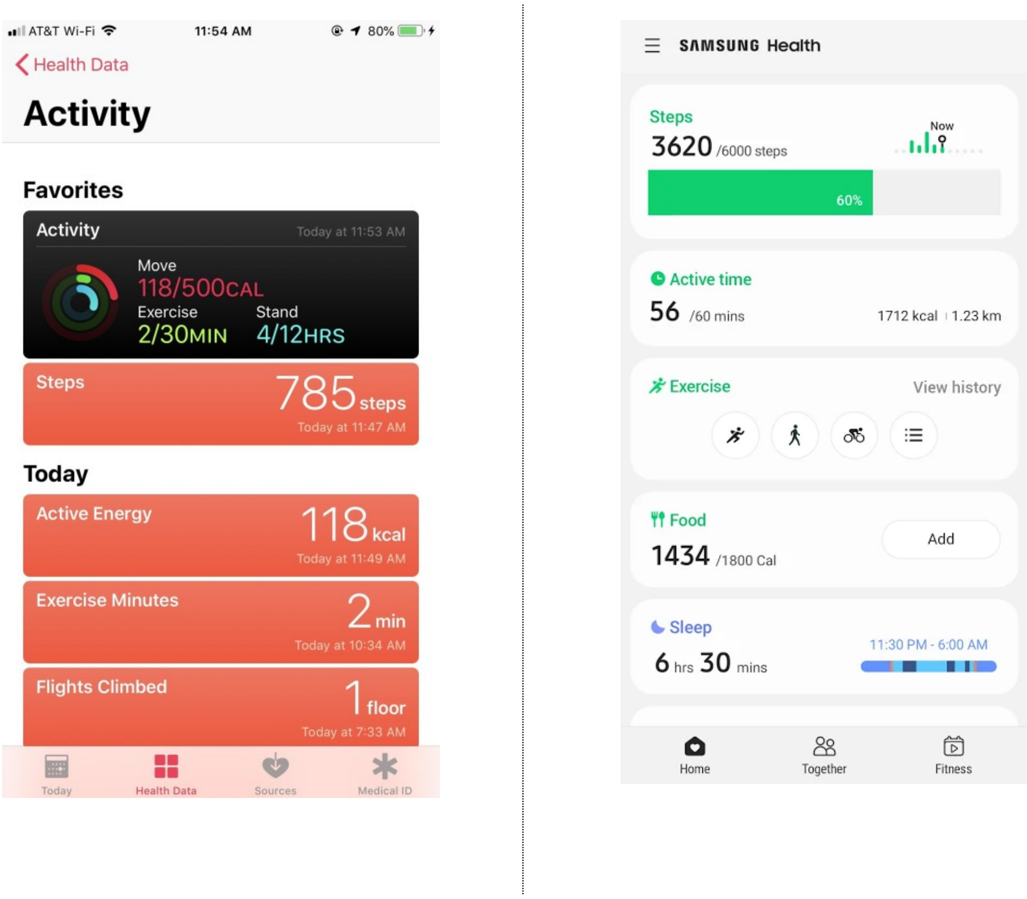

Figure 2: Comparison between a data visualization from step monitoring providing feedback (left, from Apple Health[1]) and coaching (right, from Samsung Health[2]).

Another example of integrating coaching elements in data visualization is by providing additional explanation on the values monitored. For example, Figure 3 (left), not only provides the value of haemoglobin measured, but also how the value relates to the normal range (in this case the value measured is higher than normal) and explains more information about the measurement. The screenshot on the right side of Figure 3 provides an example on how data visualization can be complemented with secondary data extraction, as in the analysis of patterns of behaviour.

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[1] Image retrieved from https://img.gadgethacks.com/img/original/77/55/63680115398972/0/636801153989727755.jpg

[2] Image retrieved from https://play.google.com/store/apps/details?id=com.sec.android.app.shealth&hl=en&gl=US

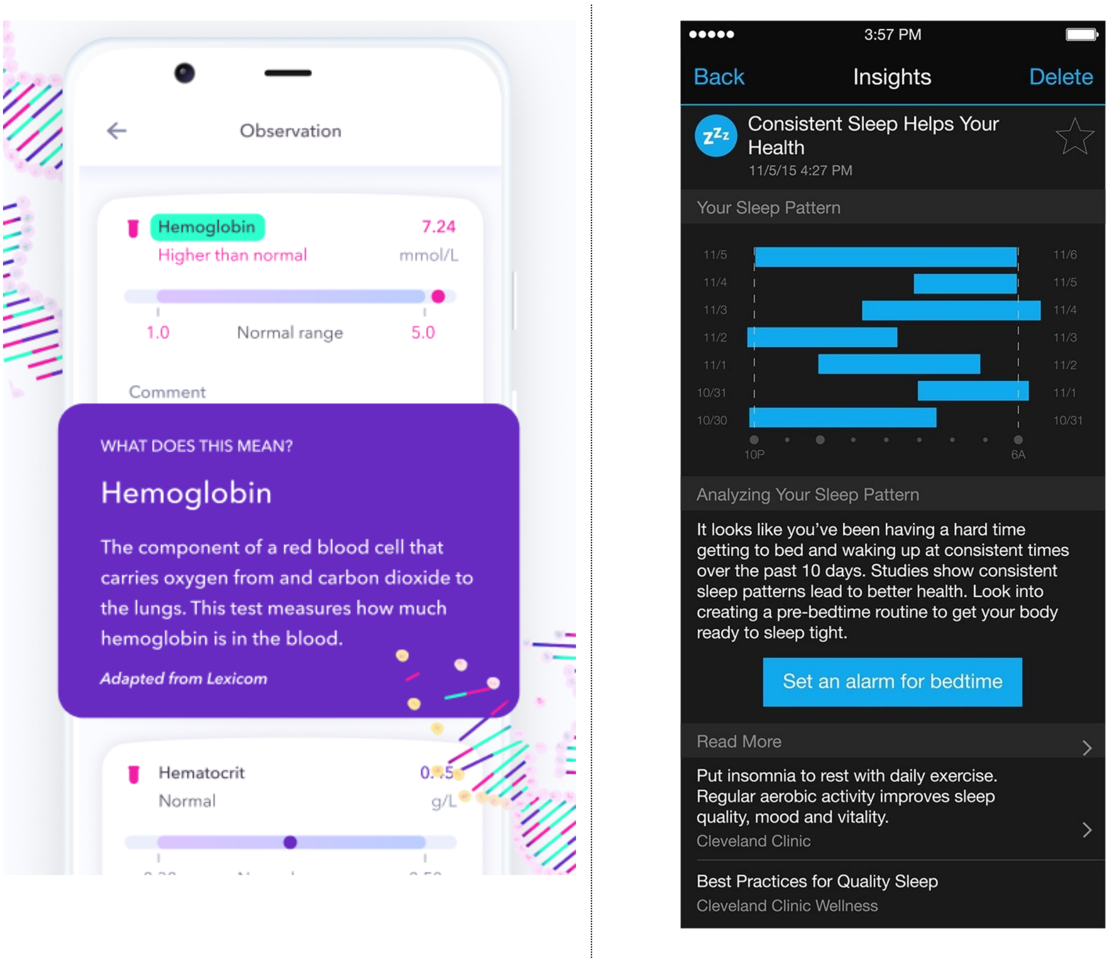


Figure 3: Examples of data visualization integrating coaching elements by adding additional educational material about the parameter being measured (*left,* from Dot Health[3]) and insights from patterns of behaviour (*right*, from Garmin Connect[4]).

[3] Image retrieved from https://play.google.com/store/apps/details?id=com.dothealthios

[4] Image retrieved from https://www.garmin.com/en-US/blog/fitness/introducing-garmin-connect-insights-smart-coaching-from-garmin/

Figure 4: Example of data visualization from the Fitbit app showing the number of steps taken on the present day (*left*[5]) and in the last 7 days (*right*[6]).

A second distinction that can be made when preparing data visualization is whether we are presenting data referring to the **present day** or **historical data** from the past days, weeks, months or even years. Figure 4 provides two examples related to physical activity monitoring, in which the figure on the left provides the number of steps taken today until the present moment, and the figure on the right side provides an overview with bar chart of the number of steps performed on the last 7 days, the actual number of steps performed on each day and whether the user reached the step goal on that day (marked with a green star). History data can also show simultaneously (i.e., on the same screen) the variation of values of different parameters measured during a period of time, for example, to help the user identifying relations between parameters. Figure 5 (left) provides the variation of seven different symptoms related to gastrointestinal conditions over the last days. On the right side, Figure 5 provides an example of data visualization showing

[5] Image retrieved from https://www.fitbit.com/global/nl/home

[6] Image retrieved from https://www.fitbit.com/nl-nl/app

relation between different variables (e.g., time spent asleep and overall mood, and quality of sleep and stress level).

Figure 5: Example of data visualization showing history of several symptoms concerning the same medical condition (*left*, from MyGiHealth app[7]) and the quantified relation between distinct parameters (*right*, from Optimized app[8]).

Applications that provide personalized advice, often require the monitoring of health and/or behavioral parameters 24/7. Next to showing historical data for each specific sensor, sometimes it is important to see the sequence of symptoms, events or activities over time. To illustrate what is happening over time, data is often visualized in a timeline. The timeline, sometimes also referred to as journal, can contain automatically detected data, self-reported information or a mixed of information from different sources. The example on the left of Figure 6 provides a daily timeline consisting of a sequence of daily activities (e.g., sleep followed by morning routine) as well as the social interactions while performing certain activities (e.g.,

[7] Image retrieved from https://mygi.health/

[8] Image retrieved from http://optimized-app.com/

at work). The figure on the right illustrates a sequence intercalating activities and symptoms (e.g., sleep followed by back pain reporting). The user complements the information by stating how did they feel during each activity.

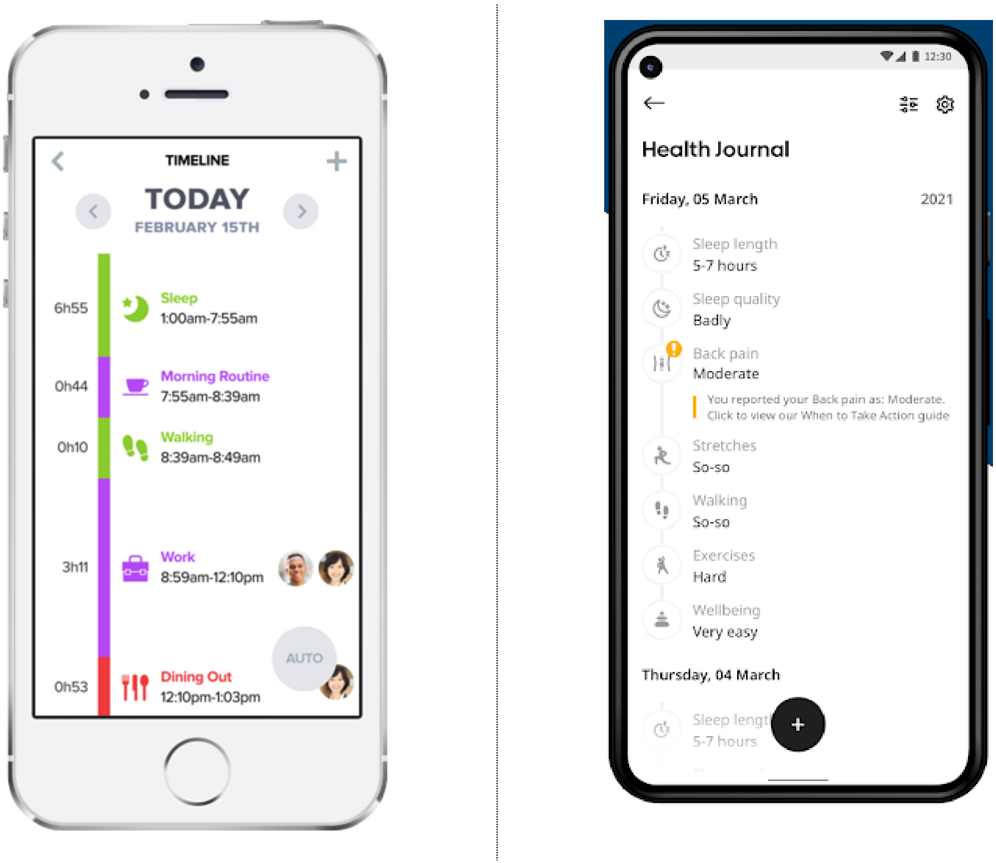


Figure 6: Example of data visualization in a timeline, showing a sequence of daily activities (*left*, from Optimized app[9]) and a sequence of activities and symptoms (*right*, from Healthily app[10]).

Some applications focus on one specific or similar medical conditions – such as the MyGiHealth application targeting gastrointestinal condition – while others target an overall perspective of health including several health-related behaviors (e.g., physical activity and sleep) sometimes mixed with medical parameters (e.g., reporting of headaches) or other life domains (e.g., work). In the case of the latest, it might be desirable to provide a first screen with a clear overview of how the user is doing in the different domains in a multi-domain glanceable daily overview. Figure 7 illustrates two examples of such glanceable overviews. On the left side, the screenshot shows how much time the user has dedicated to health, creativity, routine and pleasure activities according to the self-set goals. In this way, at the end of the day and with some time left, the user knows where to focus their attention. The umotif application allows users to self-track up to 10 different health domains (e.g., nutrition and smoking) and allows the user to track the symptom of interest (e.g., pain or mood) using a flower metaphor in which each petal of the flower corresponds to one domain. Users report the severity of the symptom by dragging the respective petal from the center outwards.

[9] Image retrieved from http://optimized-app.com/

[10] Image retrieved from https://www.livehealthily.com/

Figure 7: Example of data visualization in a multi-domain glanceable daily overview. The image on the left side is form the Optimized app[11] and the image on the right site is from the Umotif app[12].

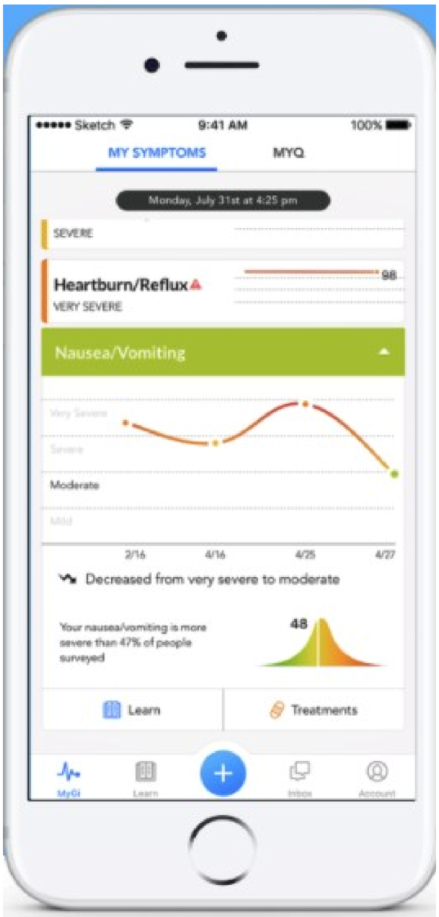
The examples provided so far only report information about the user. However, another distinction that can be made in data visualization is showing individual data vs. comparison to peers. The comparison to peers might serve the purpose of informing the user about how they are doing in a certain parameter or symptom comparing to peers. For example, on the left side of Figure 8, the MyGiHealth app provides an indication on how the severity of your symptoms (in this case nausea/vomiting) compares to the reports of other people surveyed. The image on the right side informs the user about their estimated fitness age based on the maximal oxygen consumption (VO2 Max) and compares with the values for people of the same age and gender.

A second purpose of comparing the individual data to that of peers is to promote competition, as a gamification element. Many fitness apps include rankings allowing the users to see compare, for example their weekly physical activity, with those of people they are connected with. Furthermore, some mobile applications allow for setting challenges to extra motivate people to outperform in a certain behaviour. Figure 9 provides an example of such application. Competition-based strategies to motivate healthy behaviours are particularly important for extrinsic motivated people, meaning that they require an external motivator beyond the inner pleasure of performing or accomplishing an activity.

Before concluding this section, it is important to reflect on the inclusiveness of the data visualization. Data visualization might be the simplest and most intuitive way to provide feedback on digital health solutions, but it should be designed having into account inclusiveness principles to make sure that everyone can successfully translate the data visualization to knowledge acquisition.

[11] Image retrieved from http://optimized-app.com/

[12] Image retrieved from https://www.umotif.com/



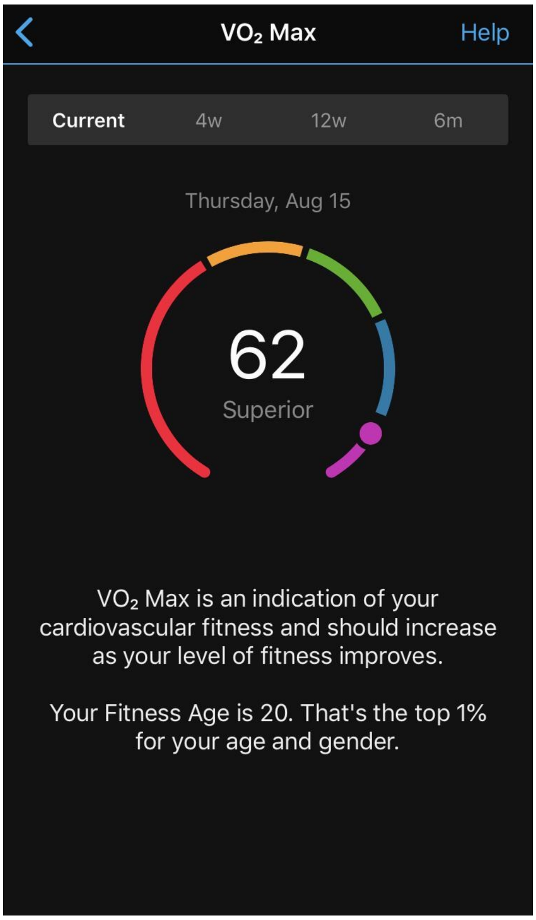


Figure 8: Example of data visualization including comparison to peers for the purpose of informing the user how his activities/symptoms relate to those of the peers. Left image from the MyGiHealth app[13] and right image from the Garmin Connect app[14].

[13] Image retrieved from https://mygi.health/app

[14] Image retrieved from https://www.reddit.com/r/Garmin/comments/e4bthk/i_posted_awhile_ago_about_my_vo2_max_and_im_back/

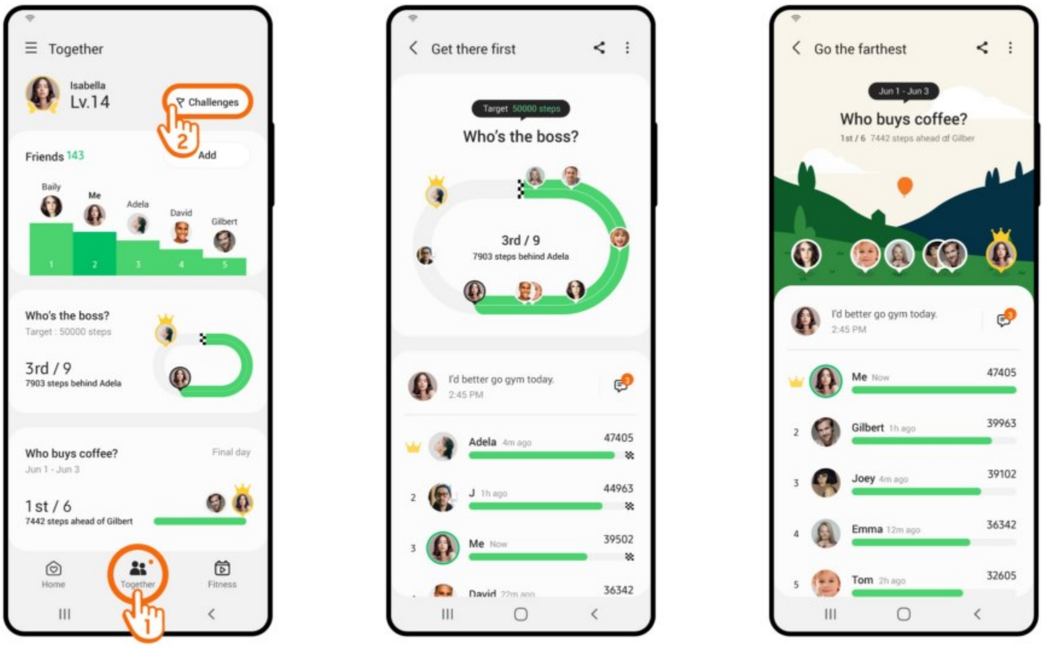


Figure 9: Example of data visualization including comparison to peers in the form of competition in challenges. Example from the Samsung Health application[15].

Literature has shown that digital health tools are used to a lower extend by people from vulnerable groups, including people with low socioeconomic status, older adults, minorities, and migrants (A., T., B., 20). This is particularly alarming as these vulnerable groups would benefit the most as they present the lowest health outcomes. Efforts are being made to design understandable visualizations of patient reported outcomes (A., W., B. 2018), (A., V., B., 15). Frameworks to assess data visualization literacy are being proposed, as in (B., B., G., 19) and could be adapted to digital health solutions.

3.2.2 Feedback messaged and nudges

The second mechanism of personalized advice delivery that we are going to address is feedback messages and nudges. Feedback messages or nudges are short, sometimes time-critical messages that are sent to the user to either inform them about their behaviour or to suggest some type of action to be taken on their behalf in order to improve their behaviour. Feedback messages and nudges are provided in natural language.

Feedback messages and nudges can occupy the full extent of the screen or be shown as push notifications. For example, in the Shleep app, feedback on performed activities is provided in full screen mode (Figure 10) while in the Human app, users receive nudges to move at pre-defined intervals between 30 and 180 minutes (Figure 11, left) in the form of push notifications.

[15] Image retrieved from https://news.samsung.com/global/achieve-your-new-years-resolution-with-new-group-challenge-feature-in-samsung-health

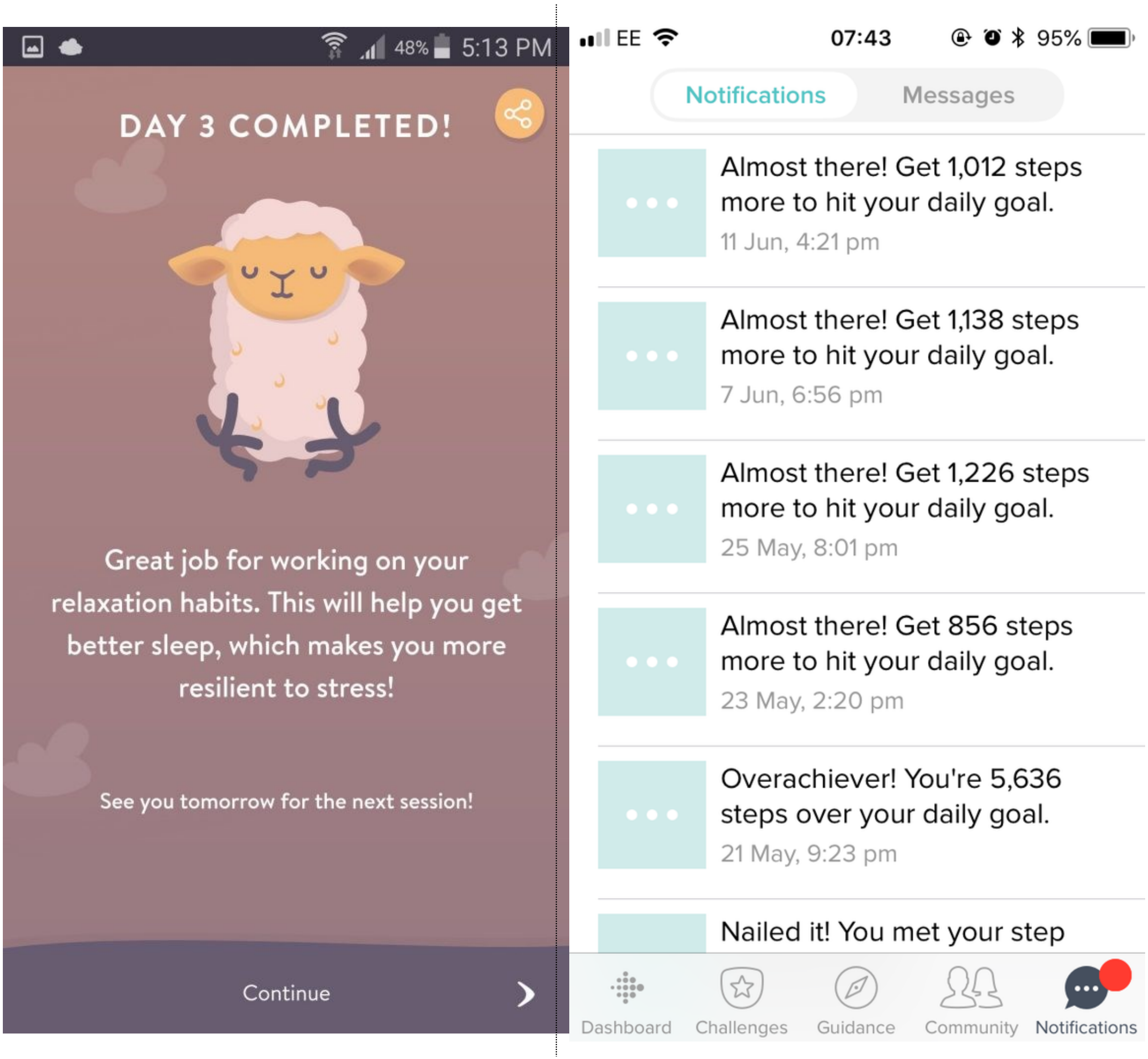


Figure 10: Example of feedback messages within the app. The Shleep app provides feedback messages on full screen mode (left, from the Shleep app[16]) and the Fitbit app provides motivational feedback messages when the user is almost reaching the goal (right, from the Fitbit app[17]).

[16] Image retrieved from https://www.shleep.com/press/computertimes

[17] Image retrieved from https://community.fitbit.com/t5/Other-Charge-Trackers/Constant-red-spot-on-notifications/td-p/2920726

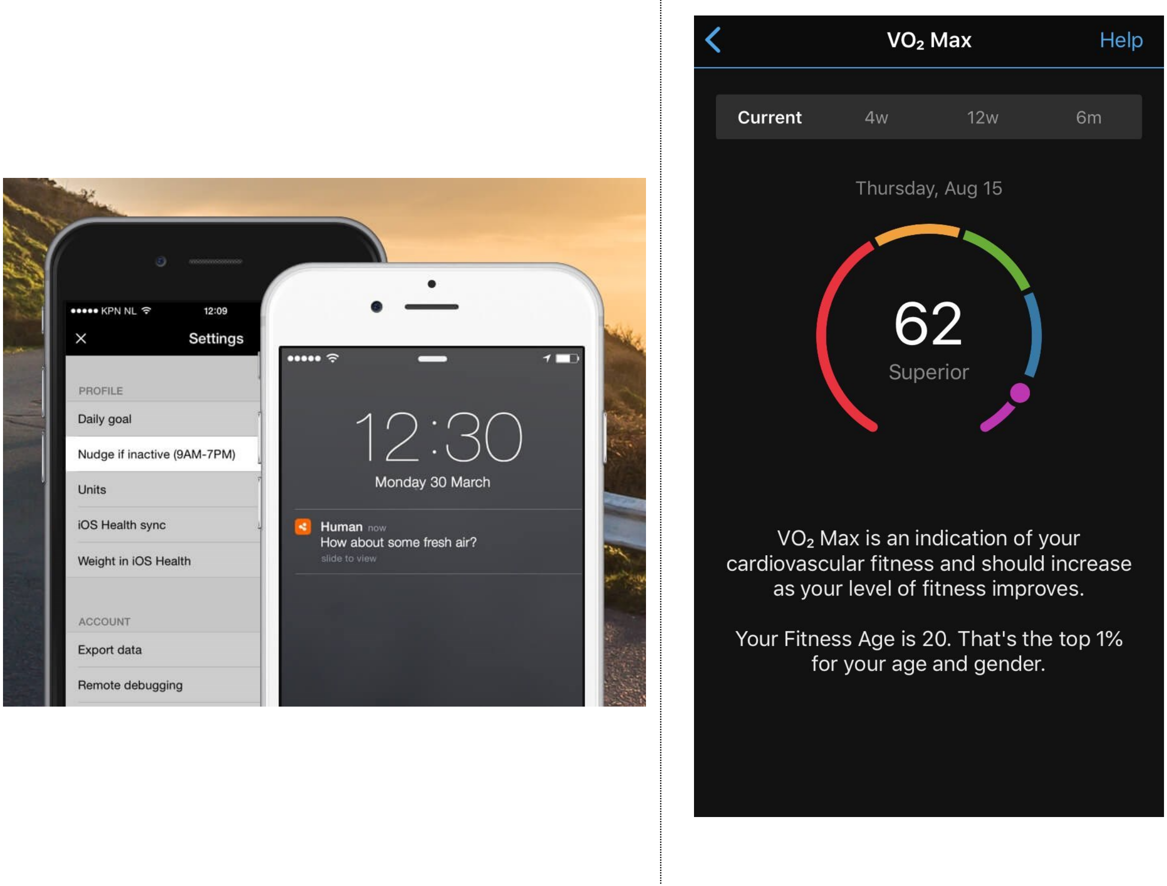


Figure 11: Example of nudges as push notifications. The Human app nudges the user to catch up some fresh air at pre-defined time intervals (from the Human app[18]) and the image on the right reminds the user to take their medication at a predefined time (from the Pharmassist app[19]).

3.2.3 Conversational coaching

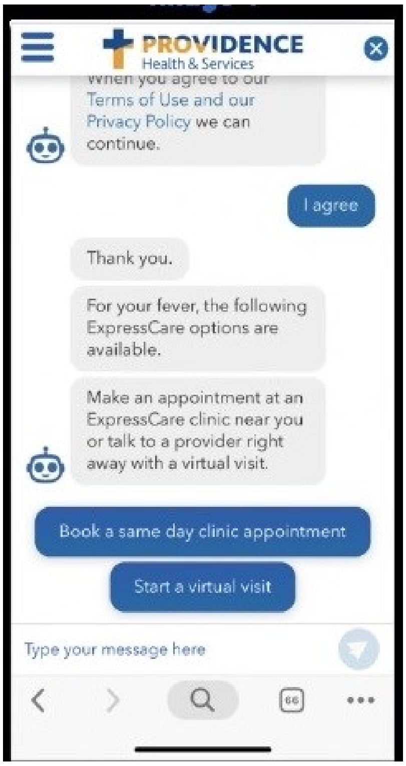
The third and final mechanism for personalized advice delivery that we will analyze is **conversational coaching**. In this mechanism, the user is invited to engage in a conversation with an agent, for example, by answering questions about their health status. This mechanism aims to make the interaction more engaging and more similar to face-to-face interactions. Unfortunately, fully automated voice interactions between a virtual coach and a user are still not possible at the present moment. As such, current applications in the serious domain of eHealth tend to focus on implementing chatbots or scripted virtual coaching dialogue. In this sub-section we will investigate two forms of embedding virtual coaches in eHealth applications: **chatbots** and **embodied conversational agents**.

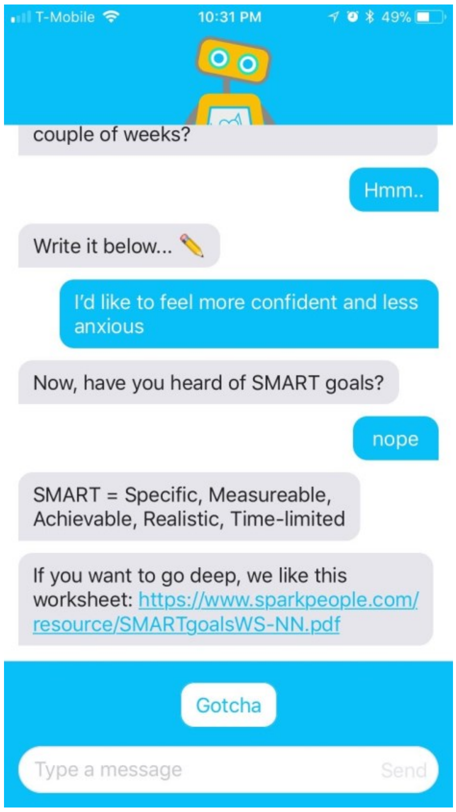
Chatbots can be visually represented by virtually anything, including robots, animals, objects or even no visual representation (as in Figure 12, bottom left). Chatbots can provide personalized advice with many purposes, including assistance and reminders along the care path (Figure 12, top left), delivering coaching strategies (Figure 12, top left), and providing additional information about a certain disease or symptom. For example, the chatbot of the OneRemission app (Figure 12, top right) provides cancer-related information as a reply to requests from cancer patients and cancer survivors. Users can interact with

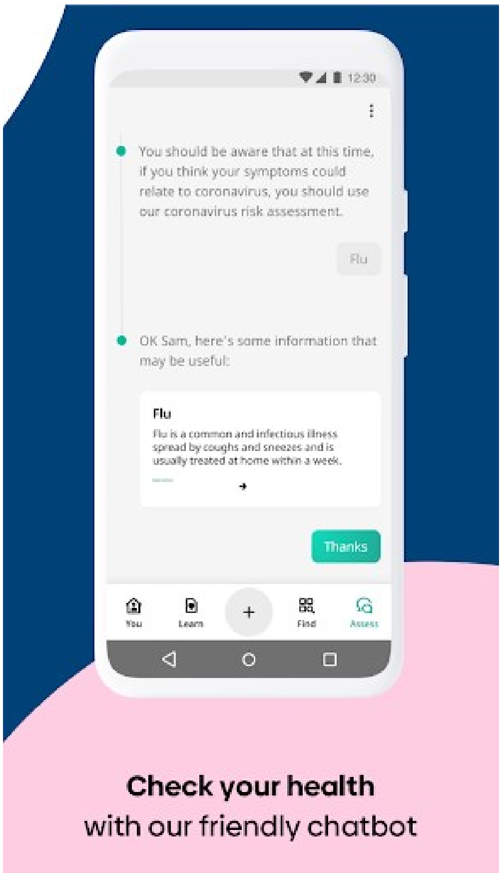
[18] Image retrieved from http://human.co/posts/human-4.2-nudge-and-club-invites.html

[19] Image retrieved from https://crystalnpetersen.wordpress.com/pharmassist-app/

chatbots using predefined answers or providing open input for a more natural interaction. Most chatbots mimic conversational applications familiar to most users, such as Whatsapp and Facebook Messenger.







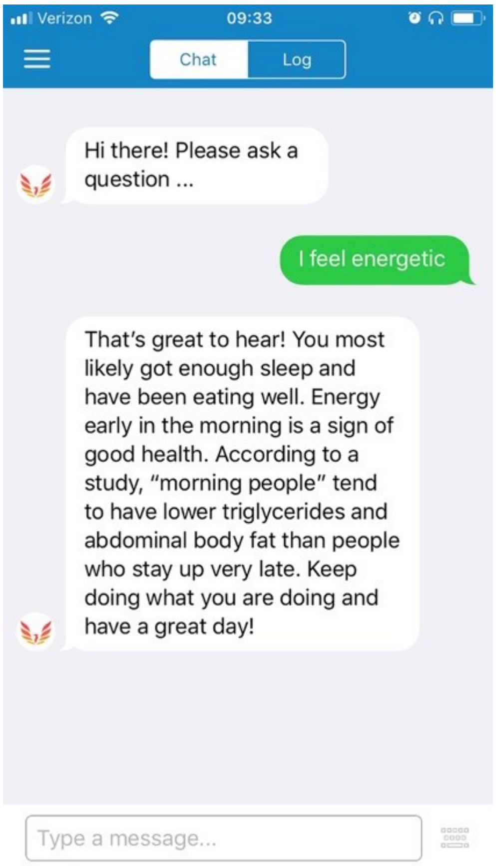


Figure 12: Examples of chatbots used for personalized advice delivery, namely in scheduling appointments (top left, from Providence Health Services app[20]), delivering personalized coaching strategies (top right, from Woebot app[21]) and providing more information about a certain disease (bottom left from Healthily app[22] and bottom right from One Remission app[23]).

Conceptually speaking, Chatbots and Chatbot frameworks such as Azure Bot Service[24], or Google's Dialogflow[25] can be seen as conversational interfaces that offer search functionality on an underlying, often well structured, database, or offer a conversational interface for a well-defined tasks (like booking a flight, or adding the breakfast option to a hotel reservation). Such frameworks allow a user to type "*I'm having a bit of a headache*", and will present the user with a step-by-step 'reading' of the knowledge-base item on headaches. Similarly, a user input "*Can I book an appointment?*" will be mapped to the "Booking Appointment Use Case", a scripted interaction whereby the chatbot will asks for the necessary details, and then perform the booking. The result is often an interactive virtual agent that seems intelligent - as long as it can match the user's input – but that requires (a) a large structured knowledge base, and/or (b) many pre-scripted interaction use cases (e.g., booking).

An alternative approach is that of offering fully scripted interactions, an approach followed e.g., in the H2020 project "Council of Coaches" (A., A., B., + 18). Figure **13** below shows a screenshot of the application, showing multiple virtual coaches ("the council") in a living room, and a conversational user interface using text balloons and reply options (bottom bar). The objectives of the Council of Coaches project are similar to the objectives related to the delivery of personalized feedback in the iHelp project: to provide feedback, and information in an engaging way, and to increase adherence to the application. In Council of Coaches, the decision was made to script all dialogues. In this way, the creators could be certain about which information would be presented to the user (I.e., a coach would never say "start smoking", unless a dialogue author would put that in). Scripted does not necessarily mean that the system is offering a one-size-fits-all solution. The WOOL Platform that powers the scripted conversations in the Council of Coaches project is specifically designed to support many different types of personalisation. The WOOL Platform[26], defining the dialogue language and various tools to support its use in e.g., eHealth applications is available as open-source and will be used in the iHelp solution to power its virtual coach.

[20] Image retrieved from http://www.consumerehealthengagement.com/consumerehealthengagement/2020/2/25/providence-healths-bot-grace-engages-and-guides-patients-to.html

[21] Image retrieved from https://www.businessinsider.com/therapy-chatbot-depression-app-what-its-like-woebot-2018-1?international=true&r=US&IR=T

[22] Image retrieved from https://www.livehealthily.com/

[23] Image retrieved from https://appadvice.com/app/oneremission/1071360838

[24] https://azure.microsoft.com/en-us/services/bot-services/

[25] https://cloud.google.com/dialogflow

[26] https://www.woolplatform.eu

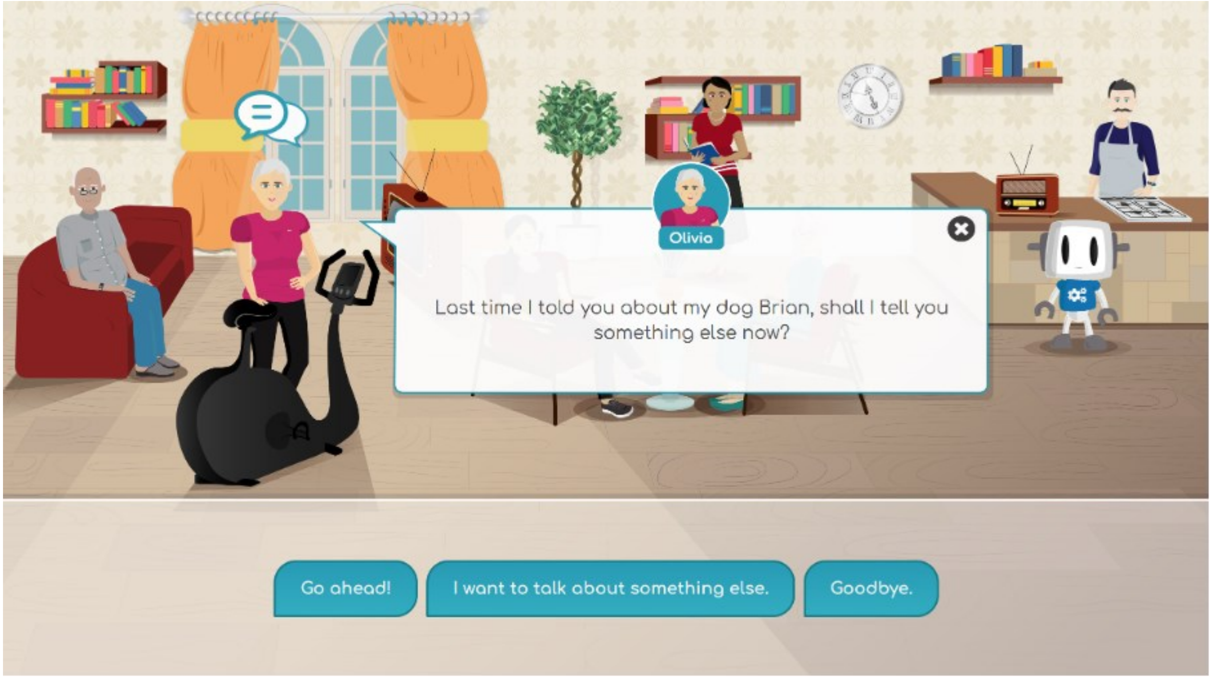


Figure 13: Screenshot of the Council of Coaches application.

3.2.4 Monitoring through self-reporting

As a result of the advances in the development of sensing technology over the last decades, nowadays behavioral information such as physical activity and sleep can be fairly easy monitored using wearable devices. In these situations, data is acquired unobtrusively, meaning that the user does not need to interact with the system. In certain situations, minimal interaction is required, such as to start a sport activity. However, some parameters are not suitable to be monitored with wearable devices. For example, the experience of pain in a certain day, or a global overview of how the patient is feeling, is best captured by directly asking the user to provide information.

In the **Experience Sampling Method (ESM)**, also referred to as Ecological Momentary Assessment, users are requested to report on their current feelings, mood, thoughts or activities (C., L., 87). By requesting for the feelings of the users at the specific moment or in a short time span (e.g., in the last hours), ESM is often mentioned to reduce the recall bias (S., S., 02), (S., C., D., 03) introduced by the other conventional methods, or even, medical appointments spread over months or years. Smartphones and smartwatches became the most common media to perform ESM considering that people carry these devices most of the time. There are four ways to trigger information via ESM: user-triggered (i.e., the user decides when to report their feelings/experiences), time-triggered (i.e., information is requested at pre-defined times), event-triggered (i.e., information is requested when the device recognizes a trigger, such as via geofencing), and random-triggered (i.e., questions are asked at random times).

The most conventional way to visualize ESM on the smartphone is replicating the paper versions, i.e., using text, as shown in Figure 14. In this example, the user is asked to report current experience of different emotions using Likert and Visual Analogue Scales (left and center images, respectively). Moreover, the user is requested to report on current social companionship through multiple choice questions (right image).

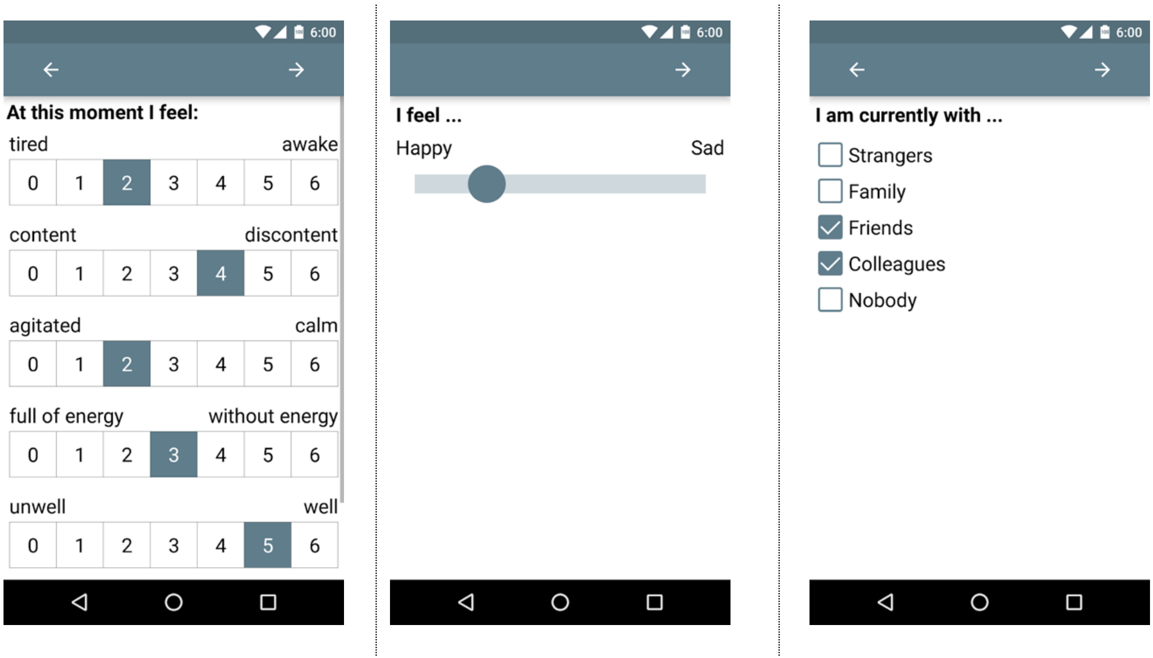
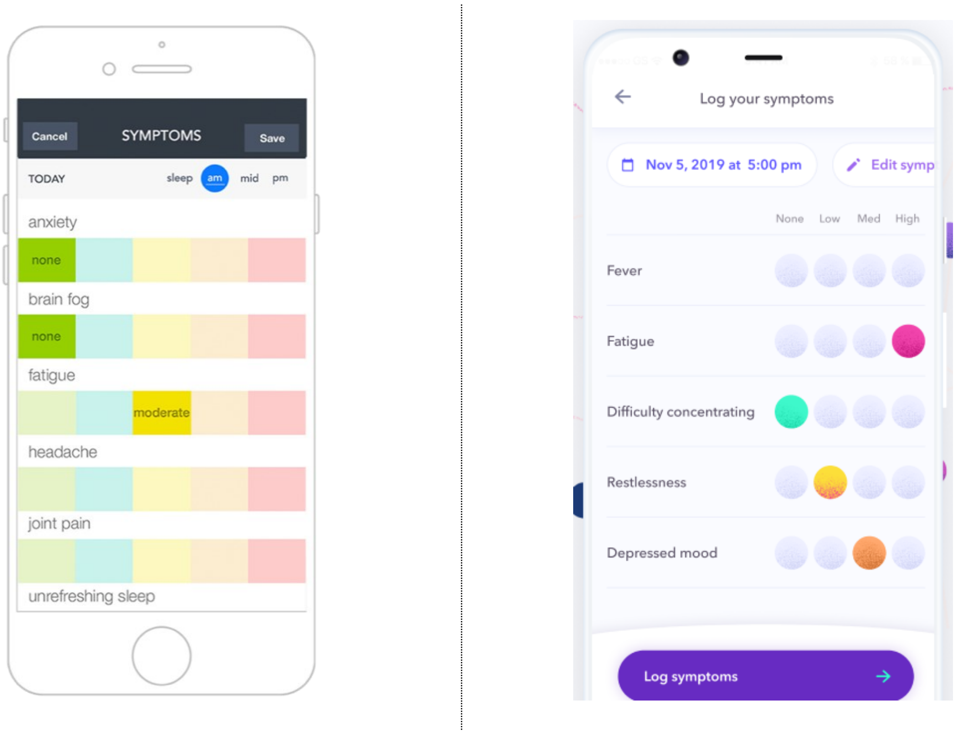


Figure 14: Example of monitoring information using ESM delivered on a smartphone application replicating the paper-based questionnaires (from movisens application[27]).

Some smartphone applications adopt more visually pleasant options to provide answers to the questions, as for example through colour schemes as shown in Figure 15.



[27] Images retrieved from https://play.google.com/store/apps/details?id=com.movisens.xs.android.core&hl=en&gl=US

Figure 15: Example of use of Experience Sampling Method for symptom tracking in a smartphone application providing answers in a colour scheme from the Symple app[28] (left) and Dot Health[29] (right).

A variation on how to deliver ESM is through the **coach-as-a-sensor** paradigm. In this paradigm introduced in the H2020 Council of Coaches project (#769553), data is collected through natural conversations with conversational agents, as those introduced in the section above. Figure 16 provides two examples on how conversational agents can request information from the user, on behavioural parameters (left image) and symptom tracking (right image).

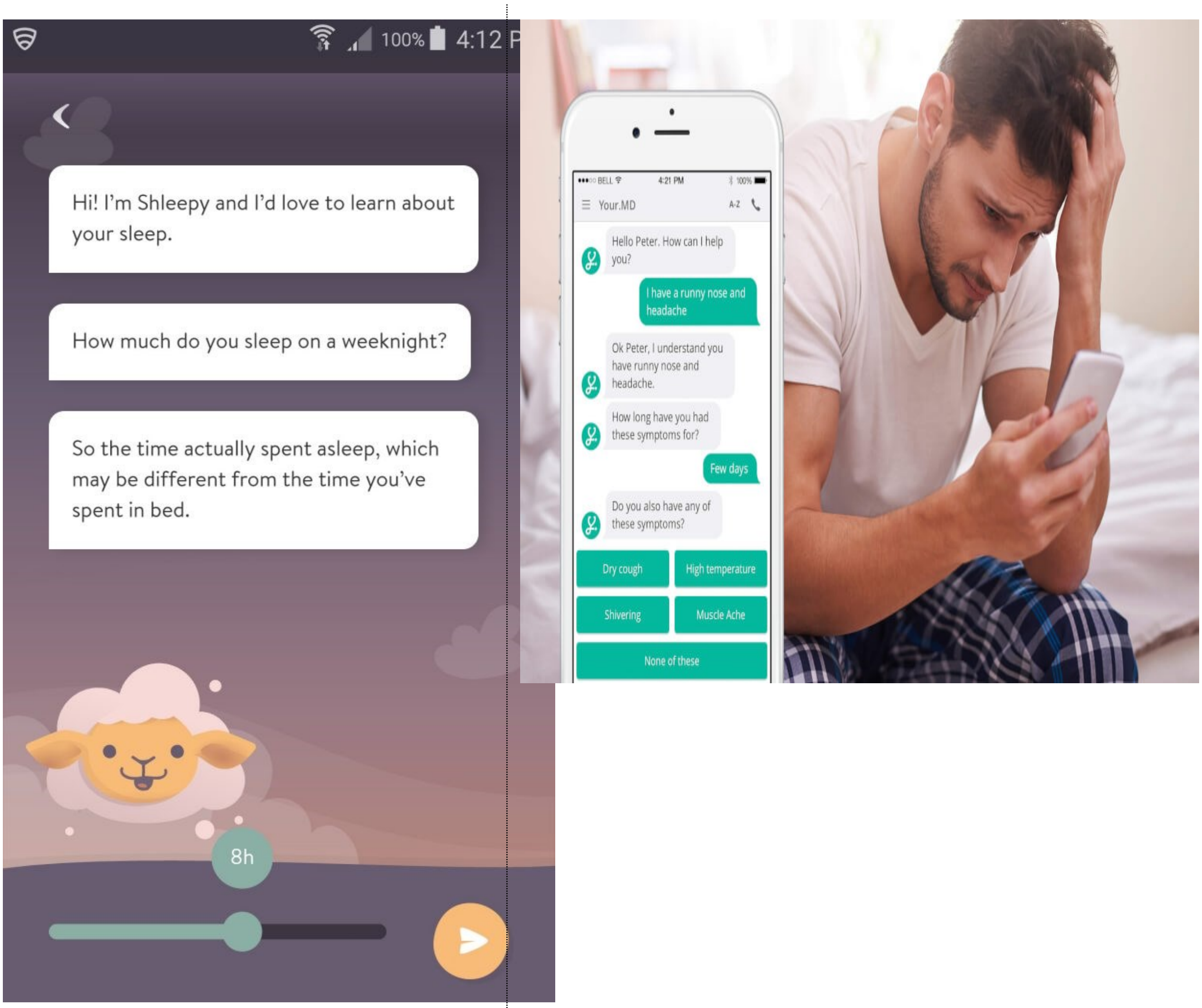


Figure 16: Examples of monitoring using ESM delivered through conversational agents, from the Shleep app[30] (left) and the Your.MD[31] app (right).

[28] Image retrieved from https://www.sympleapp.com/

[29] Image retrieved from https://www.dothealth.ca/post/covid-19-how-to-keep-safe-and-track-your-symptoms

[30] Image retrieved from https://www.shleep.com/press/computertimes

[31] Image retrieved from www.techcrunch.com

3.3 User-Centred Design

As a project, iHelp aims to create e-health software that meets the needs of all categories of its users. It therefore needs a system development approach that is user centred in that system design and behaviour is oriented towards the needs of its users and is intelligible to them, allowing their active participation in the design of the system (KLI, 77), (NOR, 86). To achieve this, we employ a set of user-centred design techniques such as personas, wireframe prototypes and feedback sessions. These are coordinated through the general approach of Design Thinking, which is explained in detail below.

3.3.1 General Approach of Design Thinking

Design thinking is a novel strategic approach to problem solving, especially well-suited to encourage innovation and growth in relation to existing or newly developed products and technologies. The approach rests on an assumption that all product or technology development should be supported by continuous user feedback and developed with users and should support different users in their progression along their behaviour (customer) journey (LIE, 15), (K., A., R., 17).

Design thinking is a framework guiding research or decision activities in the context of product development or management, with an aim to solve problems from the end-user point of view. In the context of technology development – the framework can guide the decisions related to the UI development (e.g., look and feel, functionality and usability). In Table 1 and the section below, we explain how we could apply the design thinking principles in the context of the iHelp project.

Table 1: Design thinking approach proposed for iHelp User-Centred Design.

Design thinking stage (Stanford Design School)	Empathise	Define	Ideate	Prototype and Test
Description of the stage	Learn about your consumer/user (needs, goals, lifestyles, activities and desires)	Define scope of pain points and other problems the technology could resolve. Focus on the role of the offering to achieve a specific task, objective, etc.	Propose potential solutions to be applied in the context of UI	Test potential solutions with the prototype
Feedback mechanism	Qualitative user research	Qualitative and quantitative user research	Brainstorming within agile teams	Wireframe prototyping, Evaluation

The way in which the stages of Design Thinking map to tasks and WPs of iHelp are illustrated in Figure 17 below.

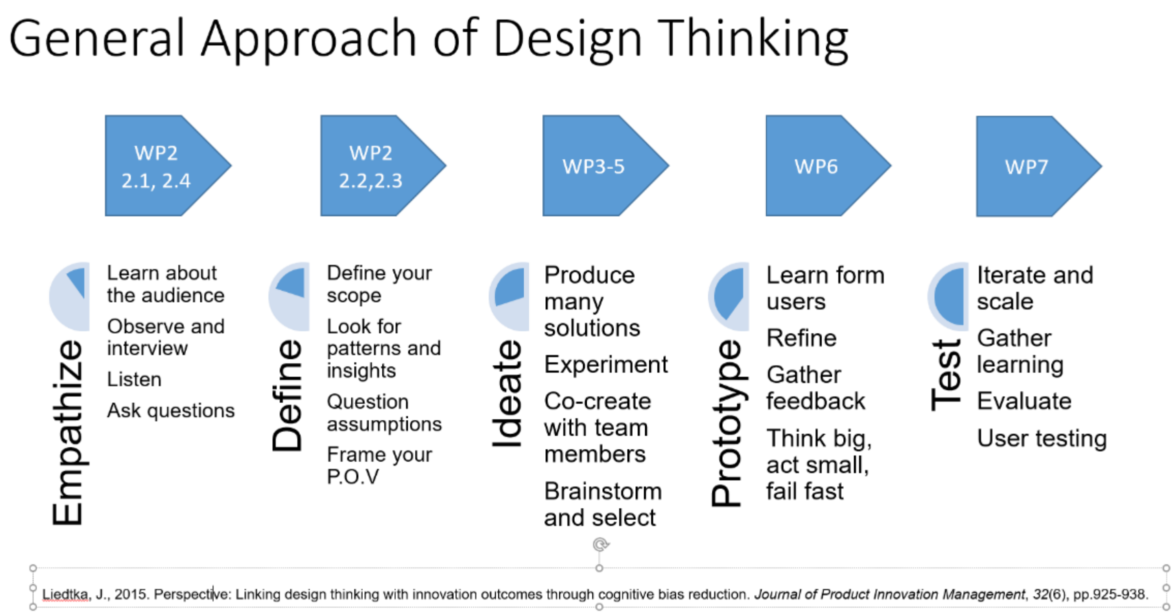


Figure 17. Mapping of Design Thinking Stages to Tasks and Work-packages of iHelp.

Emphasize

In the framework, the initial and critical step, the emphasise stage, relates to understanding of potential problems and solutions that affect the end user – here a customer or user. This stage of inquiry involves predominantly exploratory qualitative research to understand benefits and potential pain points resulting from the consumer/user journey. The focus of inquiry at this stage could be understanding basic motivations, as guided by consumer behaviour and consumer experience (H., J., K., 17), (K, J., H., 19). It is very important for a company to know their consumers, understand their lifestyles and the role a product or service can play in that lifestyle, understand activities and tasks performed with a product or service and understand perceptions of quality associated with the product and brand.

Define

After companies empathise with their consumers, the next step is to define the potential area of activity that will outline the scope of product or communication attributes that are relevant to consumers. The define stage can relate either to the area of UI development and optimisation or to development of content marketing which will be used to drive traffic to the website on different marketing channels, and in most cases in relation to both. At this stage some teams decipher different product or communication attributes that are relevant to consumers. Another aspect that needs defining relates to different aspects of the website. The navigation, product presentation, filtering and sorting functionality can all contribute to an easier, seamless customer journey, or can become pain points. At this stage, companies should be mindful to ensure the attributes they decide to emphasize in the result of this stage show consistency in relation to branding, integration across touchpoints and personalised and responsive attributes (K, J., H., 19).

Ideate

Following the design thinking route to personalisation, companies can apply the process to first understand (emphasize and define), and then ideate and prioritise potential solutions that could help to remove any pain points that a consumer can experience during the consumer journey. Using cross team/cross departmental groups for brainstorming sessions helps with coming up with a diverse set of viewpoints, ideas and solutions, and then prioritising these in line with value adding capabilities (to both consumers and the business).

Prototype and Test

The modern technology allows quick prototyping and testing which feeds to an agile way of working. These include using A/B software to compare small changes and proof of concept (POC) functionality on site, as well a different variants of marketing communications. Examples would include things like a change in positioning or colour of an element, or differences in online forms, whereas off site things like different ad copy or ad extensions can be tested against each other.

Companies should also consider the feedback mechanisms that will enable them to understand any progress relating to the implemented changes or its lack (GOW, 12), (X., D., W., 14), (M., U., B., 18).

3.3.2 Design processes compliant with Medical Devices

iHelp will create a system which will provide information based on which clinicians will make decisions with therapeutic purposes. As such this system is classified as Medical Device Class IIa according to the Official Journal of the European Union L 117/143 - Section 6.3. Rule 11[32].

It is **not** expected that the software will inform decisions that may cause death or an irreversible deterioration of a person's state of health, so the software should not be positioned in Class III.

It is also **not** expected that the software will inform decisions that may cause serious deterioration of a person's state of health or a surgical intervention, so the software should not be classified as Class IIb.

Class IIa medical devices should comply with a set of requirements for software design procedures and techniques as explained below. In the UK, for example, medical devices fall under the UK Medical Devices Regulations 2002 (SI 2002 No 618, as amended)[33], which transposes the following EU Medical Device Directives:

- Directive 90/385/EEC on active implantable medical devices (AIMDD)
- Directive 93/42/EEC on medical devices (MDD)
- Directive 98/79/EC on in vitro diagnostic medical devices (IVDD)

The Essential Requirements (ER) for medical devices like iHelp are covered in Part II of the UK MDR 2002, Annex I (for general medical devices), ensuring adequate safety and performance. These are interpreted in (MHRA, 2021), keeping in mind the updates provided in 2010 by Directive 2007/47.

These essential requirements include the following useability-related requirement:

ER 1: The devices must be designed and manufactured in such a way that, when used under the conditions and for the purposes intended, they will not compromise the clinical condition or the safety of patients, or the safety and health of users or, where applicable, other persons, provided that any risks which may be associated with their intended use constitute acceptable risks when weighed against the benefits to the patient and are compatible with a high level of protection of health and safety.

[32] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2017:117:FULL&from=DE

[33] https://www.legislation.gov.uk/uksi/2002/618/contents/made

This shall include:

- reducing, as far as possible, the risk of use error due to the ergonomic features of the device and the environment in which the device is intended to be used (design for patient safety), and
- consideration of the technical knowledge, experience, education and training and where applicable the medical and physical conditions of intended users (design for lay, professional, disabled or other users).

This extract highlights two important considerations in designing Class IIa software:

- risk-reducing design of user interfaces keeping in mind the context of using the system;
- design informed by the background of target users.

Both are critical elements of user-centric design, and ergonomic principles also appear in Essential Requirements ER 9.2, 10.2 and 13.1 in the same document. Note that whilst there are no imposed requirements on specific interface elements like screen components, colours, layout, etc, there is a strong expectation that general ergonomic principles will be observed, and that the design will carefully consider the background of target users, and the context in which they will use the system, such as brightness, noise, etc. The background of target users is made explicit in the next section through the technique of personas.

The requirements for the process of designing of a medical device provides substantial focus on the Usability Engineering Process, comprising techniques such as:

- Requirements
- Wireframing
- Validation

The use of these techniques is summarised in the typical usability engineering process shown in Figure 18 as provided in the MHRA Guidance (2021). It stipulates that a record of the process followed should be recorded in a usability engineering file of the device technical documentation, supporting a statement of compliance with IEC 62366.

This process is fully aligned with the user-centric design process embraced by iHelp, focusing on early validation of requirements with pilot users through wireframe prototyping, followed by usability testing of designs with all user groups, and finally conducting usability evaluation of the final product of modules as designed by the iHelp partners. Any use errors identified at any of these stages are fed back into the development and corrected swiftly.

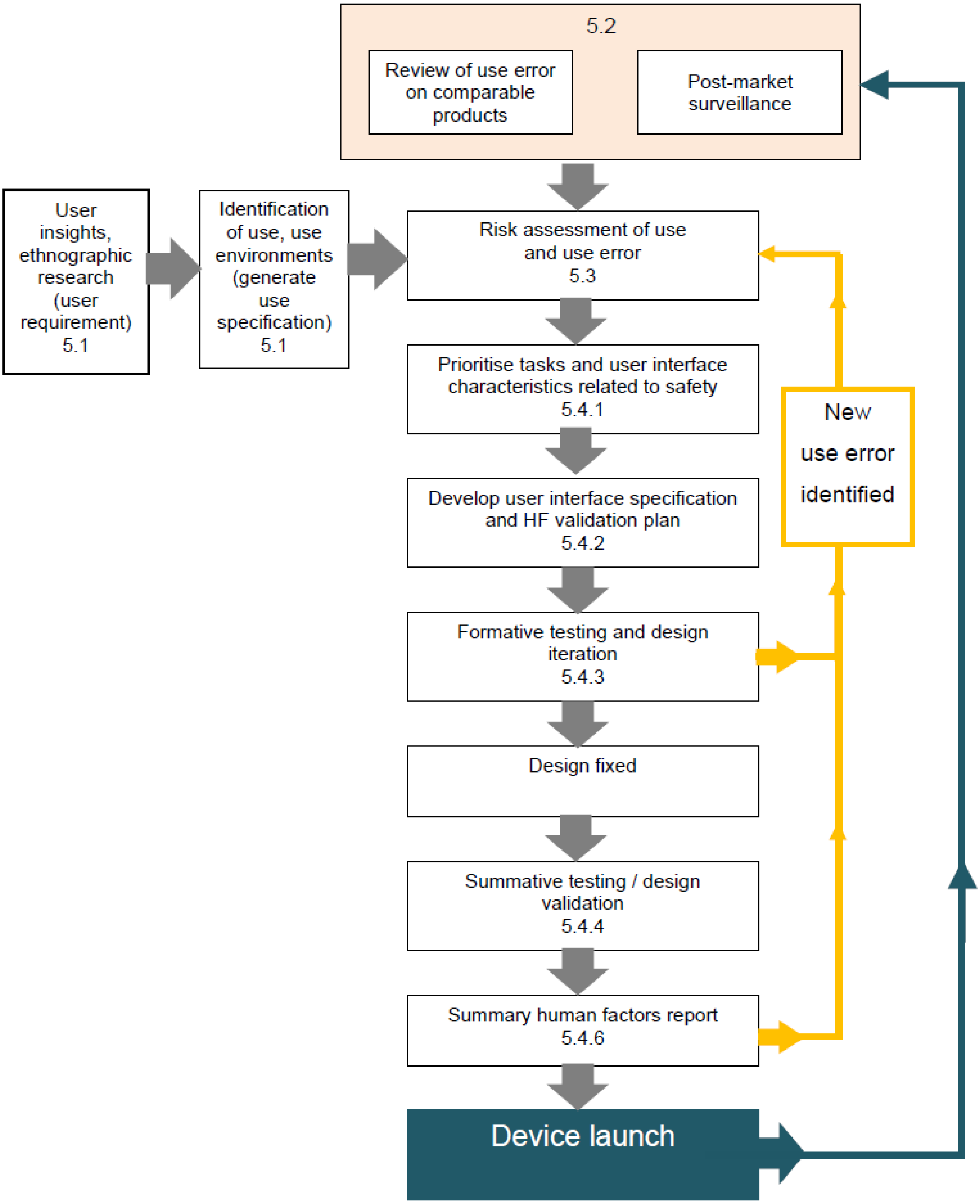


Figure 18: Design Process of Medical Devices, taken from MHRA Guidance (2021).

3.3.3 Arousing and Retaining Attention Through Gamification

A successful eHealth software will attract the attention of its users and keep it for sufficient duration so that the software may achieve the required effect on its user. This becomes increasingly critical for software like iHelp which, in most of our pilots, needs to work with the user to change behaviour to more healthy eating, exercises and removing of bad habits such as smoking and alcohol. For this we need to consider an established and widely used behavioural change model. Such a model can be found in the works of the Stanford's academic Dr. BJ Fogg, named Fogg Behavior Model (FBM) (FOG, 11), shown in Figure 19.

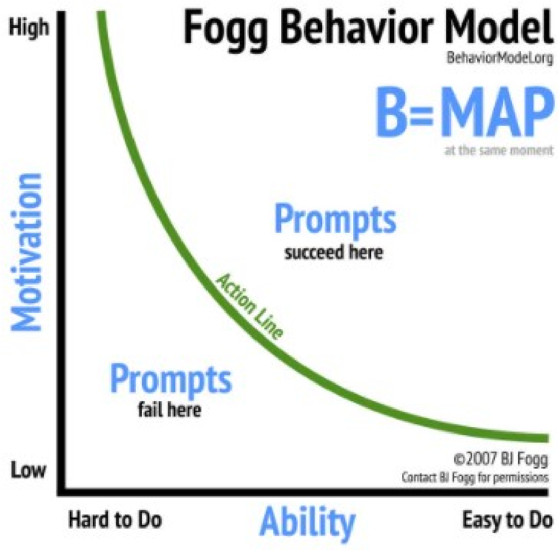


Figure 19: Fogg Behavior Model. Taken from Fogg (2011).

In this model, software can cause action by combining at the same time Motivation, Ability and Prompts. Prompts are effective only beyond certain "front" (called Action Line) describing a non-linear combination of values on the Motivation axis and on the Ability action. In other words, to successfully change behaviour, we have to continuously create the right conditions for prompts to lead to action, so we need to ensure users are highly motivated and/or the action is very easy to do.

For example, the success of social media applications is often explained with its use of the FBM as follows:

- Prompt – the screen lights up
- Motivation – the user is motivated to open app because of fear of missing out, anticipation, or perhaps they have a long-running "streak" which they don't want to break.
- Ability – it is very easy to open and login into the app. It is all ready, no password is needed once you login the first time round.
- Action – once a prompt is received with a high motivation and high ability, the user will open app and start browsing, then click "like"

Once a certain number of these actions in response to prompts is achieved, browsing becomes a habit and the behaviour is changed.

In the case of an eHealth Behaviour Change Application, these elements can be fulfilled by the following with respect to the individual whose behaviour we are aiming to change, or the patient who do we want to treat:

Prompt: a set of behavioural prompts designed to remind the user at key moments about the need for them to interact with the system. The colour of the app can also be chosen to supplement the "trigger" effect of the prompt, for example contrasting colours (yellow/black; red/black/light blue) are usually connected with heightened arousal and attracting attention. The example in Figure 20 demonstrates the use of highly effective colour scheme for attracting attention on the right contrasted with a calming scheme for a sleep application on the left.

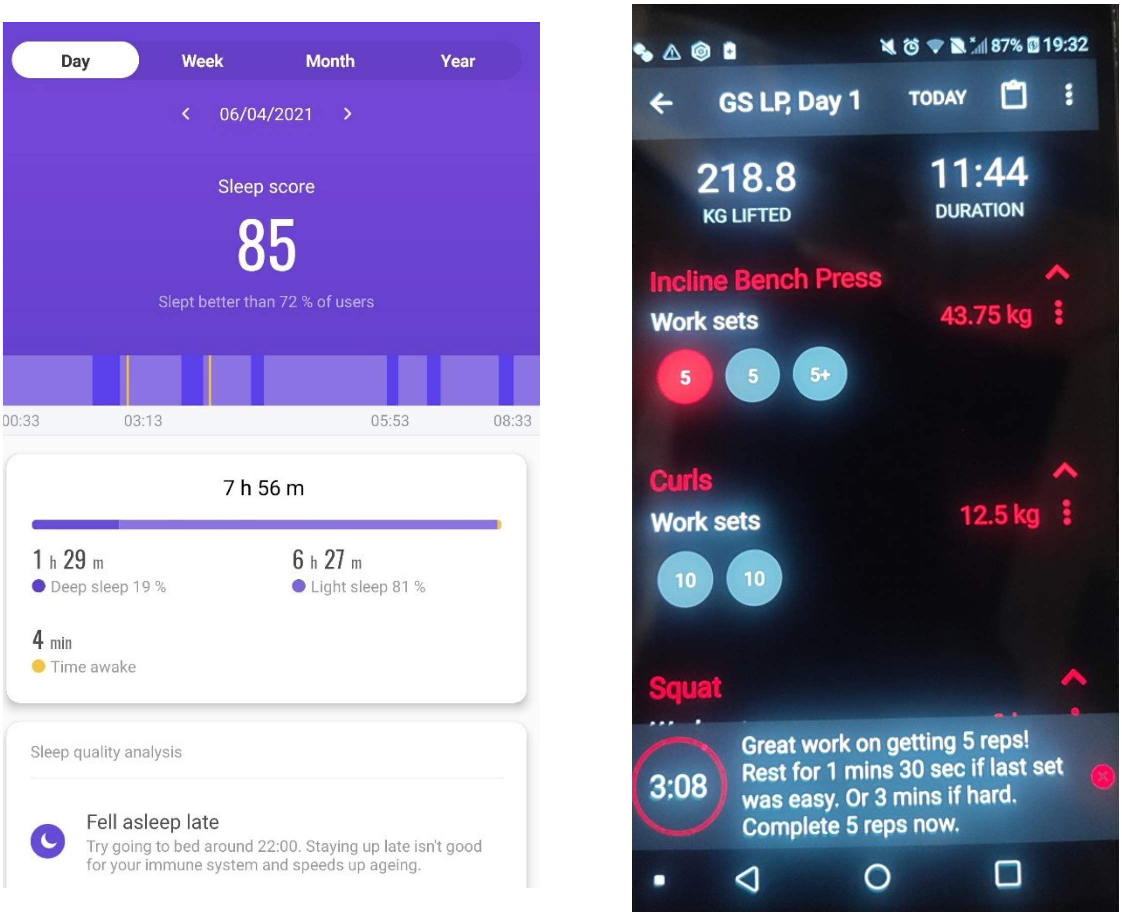
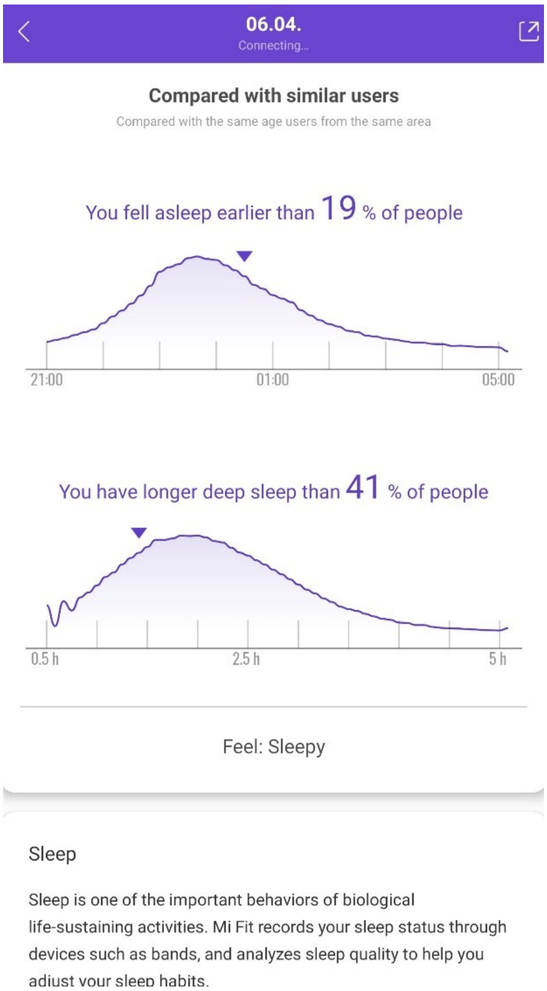


Figure 20: Two colour styles - calming (left) vs attention-grabbing (right).

Motivation: the individual is expected to be motivated to open the iHelp app because of health concerns, or by their desire to reduce the chances of developing a disease. This motivation is likely to wane over time, so we would need to also supplement it with a software feature which we know generates motivation. These are based on Identity, Competition and Reputation. These are often combined in systems where users are compared against others, and their successes can be shared with their social circle. The following techniques should be considered when designing the app:

- "Likes" – other users like the achievements shared by the user to be motivated;
- "Streaks" – the user is keeping motivated by extending a "streak" of activity, they are reluctant to stop since they will be losing their investment in the achievement so far.
- Ownership – the app is asking "what time should I prompt you?"

- Comparison with other users – left side of Figure 21 shows an app which compares user achievements with those of other users.
- Gamification combining elements from the techniques above – for example the right side of Figure 21 shows a version of the "streak" technique where you grow a tree for every unit of achievement, and if you break the positive pattern a tree dies.



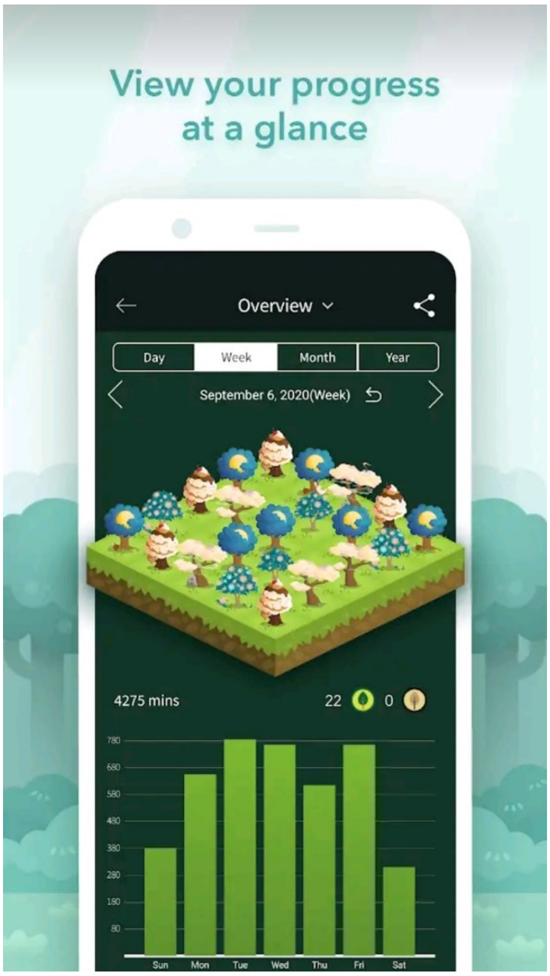


Figure 21: Two motivational techniques - social comparison with peer group (left) and gamification by tree growing (right).

Ability: To ensure that users of all skills levels and educational backgrounds are able to use the part of the system responsible for behaviour change, the iHelp should be designed carefully and evaluated by its potential target users, feeding back the results of this evaluation into the design and development effort by the software developers on iHelp. The size of user interface elements should match the expected age and vision acuity characteristics of the target users.

Action: The user actions should be used to feedback into the motivational and prompt stimuli. These would usually be obtaining information and advice from the app, and then we would monitor if the user is following this advice and adjust the stimuli and motivational characteristics accordingly using the intelligent capabilities of the system.

4 User-driven Design Process of iHelp

4.1 Process requirements for Medical Devices

As acknowledged earlier, iHelp software is considered Medical Device Class IIa since it will provide information on the basis of which clinicians will make decisions with therapeutic purposes (Official Journal of the European Union L117/143, Section 6.3, Rule 11[34]). As reviewed in Section 3, we need to implement a user-driven iterative design process, which observes general ergonomic principles, and we need to carefully consider both user backgrounds and the system use context, such as noise and light pollution.

These requirements motivate our use of usability engineering techniques including requirements and personas, wireframing and validation. The process followed will be recorded in a "usability engineering file" of the technical documentation of the device, complementing an IEC 62366 compliance statement.

4.2 Process Implemented in iHelp

This process implemented in iHelp as described in the Description of Work is fully aligned with the usability engineering techniques mandated by the consideration of iHelp as Medical Device Class IIa. It starts by explicit specification of the relevant characteristics of the target groups of users according to the system functionality they would use. This is done through the technique of Personas, with details provided in the sequel of this section.

The process of iHelp then focuses on early validation of requirements with pilot users through wireframe prototyping. This is described in Sections 5-7 of this deliverable.

The next deliverable due at the end of T2.4, will describe the next stage of user-centric design process: usability testing of designs with all user groups. This will be followed, at the start of the final year of the project, by usability evaluation of the final product of modules as designed by the iHelp partners within T7.2. Any use errors identified at any of these stages are fed back into the development and corrected swiftly.

4.3 Personas

To successfully observe general ergonomic principles, the UI design of iHelp should carefully consider the background of target users. This background is made explicit below through the technique of personas. In addition to the characteristics of different types of user we also need to consider specific general characteristics of target user population such as age. Indeed, vision acuity is generally reduced after the age of 60, imposing minimum font size requirements on our interfaces. Also, we should consider the risk that our users may be colour blind, so we should not colour-code interface components as the only way to indicate positive or negative outcome of assessment. The colour should be supported by clear textual label. The text below provides a brief overview of our personas, detailed descriptions of the most relevant ones are found in Appendix A. Persona Descriptions.

[34] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2017:117:FULL&from=DE

4.3.1 Model Builder

The persona dealing with building new risk models for pancreatic cancer is called Kevin. Kevin is 50 years old and has a doctorate in the application of analytics to epidemiology. Kevin is familiar with computers but not necessarily with AI, and he is an expert in epidemiology and statistics. He may need help with envisioned DSS interface.

4.3.2 Health Professional

The Health Professional persona is Jill. She is a 40-year-old General Practitioner, with a medical degree. She is interested in medical diagnosis and health matters. She is not technical and has no time nor inclination to learn new interfaces. She is comfortable using existing patient information systems.

An auxiliary personal is Mel, a 30-year-old nurse. Mel is interested in patient care and trained to existing patient IS, but does not have the full decision-powers of Jill, and will not be able to fully replace her in operating the system.

4.3.3 Individual

To represent the different types of individuals and patients we envision using iHelp, we divide them into three personas:

Ann is a 40-year-old gamer. She is driven by success and interested in maximising results, but is sedentary and not physically active.

Jack is 50-year-old professional. He is comfortable with apps and mobile interfaces. He is not interested in achievements but interested in health preservation. Jack is actually of higher risk to develop pancreatic cancer compared to the general population and is also a diabetic.

Pat is a 60-year-old teacher. She is diagnosed with early stages of pancreatic cancer, she also has poor eyesight and deteriorating dexterity.

4.3.4 Policy Maker

Our system will also include users who will be scanning social media and analysing trends related to eHealth and pancreatic cancer, shaping regional policies on the matter. Their profile is exemplified by Sarah. Sarah is a 40-year-old health professional, who is interested in maintaining a set of health KPIs at regional level. She is an intermediate user of IS but has strong analytics and policy skills.

4.3.5 System Administrator

Our system administrator is George, a 30-year-old IT professional. George has the job of maintaining a local deployment of iHelp, and is interested in security, data privacy and data integrity.

5 User-facing Use Case Models

Based on the functional requirements captured within T2.1 and expressed in D2.1, we have defined the main cases where our personas interact with the system in a significant manner, encapsulating these cases into an over-arching use-case model focus on the main areas of focus on user-driven user-interface development.

The use case model in Figure 22 below is based on the pilot of Medical University Plovdiv, developed to provide a generic all-in-one overview of the interactions between the system and its stakeholder in the UI-intensive interactions with the model builder (Ken), Health Professional (Jill) and Individuals (Ann, Jack and Pat). Each of these key stakeholders will be using a very different interface:

The **Model Builder Ken** will be using an analytics tool to test different risk assessment models on the data available in the system, customising them for a specific country and deployment context expressed as different pilot scenarios in our system.

The **Health Professional Jill** will be using a desktop or tablet interface aiming to present all relevant information and system advice on a single screen to facilitate Jill in making the correct decision regarding the risk of the individual and ways of reducing this risk.

The **Individual (Ann, Jack or Pat)** will be working with a mobile device to ensure convenience of operation, to lower the barriers to engaging with the system, and to maximise the range of mobile and wearable sensors such as smartbands and other body-warn sensors which can be used to gather user data regarding lifestyle, exercise and health parameters such as pulse rate.

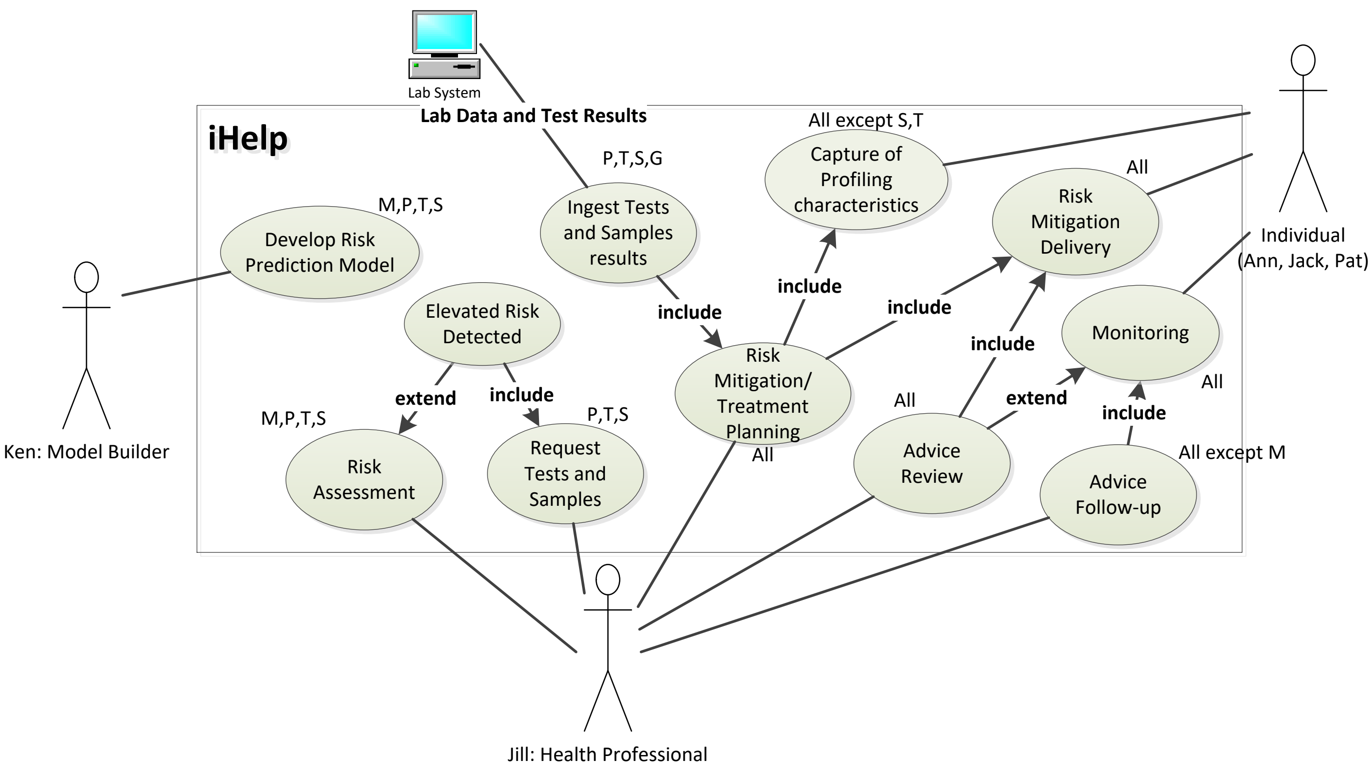


Figure 22: Use Case Model of overall iHelp interaction with its Users, based on the Pilot of Medical University Plovdiv.

The use case model shows each of these main users and the use cases they use to interact with the system. Each use case is relevant to different pilots. The pilots associated with each use case are indicated in Figure 22 using the abbreviations explained in Table 2 below:

Table 2: Abbreviations Indicating Relevance of Use Cases for Pilots

Abbreviation	Site	Partner
M	Manchester	The University of Manchester
P	Plovdiv	Medical University Plovdiv
T	Taiwan	Taipei Medical University
G	Gemelli	Agostino Gemelli University Policlinic
S	Marina Salud	Hospital de Dénia-MarinaSalud

Further details about the high-level functionality of each use case and their interaction will be provided in the below subsections.

5.1 Model Builder's Interface

In this part of the system functionality, the Persona Ken will be working with the system within the "Developing Risk Prediction Model" use case to develop new risk prediction models and customise existing models to specific local conditions (e.g. missing variable from the EHR dataset) or specific patient segment (e.g. patients with compounding problems such as diabetes, or early indications of predisposition amongst young patients).

Once the model is developed, it will be incorporated in the "Risk Assessment" use case from the Health Professional's interface below. There is no direction invocation nor temporal dependency between this use case and any of the other cases in the system.

The Model Building Interface will be developed to fit with the personal and education attributes of the Persona Ken, who is highly educated epidemiology specialist with expertise in data analysis but not necessarily in AI. The interface should be quite concise and productive, formal representation of constructs is encouraged but should match to representations used in the epidemiology domain. These ideas are developed further in Section 6.1 below.

5.2 Health Professional's Interface

This is one of the two most complicated parts of the system functionality. Using this interface, the Health Professional will assess risk for a specific individual or patient and provide advice regarding ways in which the individual can reduce the risk from developing pancreatic cancer.

The main persona interacting with the system through this interface is Jill. Jill is not a technically minded person but a trained medical doctor with understanding of patient health and well-being. She is trained in using existing Patient Information Systems which mostly employ single-screen form-based information presentation using a mixture of tables and charts to summarise information for decision-making linked with patient's health. It is important that the potential for Jill to be colour-blind to be taken into considerations, with all color-coded visual representations also containing explicit lettering duplicating the information conveyed by the colours. It is also possible that the interface may be accessed by Mel, who is a trained medical nurse, with less authority to make strategic medical decisions but still trained to use patient information systems. If this is requested by the pilots, the system should offer more limited access options to Mel based on her role.

The following use cases work together to deliver the functionality within this interface.

5.2.1 Risk Assessment and related use cases

The Risk_Assessment is the initial use case triggered by an individual requesting the risk analysis by visiting a doctor's office or a website. The standard flow of information between the Health Professional and the system is provided in Appendix A. Here the risk assessment model is run against the data available in the system and provided by the patient. If elevated risk is detected, the use case is extended by the Elevated_Risk_Detected use case, where the system signals and explains the risk to the Health Professional and suggest further tests to be done via the Request_Tests_and_Samples use case.

5.2.2 Risk_Mitigation_Planning and related use cases

The central use case of this group is Risk_Mitigation_Planning. There the Health Professional is working with the system and the individual to plan the best treatment and risk mitigation plan according to the results of the tests. This is triggered by the system receiving the results from the tests via the "Ingest_Tests_and_Samples_results" use case, which in fact constitutes a separate interface but it is a machine-to-machine interface and as such of no interest to this deliverable. If the results of the tests confirm a heightened risk of developing pancreatic cancer, the patient is profiled through the mobile interface and a risk mitigation plan is proposed by the system aligned with the patient profile and test results. The plan is approved and possibly modified by the Health Professional and delivered to the patient through the mobile interface, possibly over a period of time.

5.2.3 Advice Review and Follow-up use cases

When the monitoring functionality of the mobile interface detects significant changes in the patients parameters such as heart rate, or habits such as smoking, it would trigger the Advice_Review use case, where the risk mitigation plan devised earlier is reviewed by the clinician in discussion with the individual, and the new plan is fed into the advice delivery functionality on the mobile interface. Even if no change in parameters is detected, the health professional may still trigger the Advice_Follow-up use case, where a similar review of risk mitigation plan will take place after certain period of time.

5.3 Individual's Interface

The interface on the side of the individual comprises three separate use cases, which work together with the use cases on the Health Professional's side to deliver integrated planning and follow-up of the risk mitigation strategy. There are also three different personas capturing the main clusters of customers expected to use this interface:

- **Ann**: a 40-year-old gamer, interested in maximising results but sedentary, with poor fitness parameters;
- **Jack**: 50-year-old professional, comfortable with apps, interested in health preservation, he has a high risk of pancreatic cancer and is a diabetic;

- **Pat**: a 60-year-old nearing retirement, diagnosed with early stages of pancreatic cancer, poor eyesight and dexterity.

These three personas put different requirements to the user interface, and would react in a different way to different nudges and behaviour change stimuli. The way in which iHelp is dealing with these differences is via customising the messaging and even the format of the mobile interface to their varied needs. For example, Pat will have an interface with much larger letters and high-contrast colours, and the nudge messages to Ann and Jack will be quite different because of their different orientation to achievements (Ann) and health preservation (Jack).

The mobile interface of iHelp comprises the following three use cases.

5.3.1 Capture of Profiling Characteristics use case

This use case presents a profiling questionnaire in a form-based or dialogue-based form to the Individual user. The content of the profiling questionnaire will vary between the pilots, and will be used by the AI engine powering the Risk_Mitigation_Planning use case to deliver a plan and ways of delivering this plan which is tailored to the user profile established by the use case.

5.3.2 Risk Mitigation Delivery use case

This use case delivers the risk mitigation plan to the individual in the right form and with a message style tuned to the profile of the individual. It can take the form of a list of actions, set of goals, or be delivered over time as a coaching dialogue as explained in Section **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.** below.

5.3.3 Risk Monitoring use case

It is expected that the Risk_Monitoring use case will rely on a combination of biometric data sourced from a smart sensor bracelet or wearable device, such as daily step count, oxygen concentration and pulse on one side, and on textual answers provided by the user regarding how they feel and what exercises they have done, on the other side. When the Risk Monitoring use case detects substantial deviation between the expected values and the observed ones, it will trigger the Advice_Review use case from the Health Professional's interface.

5.4 Policy Maker's Interface

As part of T5.1 the consortium partner ICE is developing a Social Media Analysis tool that allows the policy makers to analyse the message exchanges and discussions taking place across multiple social media platforms on different topics of interest. The insight gathered from the analysis of social media discussions can enable policy makers to develop a better understanding of societal trends, general perception of specific policies or the impact and effectiveness of policies in the target area or communities. Social media analysis can also support effective decision making by policy makers, based on the gathering and analysis of social interactions that are presented to them through an intuitive dashboard of the social media analysis tool. The dashboard will enable the policy makers to extract meaningful data from the social media platforms through a friendly GUI where the outcome of this data is visualised in graphs and charts to highlight the trends and patterns concerning social interactions on specific topics, social implications of existing policies or societal influences on policy making processes.

The graphical UI of the social media analysis tool is tuned to the needs of the **Persona Sarah**, who is a 40-years-old health professional and part of the policy making setup at regional level. Through her involvement in policy making processes, Sarah is interested in maintaining health at regional level. Sarah is an intermediate user of information systems and is familiar with general analysis tools, rather than specific medical record databases. The interfaces developed for Sarah are therefore tuned to the look-and-feel of traditional social analysis packages and looks a similar complexity and type to the model developer's interface.

Inside the sub-system behind this interface, we have an innovative social media analysing tool, which employs AI, Natural Language Processing (NLP) and Sentiment Network Analysis (SNA) techniques to identify events (in the social media space) and raise alerts based on evaluation of the situations. This would also help in indication of probabilistic events for early risk identification. Furthermore, the core functionality will allow to track the impact of specific health related policies, iHelp outcomes (advice, recommendations, etc) and also elevate the status of specific alerts based on evolving situation.

The use case model for the social media analyser is shown in Figure 23. The functional units which work together to provide the social media functionality analysis are as follows.

5.4.1 Custom Social Media Analysis Solution

The Custom solution that we have created is composed of a set of Docker containers (representing different sub-components such as NLP, SNA etc) that communicate and process data gathered though Apache Kafka, which is responsible for orchestrating data gathered from the social media platform(s). Each set of containers start with a Social Media Source that is outputted to Kafka. The data from Kafka is passed through other containers that perform SNA and NLP before the data is ready for processing through the Complex Event Processing (CEP) containers. Each CEP container will have its own (data analysis) rules to process data concerning specific topics of interest. Alerts are generated by the CEP when certain rules are triggered. The alerts are stored and then displayed to the user through the visualisations on the GUI generated by Apache Superset.

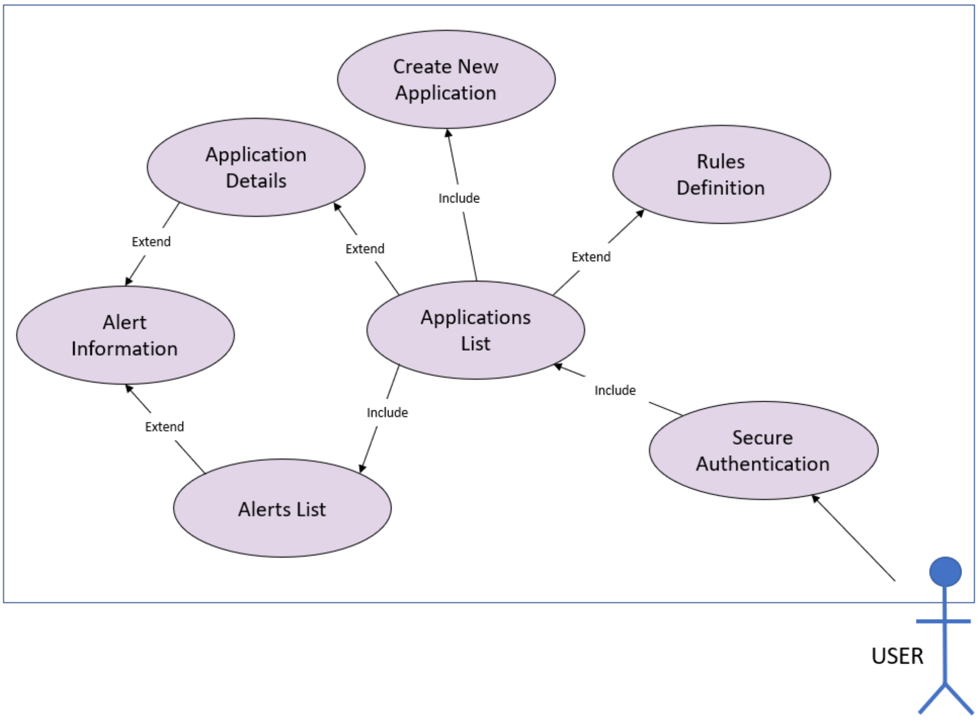


Figure 23: Social Media Analyser use case model.

5.4.2 Application Creation Use-Case

The iHelp Graphical User Interface (GUI) is a web page and what will be used by the user to create a social media analysis 'application'. Each application will be tuned to monitor the social media platform for specific topics (or keywords) of interest. The policy makers can setup multiple applications on the GUI, each monitoring specific topics based on the definition of rules and raising alerts when certain situations are detected e.g., when a number of messages matching the topics of interest are recorded within a short span of time, which can be configured in the application. From this GUI, as well as creating an application, applications can be viewed, modified, started and stopped – through the Application List on the GUI (as shown in Figure 23)

5.4.3 Management of Alerts

In addition to the management of applications Sarah, the policy maker, can also review the alerts on the GUI. These alerts are triggered when the application specific rules are matched with the data that is analysed by the social media analysis application. In this respect, Sarah is able to monitor the alerts through the Alert List on the GUI as well as study the details of each individual alert through the Alert Information UI (as shown in Figure 23).

6 User interactions within key scenarios including key screen designs as Wireframes

In this section we revisit the interfaces covered in Section 5 and demonstrate the initial design of the interfaces and the way in which they will interact with their target users. The tool used to sketch the interfaces is Balsamiq Cloud[35] platform, tuned to deliver purposefully low-fidelity sketches which have been demonstrated to facilitate discussion between users and developers by signalling to end users that the tool is not complete and is still open to comments and improvements.

6.1 Model Builder's Interface

The Model builder Persona Ken develops the composition functionalities of the DSS from analytic algorithms, queries, and visualizations. The Model Building suite will allow the Model Builder to create this functionality through the design of data analytics pipelines or workflows that allow Ken to perform database queries and the execution of different analytic algorithms whose results will be prompted using different visualization mechanisms (tables, charts, etc.). To achieve that, Model Builder users will access the Model Builder UI that is based on Node-Red[36]. Figure 24 shows the initial wireframe of the Model Builder UI, where the user can create and store its own model using the drag-and-drop interface. The UI is divided in different panels, the one at the left side, Models Panel, allows to create a new model or select the previously created and stored ones. The second panel, the Workflows Panel, allows the creation of workflows using the previously created database query, analytic algorithms and visualization nodes. The database nodes allow to create SQL like queries to access the data stored in the iHelp Storage, this queries data can be show in other DSS screens or can be used as input for the analytic algorithms.

[35] https://balsamiq.com/

[36] https://nodered.org/

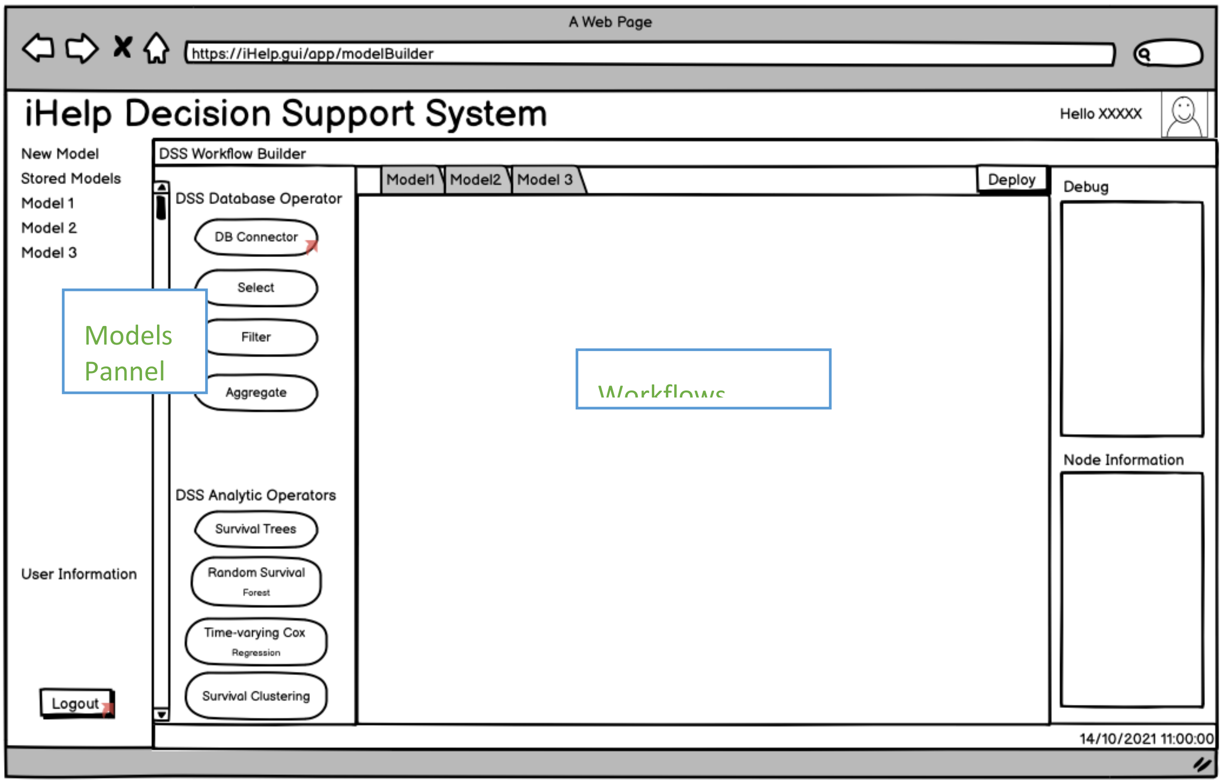


Figure 24: Model Builder UI - Initial Wireframe.

Each of the available nodes can be configured individually, for instance Figure 25 shows a DB Connector node that will allow the Model Builder to select the database and the table from which that is going to be requested.

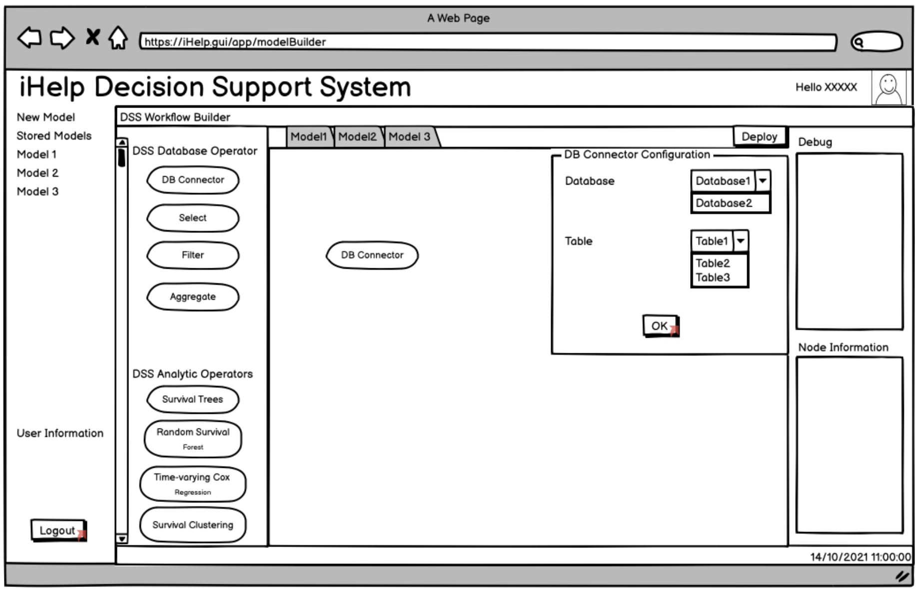


Figure 25: DB Connector node configuration panel.

Nodes can be connected creating workflows. Figure 26 shows a workflow example where data is selected from the iHelp Storage and is sent to an analytic algorithm (Survival Tree), the result of the algorithm is presented through a chart that will be displayed in any of the Dashboard's interfaces that will be designed to help clinicians and policy makers to analyse the data and to make its own decisions.

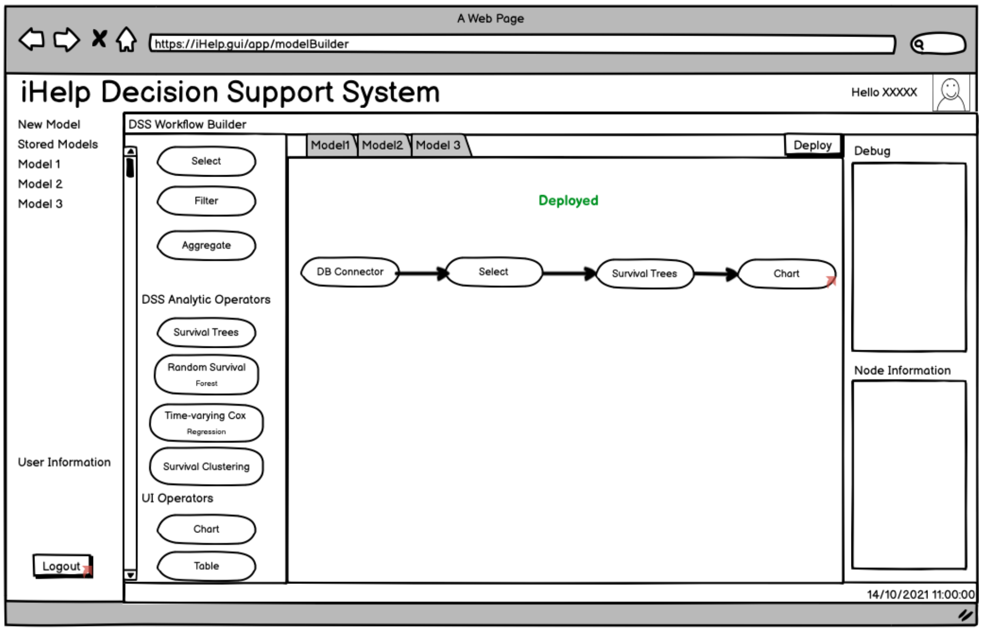


Figure 26: Example of Analytics Workflow.

6.2 Health Professional's Interface

The Risk Management Interface is used by the Health Professional – Persona Jill, to ensure all information is available when risk is assessed, and that the correct advice is given to the individual. We do this by combining AI reasoning on the background with advisory and explanation facilities which are displayed on the same screen as the most pertinent information about the patient and the case.

Because of the wealth of confidential information available, the interface should be protected by password and dual-factor authentication, according to the standards at the medical institution in which the Health Professional works. An example landing screen is shown in Figure 27.

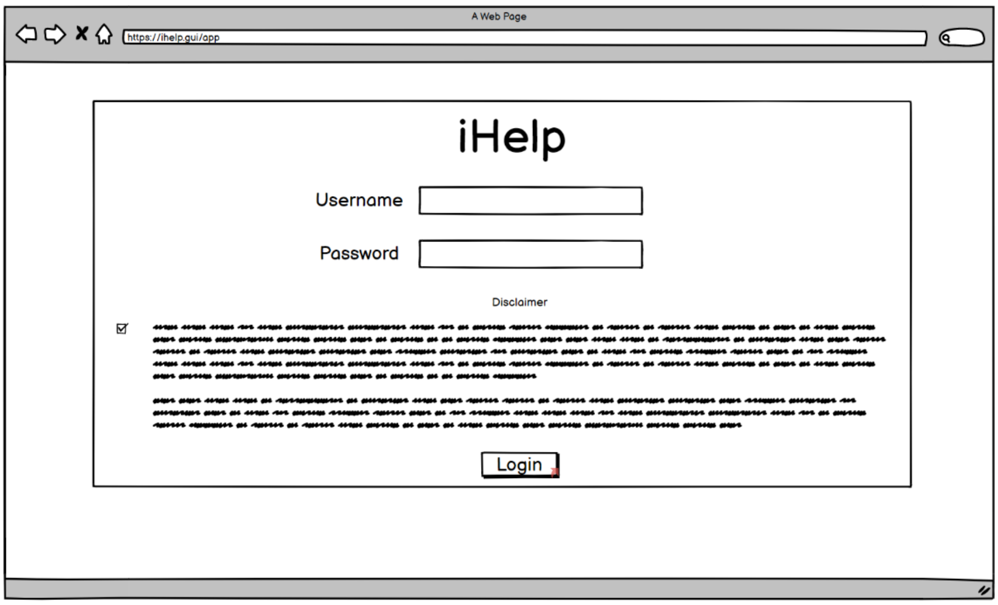


Figure 27: Login Screen by Health Professional - Password-protected Access ensures Confidentiality of Data.

After authentication, Jill is shown the Health Professional's Dashboard shown in Figure 28. It has entry points to the four main use cases on the interfaces as described in Section 5.2.

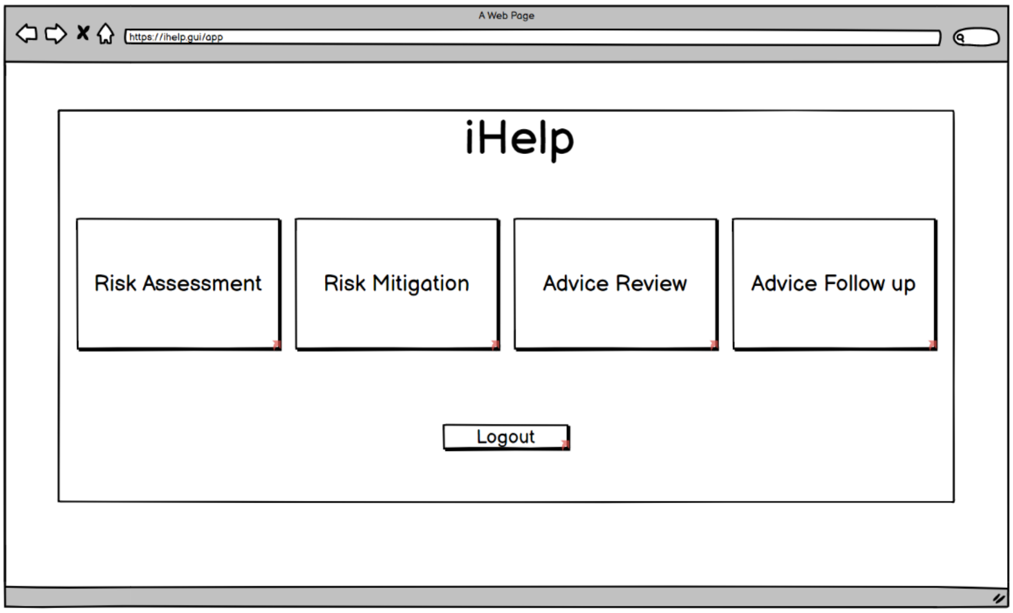


Figure 28: Health Professional's Dashboard.

The first point of entry into the Dashboard with a new case would be the "Risk Assessment" use case. The initial screen is shown in Figure 29 below. The patient is asked to provide details relevant to the diagnosis, further information is also collected from the Electronic Health Record.

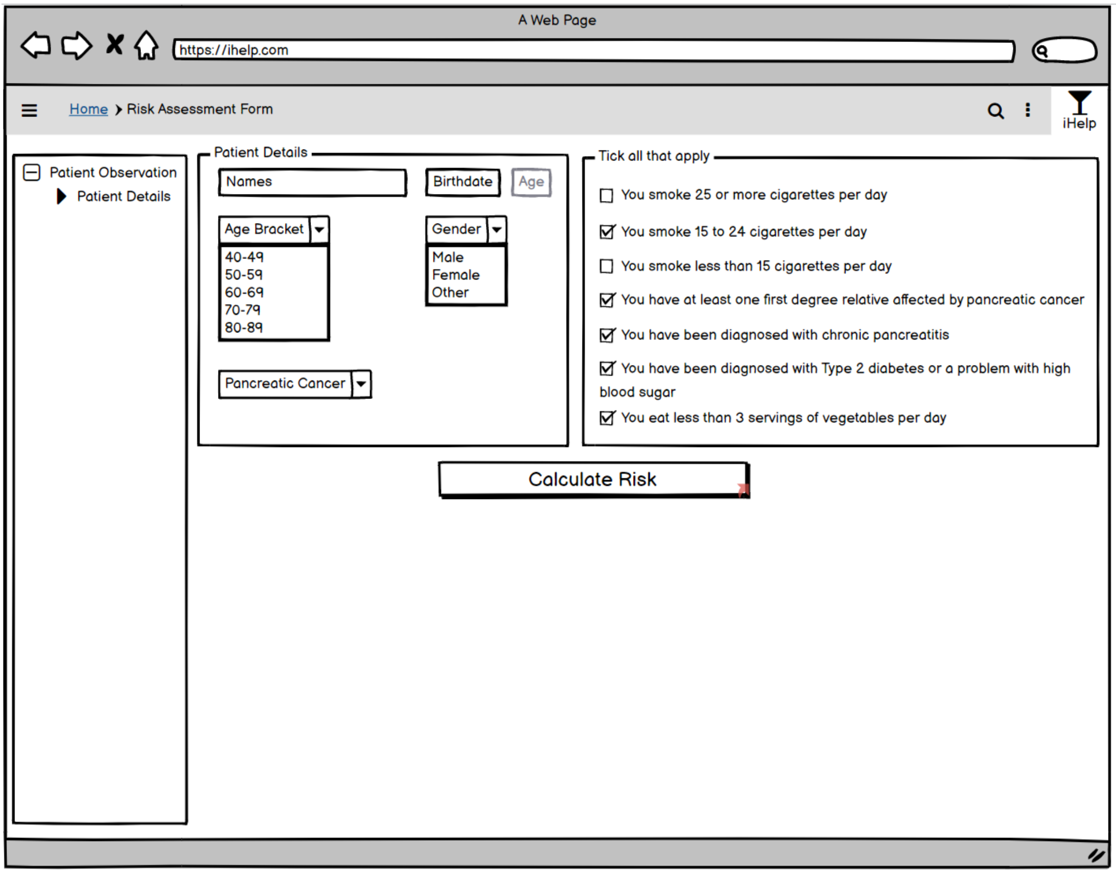


Figure 29: Initial Screen of Risk Assessment Use Case.

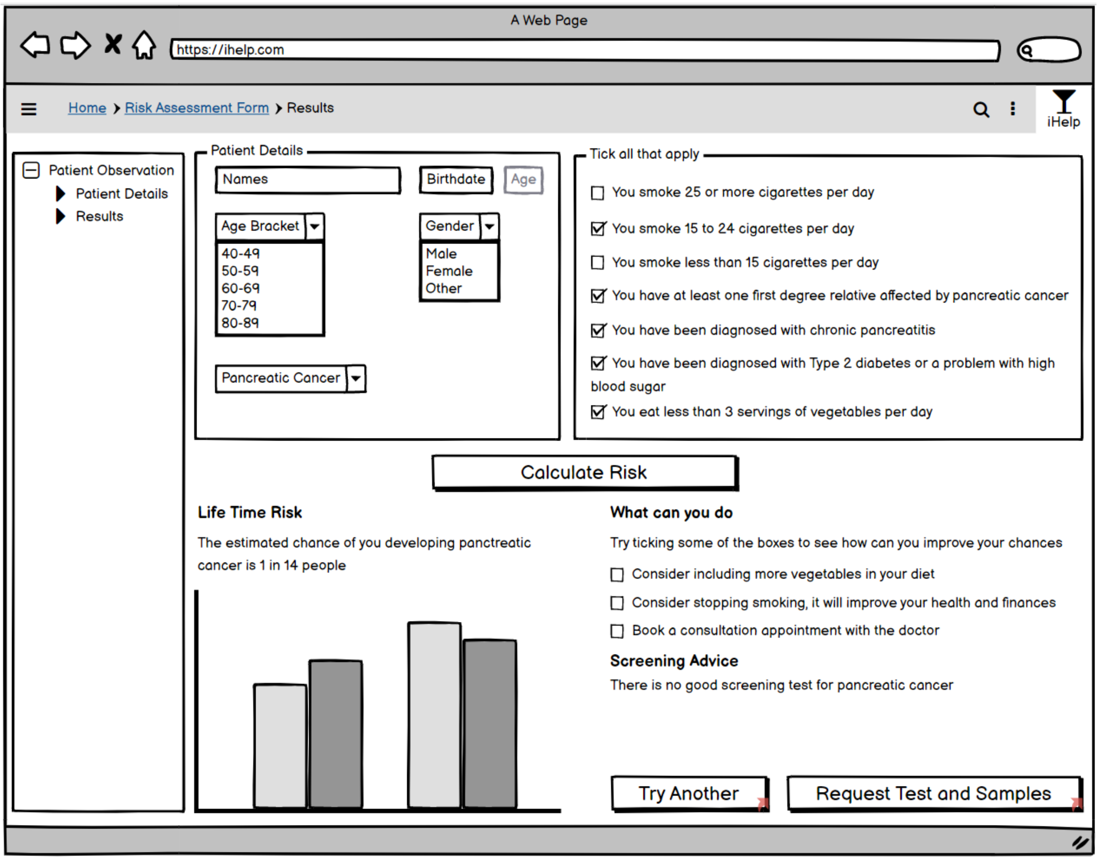


Figure 30: Displayed Risk Together with Some Exploration Options.

The AI reasoning engine uses the model developed by the Model Builder Ken and calculates the risk of the patient developing pancreatic cancer. Example of results are shown in Figure 30.

These results show somehow elevated risk of developing pancreatic cancer, and processed by the Elevated Risk Detected use case, which also allows some exploration with different decision parameters.

The Health Professional can at this point accept some the recommended tests or specify new ones. The interface of the "Request Tests and Samples" use case shown in Figure 31 is allowing time for the tests to be booked.

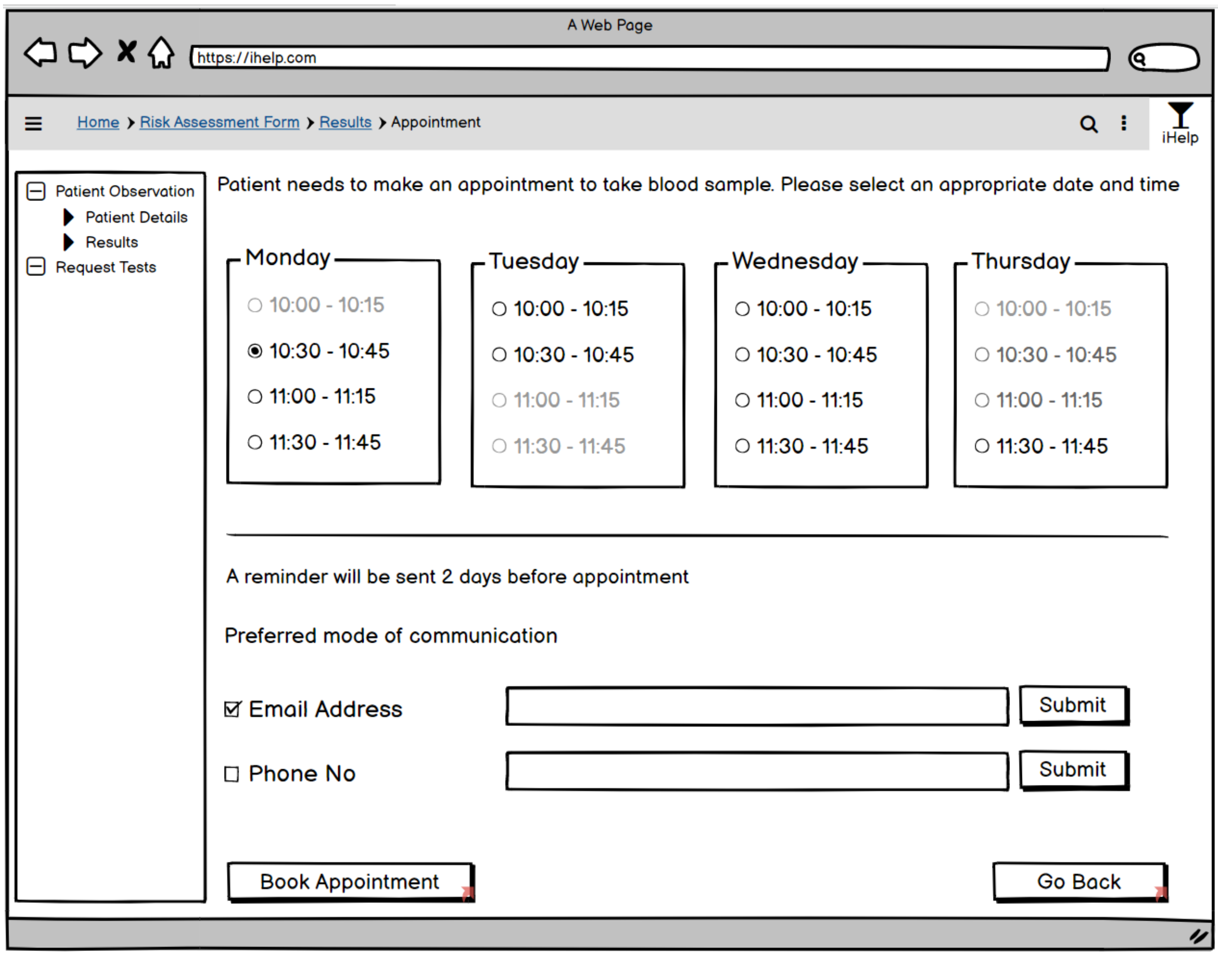


Figure 31: Interface of the Request Test and Samples use case.

Once the lab samples are taken and the tests are ready, the Health Professional Jill can meet again with the individual and decide on the best course of action to mitigate the increased risk detected. Jill is again helped on by the AI in iHelp and provided with several options which can be done separately or together. An example of this Risk Mitigation use case is shown in Figure 32.

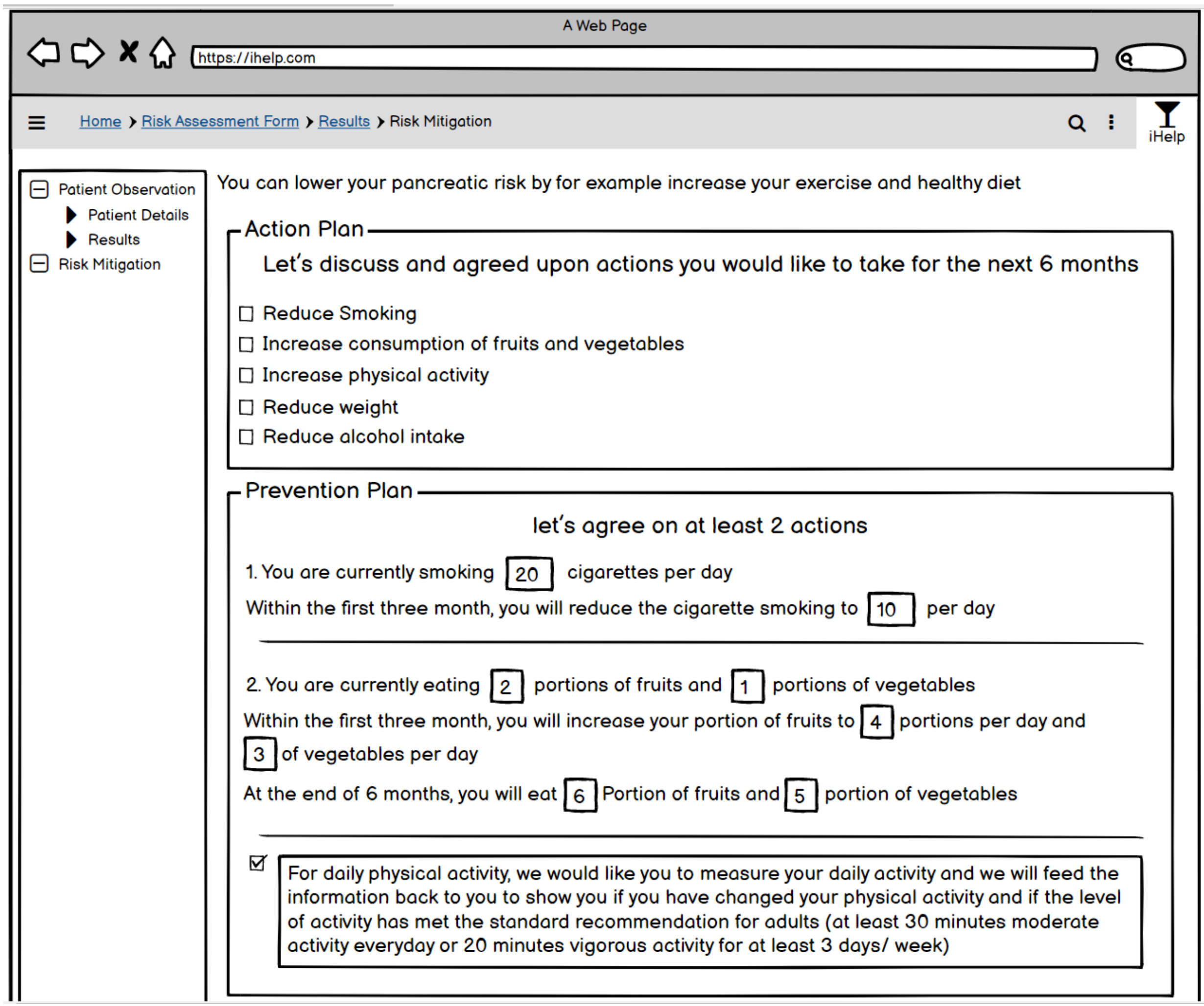


Figure 32: Risk Mitigation Use Case Interface, Allowing the Exploration of Alternatives.

Once the plan is developed, it can be explained to the individual on the screen or printed. In most cases the plan will also be sent off to the mobile device which the individual will use to follow up the plan with. An example of the plan is shown in Figure 33.

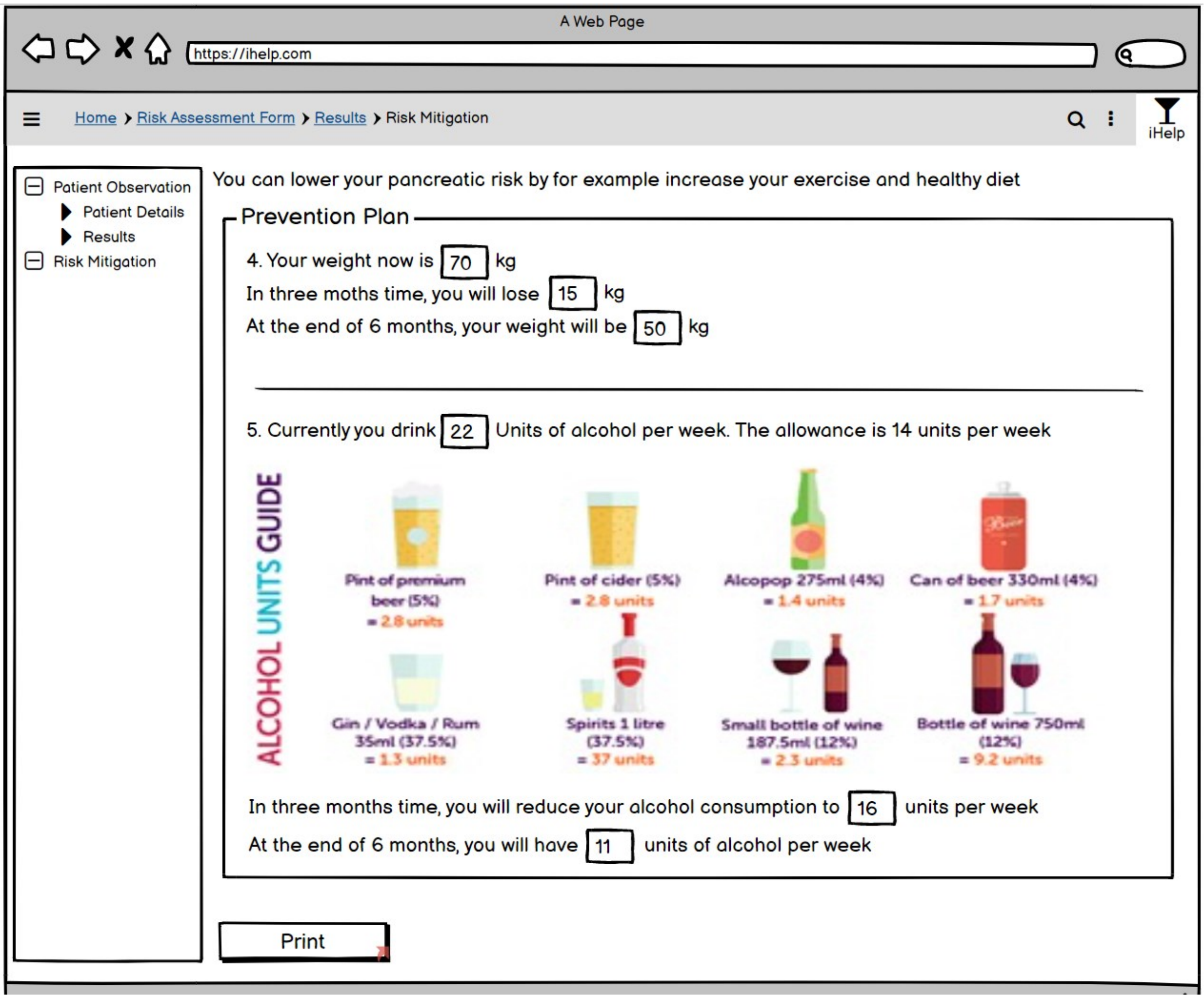


Figure 33: An Example of a Risk Mitigation Plan focused on Reducing Weight and Alcohol Consumption.

The next use case shown in Figure 34 is the Advice Follow-up use case, where the Health Professional will meet the individual and review the progress against the objectives set, using the information gathered by the mobile interface and by the patient themselves.

The last use case, Advice Review, has a similar interface to the Advice Follow-up use case, but is triggered by the Monitoring module when it is detected but the patient fails to meet the goals set and this should be addressed faster than the date of the next Advice Follow-up meeting, perhaps because the system has observed worsening of the vital signs of the patient, or rapid increase in weight.

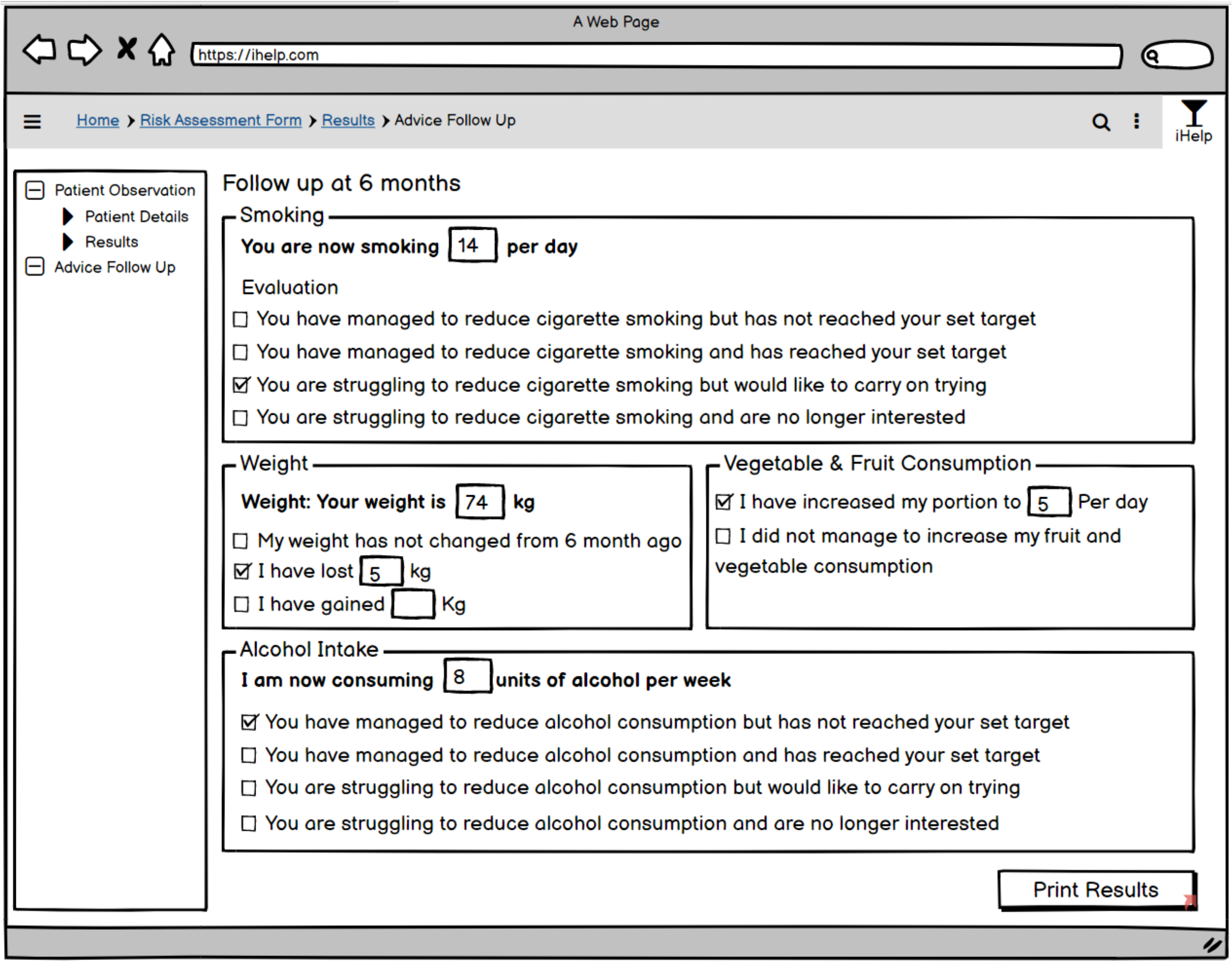


Figure 34: Interface of the Advice Follow-up Use Case.

6.3 Individual's Interface

The advice delivery mechanisms in iHelp will consists of three separate mechanisms, as detailed in an earlier project deliverable D2.1 - "State of the Art and Requirements Analysis I": (1) data visualisation, (2) feedback messages and nudges, and (3) Conversational coaching. Although each of these elements will require design, wireframes, mock-ups, etc... before being finally implemented, it is the conversational coaching aspect that is the most significant addition to the existing background application that is used as the basis for the iHelp application in the various pilots – the Healthentia mobile app. Therefore, for this version of the deliverable, the generation of wireframes focus on the Conversational Coaching element.

Although the iHelp application may look different for each of the 5 different iHelp pilots, each time a Patient or Citizen (i.e., "User") starts using the application, he or she will be presented with a Home screen as depicted in Figure 35 (left) below. This is the current default home screen with the visual styling of the Healthentia app. Importantly, this screen shows the two different ways on how users can reach the Virtual Coach: (1) through the notification at the top of the screen – currently showing the welcome message "*Today is a great day to keep track of your health*!", and (2) through the Virtual Coach icon in the bottom right of the screen.

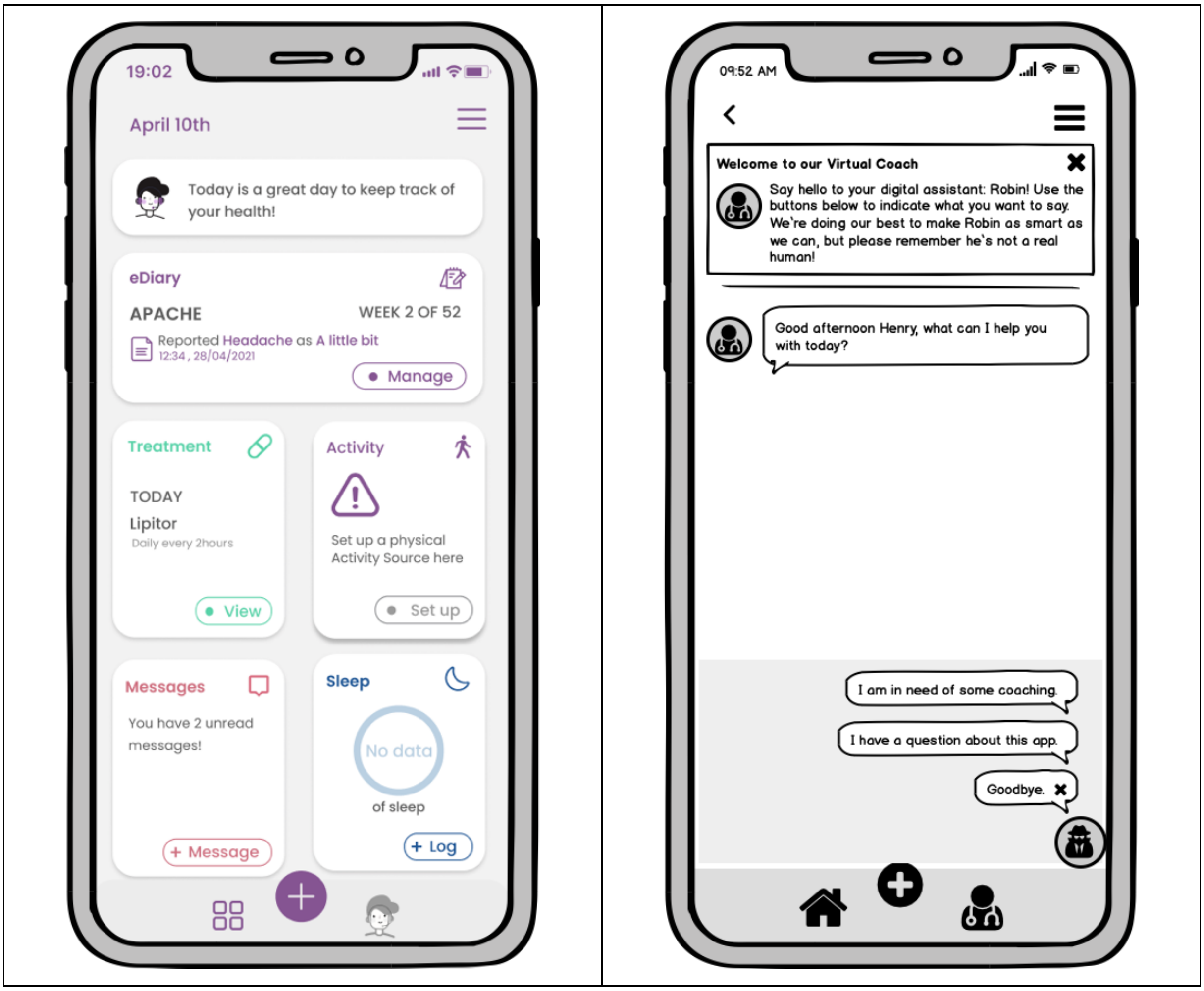


Figure 35: Screen number 1 and 2 of the Virtual Coaching UI Wireframe.

Using either of the two options, users can navigate from the Home screen (left), to the start screen of the Virtual Coach user interface (right). The image on the right is the wireframe for the first time the user visits the Virtual Coach: at the top of the screen, an info box is explaining to the user what the virtual coach is: "*Say hello to your digital assistant: Robin! Use the buttons below to indicate what you want to say. We're doing our best to make Robin as smart as we can, but please remember he's not a real human*!". This message can be closed by the user, leading to the screen as shown in Figure 36 below (left).

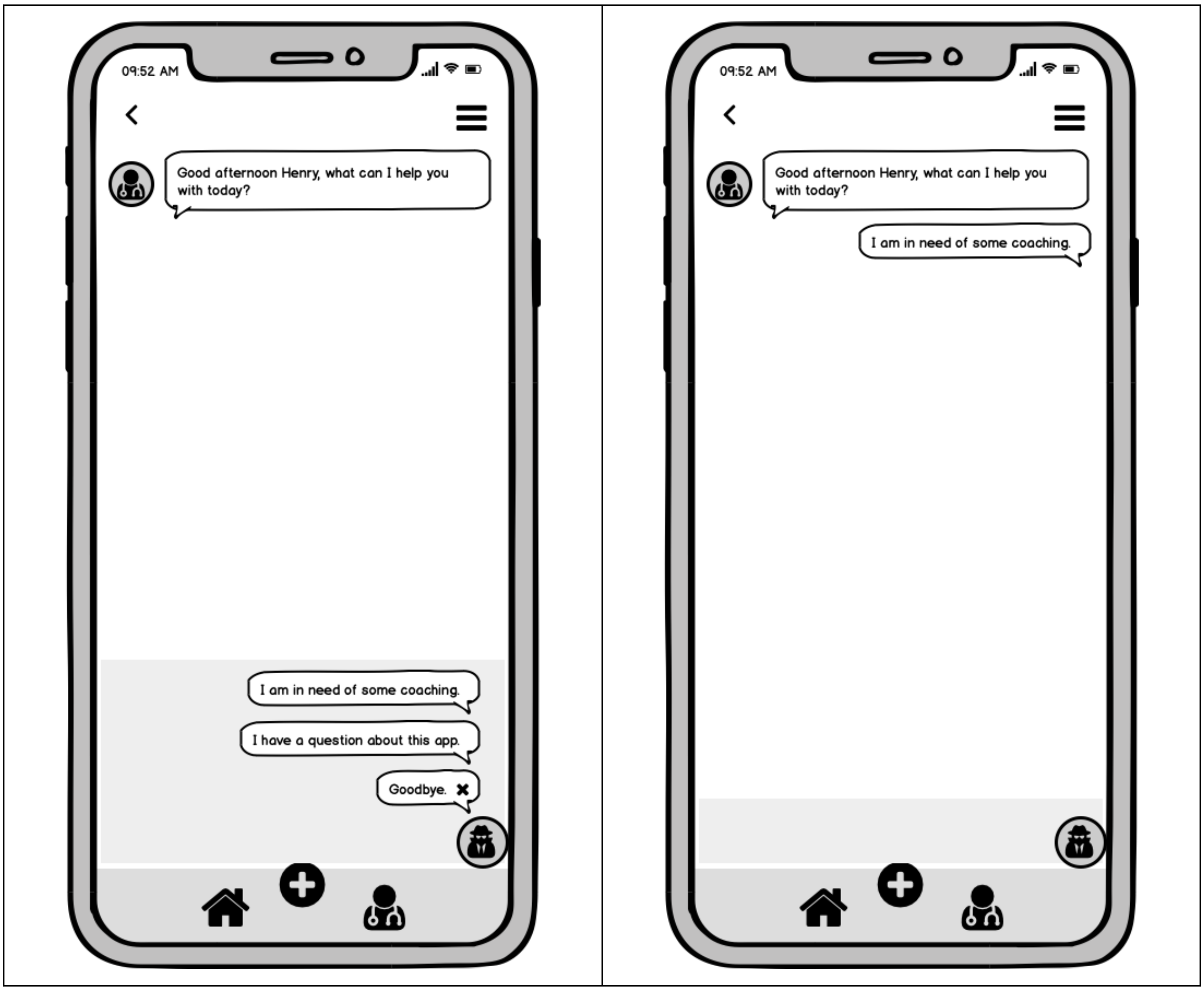


Figure 36: Screen number 3 and 4 of the Virtual Coaching UI Wireframe.

From here we can see how the user can start the conversation with the virtual coach. The coach is asking the user ("Henry") what he wants to talk about: "*Good afternoon Henry, what can I help you with today?*". At the bottom of the screen, the user is depicted with an Icon and his three different reply options:

- I am in need of some coaching.
- I have a question about this app.
- Goodbye.

Each of these reply options are things that the user can say in reply to the coach, and each of the text elements are buttons that the user can tap. Our user (Henry) selects the option "*I am in need of some coaching*.", tapping the button and leading to Figure 36 right.

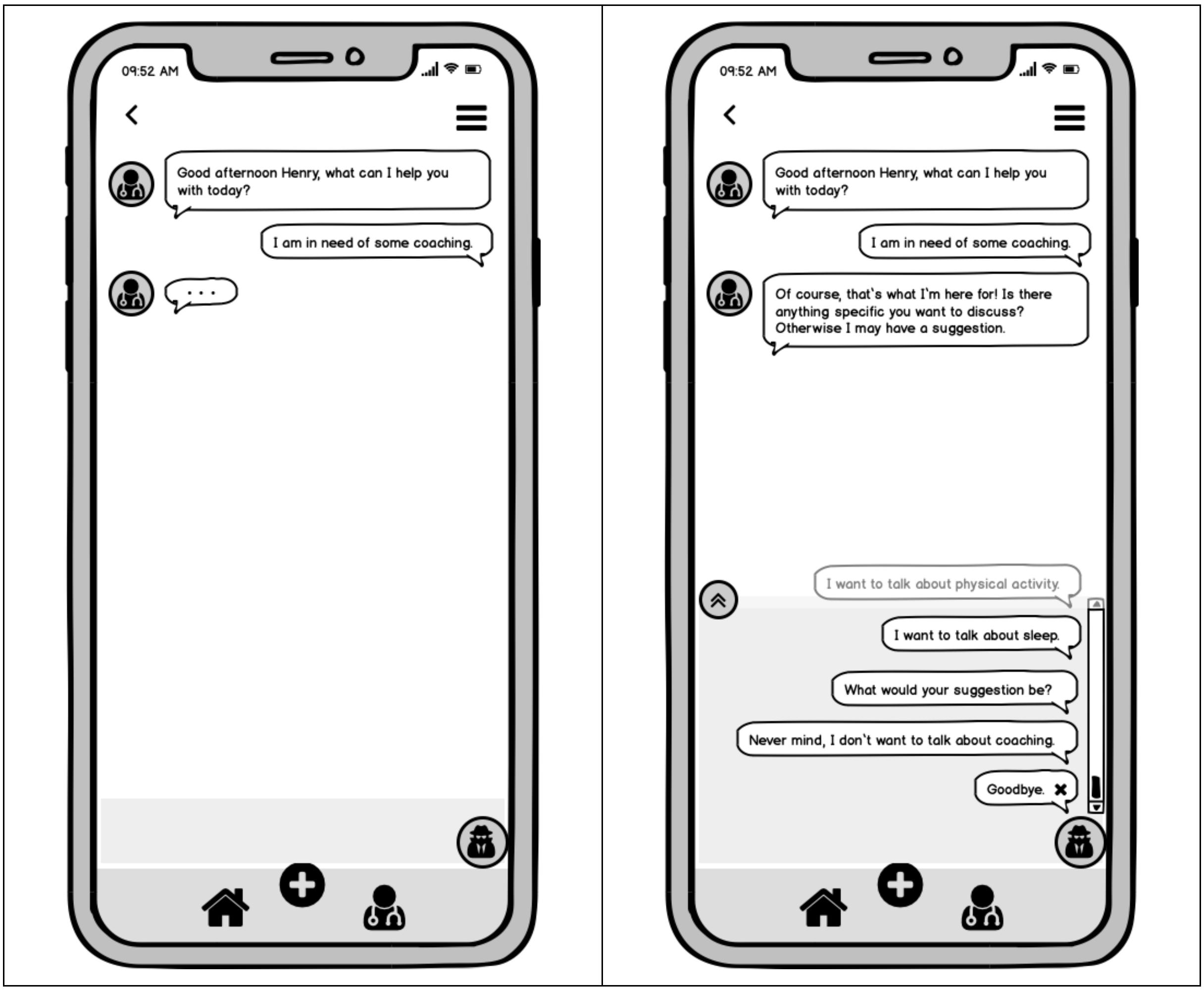


Figure 37: Screen number 5 and 6 of the Virtual Coaching UI Wireframe.

The next wireframe (Figure 37 above – left) shows that the virtual coach is now "thinking" about what to say next. This is an artificial step, as in fact the reply of the virtual coach could appear almost instantly (depending on the server load and/or the internet connection speed of the user). After a moment, the next statement from the virtual coach appears (see Figure 37 above – right): "*Of course, that's what I'm here for! Is there anything specific you want to discuss? Otherwise I may have a suggestion*.". Now, the user is presented with a large number of possible reply options – so many in fact that they do not all fit inside his "reply window" (a scrollbar has appeared here).

The next screen (Figure 38 below – left) shows the "expanded" reply options area, revealing additional things that the user can say. This is an extreme example for how the UI could handle a dialogue step in which over 10 reply options are available – in practice, dialogues should ideally be limited in the number of things a user can say in order to keep up the speed of the conversation.

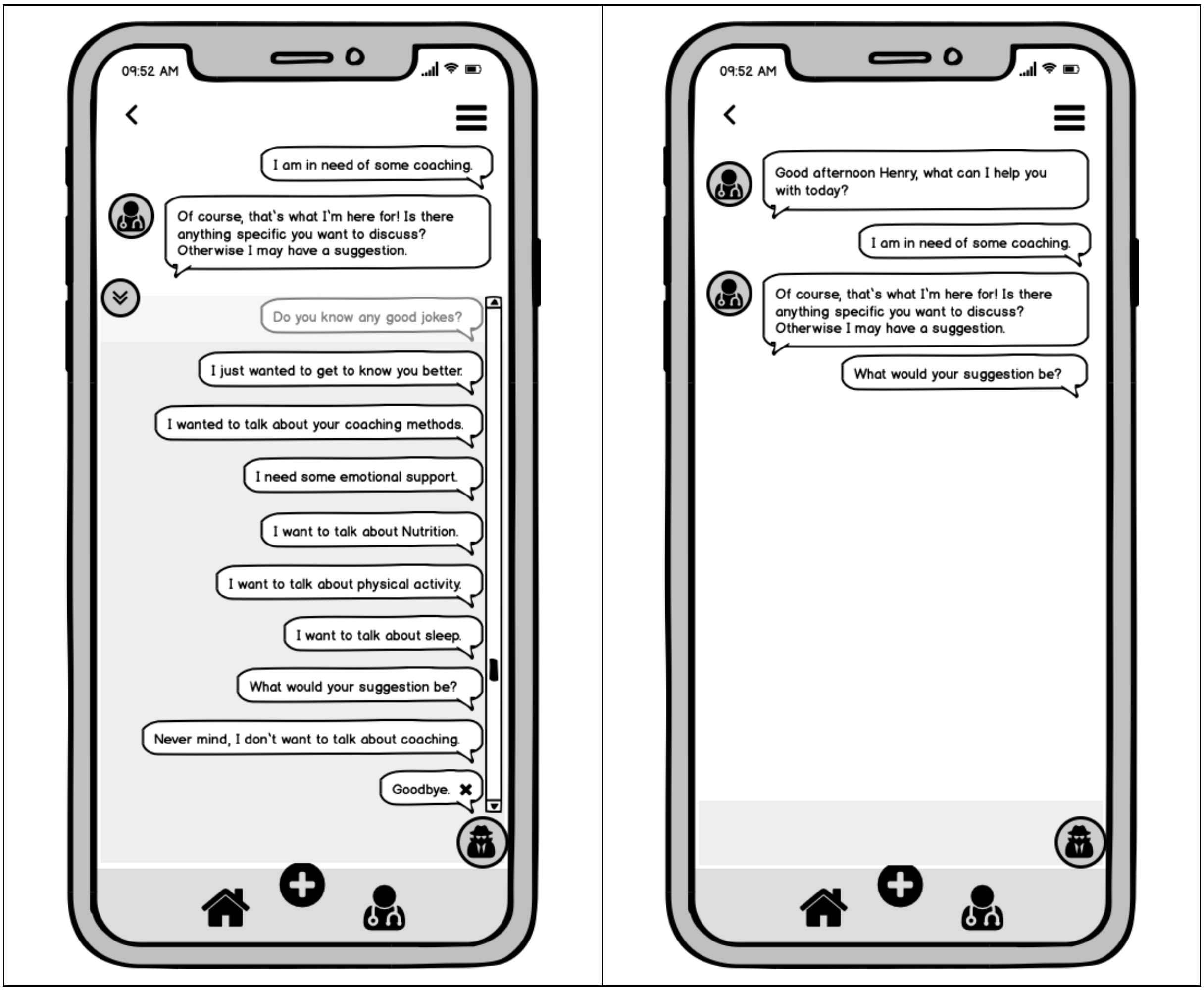


Figure 38: Screen number 7 and 8 of the Virtual Coaching UI Wireframe.

In the next screen (Figure 38 above – right), we can see that the user has chosen the option "*What would your suggestion be?*".

The following two images (Figure 39 below – left and right) show the UI representation for when a user does not get any reply options (an Auto-forward reply in WOOL terminology). The virtual coach says "*Well, let me think a little bit... what had we discussed again last time, hmmm...*" and has more to say without requiring user input. To represent this, the UI shows a Continue button with a progress bar on top of it: the idea is that the user can either tap "Continue", or the dialogue will automatically move forward (hence the term "Auto-forward reply"), once the timer has passed.

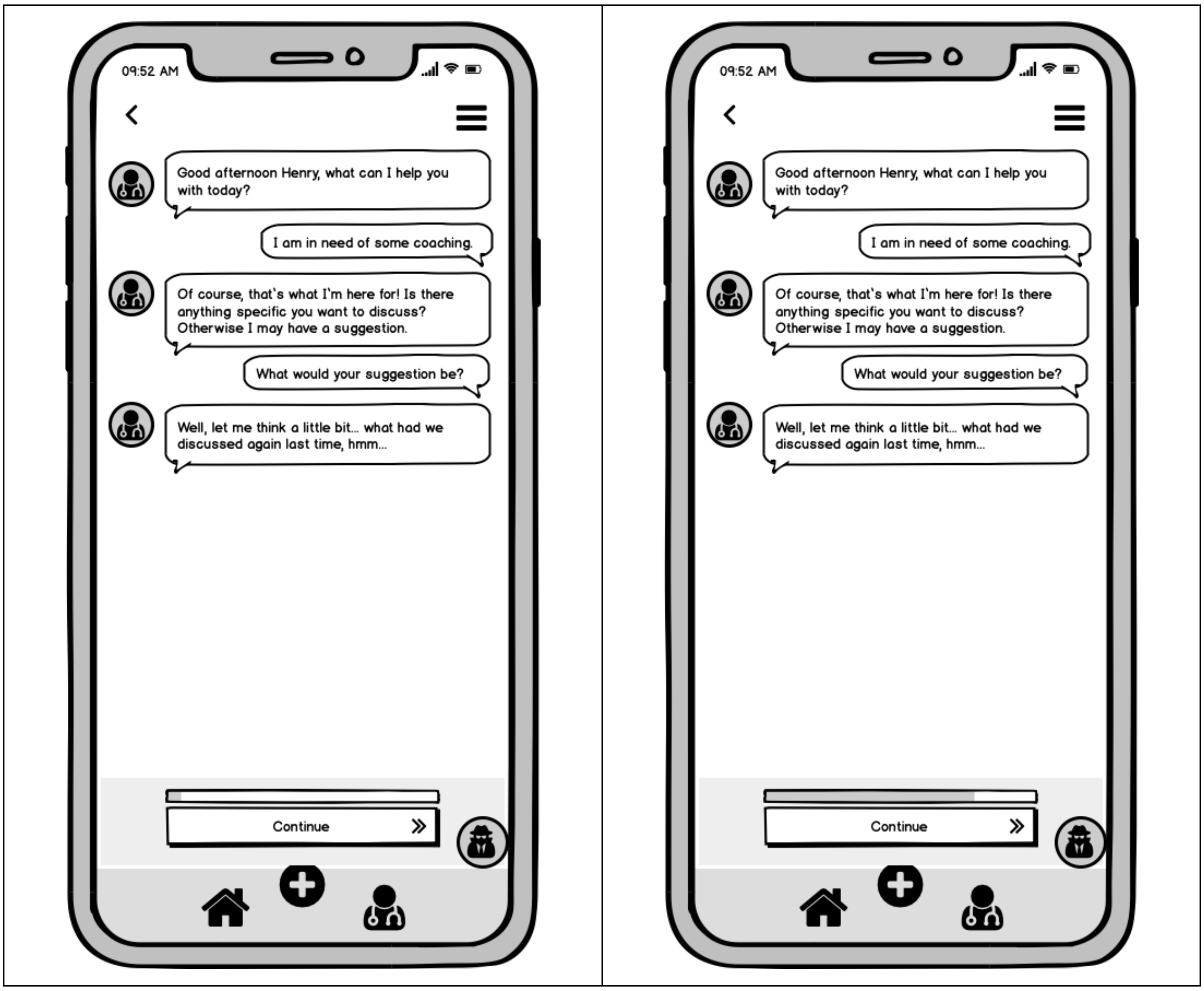


Figure 39: Screen number 9 and 10 of the Virtual Coaching UI Wireframe.

No matter how, the conversation continues as shown in the final Figure 40 below: "*We haven't talked about your long term physical activity goals in a while, maybe we could revisit them?*".

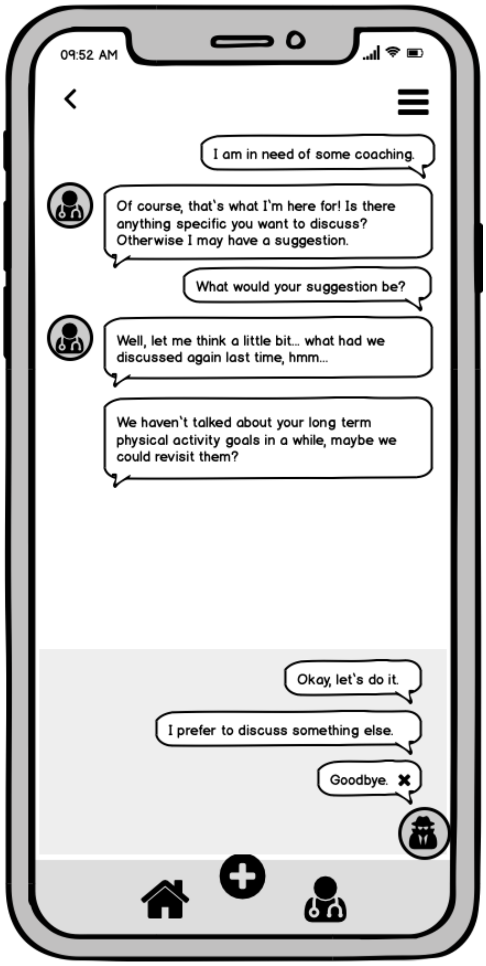


Figure 40: Screen number 11 of the Virtual Coaching UI Wireframe.

From a user interface perspective, this last step shows no new interaction elements. However, it does show how the iHelp user is presented with information coming from the intelligent decision-making components that power the iHelp platform. In this case, the user has requested the system to provide a suggestion on a coaching topic, and the system has made the decision that it would be a good time to talk about "long term physical activity goals".

6.4 Policy Maker's Interface

The Social Media Analyser tool developed by ICE in the T5.4 will assist the Policy Maker to derive informed decisions based on the analysis of the data gathered by this tool. The user interface for this tool is explained in the sections below

6.4.1 Login Screen

This is the first screen for the user to log into the system, shown in Figure 41. The user will use the assigned username and password. The functionality on this screen is explained below

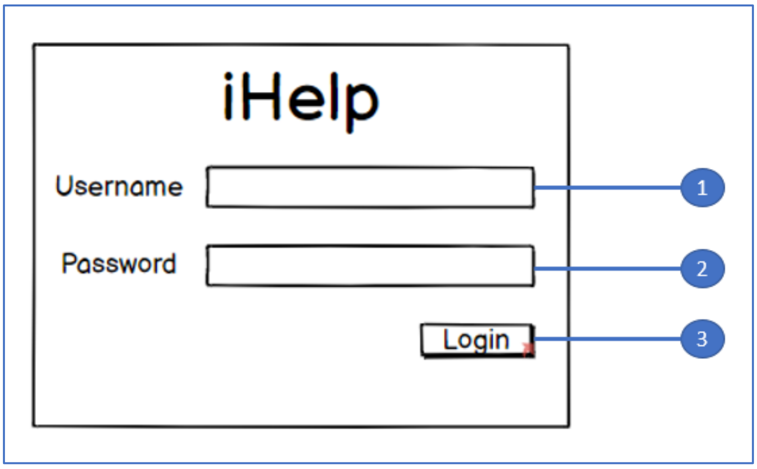


Figure 41: Login Screen for the Social Media Analyser Tool

1. User inputs their unique username
2. User inputs their assigned password
3. Action button to log into the system

Once the user is securely logged in, he/she will be taken to the Applications List screen explained in section 6.4.2.

6.4.2 Applications List

After logging securely into the system, the user will reach on the Applications List screen shown in Figure 42. The envisioned functionalities of this screen are shown in the following wireframe. This screen will summarise the number of applications (already created) on the social media analysis tool, with a list of options that are available to the users in order to examine each application or to create new ones. As described earlier, in the social media analysis tool, each application monitors the social media platforms in order to gather and analyse data concerning specific topic(s) of interest.

The Application List screen is designed in a way that allows the user to navigate through the existing applications, change the status of a particular application or create a new one. In this respect, the Application List allows the users to get a good understanding of what topics are being monitored and how the existing applications can be tuned to get better results.

On the Application List, the user can click on an application and go to the application details screen where they can see the details of a particular application. The functionality of this screen is explained in Section 6.4.3. This screen also allows the user to define the rules and conditions for each application. Section 6.4.5 explains the functionality of the Rules screen.

The following annotated wireframe described the envisioned functionality of the Application List UI.

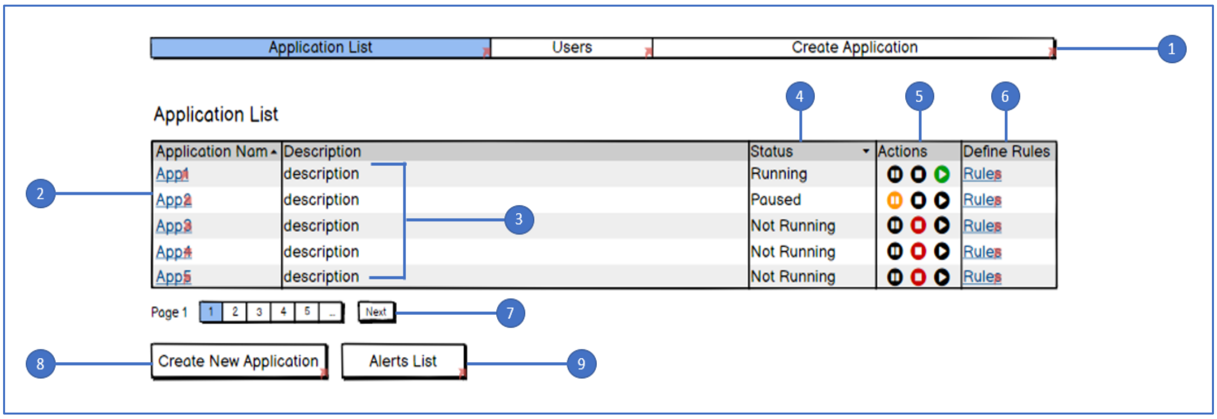


Figure 42: Wireframe Showing the List of Existing Applications within the Social Media Analyser Tool

4. Top bar to navigate through different screens
5. Names of active applications created in the system. User can click on application name to go into the application details
6. Brief description of application
7. Current status of application
8. Action buttons to pause, stop or start an application
9. Link to rules/conditions screen for the application (Section 6.4.5)
10. Navigation function to browse through applications
11. Action button to create a new application
12. Action button to go to Alerts List (Section 6.4.4)

The above wireframe also shows the navigation options that are available to the user e.g. an option to create a new application which is explained in the section 6.4.4 or they can proceed to the Alerts list (see Section 6.4.6).

6.4.3 Application Details

The purpose of this screen is to provide the information about an application. As shown in the following wireframe, the Application Details screen shown in Figure 43 should allow the user to see description and status of an application with the options to stop or pause a running application. This screen should also allow the user to see the number of alerts triggered by this application along with the level of alert. Further information on this can be found in section 6.4.6. Alterations in an existing application should also include the ability to add/append/delete the keywords or topics that the application is monitoring on the social media platforms.

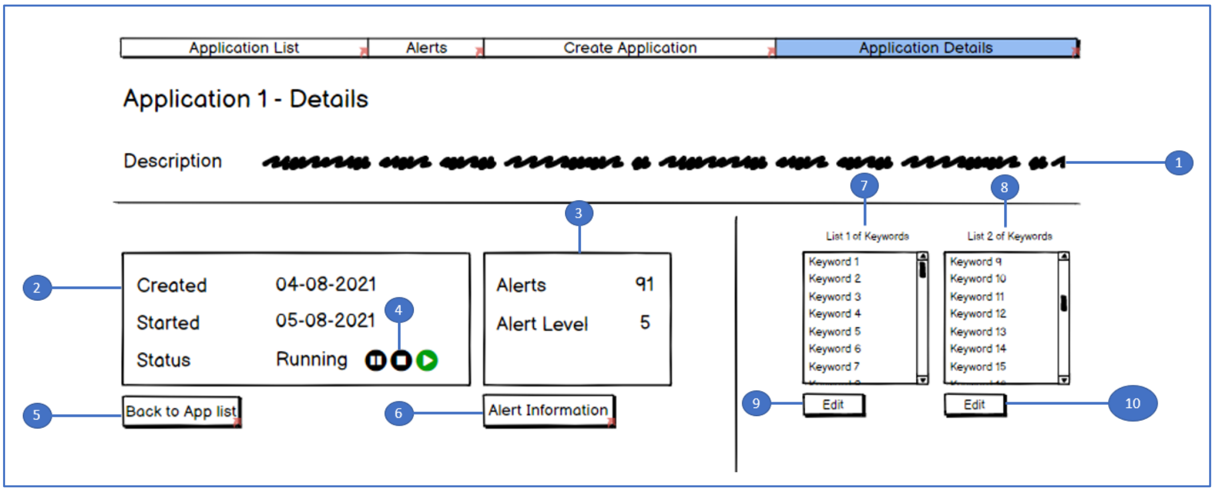


Figure 43: Wireframe Showing the Details of a Specific Application within the Social Media Analyser Tool

This means that this screen would allow the users to finetune or change the scope and focus of an existing application at any time. Section 7.6.4 explains the functionality where a new application can be created, and the list of keywords is uploaded. The functionalities envisioned on the Application Details screen are annotated in the above wireframe - as follows:

1. Name of the application with a description
2. Widget with application details, status
3. Widget to show the number and the level of alerts generated by this application
4. Action buttons to pause, stop or start the application
5. Action button to go to Applications List screen (Section 6.4.2)
6. Action button to go to Alert information screen (Section 6.4.7)
7. List 1 of keywords uploaded during application creation
8. List 2 of keywords uploaded during application creation
9. Action button to manually include new keywords in List 1
10. Action button to manually include new keywords in List 2

The above wireframe also shows the options that are made available to the user, allowing them to navigate back to the Applications list (Section 6.4.2) or proceed to the Alert Information screen which is explained in Section 6.4.7.

6.4.4 Create Application

This screen should allow the users to create a new application in order to monitor specific topics of interest on the social media platforms. The wireframe representing the application creation functionality is shown below. As illustrated in the wireframe, the user will need to fill a form to create a new application. This form will require the user to assign a name and description to the new application, select the social media platform (Twitter, Facebook, or Reddit) that will be monitored, select the preferred language, and provide the keywords or topics of interests.

Users should be able to provide the keywords in two easy ways. In the first way, the users can upload two CSV files containing lists of keywords. In the second way, the users can directly enter the keywords in the given field. The need for the two lists of keywords arises from the underlying technology solution (Apache Flink) that is selected as the core data analysis (CEP) engine.

The wireframe in Figure 44 describes envisioned features of the Create Application screen.

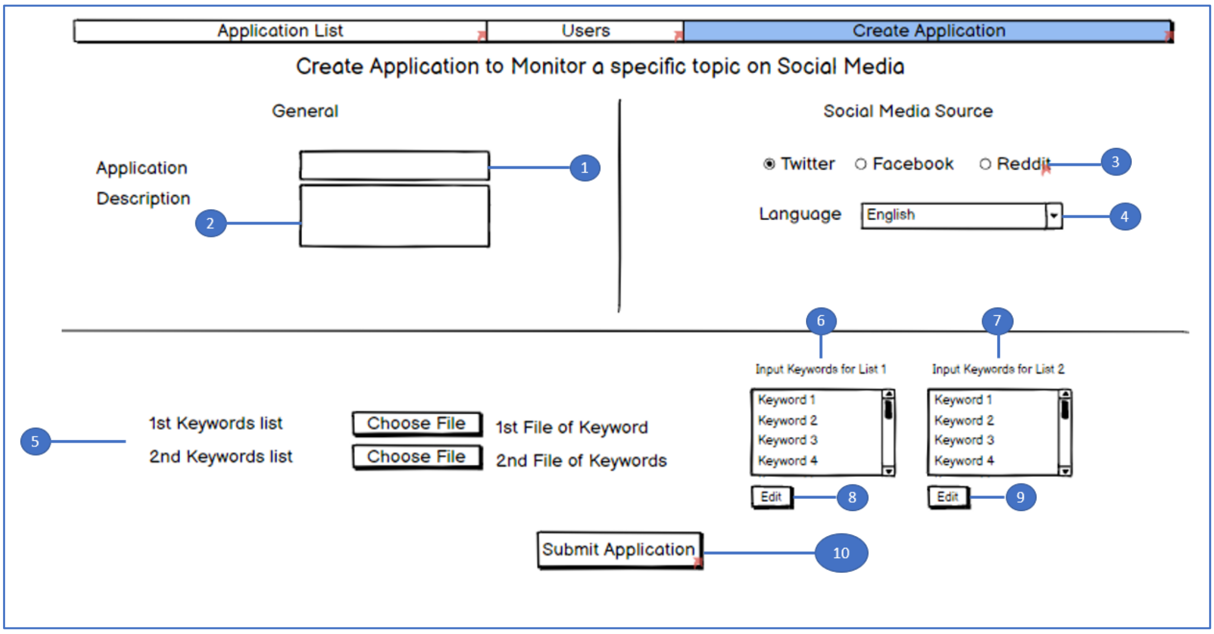


Figure 44: Wireframe Showing the Create Application Screen

The annotations on the wireframe are described below:

1. Assign the name of application
2. Brief description of the purpose of this application
3. Option to select a social media platform
4. User can select the intended language. The default language is selected as English
5. A single application support two lists of keywords. User can upload the keyword files with this functionality
6. The keywords from List 1 will show in this widget after the list is uploaded in the system
7. The keywords from List 2 will show in this widget after the list is uploaded in the system
8. User can add new keywords to List 1 through this function
9. User can add new keywords to List 2 through this function
10. This function would complete the creation of the application, list it, and take user to the Applications List screen (Section 6.4.2)

After the user is able to register/create a new application on this screen, the user should be able to return to the Applications List Screen, where the newly created application should be visible – as explained in Section 6.4.2

6.4.5 Rules/Conditions definition

The creation of application is merely the setup of a skeleton program that monitors the social media platform to gather data about specific topics of interest. From here, the user would need to define custom rules that dictate how the gathered social media data should be analysed and what particular insight or meaningful information should be extracted. To enable the user to define custom rules, a dedicated screen is envisioned as shown in Figure 45. On this screen, the user can define a rule with a set of conditions to trigger alerts in a specific application. This screen is accessible through the Applications List Screen (Section 6.4.2).

As shown in the wireframe, this screen should allow the user to define the conditions and rules for a particular application. This can be done by allowing the users to select a particular keyword from list 1 and select a condition from the drop-down list that best describes the intended relationship with another keyword from list 2. User can choose to add further conditions to increase the focus of results from this application. By using the GUI elements to define complex programming logic, this wireframe hides the complexity from the target users that are not expected to have technical backgrounds.

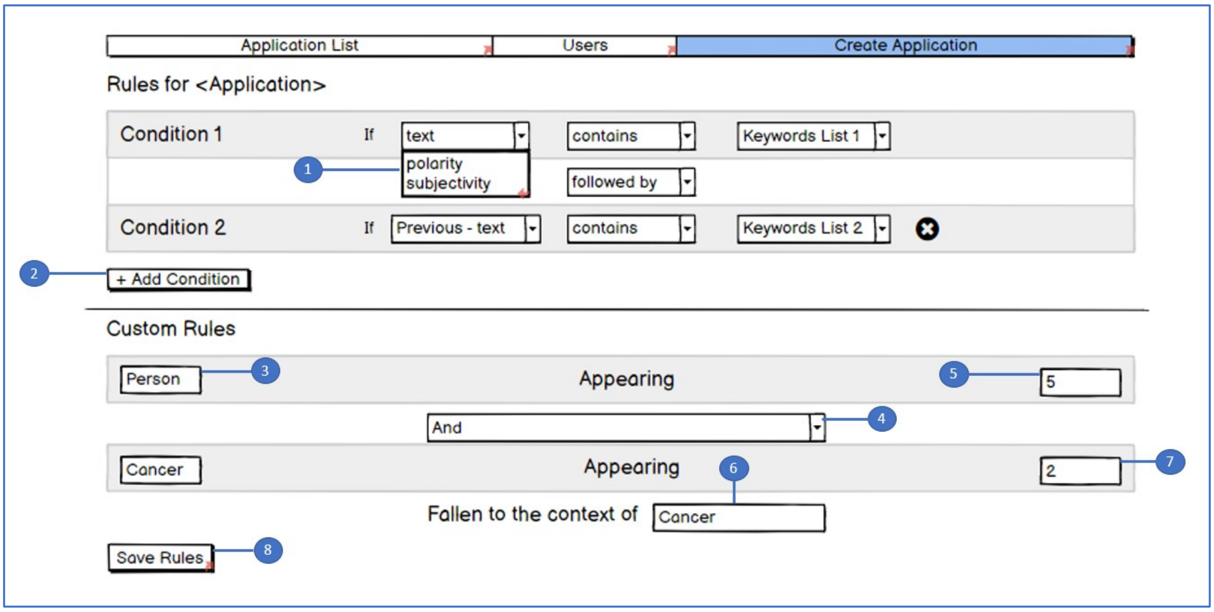


Figure 45: Wireframe Showing the Screen Where Detailed Conditions and Rules of Each Application can be Defined

The annotations in the above wireframe describe the different features that allow the users to program an application without coding or having deep technical knowledge.

1. The drop-down list is used for the condition. There are 3 options: Text, Polarity and Subjectivity.
2. The Text field accepts a text file with a set of words. The text will be compared to this word set and find if each word is contained within the text.
3. Polarity accepts a number between -1 to 1 which determines how negative (-1) or positive (1) the text is
4. Subjectivity accepts a number between 0 to 1 which determines how objective (0) or subjective (1) the text is
5. User can add a new condition to the rules
6. This field is for the text that will be searched by this rule
7. A dropdown to show the and/or condition between each rule to determine how the alert is processed, e.g. In the example, 'Person' needs to appear 5 times and 'Cancer' needs to appear 2 times for the alert to be generated
8. User can establish how many times thew word needs to appear before triggering the alert
9. This field is to define this rule under a name
10. User can establish how many times thew word needs to be appeared before triggering the alert
11. Action button to save the rule with the defined conditions

Once user completes defining the rules and conditions for an application, they can return to the main Application List screen (Section 6.4.2).

6.4.6 Alerts List

Once the designed applications are performing the real-time analysis of social media data, they are expected to generate alerts when the defined rules are triggered. The following wireframe is design to describe the information concerning alerts that will be generated by running applications.

As shown in Figure 46, the user should be able to see a list of alerts generated by all running applications. In addition to the simple table (showing list of alerts with relevant information), the wireframe also illustrates several visualisations that are designed to provide a quick overview of the alerts related information.

In this respect, the table matrix shows the summary of alerts by the running application together with the highlighting of the rules that triggered them. Alongside that, the visualisations show the counter of total number of alerts triggered by the running applications and the number of active applications. Moreover, a linear graph and an alerts matrix are illustrated to represent the activities of the running applications over time.

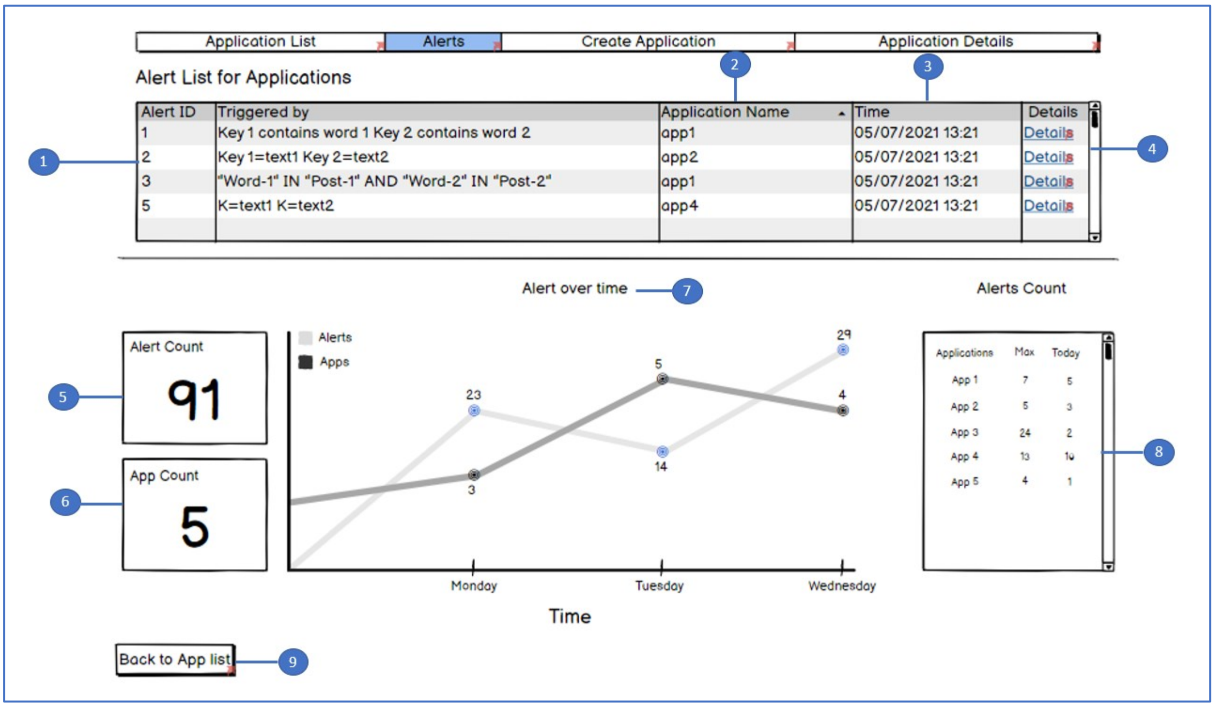


Figure 46: Wireframe Showing the Main Alerts Screen Where Alerts of All Active Applications are Shown

The annotations shown in the above wireframe are described below:

1. User can view the list of all alerts (assigned with an ID number) in this table matrix
2. The name of application that generated the alert
3. Time stamp of the alert
4. User can access to the next screen to view more details about this alert
5. Total number of alerts generated by all applications
6. Number of applications that generated the alerts

7. A chart which shows the alerts in a graph with Polarity being displayed on the Y-axis and the timestamp being used on the X-axis
8. User can view how many alerts have been generated by each application showing the maximum number of alerts in a day the application has generated and how many alerts have been generated today
9. Action button to go back to the applications list screen (Section 6.4.2)

The above wireframe also shows the navigation options available to the users e.g. the user may navigate back to the main Applications List (Section 6.4.2) or they can proceed to view the detailed information about each alert (Section 6.4.7), by clicking the link in the table matrix.

6.4.7 Alert Information

Coming from the Alert List (Section 6.4.6), the user should be allowed to review the details of a particular alert in order to get the necessary insight into the underlying situation that has developed or is developing on the social media. The following wireframe shown in Figure 47 is designed to provide such details about a particular alert generated by an application. The wireframe describes the detailed view of a particular alert e.g., describing the social media messages that triggered the alert, the actual keywords that matched with the keyword list provided by the user, the information about the underlying users, as well as the polarity and subjectivity rating of the alert calculated by the social media analyser tool.

In order to present an overarching picture of where this alert fits within the other alerts generated by the running applications, the wireframe also illustrates a summarised view of all the alerts that are generated by the running applications.

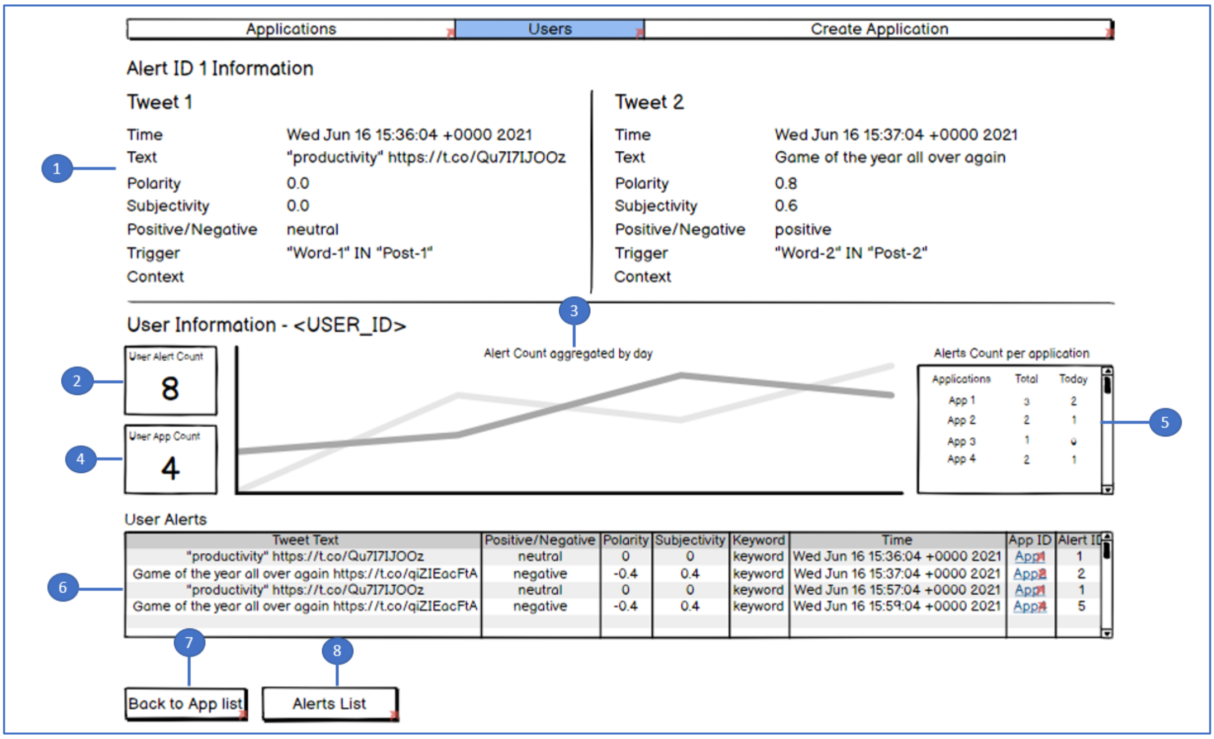


Figure 47: Wireframe Showing the Screen Where Information About Alerts Can be Presented to Each User

The annotations in the above wireframe describe the different features envisioned within the Alert Details screen.

1. Details of each social media message which triggered the alert
2. Number of alerts generated by this particular social media account
3. This graph show alerts this social media account has generated with Polarity being displayed on the Y-axis and the timestamp being used on the X-axis
4. Number of applications triggered alert for this social media account
5. Breakdown of alerts being generated by each application for this social media account showing the maximum number of alerts in a day the application has generated and how many alerts have been generated today
6. User can see the messages text from the social media account with a polarity and subjectivity rating given
7. Action button to go back to Applications List screen (Section 6.4.2)
8. Action button to go back to Alerts List screen (Section 6.4.6)

The mock-up also describes the navigation options available to the user e.g. the user can navigate back to the main Application List screen (Section 6.4.2) or back to the Alerts list screen (Section 6.4.6) using the relevant action buttons.

7 Feedback on Key Screen Designs

Early feedback from potential end users of the system and their representatives in the project is an essential feature of user-driven design and user-centric system development. The maturity of the ideas within iHelp motivated a limited exercise for this first period, with a more extensive and detailed review workshops planned for D2.9 in the second year of the project, allowing us to formulate success criteria to help with the iHelp evaluation in WP7.

The user pilots were split into three groups:

Pre-clinical Pilots – Medical University Plovdiv (MUP) and the University of Manchester (UNIMAN). These pilots focus on early risk detection and preventive measures to reduce the risk, the Health Professionals are involved in primary care, and the focus is on scale and automation of initial detection.

Pre-diagnosis Pilots – the Taiwan Medical University (TMU) and Hospital De Marina-Salud (HDM). These pilots work with Electronic Health Record and Holistic Health Record of patients in clinical setting, focused on balancing different needs of patients and health professionals to enable best possible care.

Post-diagnosis Pilot – the Agostino Gemelli University Policlinic (FPG). This pilot focuses on reducing the risk of toxicity within pages of advanced stages of pancreatic cancer, who are receiving chemotherapy. The focus is on dealing with the unique requirements and sensitivities of hospital treatment of terminally ill patients.

The sessions were organised on a rota basis, with the pilots from each group meeting the representatives of the partners who have developed wireframes under each of the main interfaces explained in the previous section. The interface was demonstrated, and the pilots were asked a set of formative feedback questions, aiming to assert the suitability of the interface to their context and needs. The sections below describe the feedback received for each of the four main interface groups.

7.1 Model Builder's Interface

The Decision Support System (DSS) Suite will help Model Builder users to create analytic workflows, visualize data and assist in the design of the different dashboards for Clinicians and Policy Makers. The DSS was presented to all pilots during three different meetings based on the scenarios of the pilots: pre-diagnostic pilots, pre-clinical pilots, and clinical trial pilots.

In all meetings pilots asked about the characteristics of the persona in charge of the creation of the workflows and dashboards, and what role they may play in the deploying organisation.

During these meetings the different wireframes were presented and explained in detail. The pilots agreed on the key screen designs.

7.2 Health Professional's Interface

The wireframe prototype of the Health Professional's Interface was presented to three groups of pilot users in a rotating basis, and the feedback was voice-recorded and then transcribed on a confidential basis. In addition, we obtained written feedback by some of the pilot sites, and by the leaders of WP2 regarding the feasibility of some the features, and also of the changes requested by the pilots in terms of both technical feasibility and privacy/regulatory feasibility.

In summary, the main user feedback was focused on the modality of applying risk analysis – for some pilots it was a batch screening as data was loaded into the system, for others it was checking the risk for individuals as they presented themselves to the health system. Some of the pilots where mass-screening was recommended stated that they would not be explicitly calling patients of medium risk in, instead flagging their health records and waiting for the next time these patients appear in front of a health practitioner with possibly related symptoms, in order to avoid unnecessary panic.

7.2.1 Feedback from Pre-clinical Pilots

The following feedback points were made by the two pilots dealing with pre-clinical stages of individual's risk journey: MUP and MAN:

Representation of Risk: A significant feedback point regarding risk was its calibration and explanation to the individual. A single number or percentage is likely to be incomprehensible and misleading. Instead, we need to compare the risk against the general risk within the population, and also specify a timeline for the risk stated – for example 10 years or lifetime.

Information presented as relevant to risk assessment: A health professional has a fixed time slot within which they need to see a patient, make a diagnosis and prescribe treatment. They are unlikely to be able to enter all the relevant health information and other conditions information presented on the risk assessment screen. As much as possible of this information should be collected from the patient's electronic health record, but this would depend on the local regulations. Our system may not have access to this information to present at the relevant screen.

System requesting tests and samples: Tests and samples (blood/epigenetic and others) are mostly required when the risk assessment is high, for medium risk result the recommendations will be focused on setting up goals such as exercise and smoking reduction.

Setting and following goals: Whilst it is clear that following goals happens through the mobile interface, it is less clear where these goals are set. In the current version this is done by the Health Professional in discussion with the patient and in collaboration with the AI part of the iHelp system through the Health Professional interface. But some of this can be done through the mobile interface.

The iHelp system should consider a wider range of health conditions. For example, when risk reduction strategies such as physical exercise is discussed, we need to be aware of any conditions such as arthritis, which would prevent an individual embarking on a physical fitness programme. The problem is that the range of the relevant conditions is quite large, and the current state-of-art in medical systems is not able to easily monitor all the relevant conditions.

7.2.2 Feedback from Pre-diagnosis Pilots

The two pre-diagnosis pilots are Hospital de Marina-Salud (HDM) and Taiwan Medical University (TMU). They found the user interaction proposals appropriate, yet they also brought unique constraints and insights into the functionality of the iHelp system.

Information presented as relevant to risk assessment: Health Professional will also have access to subjective data when making the risk assessment: pain, tiredness, anxiety. This is because at pre-diagnosis stage we may have already symptoms developing. These can be collected via the app. This point should be discussed in Year 2 of the project, since the mobile application is also deployed once the initial risk assessment is made, and these subjective characteristics could be initially gathered via the personalisation questionnaire.

Health Professionals should work with one interface: To facilitate uptake of iHelp, Health Professionals working for HDM would ideally regard iHelp as another screen of their existing system. This may suggest a different deployment between primary care setting, where the system can be somewhat stand-alone, and the clinical deployment where deep integration may be more appropriate. This should be discussed in Year 2 since this may not be trivial to achieve within the constraints of the pilot development on the project.

Country-specific constraints should be considered when deploying: A separate deployment of iHelp would need to be executed in Taiwan since otherwise data cannot be exported into iHelp.

7.2.3 Feedback from Post-diagnosis Pilot

The pilot of Gemelli (FPG) provides its own unique challenges and requirements to the i-Help software system, because of its position at the end of the risk lifecycle for an individual. Indeed, the patients included in this trial would have developed pancreatic cancer and will be undergoing chemotherapy under observation by a cancer specialist. The risk is thus calculated during a visit to a Health Professional. The participants in the feedback session from FPG provided the following feedback:

Representation of Risk: in this pilot, the risk calculated is not of developing pancreatic cancer, indeed for the patients involved that risk has become reality. It is the probability for the patient to develop high level of toxicity given their current treatment and general state of health.

Information presented as relevant to risk assessment: FPG Pilot will use clinical data together with staging data and treatment data to establish the risk of the patient developing toxicity. In fact, the health professionals at the hospital will not be allowed to input data directly in iHelp, they will be inputting the data into their existing clinical systems, and the FPG team will ensure this data is exported into iHelp.

Health Professional and System-provided Advice: The marking of a patient as someone who is of high risk of toxicity is extremely valuable feature of the system, yet the question of the reliability of this advice is even more critical at this clinical of the risk lifecycle. Indeed, it is possible that the Health Professional will not agree with the advice for risk management or the risk calculation provided by the system. In this case we have to consider how we can use this signal to improve our risk calculation and advice-giving models by introducing a feedback/learning loop.

7.3 Risk Advice Delivery

The Wireframes for the "Risk Advice Delivery" component – i.e. virtual coaching wireframes were presented to expert users in three different sessions. In the first session, the wireframes were presented to the pilots focusing on pre-clinical stage (UNIMAN and MUP); in the second session pilots focusing on the pre-diagnosis stage (HDM and TMU); and in the third session to the FPG Pilot that focuses on the advanced stages of pancreatic cancer. We describe the feedback that was collected in the below subsections.

7.3.1 Feedback from Pre-clinical Pilots

Overall, the Pilots lead by the University of Manchester (UNIMAN) and the Medical University of Plovdiv (MUP) found that the wireframes matched the needs of the pilots very well, and that there was a good functionality and scope of the presented coaching activities.

In terms of improvements, they mentioned the following items:

- Ensure the coaching is personalized and that feedback provided to users contains some elements of personal data/performance.
- Ensure coaching at all stages of the behaviour change journey.
- Enable notification to a healthcare professional in case some of the health metrics change in undesirable direction (NOTE: suggested to be considered as an element of the monitoring component).

7.3.2 Feedback from Pre-diagnosis Pilots

Overall, the feedback from the pre-clinical pilots was positive, in the same way as the feedback received from the pre-diagnosis pilots: they found that the wireframes provided a good match and functionality, in line with the pilot needs.

The suggested improvements were as follows:

- A recommendation was made to add an option to contact a physician in case some of the advice relates to medications/blood tests, etc...
- Advice to consider different presentation options for increased accessibility (e.g., visual data representation, size of font, etc). Please consider the information/advice in the following video: https://www.youtube.com/watch?v=meNLXEmbDOM&ab_channel=Figma
- The virtual coach should support multiple languages (e.g. Chinese).

7.3.3 Feedback from Post-diagnosis Pilot

Overall, the feeling from the FPG pilot, focusing on the advanced stages of pancreatic cancer, was that the wireframes and functionality should be enhanced to match the specific needs of the pilot (dealing with terminally ill patients).

Specifically, the suggestions for improvements given were as follows:

- Coaching as giving recommendations, supporting goals, feedback is not recommended for this context/pilot
- The coaching functionality could in this case be applied to do the following:
  - elicitation of information about patient’s experiences, feelings, or changes in physical status that could enable physicians to react faster (e.g. change treatment), and;
  - provide some generic information about treatments and potential procedures (some generic information typically shared in healthcare leaflets)
- The important recommendation here is that the coaching is not used to replace communication with a physician (anything that relates to a patient’s state, treatment, etc...).
- There is a two-stage approach to understanding how to develop this coaching functionality further: consult (a) psychologists and (b) ethical/legal experts on the best communication approaches in relation to this specific group of users

7.4 Social Media Analysis – Policy Maker

The Wireframes for the “Social Media Analyser” tool were presented to expert users in a dedicated session organised during a plenary meeting of the iHelp project. In the session, the wireframes were presented to the project partners, including both research partners and pilot partners who are either currently involved or have been involved in the health-related decision-making activities. The feedback that was collected is described below:

Overall, the partners found that the wireframes provided a good overview of the innovative functionality envisioned through the social media analyser tool. The partners also agreed that the overall functionality and the purpose of different features of the social analyser tool was also being adequately conveyed by the wireframes. However, owing to the innovative and somewhat disruptive nature of the envisioned functionality, the partners asked several questions about the details of the different features and make suggestions about how those questions can be answered through specific improvements and enhancements in the various screens.

In terms of improvements and enhancements, the partners provided the following:

- Create a new user account – This option should be available on the login screen to allow the registration of new users
- Logout – An Action button should be added to all screens to enable the user to logout at their convenience
- Explanation of features – Tooltips should be provided on the different links and navigational options to assist users in developing a better understanding of available features. Moreover, brief descriptions or explanations should be provided on various screens to elaborate the technical features, such as the specification of keywords and definition of rules
- Actionable insight: The alerts related information should be provided to users in such a way that provide some clarify on how this information can be used in the policy making activities
- Data Security and privacy: The compliance with relevant data security and privacy regulations should be highlighted somewhere in the tool to give users more confidence in using the tool
- Clarity over the process: The navigational flow or the flow of activities required to setup the application and view the alerts should be clarified on the UI. Guidelines should be provided to inform the user about which step of the process they are currently in and what can be done to complete the process or to make effective user of the tool

7.5 Feedback by Software Engineers

WP2 representatives who were coordinating the software engineering effort attended the user feedback sessions and raised a set of specific considerations which should shape the future discussions with pilot partners and constrain the degree to which user requirements can be implemented within iHelp.

Connection to proprietary systems within Pilots will be severely limited in pilot stages because of resource limitations. For example, iHelp will not have the capability to link into systems to schedule test times. We do not have neither the authorisation to do so neither the effort to develop at least 5 different "connectors". For the moment we should only advise the individual the need to book the test. Also, the user information at the start of the Risk Assessment screen cannot at present be read from the existing systems, since we cannot integrate iHelp with the existing EMR systems. Instead, during the enrolment phase the HCP will insert, ex-novo, from scratch, all the needed data. We should only enter data which is needed for the AI to run, because of the "data by default" regulation. The argument which data is necessary should be made by the project. This stage of entering the necessary data is not documented in D2.1 because no one of the pilots envisaged it at that time.

Privacy considerations with restrict the system at pilot stages. For example, personal names or photographs will not be present in the GUI, but will be replaced by a simple ID.

Architectural considerations about the flow of control between use cases. The policies of the Risk Mitigation and the intervention selected should be communicated to the Monitoring Alerting service and aligned to what the Personalised Advisor can offer. The threshold for triggering the automatic behaviour could be personalised. We also need to consider which part of iHelp will provide the alerting that an individual visiting a Health Service Professional has an increased risk of developing Pancreatic Cancer. This could be done by the Monitoring & Alerting components, which work on the data during the iHelp project, so this will present no privacy breach but may escalate the certification needed for the Monitor & Alerting components to Class IIb, following the MDR.

8 General guidelines for constructing user interfaces in iHelp

The uptake of any technology-based solutions requires a combination of factors: usability, usefulness, promotion, peer-pressure, social factors. These need to work together to ensure impactful uptake, especially when the software is intelligent and therefore less clear by default.

Our review of state-of-art in intelligent medical interfaces concludes we need to focus on the following aspects of user interface development:

Personalisation and interactivity – the interface addressing the end user (individual) in our system should be personalised to their circumstances and context. This personalisation should extend to the messages and communication style from the system to the user, if we wish for the system to be impactful and change behaviour in a significant and meaningful manner. A particular paradigm we will be exploring in this direction is the "coaching" dialogue based on personalised model of the specific individual.

Arousing and retaining attention using techniques structured around the Fogg Behavioural Model, including bright colours, low barriers to opening the app, and personalised gamification features, especially in the individual-facing interfaces. In establishing the proposed colour schema, for example, we tried to balance the principles of attracting and keeping attention on one side, and the health-care related theme of our application, which suggested more pastel-like and less aggressive colour schema. The results are illustrated in the proposed templates for desktop interface and mobile device interface.

User-centric design process to drive the development of our interfaces. These should be prototyped in an iterative manner with the active participation of our pilot participants at first, then followed by representatives of all target stakeholder groups. This process has started with this deliverable as demonstrated in Sections 6 and 0, and will continue with the work leading to D2.8 and then with the user-oriented usability evaluation conducted in WP7 and especially Task 7.2.

8.1 Desktop Interface

The draft templates for desktop-based interface of iHelp shown in Figure 48 and Figure 49 are orthogonal to the wireframe prototypes described earlier.

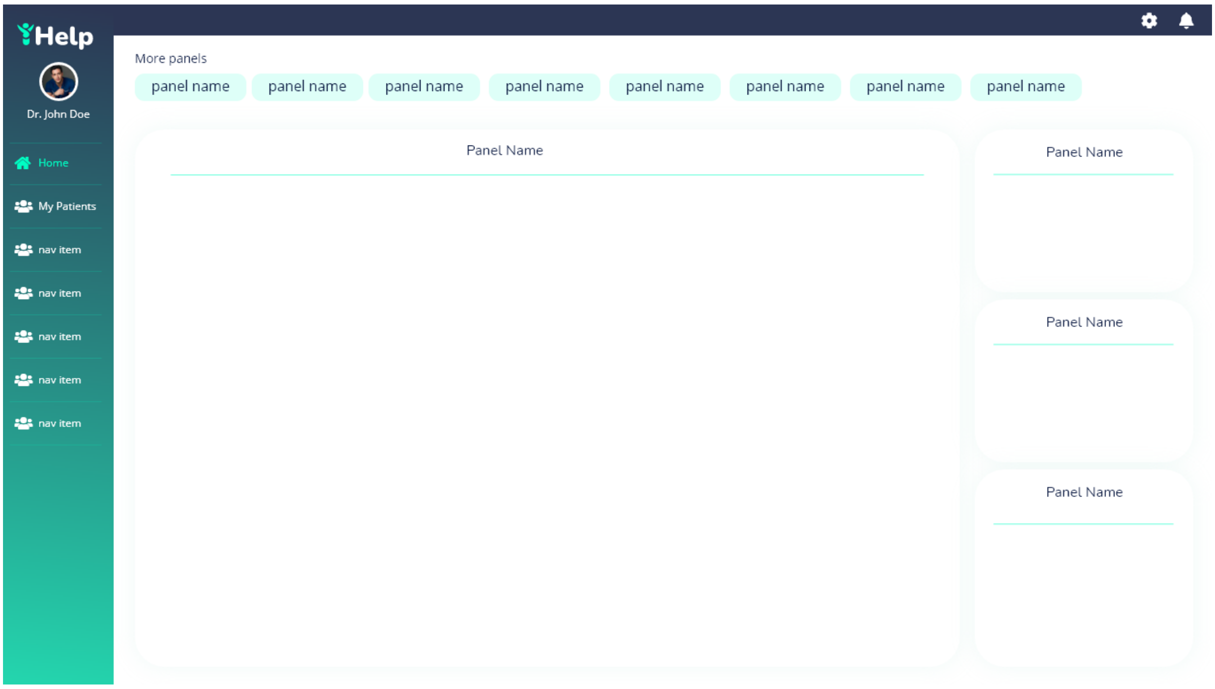


Figure 48: Example Layout and Colours for the Health Professional Desktop Interface – a Main Panel Version.

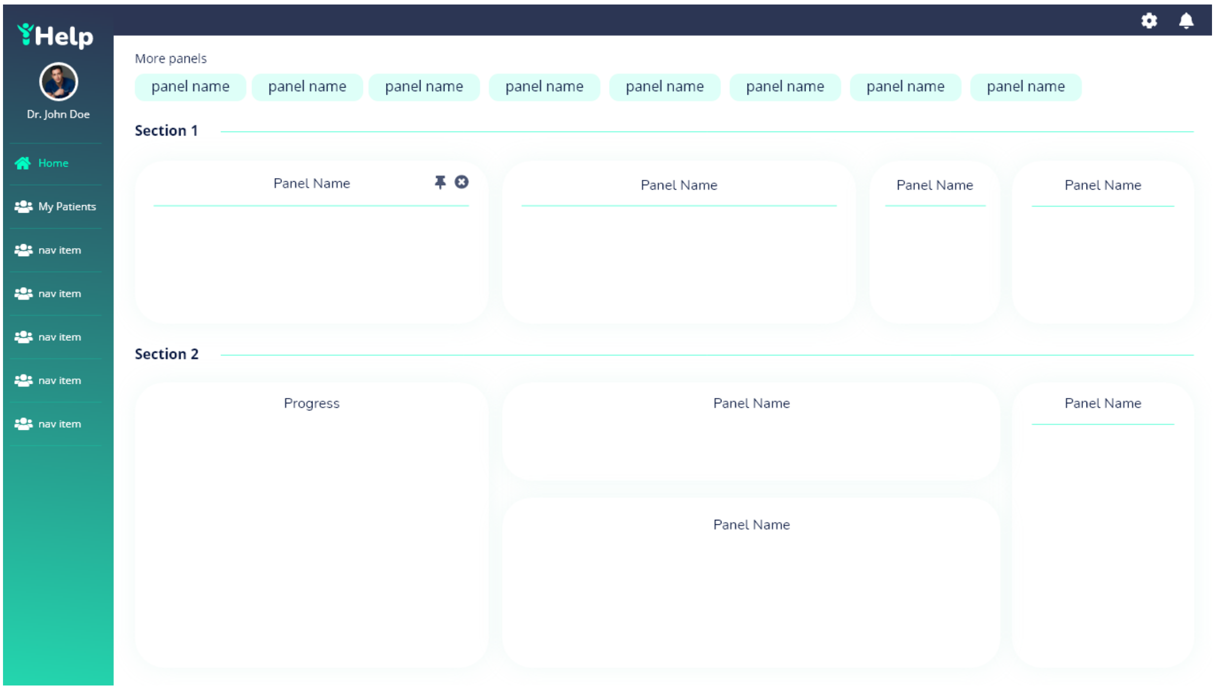
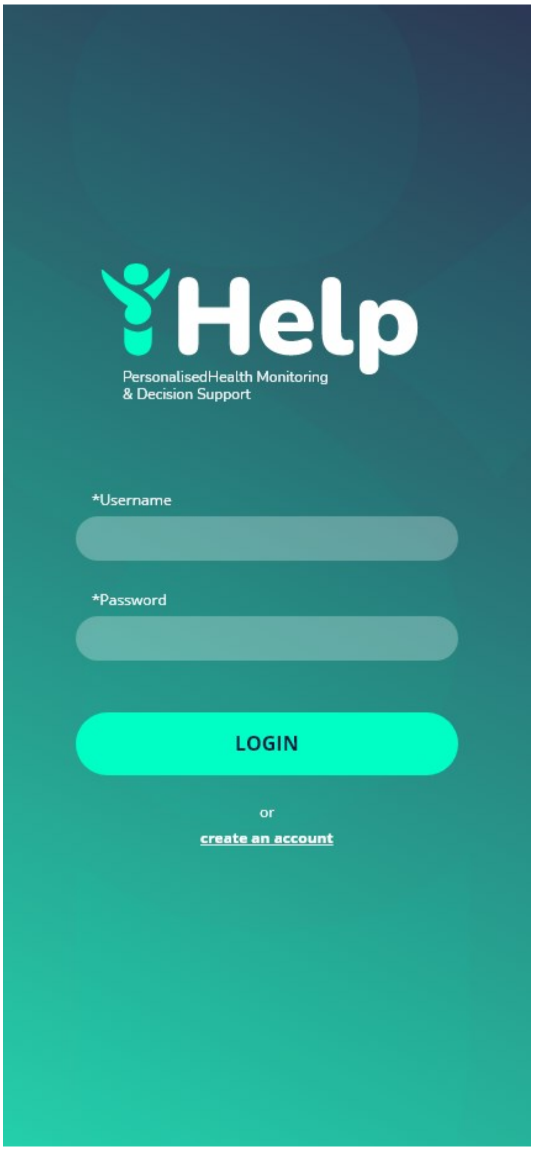


Figure 49: Example Layout and Colours for the Health Professional Desktop Interface - Multiple Panels Version.

Whilst the Wireframes serve to illustrate the information content and functionality, the draft templates demonstrate the key design elements and colours which will comprise the desktop interface. The focus here is on clarity and visibility of key information delivered via the interface, without the interface and menu elements overwhelming the window viewed by the Health Professional, Model Builder or Policy Maker Personas.

8.2 Mobile Interfaces

The draft templates for the mobile interface fall into two main classes – supplementary pages and interactive/functional pages. The supplementary pages include the landing/login page and the processing page shown in Figure 50, and they are aligned with the neutral health-related colours of the desktop interface. In contrast, the interactive/functional pages shown in Figure 51 bring richer colour contrast to facilitate understanding of information and act as attention-stimulus attracting the individual to the interface and to the application overall.



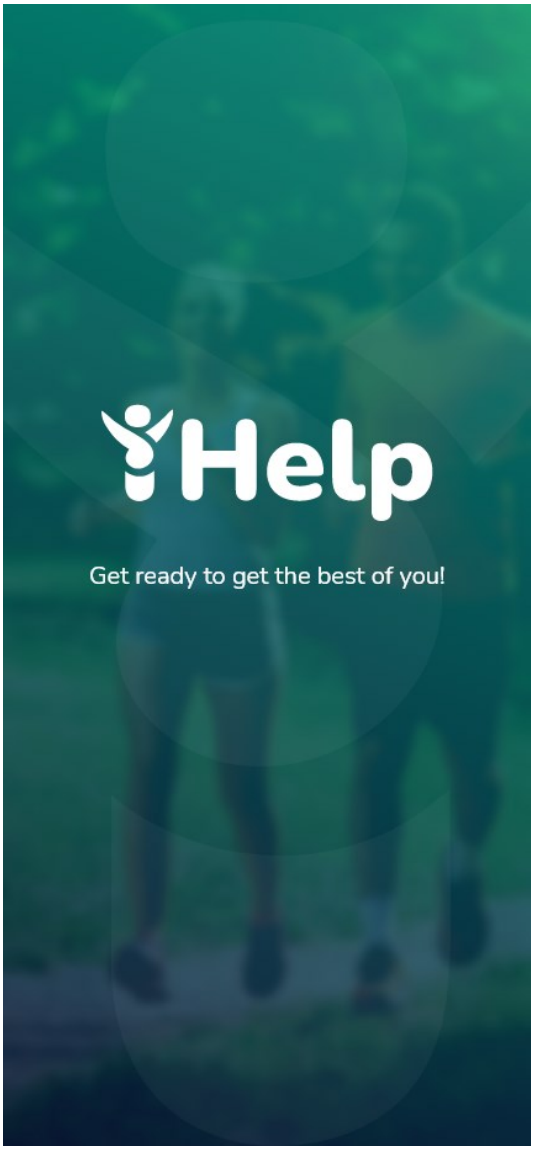


Figure 50: Proposed Landing Page on Mobile Interface (left) and processing (thinking) page (right).

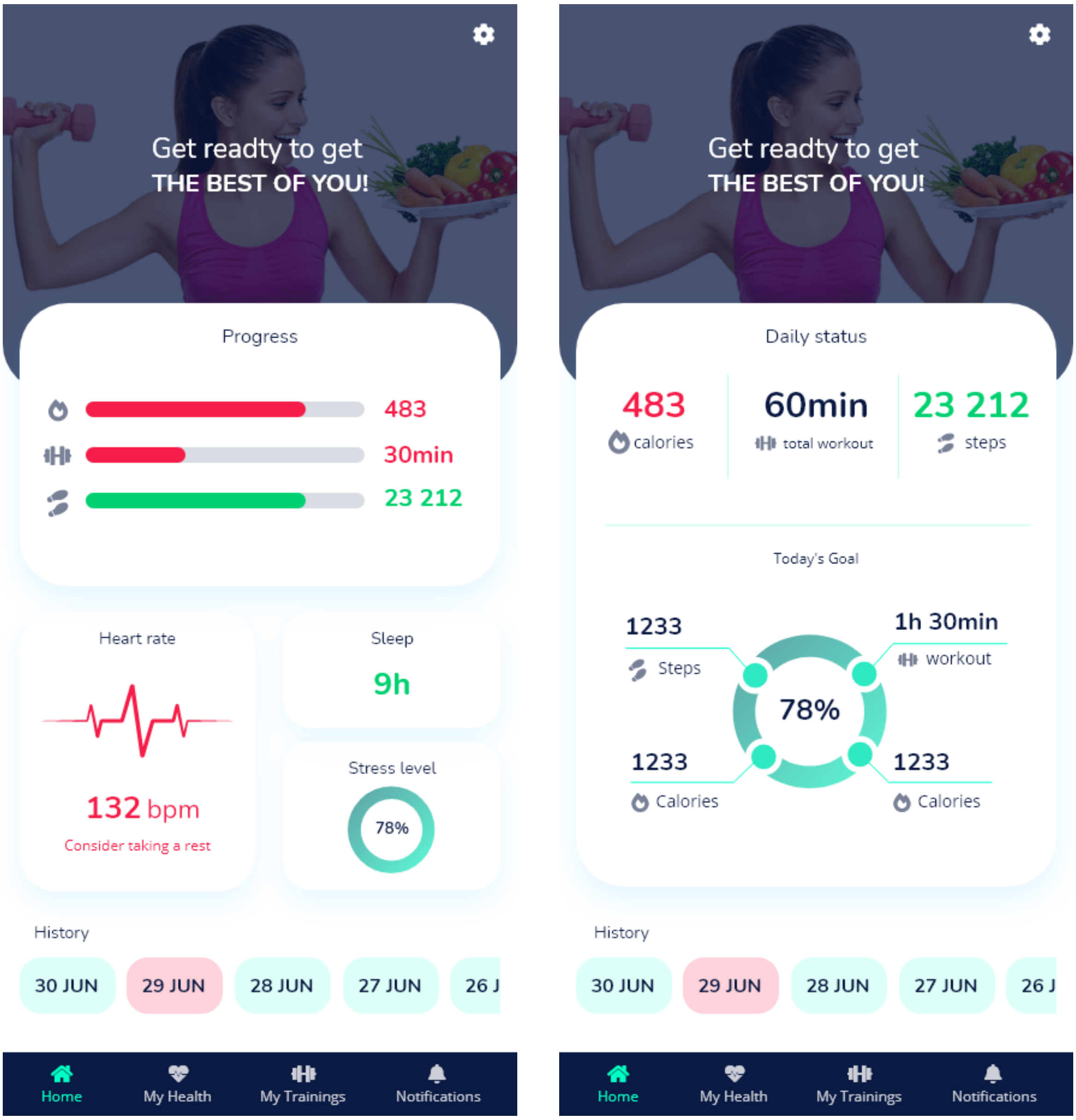


Figure 51: Example Colour Schema for the Mobile Interface - Progress to Goals Screen (left) and Daily Status Screen (right).

9 Summary and Conclusion

9.1 Summary of the Deliverable

This deliverable reports the results achieved by the first half of T2.4 - "User Centred Design". The task aims to ensure that the interfaces produced by iHelp are perceived as enjoyable, easy to understand and effective by the different groups of potential users. We also aim to ensure iHelp software will be developed in alignment with the requirements stipulated in relation to developing medical devices, and that users continue to use the mobile interface for sufficiently long periods of time to execute behavioural change and thus we can make substantial difference in the health of the population targeted by the iHelp future deployments.

This deliverable:

- reviews the state of art in health systems personalisation and AI;
- defines key user groups and their characteristics;
- provides a set of use case models and descriptions for the user-facing use cases; and
- creates and evaluates the first draft of wireframe models of key interface screens.

This work leads to the first set of user development guidelines presented in Section 8. The definition of evaluation criteria is left for the second deliverable of T2.4, D2.9 due to be released in M20 (August 2022).

9.2 Further work leading to D2.9

Many of the discussion points regarding the functionality of the user interfaces and the sources of user data will be resolved during the second year of the iHelp project. Those which are directly related to the user interfaces and to the usability guidelines to drive the rest of the project, will be immediately disseminated to all relevant partners of iHelp, and documented in D2.9.

In addition, we will continue to work with the pilots to derive a set of robust and user-oriented usability evaluation indicators, which will be used in WP7 and especially by T7.2 to evaluate the usability of the user interfaces produced by the project.

Bibliography

H. Akker et al, “Council of coaches a novel holistic behavior change coaching approach”, *in 4th International Conference on Information and Communication Technologies for Ageing Well and e-Health, ICT4AWE 2018*, pp. 219-226, 2018. SciTePress.

A. Arcia, M. Velez, and S. Bakken, “Style Guide: An Interdisciplinary Communication Tool to Support the Process of Generating Tailored Infographics From Electronic Health Data Using EnTICE3”, *eGEMs* 3 (1), 2013.

A. Arcia, J. Woollen, and S. Bakken, “A Systematic Method for Exploring Data Attributes in Preparation for Designing Tailored Infographics of Patient Reported Outcomes”, eGEMs 6 (1), 2018.

J. Arsenijevic, L. Tummers, and N. Bosma, “Adherence to Electronic Health Tools Among Vulnerable Groups: Systematic Literature Review and Meta-Analysis”, *Journal of Medical Internet Research 22*, no. 2, p. e11613, 2020.

S. J.H. Biddle et al., “Motivation for physical activity in young people: Entity and incremental beliefs about athletic ability”, *Journal of sports science*, vol. 21, no. 12, pp. 973-989, 2003.

A. Blandford, “HCI for Health and Wellbeing: Challenges and Opportunities”, *Int. J. Hum. Comput. Stud.* 131, pp. 41-51, 2019.

K. Börner, A. Bueckle, and M. Ginda, “Data Visualization Literacy: Definitions, Conceptual Frameworks, Exercises, and Assessments”, *Proceedings of the National Academy of Sciences*, vol. 116, no. 6, pp. 1857-64, 2019.

G. Chen et al., “Understanding programmatic creative: The role of AI”, *Journal of Advertising*, vol. 48, no. 4, pp. 347-355, 2019.

K. L. Cheung, D. Durusu, X. Sui, and H. de Vries, “How Recommender Systems Could Support and Enhance Computer-tailored Digital Health Programs: A Scoping Review”, *Digital health*, vol. 5, 2055207618824727, 2019.

C. L. Colby, S. Mithas, and A. Parasuraman “Service robots: How ready are consumers to adopt and what drives acceptance”, *The 2016 Frontiers in Service Conference*, Bergen, Norway, 2016.

M. Csikszentmihalyi, and R. Larson “Validity and reliability of the experience-sampling method”, *J. Nerv. Ment. Dis.*, vol. 175, no. 9, pp. 526-536, 1987.

A. De Angeli, M. Jovanović, A. McNeill, and L. Coventry, “Desires for active ageing technology”, *Int. J. Hum. Comput. Stud.*, vol. 138, p.102412, 2020.

Directive 90/385/EEC, 1990. Council Directive 90/385/EEC of 20 June 1990 on the approximation of the laws of the Member States relating to active implantable medical devices, Official Journal L 189, 20/07/1990 (pp. 0017 – 0036).

Directive 93/42/ECC, 1993. Council Directive 93/42/ECC of 14 June 1993 concerning medical devices, Official Journal L 169, 12/07/1993 (pp. 0001 – 0043).

Directive 98/79/EC of the European Parliament and of the Council, 1998. Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on in vitro diagnostic medical devices, Official Journal of the European Union L 331, 07/12/1998 (pp. 0001 – 0037)

Directive 2007/47/EC of the European Parliament and of the Council, 2007. Directive 2007/47/EC of the European Parliament and of the Council of 5 September 2007 amending Council Directive 90/385/EEC on the approximation of the laws of the Member States relating to active implantable medical devices, Council Directive 93/42/EEC concerning medical devices and Directive 98/8/EC concerning the placing of biocidal products on the market, Official Journal of the European Union L 24, 21.9.2007, (pp. 21–55).

5.5.2017, 2017. EN Official Journal of the European Union, L 117/143 - section 6.3. Rule 11

B. J. Fogg, "A behavior model for persuasive design", *In Proceedings of the 4th international Conference on Persuasive Technology*, pp. 1-7, 2009.

C. Goward, "You should test that: conversion optimization for more leads, sales and profit or the art and science of optimized marketing", *John Wiley & Sons,* 2012.

C. Homburg, D. Jozić, and C. Kuehnl, "Customer experience management: toward implementing an evolving marketing concept", *Journal of the Academy of Marketing Science*, vol. 45, no. 3, pp.377-401, 2017.

MH. Huang, and R. T. Rust, "Artificial Intelligence in Service", *Journal of Service Research*, vol. 21, no. 2, pp. 155-172, 2018.

MH. Huang, and R. T. Rust, "Engaged to a Robot? The Role of AI in Service", *Journal of Service Research*, vol. 24, no. 1, pp. 30-41, 2021.

MH. Huang, R. T. Rust, and V. Maksimovic, "The Feeling Economy: Managing in the Next Generation of Artificial Intelligence (AI)", *California Management Review*, vol. 61, no. 4, pp. 43-65, 2019.

iHelp, "Deliverable D2.1. State of the Art and Requirement Analysis", 2021.

D. Jannach, P. Resnick, A. Tuzhilin, and M. Zanker, "Recommender Systems--Beyond Matrix Completion", *Communications of the ACM*, vol. 59, no. 11, pp. 94-102, 2016.

M. Kupp, J. Anderson, and J. Reckhenrich, "Why design thinking in business needs a rethink", *MIT Sloan Management Review*, vol. 59, no. 1, p. 42, 2017.

J. Liedtka, "Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction", *Journal of Product Innovation Management*, vol. 32, no. 6, pp. 925-938, 2015.

R. Kling, "The Organizational Context of User-Centered Software Designs", *MIS Quarterly*, vol. 1, no. 4, pp. 41–52, 1977.

C. Kuehnl, D. Jozic, and C. Homburg, "Effective customer journey design: consumers' conception, measurement, and consequences", *Journal of the Academy of Marketing Science*, vol. 47, no. 3, pp.551-568, 2019.

S. H. Mahboobi, M. Usta, and S. R. Bagheri, "Coalition Game Theory In Attribution Modeling: Measuring What Matters at Scale", *Journal of Advertising Research*, vol. 58, no. 4, pp.414-422, 2018.

Medicines and Healthcare products Regulatory Agency (MHRA), “Guidance on applying human factors and usability engineering to medical devices including drug-device combination products in Great Britain”, Version 2.0., 2021.

M. Nieroda, K. Keeling, and D. Keeling, “Acceptance of Mobile Apps for Health Self-management: Regulatory Fit Perspective”, *UMAP Workshops*, 2015.

D. A. Norman, “User-Centered System Design: New Perspectives on Human-Computer Interaction”, *CRC Press,* 1986.

U. Panniello, A. Tuzhilin, and M. Gorgoglione, “Comparing Context-aware Recommender Systems in Terms of Accuracy and Diversity”, *User Modeling and User-Adapted Interaction*, vol. 24, no. 1, pp. 35-65, 2014.

C. N. Scollon, K. P. Chu, and E. Diener, “Experience sampling: promises and pitfalls, strengths and weaknesses”, *J. Happiness Stud.*, vol. 4 (1925), pp. 5-34, 2003.

A. A. Stone, and S. Shiffman, “Capturing momentary, self-report data: a proposal for reporting guidelines”, *Ann. Behav. Med.*, vol. 24, no. 3, pp. 236-243, 2002.

J. Torous et al, “Towards a Consensus Around Standards for Smartphone Apps and Digital Mental Health”, *World Psychiatry*, vol. 18, no. 1, p. 97, 2019.

UK Medical Devices Regulations, 2002. (SI 2002. No 618, as amended). [Online]. Available: https://www.legislation.gov.uk/uksi/2002/618/contents/made [Accessed: 20-Dec-2021]

M. Wedel, and P. K. Kannan, “Marketing analytics for data-rich environments”, *Journal of Marketing*, vol. 80, no. 6, pp. 97-121, 2016.

G. Villalobos-Zúñiga, M. Cherubini, “Apps That Motivate: a Taxonomy of App Features Based on Self-Determination Theory”, *Int. J. Hum. Comput. Stud.*, p.102449, 2020.

L. Xu, J. A. Duan, and A. Whinston, “Path to purchase: A mutually exciting point process model for online advertising and conversion”, *Management Science*, vol. 60, no. 6, pp.1392-1412, 2014.

R. Xu, R. M. Frey, E. Fleisch, and A. Ilic, “Understanding the Impact of Personality Traits on Mobile App Adoption – Insights From a Large-scale Field Study”, *Computers in Human Behavior*, vol. 62, pp. 244-256, 2016.

M. Zanker, L. Rook, and D. Jannach, “Measuring the Impact of Online Personalisation: Past, Present and Future”, *International Journal of Human-Computer Studies*, vol. 131, pp. 160-168, 2019.

List of Acronyms

AI	Artificial Intelligence
ATC	Athens Technology Centre
CA	Consortium Agreement
CEP	Complex Event Processing
DoA	Description of Action
D	Deliverable
DS4	Digital Systems 4
DSS	Decision Support System
EHRs	Electronic Health Records
ER	Essential Requirements
ESM	Experience Sampling Method
EU	European Union
FBM	Fogg Behavior Model
FPG	Agostino Gemelli University Policlinic
GUI	Graphical User Interface
HDM	Hospital De Marina-Salud
HHRs	Holistic Health Records
HI	Human Intelligence
HCI	Human-Computer Interface
ICE	Information Catalyst for Enterprise
iSPRINT	Innovation Sprint
KPI	Key Performance Indicator
KOD	KODAR Systems
MUP	Medical University Plovdiv
NLP	Natural Language Processing
SNA	Sentiment Network Analysis
SOTA	State of the Art
UC	Use Cases
UCD	User-Centred Development
PM	Policy Maker
PC	Pancreatic Cancer
T	Task
TMU	Taiwan Medical University
UI	User Interface
UK	United Kingdom
UNIMAN	University of Manchester
UPM	Universidad Politecnica de Madrid
UPRC	University of Piraeus Research Centre
WP	Work Package

Appendix A. Persona Descriptions

Model Builder

Name	Kevin	**Age**	50
Goals	Kevin wants to build risk models aligned to local context and data availability. He may also want to publish the results of his work, for which he will need data about the validity of his model.		
Education	Doctorate in Application of Analytics to epidemiology		
Experience	20 years in the role of academic, risk modelling for last 5 years.		
Lifestyle	Devoted to work, not much time for hobbies.		
Nature of work	Statistical analysis of large volumes of data, discovering patterns in data, modelling epidemiological theories in analytics tools.		
Environment	Own office, no noise or interruptions.		
IT Skills	Advanced but often looses patience with IT		
IT Equipment	Advanced Desktop Computer with large screen		
Key use cases	Develop Risk Model		

Health Professional

The Health Professional persona is Jill. She is a 40-year-old General Practitioner, with a medical degree. She is interested in medical diagnosis and health matters. She is not technical and has no time nor inclination to learn new interfaces. She is comfortable using existing patient information systems.

An auxiliary personal is Mel, a 30-year-old nurse. Mel is interested in patient care and trained to existing patient IS, but does not have the full decision-powers of Jill, and will not be able to fully replace her in operating the system.

Name	Jill	**Age**	40
Goals	Jill wants to help her patients to improve their health		
Education	Medical Degree		
Experience	10 years in the role of General Practitioner, 5 years Hospital Doctor, possibly 5 years as consultant (FPG)		
Lifestyle	Loves walks in the countryside with family		
Nature of work	Interacting with patients and records system to match symptoms to diagnosis		
Environment	Own office, no noise or interruptions.		
IT Skills	Intermediate, focused on specific Clinical Information System		
IT Equipment	Desktop Computer with medium screen		
Key use cases	Risk Assessment, Risk Mitigation/Treatment Planning, Advice Review, Advice Follow-up		

Individual (Patient)

To represent the different types of individuals and patients we envision using iHelp, we divide them into three personas:

Name	Ann	**Age**	40
Goals	Ann wants to reform and become the best in improving her health		
Education	Marketing degree		
Experience	Part-time teacher		
Lifestyle	Devout gamer, attends international tournaments		
Nature of work	Interacting with children and other gamers		
Environment	Indoors		
IT Skills	Advanced user of IT, interests in modding PCs to improve performance		
IT Equipment	Mobile device and gaming machine		
Key use cases	Capture Profiling Characteristics, Risk Mitigation Delivery, Monitoring		

Name	Jack	Age	50
Goals	Jack wants to preserve his health, he is diabetic and has higher than average risk of developing PC		
Education	Accounting degree		
Experience	Accountant for last 30 years		
Lifestyle	Sedentary, main hobby is cooking		
Nature of work	Sedentary, works with numbers.		
Environment	Indoors		
IT Skills	Skilled with desktop computers, not very experienced with mobile phones		
IT Equipment	Mobile device and gaming machine		
Key use cases	Capture Profiling Characteristics, Risk Mitigation Delivery, Monitoring		

	**Name**	Pat	**Age**	60
	Goals	Pat wants to improve her quality of life and prognosis after diagnosis with Pancreatic Cancer		
	Education	Teacher		
	Experience	Teacher for the last 25 years		
	Lifestyle	Moderately Active, enjoys gardening		
	Nature of work	Working with people		
	Environment	Indoors and outdoors		
	IT Skills	Not skilled with IT, poor eyesight and deteriorating dexterity		
	IT Equipment	Mobile device		
	Key use cases	Capture Profiling Characteristics, Risk Mitigation Delivery, Monitoring		

Policy Maker

Our system will also include users who will be scanning social media and analysing trends related to eHealth and pancreatic cancer, shaping regional policies on the matter. Their profile is exemplified by Sarah. Sarah is a 40-year-old health professional, who is interested in maintaining a set of health KPIs at regional level. She is an intermediate user of IS but has strong analytics and policy skills.

Name	Sarah	**Age**	40
Goals	Sarah is interested in maintaining a set of Health-related KPIs at regional level.		
Education	MSc in Health Science		
Experience	15 years in health administration role.		
Lifestyle	Juggles professional life with looking after her young family, enjoys cycling.		
Nature of work	Analysis of Social Media data.		
Environment	Own office, no noise or interruptions.		
IT Skills	Advanced but often looses patience with IT		
IT Equipment	Advanced Desktop Computer with large screen		
Key use cases	Social Media Analysis		

Appendix B. Main Use Case Descriptions

Risk Assessment

Use Case:	Risk Assessment
Actor:	Health Professional (HP)
Goal:	Health Professional aims to gauge the risk level of the current patient for developing pancreatic cancer. The expect the system to provide them with a clear and simple risk estimation out of [low, medium, high] or [1..100].
Overview:	This use case will take place during routine examinations of a patient. Health professional will enter a number of parameters as required by the risk model, if these are not available from the holistic patient record. If elevated risk is detected [medium or low], the use case will continue with a different screen /use case for elevated risk.
Cross-Refs:	*What functional and non-functional requirements are relevant to that use case? We will provide those functional requirements which are (partially) fulfilled through the use case, and those non-functional requirements which constrain the operation of the use case.*

Typical Course of Events:	
Actor action	System Response
1. HP enters patient id. 4. HP enters required information.	2. System retrieves patient details from HHR 3. System requests additional parameters of the risk model, not available from the HHR for this specific patient. 5. System runs risk model and calculates risk. 6. System informs HP of calculated risk level.

Alternative Course of Events	
Actor action	System Response
At 1. HP can enter patient name and birthdate At 4. HP may not have some of the requested information, perhaps since the patient refuses to provide it.	At 2. System may inform HP that patient details cannot be found in HHR database. At 6, if calculated risk level is medium or high, the use case is extended by Elevated Risk Detected Use Case.

Request Tests and Samples

Use Case:	Request Tests and Samples
Actor:	Health Professional (HP)
Goal:	Health Professional will be advised by the system which tests will help them establish with some precision the exact type and degree of risk for the patient.
Overview:	This use case will take place once elevated risk has been detected during routine examinations of a patient. Using information available, the system will specify which tests and samples are necessary for a more precise risk assessment to be provided.
Cross-Refs:	*What functional and non-functional requirements are relevant to that use case? We will provide those functional requirements which are (partially) fulfilled through the use case, and those non-functional requirements which constrain the operation of the use case.*

Typical Course of Events:	
Actor action	System Response
2. Health Professional confirms that these tests and samples are indeed appropriate.	1. System proposes tests and samples it considers helpful in estimating the risk level with precision. 3. Report on which samples are recommended is produced by the system.

Alternative Course of Events	
Actor action	System Response
At 2. HP can remove tests or add additional tests. At 2. System may not need approval from HP for trivial cases (Manchester).	At 1. System may not propose any tests nor samples as required. 3. At 3, system may communicate tests with individual directly.

Elevated Risk Detected

Use Case:	Elevated Risk Detected
Actor:	Health Professional (HP)
Goal:	Health Professional aims to confirm the elevated risk detected and to establish the next course of action, which could be to order additional tests.
Overview:	This use case will extend the Risk Assessment use case when the latter detects elevated risk for the patient developing pancreatic cancer. The system will explain why elevated cancer is detected, and the HP will have to confirm the conclusion of the system, after which the system will invoke the Request Tests and Samples use case.
Cross-Refs:	*What functional and non-functional requirements are relevant to that use case? We will provide those functional requirements which are (partially) fulfilled through the use case, and those non-functional requirements which constrain the operation of the use case.*

Typical Course of Events:	
Actor action	System Response
	1. System provides explanation as to why it has calculated an elevated risk of pancreatic cancer [medium or high]. 2. System requests HP to confirm its conclusion.
3. HP confirms conclusion of system.	
	4. System includes “Request Tests and Samples” use case.

Alternative Course of Events	
Actor action	System Response
At 3. HP can reject conclusion of system	

Capture Profiling Characteristics

Use Case:	Capture Profiling Characteristics
Actor:	Individual
Goal:	*User's goal is to answer personalisation questionnaire*
Overview:	*User provides answers to personalisation questionnaire. The system profiles an individual (categorises them as a specific type of user).*
Cross-Refs:	

Typical Course of Events:	
Actor action	System Response
2) Fill in the questionnaire	1) System shows questionnaire to user 2) System acknowledges completion 3) System applies profiling formula/model to segment/profile users

Alternative Course of Events	
Actor action	System Response
At (2) user may refuse to complete questionnaire	System will use a generic user type in its interactions with user, warning them that effectiveness may be reduced.

Risk Mitigation Delivery

Use Case:	Risk Mitigation Delivery
Actor:	Individuals
Goal:	*Motivate users to change their behaviour*
Overview:	*The risk mitigation strategy is delivered to individuals through a sequence of interactions using the mobile interface over a period of time.*
Cross-Refs:	

	Typical Course of Events:	
	Actor action	System Response
	User agrees to start behaviour change journey	System starts sending messages and coaching dialogies taking into consideration the profiling characteristics

	Alternative Course of Events	
	Actor action	System Response
	Individual agrees or reschedules the meeting.	At regular periods, user is asked to see Health Professional for Advice Follow-up

Monitoring

Use Case:	*Monitoring*
Actor:	*Individual*
Goal:	*Monitor user progress and trigger corrective action if necessary*
Overview:	Providing feedback to users in a way it is consistent with their needs (as dictated by their profile characteristics).
Cross-Refs:	

	Typical Course of Events:	
	Actor action	System Response
	Track or record activity	Record the data, provide personalised feedback (recommendations on how to provide the feedback will be designed in WP 5.2 and 5.3)

	Alternative Course of Events	
	Actor action	System Response
	User agrees to meeting or requests to reschedule	If tracked data deviates from parameters, user is asked to see Health Professional for Advice Review.

Social Media Analysis

Use Case:	Social Media Analysis
Actor:	Policy Maker (PM) Health Professional (HP)
Goal:	Policy maker aims to determine the need or the impact of a health-related policy by analysing the public opinion and sentiments. They expect the system to provide them with relevant information that can help them either define new policies or adapt/refine existing ones.
Overview:	This use case will take place when the policy maker wants to analyse the need or impact of specific policies. The policy maker will enter different topics, around which the trends and sentiments from social media discussions will be presented with the help of visualisations. The visualised information will inform the policy maker about how the discussions (on specific) topics are shaping up in terms of evolution and further propagation. The visualised information can be stored and further monitoring of specific discussion threads can be activities by the policy maker.
Cross-Refs:	*What functional and non-functional requirements are relevant to that use case? We will provide those functional requirements which are (partially) fulfilled through the use case, and those non-functional requirements which constrain the operation of the use case.*

Typical Course of Events:	
Actor action	System Response
1. PM enters a set of topics (keywords) and a time period (in minutes) under which a situation can be created for analysis 6. PM reads the visualisation dashboard and collects relevant information for his/her decision making	2. System monitors the social media platform(s) and tried to establish situations e.g. 2 or more posts on the same topic within the given time period 3. System triggers an alert when a situation is detected. The situation information (e.g. number of posts, post contents, post owners) is analysed to unravel underlying context and sentiments. 4. The situation information and further analysis (underlying context, sentiment etc) is presented to the user through the visualisation dashboard 5. The system keeps monitoring the situation and updates the information concerning each situation on the dashboard

Alternative Course of Events	
Actor action	System Response
1. PM enters a set of topics (keywords) and a time period (in minutes) under which a situation can be created for analysis 3.PM updates the set of topics (keywords) in order to further expand the scope of the system	2. System monitors the social media platform(s) and tried to establish situations but does not find any situation for a prolonged period of time