Design, Development, and Evaluation of a TeleHealth Platform

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Background

Historically, telemedicine can be found in the mid to late 19th century. One of the first published accounts occurred in the early 20th century when electrocardiograph data were transmitted over telephone wires [8]. Around half a century ago, telemedicine was considered an unwieldy, unreliable, and unaffordable technology. However, rapidly evolving telecommunications and information technologies have provided a solid foundation for telemedicine as a feasible, dependable, and valuable technology[6]. As a result, telehealth technology has been on the rise, even before the emergence of COVID-19 as a global pandemic. In 2015 the U.S. The Department of Health & Human Services introduced a series of nine "Consumer Centered Telehealth Design Principles" in the whitepaper "*Designing The Consumer Centered Telehealth & eVisit Experience*." Unarguably, the pandemic accelerated this process, like healthcare systems, government agencies, and startups companies come together to build telehealth solutions: E25Bio of Cambridge, Massachusetts, is developing a low-cost antigen test, which detects covid by identifying proteins called antigens; Switch Health of Toronto, Canada, developed COVID-19 at-home specimen collection kits. According to the American Association of Telemedicine, " *Telemedicine is the use of electronic communications and information technologies to provide clinical services when participants are at different locations*" in addition utilizes "*videoconferencing, the transmission of still images, e-health including patient portals, remote monitoring of vital signs, continuing medical education and nursing call centers*" furthermore "*telemedicine does not represent a separate medical specialty; rather it is a tool that health providers can use to extend the traditional practice of medicine outside the walls of the typical medical practice*"[9].

World Health Organization provided us with insight into the five areas of telehealth services, which are:

- Specialist Referral - involves a specialist aiding a general practitioner in providing a diagnosis, typically in a written order.
- Direct Patient Care - sharing audio, video, and medical data between patients and health professionals to render a diagnosis, treatment plan, prescription, or advice. Patients might be stationed at a remote clinic, physician's office, or home.
- Remote Patient Monitoring - uses devices to remotely collect and send data to a monitoring station for interpretation. Such devices might be added to nurse's visits.
- Medical Education and Mentoring - online seminars or/and interactive expert advice provided to another professional performing medical procedure
- Consumer medical and health enlightenment - incorporates the internet for consumers to obtain broadened health details and online dialogue groups to provide peer-to-peer support.

Patient monitoring is initiated for various purposes, indeed within the context of ongoing treatment as the primary tool for treatment iteration and maintenance, with the goal being to maintain test results within certain limits of a given marker until such a time as treatment can be discontinued, or alternative medicine is needed[1]. You will find examples, for instance, on Pulmonary Rehabilitation(telePR), a study on American disadvantaged population groups conducted by D'Arcy King, Sundas Khan, Jennifer Polo, Jeffrey Solomon, Renee Pekmezaris, Negin Hajizadeh, 2020[2], that consisted of exercise bikes equipped with software that enables a respiratory therapist to remotely conduct a pulmonary

rehabilitation session with a patient while they are at home[3]. Another study investigated Type 2 Diabetes Mellitus (T2D) with an in-home device to manage T2D from home [4]. Next, management of Bipolar disorder[7], not to mention the COVID-19 pandemic, namely, 2628/Quyet Dinh-Bo y te (QD-BYT) in Vietnam or the multimodal telemedicine network in Sichuan Province in Western China[11], amongst others. Mobile health apps (mHealth) have emerged as a public-health tool for managing information sharing, risk assessment, self-management of symptoms, contact tracing, and home monitoring[12],[13].

A common practice in HCI is to understand user experience (UX) to design and develop a human-centered technology. UX refers to how a product behaves and is used by people in the real world [5]. Then, from a UX standpoint, telehealth can be seen as the umbrella term for the relationship between patients and the healthcare system, inclusive of nurses, specialists, and mental health practitioners.

Keywords
mobile apps; usability testing; user experience design; mobile phone; telehealth; iterative testing; participatory research; user demographics;

Objective
This study aims to design, prototype and evaluate a mobile telemedicine platform for medical providers and patients for consultation, diagnosis, referrals and treatment of patients.

Considerations and Scope of Analysis
We focussed on 3 of the five areas of telemedicine: specialist referral, direct patient care, and remote patient monitoring. Since telemedicine relies heavily on effective communication, we incorporated features that ensure ease and efficiency for interactions between both parties or user roles. These include:

1. Medical Provider user profile set up.
2. Patient's COVID-19 assessment tool.
3. Medical Provider pre-appointment.
4. Medical Provider patient referral.

Our task analysis speaks of the vast practice of investigating how our audience works (i.e., the tasks they perform) to achieve their goals[15]. The initial task analysis is represented in Appendix 1.

1. Medical Provider: User Profile Setup
As a medical provider on a telemedicine platform, you'll need to set up a user profile to provide pertinent details for any patient to evaluate the professional experience.

2. Patient: COVID-19 Assessment Tool
Given the significant adoption of telehealth during the covid pandemic, we selected a COVID-19 feature. This feature aims to offer patients a "first course of action" before scheduling an in-office appointment with a doctor.

3. Medical Provider: Pre-Appointment
According to Stephen M. Shortell and Odin W. Anderson, individuals enter the telehealth system by '*their definition of the sick role, help-seeking behavior, and some organizational dynamics (hospitals)*.' Thus this feature relies on the preparation of patients for each visit to determine who the patient is, what

his/her medical history is, and so on [21]. This function is a segway that leads from a profile setup to how a provider will use the app regularly to identify what appointments they have and how they can best prepare for those. We used entering the patient call as our stopping point, as it is the logical split from when a provider is preparing to engage with a patient to engaging actively [22].

4. Medical Provider: Patient Referral

Referral patterns are fundamental, but the percentage of referrals is low, 5 in 1000 adults[10]. A patient who presents an illness outside the physician's scope of practice will be referred. However, a study of North Carolina general practitioners judged that referral physicians were not utilized enough. Clute [11, p. 311], in a similar study of general practitioners in two Canadian provinces, found that approximately 30 percent of the physicians saw and treated patients they should have referred to specialists[10]. Additionally, a patient who does not have insurance and is socially disadvantaged might not be referred. There is little information on the habits of physicians. How do they relate with one another in the coordination of patient care? The choice of specialist is critical, in particular, for patients who may need desperate treatment; an efficient referral could lead them to recovery, whereas a wrong decision on referral can cause severe problems for the provider, from legal actions to unwanted costs. However, telemedicine has the potential to overcome some of these barriers. "*The direct costs of an outpatient visit were 45% greater per patient than for a teleconsultation*"[16]. The analysis within this study refers to the real-to-life referral process flow, which starts with a patient who presents an illness outside the physician's scope of practice. Typically, this process includes a primary care provider, who selects the most appropriate available specialist to forward the patient's relevant information. The specialist reviews the patient's file triages for urgency and schedules an appointment. Then, according to the exchange theory developed by Homans [13,14], Thibaut and Kelley [15], and Blau [16], a physician's decision to refer a patient to another physician is responded to by the other physician in such a way as to reward or "punish" the referring physician.

Methods

First, to explore the problem, we gathered information by reviewing literature and current architecture that typically comprise these systems, such as Computerized Patient Records System (CPRS) and Telehealth Mobile Apps. Second, we conducted a brainstorming workshop, where we defined our user groups and gathered requirements (https://miro.com/app/board/uXjVOQNy_U8=/). Third, we did a task analysis. Consequently, we ran a card sorting test to assist in designing the information architecture to resemble users' mental models and validate the effectiveness of our proposed task analysis. Next, we created sketches, high-fidelity wireframes, and prototypes. Wireframes were created using an Adobe XD Kit [24]. Lastly, we conducted usability assessments to understand user-task interaction as early feedback from potential users can improve the system's quality.

Card Sorting

A card sorting technique is one of the most effective methods for acquiring categorical and hierarchical data about existing domains.

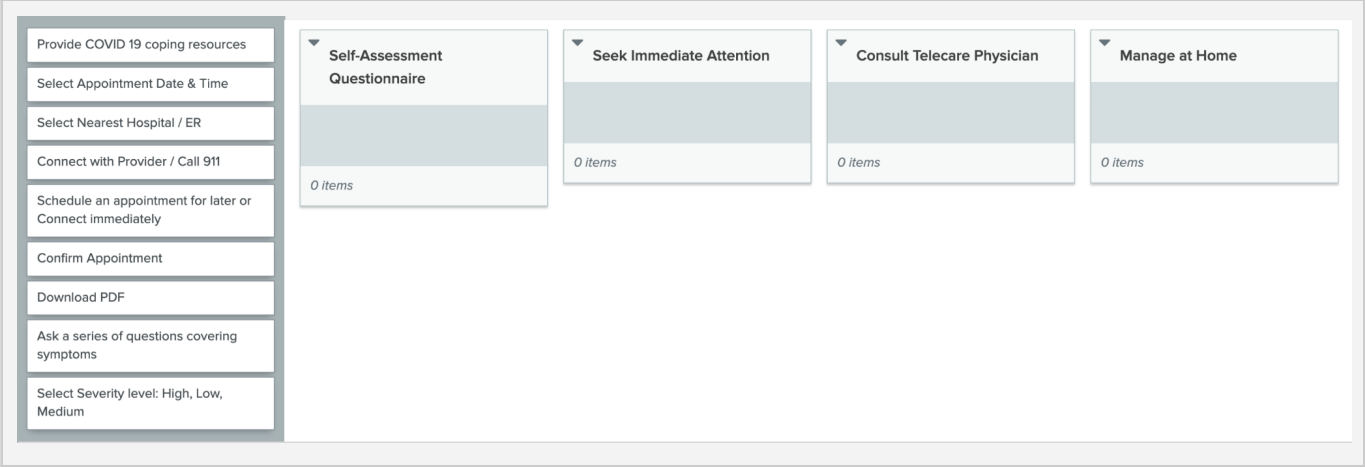
Sample

Two user groups targeted for our study: patient healthcare professionals. The total number of recruited participants was 84. Of those, 44 completed their sort, and 40 abandoned the study. The results cover the 44 participants who indeed attempted to sort the cards. Inclusion criteria were adults (>18 years of age), patients and health professionals.

Procedures

Participants made sense of the information on each card, then gathered the cards into meaningful groups. Some categories were already defined, but when a specific card did not fit well into the available categories, participants could create their own, thus delivering ideas for labeling. Example of the card sorting provided in Textbox 1.

Textbox 1. Card Sorting



Data Analysis

We worked from the cluster analysis, dendrograms and notes to put together the group of items, this resulted in the revised task analysis Appendix 2. With this said, there were some business and world constraints which made some items go in certain places.

Usability Testing

We conducted remote-based usability testing [23] on the prototype to identify usability problems; the study uses heatmaps and a think-aloud approach to facilitate this process. Initially, participants were asked to complete a demographic section . Then, they were presented with a use case scenario and introduced to the think-aloud approach to verbalize their thoughts and experiences as they moved through the app. All verbalizations were audio-recorded. Task performance metrics, critical errors, task completion rate per task and time spent were measured. In addition, we also used a survey to collect empirical data concerning our app.

System Design and Development

The team developed sketches to develop the product concept in early iterations, followed by high-fidelity wireframes. Then we used iterative prototyping with Adobe XD Appendix 3. to seek early feedback from end-users to improve the product concept. In the later iterations, the team wrapped up the mock-up screens of the product, as shown in Appendix 6.

Understanding Design Principles and Evaluating Solutions

The designs on our project were created with the design display & control principles framework in mind. Evaluating is a crucial task in the development process that ensures the resulting design artifacts' utility, quality, and impact. We followed the guidelines stipulated in Chapter 3 of the book Designing for People: An Introduction to Human Factors Engineering to evaluate our design artifacts.

Subject Recruitment

We utilized the software Maze to hire for usability testing. In this first version of the app, we concentrated on the feedback from the participants to ensure that our priorities, trade-offs, and design considerations were piloted by the realities of individuals most likely to seek tele-health care. A total of 15 participants aged between 20 and 60 years who had access to a mobile device were included in the final sample. The details of the participants are provided in Appendix 5.

Scenarios

The participants went through the scenarios listed in Textbox 2 below on the app.

Textbox 2. Scenarios

Scenario 1, Medical Provider User Profile Set Up

1.1. Imagine you are a medical provider, downloaded a Tele-Health app, signed up, and now you just started setting up your account. As a next step, you are prompted to create your medical profile. Add your key info details and anything relevant to your skills and professional experience. Then, add a bio. Click 'Next.'
1.2. Add only your primary education information.
1.3. Imagine you're about to add post-graduate training, but you changed your mind. Please show us what you would do.
1.4. Skip hospital affiliations & insurance providers. Next, turn on reviews and ratings on your profile. Can you describe and show us how you would proceed?
1.5. Next, you had a change of heart and thought of canceling and setting up your profile. Can you describe and show us how you would proceed?
1.6. You finished setting up your profile; show us how to publish it.

Scenario 2, Patient's Covid-19 Assessment Tool

2.1. You are a patient. You're experiencing some symptoms that could be related to COVID-19. Therefore you take a COVID-19 pre-assessment questionnaire. Show us how you would start the questionnaire.
2.2. Your symptoms are 'Difficulty breathing', 'Cough.' You do not have any high-risk health conditions. Respond to the questions accordingly. Next, proceed to view the recommended course of action.
2.3. Next, proceed with the recommended course of action, select a provider and book an appointment. Stop when your appointment is confirmed.

Scenario 3, Medical Provider Pre-Appointment

3.1. It is 6:42 am, and you have received a notification on your calendar that the Anna Sviatoslav appointment is about to start at 18m. Show us how you would view her appointment request in your calendar. Review the information Anna provided; what conditions does she have?
3.2. Start the appointment, and enter the virtual room. Stop when you think you are done.

Scenario 4, Medical Provider Patient Referral

4.1. Imagine you are a medical provider. You have an appointment with Anna Sviatoslav. You decide that her healthcare plan should be divided into a prescription and a referral. You sent her a medicine prescription, and now you have to take care of the referral request; show us how you would proceed. Stop when you find the option to send a referral request.
4.2 You want to send the referral request. Select the type of severity 'high' and frequency of updates 'monthly.' Next, find Cynthia Wheeler - the medical provider that will work with Anna and send the referral request.

Usability Survey Questionnaire

The full usability survey questionnaire is represented in Appendix 4.

Results

Medical Provider User Profile Set Up

67% were male 33% were female. The age group information is displayed in Table 1. 33% had an appointment with a doctor, nurse, or another health professional by video or phone in the last two months, 20% more than a year ago, and the remaining 80% had none.

Table 1. Age Group

20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
7%	53%	40%	0%	0%

Comfort Level With Using Telehealth Apps

1	2	3	4	5	6	7
0%	0%	7%	27%	7%	40%	20%

[Scale: 1 = Extremely Uncomfortable, 4 = Neutral, 7 = Extremely Comfortable]

Scenario 1.1. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	0%	7%	93%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.9** out of **7**

Scenario 1.2. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	0%	7%	93%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.9** out of **7**

Scenario 1.3. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	20%	33%	47%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.3** out of **7**

Scenario 1.4. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	7%	13%	80%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.7** out of **7**

Scenario 1.5. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
29%	14%	7%	21%	0%	7%	21%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **3.6** out of **7**

Scenario 1.6. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	0%	14%	86%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.9** out of **7**

The average time spent on the screen to complete the task was 5.2s and the missclick rate was 63.5%. This might be caused by the user interpreting the filled form states incorrectly due to the gray shaded wireframe prototype, which led to perceiving it as a placeholder instead of a filled-out form. For the second scenario, 3s, the average missclick rate was 30% and the success average was 100%. For the third scenario, 5.2s is the time taken to complete the task; the average missclick rate was 47.3%, the success average was 93%, and the bounce rate was 6.7%. The misclicks from the education details screen might be caused by the user getting confused with the modal window, which opened inside a current page; For the fourth scenario, 3.6s, the average missclick rate was 35.7%, and the success average was 100%. For the fifth scenario, 10.9s, the average missclick rate was 38.5%. Moderate success is 20%, and the bounce rate at 80%. When canceling the flow, 11 testers got lost; this might be due to the word “cancel” as opposed to the use of an icon. For the sixth scenario, 3.6s, the average miss click rate was 21%, and the success average was 100%.

The way I interact with this system is pleasant:

1	2	3	4	5	6	7
0%	0%	0%	7%	0%	50%	43%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.3** out of **7**

I like using the system

1	2	3	4	5	6	7
0%	0%	0%	7%	21%	14%	57%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.2** out of **7**

The system is simple and easy to understand

1	2	3	4	5	6	7
0%	0%	0%	0%	14%	29%	57%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.4** out of **7**

This system is able to do everything I would want it to be able to do

1	2	3	4	5	6	7
0%	0%	0%	7%	14%	43%	36%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.1** out of **7**

The app performed the way I expected

1	2	3	4	5	6	7
0%	0%	0%	14%	0%	36%	50%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.2** out of **7**

Critical issues from usability test

Issue	Severity	Steps taken
Unavailability of avatar picture: no option allows users to upload their profile picture during profile setup.	Low	Allowed user to upload a picture by tapping on the profile photo or the blank circle
Education Detail: adding education details on a modal added confusion	High	Blended the content into the education and board certifications page
Scrollbar: there was no scrollbar to indicate that the user was not viewing the entire area's content; users felt confused and frustrated with not finding the	High	Displayed a scroll bar control

options.		
Using "**Cancel**" as an explicit text label	Medium	Add the X icon, which is commonly recognized by users to mean either to cancel or to close.

Theme I-1. Appraisal of ease of use

"It is modern and intuitive. It is easy to work with, and I enjoyed the interface."
"The product is easy to use and navigate. It felt familiar in a good way."
"I like the ease and simplicity of each step which could be accomplished with no more than three clicks, the menu of each step was uncluttered with unnecessary visuals and very straightforward, making it easy to understand."

Theme I-4 Limitations of high fidelity prototyping

"I had trouble canceling my profile; not sure if it was the app or the hit loading which irritated me, but other than that, I found everything to be straightforward, so I enjoyed it."
"Decent UI, needs to be coloured and stuff, but it is nice."
"The colors need to be changed. There is so much white, and the gray text is hard to read on the white background, and I have good vision."

Patient's Covid-19 Assessment Tool

40% were male 60% were female. The age group information is displayed in Table 2. 27% had an appointment with a doctor, nurse, or another health professional by video or phone in the last two months, while the remainder, 80%, had not. 18% more than a year ago, 9% in 6 months to a year and 73% had none recently.

Table 2. Age Group

20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
13%	47%	40%	0%	0%

Comfort level with using Telehealth Apps

1	2	3	4	5	6	7
0%	7%	7%	27%	20%	27%	13%

[Scale: 1 = Extremely Uncomfortable, 4 = Neutral, 7 = Extremely Comfortable]

Scenario 2.1. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	0%	7%	93%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.9** out of **7**

Scenario 2.2. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
1%	0%	0%	0%	7%	13%	73%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.3** out of **7**

Scenario 2.3. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	7%	13%	80%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.7** out of **7**

The average time spent on the screen to complete the first scenario was 2.6s, the average missclick rate was 7%, and the average success rate was 100%. The misclick rate was due to users tapping on the slider navigation, which could be due to the high-fight prototype being closest to the final product in its detail and functionality. For the second scenario, 3.4s, and 14.7% for average missclick rate. The success was 80%, bounce 13.3%. This was due to the lack of scrollbar indication or any other visual indication that there is more content left to see. For the third scenario, 2.1s, the average miss click rate was 21.8%, and the success average was 100%.

The way I interact with this system is pleasant

1	2	3	4	5	6	7
0%	7%	0%	7%	0%	33%	53%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.1** out of **7**

I like using the system

1	2	3	4	5	6	7
7%	0%	0%	7%	0%	27%	60%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.1** out of **7**

The system is simple and easy to understand

1	2	3	4	5	6	7
0%	7%	0%	0%	0%	7%	87%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.6** out of **7**

This system is able to do everything I would want it to be able to do

1	2	3	4	5	6	7
0%	7%	0%	7%	0%	20%	67%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.3** out of **7**

The app performed the way I expected

1	2	3	4	5	6	7
0%	7%	0%	0%	7%	20%	67%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.3** out of **7**

Critical issues from usability test

Issue	Severity	Steps taken
Booking an appointment based on doctors/patients' availability: The user should be able to choose the time slot based on their availability and the doctor's availability.	Medium	Added validation rule to the booking, see whether any booking requests have conflicts
Ability to search for physicians: The ability to search for physicians is not explicitly stated	High	Added a search option to search for other physicians

Scrollbar: there was no scrollbar to indicate that the user was not viewing the entire area's content; users felt confused and frustrated with not finding the options.	High	Displayed a scroll bar control

Themes and quotes of content analysis from the interviews

Theme I-1. Appraisal of ease of use
"The layout is suitable and easy to follow."
"Very easy to follow and understand what was being asked."
"I did not find the product confusing or hard to learn."

Theme I-2. Additional preference for interaction design
"In the beginning, you had to select options. After selecting the option, it would jump back to the top of the options, this adds time and effort."

Theme I-3. Additional preference for available features
"I would add a faqs page in the app or a real-time guide to help users."

Theme I-4. Limitations of high fidelity prototyping
"Boring."
"Perhaps changing the colors for the options that are chosen."
"Colors."

Medical Provider Pre-Appointment

73% were male 27% were female. The age group information is displayed in Table 3. Only 27% had an appointment with a doctor, nurse, or another health professional by video or phone in the last two months, the remainder 73% had none. 8% less than three months ago, 8% six months ago to a year ago and 8% more than a year ago.

Table 3. Age Group

20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
7%	53%	33%	0%	7%

Comfort level using Telehealth Apps

1	2	3	4	5	6	7
0%	0%	7%	27%	20%	33%	13%

[Scale: 1 = Extremely Uncomfortable, 4 = Neutral, 7 = Extremely Comfortable]

Scenario 3.1. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	7%	0%	93%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.9** out of **7**

Scenario 3.3. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
0%	0%	0%	0%	0%	7%	93%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **6.9** out of **7**

The average time spent on the screen to complete the first scenario was 9.2s, the average missclick rate was 3.5%, and the average success rate was 100%. For the second scenario, 2.2s, the average missclick rate was 6.5% for users from the 35 - 47 age range. We analyzed the heatmap, which showed that this could be due to grouping many small elements together; users might not be able to tap smaller buttons in the UI easily.

The way I interact with this system is pleasant

1	2	3	4	5	6	7
0%	0%	7%	0%	13%	7%	73%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.4** out of **7**

I like using the system

1	2	3	4	5	6	7
0%	0%	7%	0%	7%	13%	73%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.5** out of **7**

The system is simple and easy to understand

1	2	3	4	5	6	7
0%	0%	0%	0%	7%	0%	93%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.9** out of **7**

This system is able to do everything I would want it to be able to do

1	2	3	4	5	6	7
0%	0%	0%	7%	13%	27%	53%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.3** out of **7**

The app performed the way I expected

1	2	3	4	5	6	7
0%	0%	0%	0%	7%	0%	93%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.9** out of **7**

Critical issues from usability test

Issue	Severity	Steps taken
Schedule view: No option allows the user to **view** a single **day**, week or whole month.	Medium	Added validation rule to the booking, see whether any booking requests have conflicts
Schedule view: there was a back button to get back to the previous page on-screen notifications.	High	Added a search option to search for other physicians
Join appointment screen: users inadvertently tap the wrong button by mistake, e.g. selecting to join the call and not to join simultaneously. This could be related with the buttons being too small or too close together on the screen.	High	Redesigned the UI to focus on the option to join and with the added a cancel icon on the top right of the screen that cancels the action to join.
Scrollbar: there was no scrollbar to indicate that the user was not viewing the entire area's content; users felt confused and frustrated with not finding the options.	High	Displayed a scroll bar control

Themes and quotes of content analysis from the interviews

Theme I-1. Appraisal of ease of use
"I think it is very easy and simple to use."
"It was simple and intuitive; I did not make any mis-clicks or go down many blind alleys when completing the tasks."
"The product looks straightforward and efficient. I feel that I will not have issues using the app."
"It is good. I would feel comfortable using this."
"Simple and quick. Great design for telehealth."

Theme I-2. Usefulness for interaction needs
"It is great! It is easy to see what appointments I have, the reason for each, and enter the appointment when I am ready.'

Theme I-3. Additional preference of available features.
"This has more to do with functionality overall, but I like when there is a test feature to see that my video and audio work before the dog gets there. Otherwise, I get anxious about tech issues, and I am good with tech."
'I would add a chat feature where I can ask questions 24/7"

Theme I-4. Limitations of high fidelity prototyping
"Bland and boring."
"It is as intuitive and straightforward as it gets. Colors could use some contrast work."

Medical Provider Patient Referral

53% were male 47% were female. The age group information is displayed in Table 3. 40% had an appointment with a doctor, nurse, or another health professional by video or phone in the last two months, while the remainder had not. 22% more than a year ago, 11% six months to a year, whereas others had none recently.

Table 4. Age Group

20 - 30	30 - 40	40 - 50	50 - 60	60 - 70
13%	60%	27%	0%	0%

Comfort level with using Telehealth Apps

1	2	3	4	5	6	7
0%	7%	7%	27%	13%	20%	27%

[Scale: 1 = Extremely Uncomfortable, 4 = Neutral, 7 = Extremely Comfortable]

Scenario 4.1. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
7%	0%	0%	7%	33%	27%	27%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **5.5** out of **7**

Scenario 4.2. How difficult or easy was the task to complete?

1	2	3	4	5	6	7
7%	0%	0%	7%	13%	33%	40%

[Scale: 1 = Extremely Difficult, 4 = Neutral, 7 = Extremely Easy] Average: **5.8** out of **7**

The average time spent on the screen to complete the first scenario was 6.1s, the average missclick rate was 2.35%. Some users understood the scenario. However, they seemed confused when looking at the UI; they thought there was a patient as opposed to the doctor; this could be because of the visual stylings of the conversation Design. Lack of timestamps, layout, how far apart the chat bubbles are space, Avatar is missing, the style and location of the user avatar. The one user potentially, because of this, thought she, as a doctor, could edit the patient, profile, name, etc.; however, she ultimately understood the flow. For the second scenario, 1.4s, the average missclick rate was 4.3%. Users ranked 6.9 out of 7 on how easy or difficult. In this scenario, the one user that rated extremely difficult expressed verbally how easy it was to complete the task.

The way I interact with this system is pleasant

1	2	3	4	5	6	7
7%	0%	0%	7%	13%	40%	33%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **5.7** out of **7**

I like using the system

1	2	3	4	5	6	7
7%	0%	0%	7%	7%	33%	47%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **5.9** out of **7**

The system is simple and easy to understand

1	2	3	4	5	6	7
0%	0%	0%	7%	20%	7%	67%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.3** out of **7**

This system is able to do everything I would want it to be able to do

1	2	3	4	5	6	7
0%	0%	0%	0%	13%	33%	53%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.4** out of **7**

The app performed the way I expected

1	2	3	4	5	6	7
0%	0%	0%	0%	27%	13%	60%

[Scale: 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree] Average: **6.3** out of **7**

Critical Issues from usability test

Issue	Severity	Steps taken
Navigation on the chat: no option allowed the user to initiate a voice call or go back with a single click.	Medium	added call-to-action button to a video and voice call
Chat: the layout (how far apart the chat bubbles are space) and visual stylings of the conversation design created confusion	High	added timestamps, avatars to the conversation design
Search: unable to choose provider for the list	Low	be able to choose a provider from the list if I see it from the find provider page

Scrollbar: there was no scrollbar to indicate that the user was not viewing the entire area's content; users felt confused and frustrated with not finding the options.	High	displayed a scroll bar control

Themes and quotes of content analysis from the interviews

Theme I-1. Appraisal of ease of use
"I think the layout is great and easy to find what you need."
"I thought that the layout was well organized and easy to navigate."
"It was intuitive, and it flowed well. The product is easy to use even for the first time."

Theme I-3. Additional preference of available features
"The layout and content are quite clear. Only sending referral and share profile options could be upfront and not inside a menu."
"I thought it was a bit unnecessary to have the referral request where it is at. I think a drop-down menu would have been more useful."
"Have referral requests be part of a drop-down menu. Also, be able to choose a provider from the list if I see it from the search."

Theme I-4. Limitations of high fidelity prototyping
"It was pretty intuitive. Contrasting colors would help a great deal."
"Smooth and structured. A bit bland due to everything being gray."
"Colorize it; make everything clickable."

Theme I-5. Unhappiness
"It is a little clunky to navigate, not that intuitive."
"It was not bad. It was not super intuitive, but I could figure it out."

Last Phase

Later on, we ran a second usability test with the high-fidelity polished user interface. We had 40 participants, 10 participants per feature. Throughout the features it was verified that the changes solved for most of the usability issues identified. For example, Medical Provider Patient Referral, Q.7 Scenarios - Overall, how difficult or easy was the task to complete? - Rated significantly higher, 6.5 and 6.7 respectively.

Limitations

This study had various limitations. One fragility of our research is that the tiny end-user sample restricted the ability to stratify by demographics, site, or other variables of interest. Then, significant efforts were made to recruit a sample of young and older adults, both male and female; however, most participants (%) were male and around 30-50. Initially, we based our task analysis exclusively on literature. Then, for the card sorting, we had a limited number of end-users, including 11 participants per feature/task, from those only two who were medical providers. As a result, the matters pin down in the task analysis may not be wholly derived from medical settings. Another limitation is that not all the problems were identified during the usability testing review. We refined the prototypes based on severity or priority of concerns. Moreover, most of the participants of the usability tests were from the United States or Canada; in consequence, the sample of participants ought not be universal. However, our focus was not on the generalizability of our findings but on gathering practical insights about user goals and challenges

participants face. Furthermore, the prototype also had some limitations; the user was under the expectation that all the options would be available despite being indicated otherwise.

Conclusions

With the exacerbating cost of care, telemedicine has become crucial. This study discusses the design, development, and scientific evaluation of a telemedicine app that supports both providers and patients by facilitating virtual treatment and/or condition monitoring. Future research can be beneficial by developing design artifacts for other medical-related issues pertinent to this type of application and exploring the legal and ethical guidelines for using such platforms. Teams creating a digital mobile app would benefit from task analysis and early and iterative user testing to address any issues and measure product success.

We attest that the contents of this document are not reproduced or plagiarized anywhere, and are not brought with it from anywhere other than our analysis and data listed in the references list. Accordingly, we inform you that all copyright-related ownership is in the creator.

Appendix 1 - First HTA

Figure 1. Medical Provider User Profile Set Up

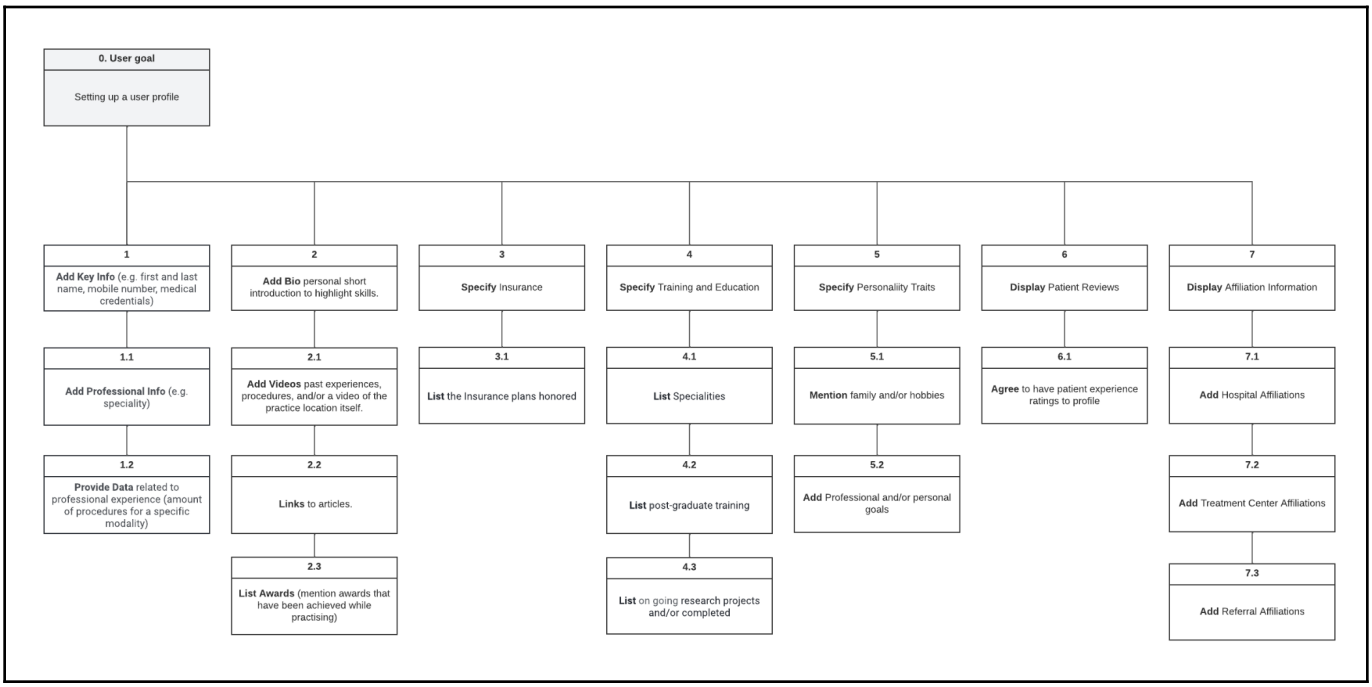


Figure 2. Patient's Covid-19 Assessment Tool

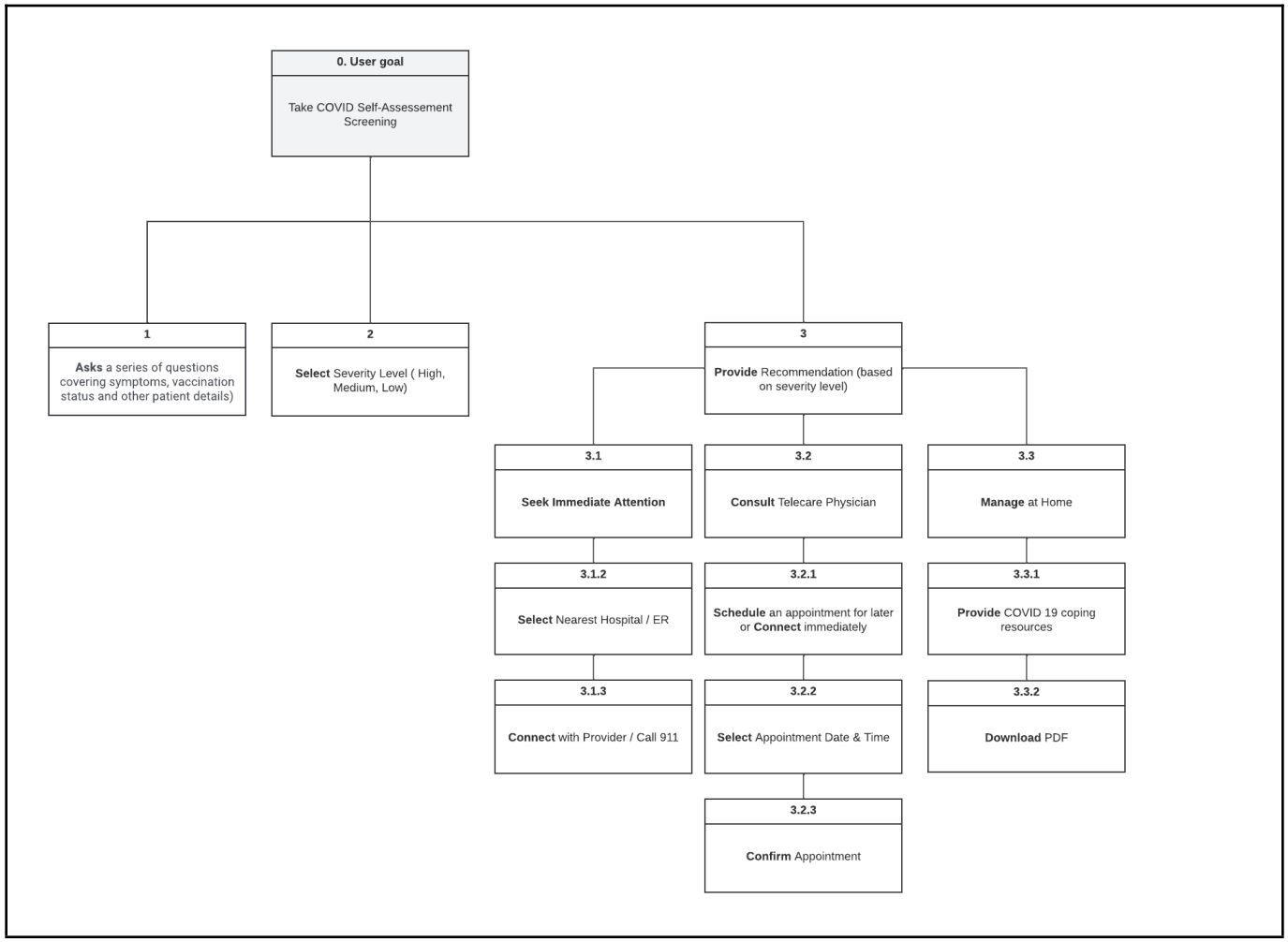


Figure 3. Medical Provider Pre-Appointment

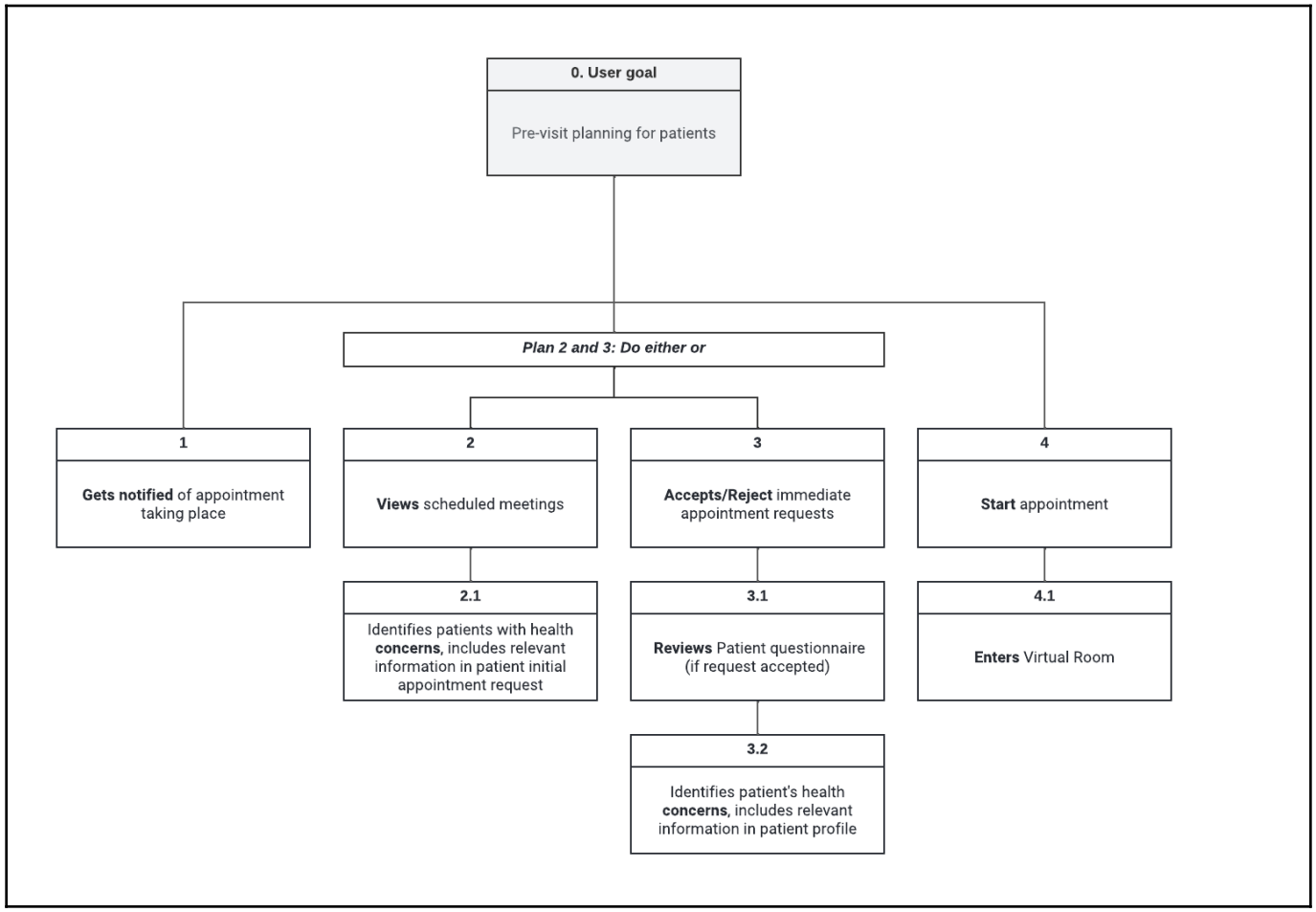
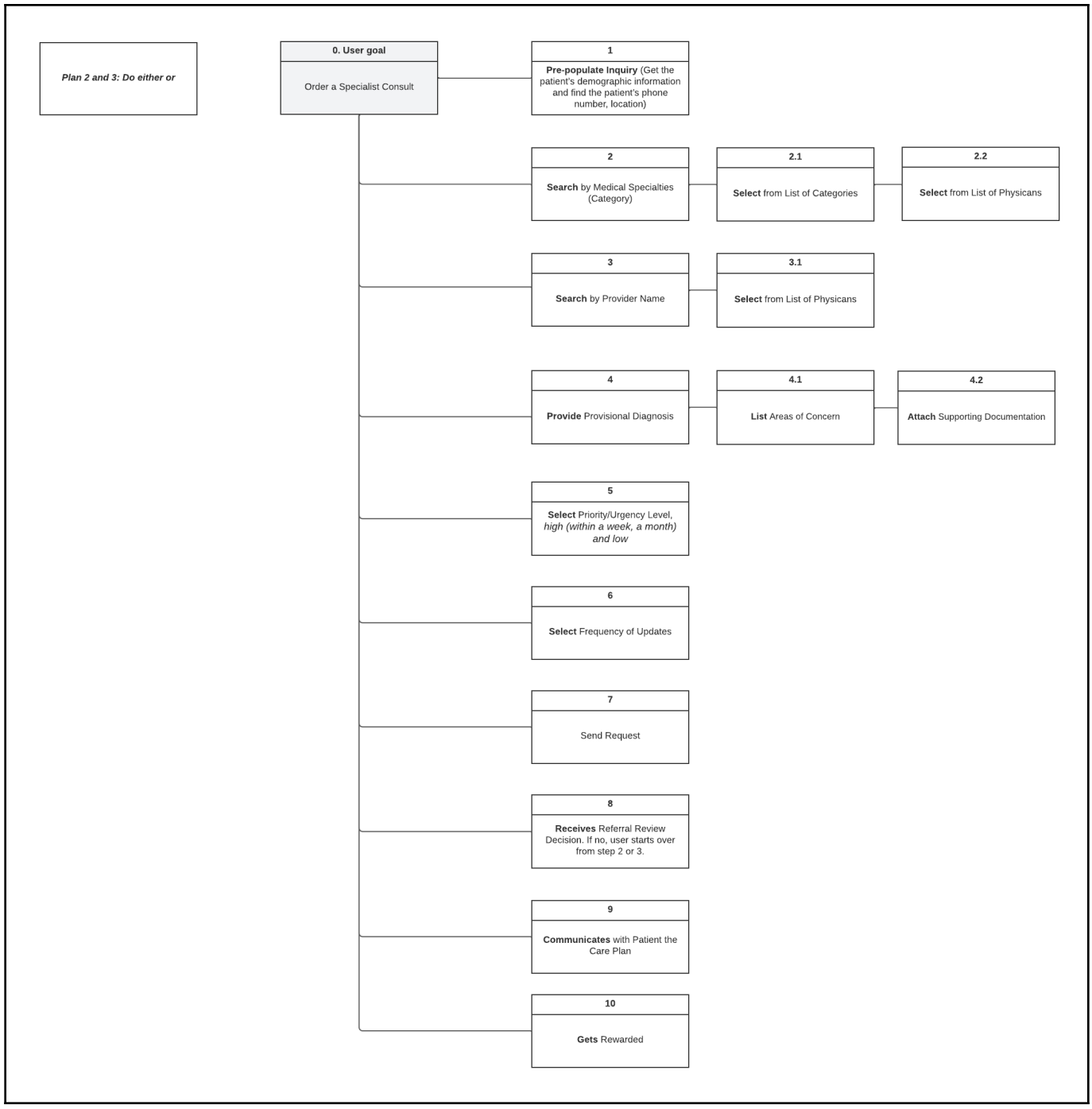


Figure 4. Medical Provider Patient Referral



Appendix 2 - Revised HTA

Figure 1. Medical Provider User Profile Set Up

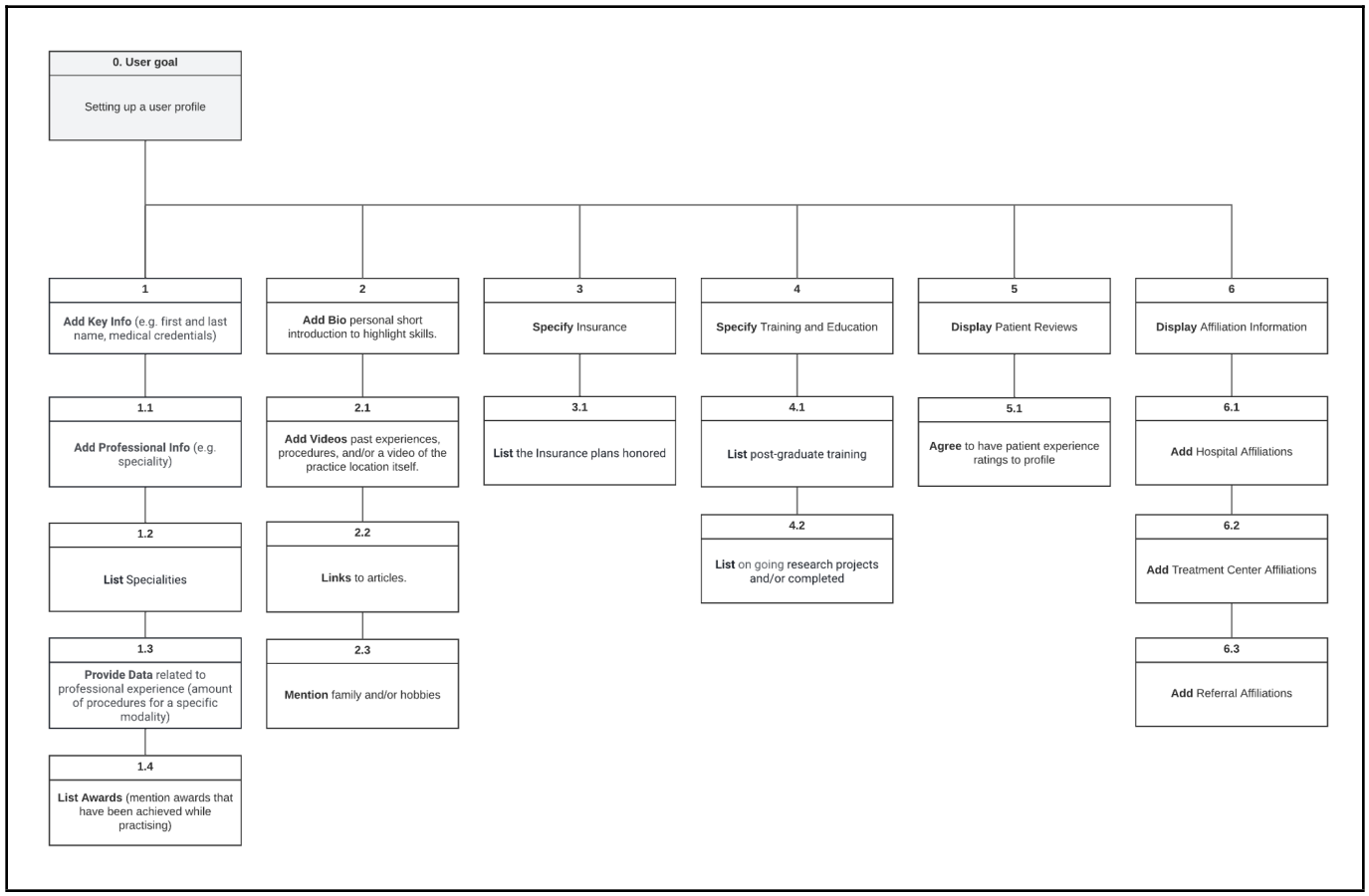


Figure 2. Patient's Covid-19 Assessment Tool

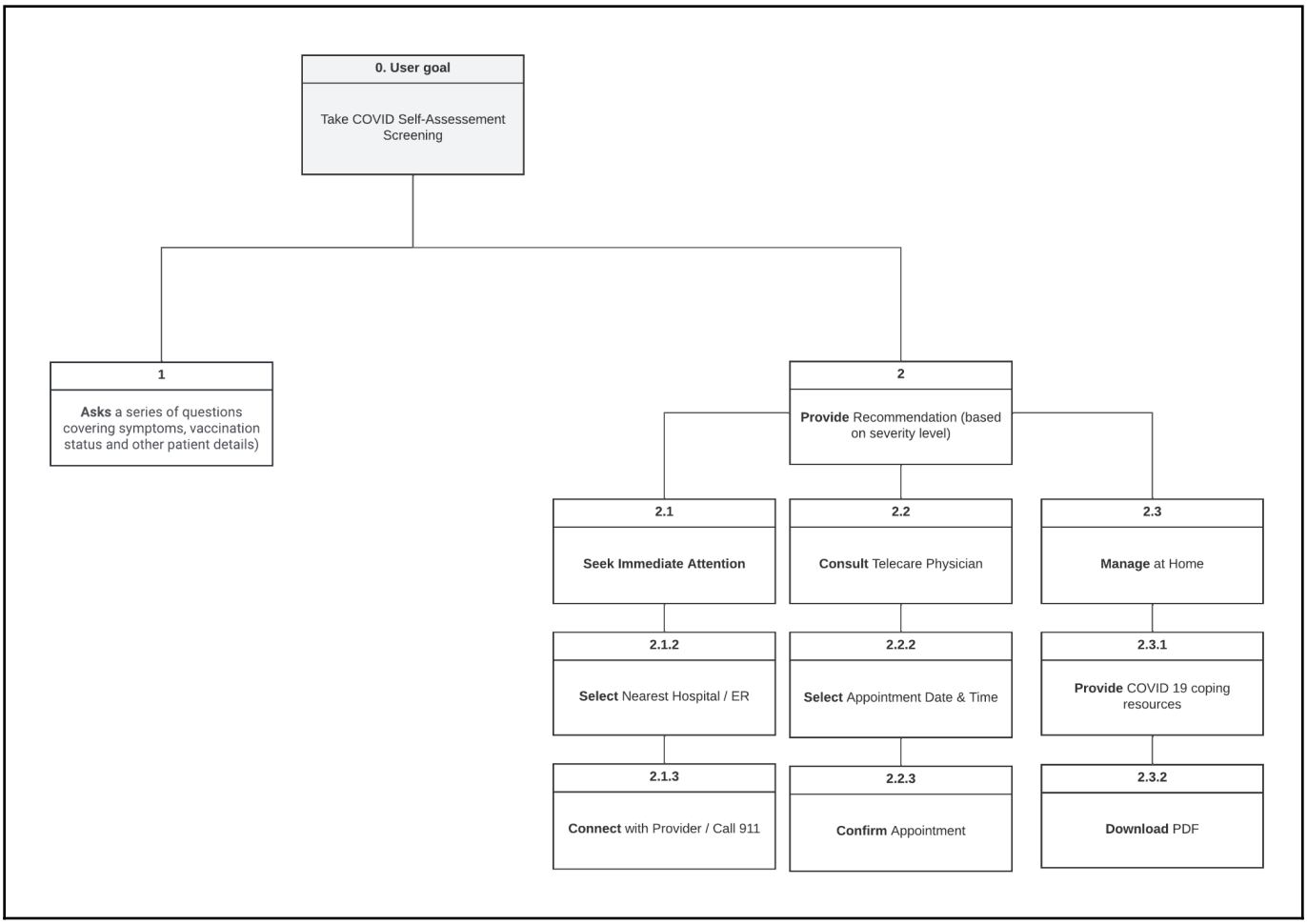


Figure 3. Medical Provider Pre-Appointment

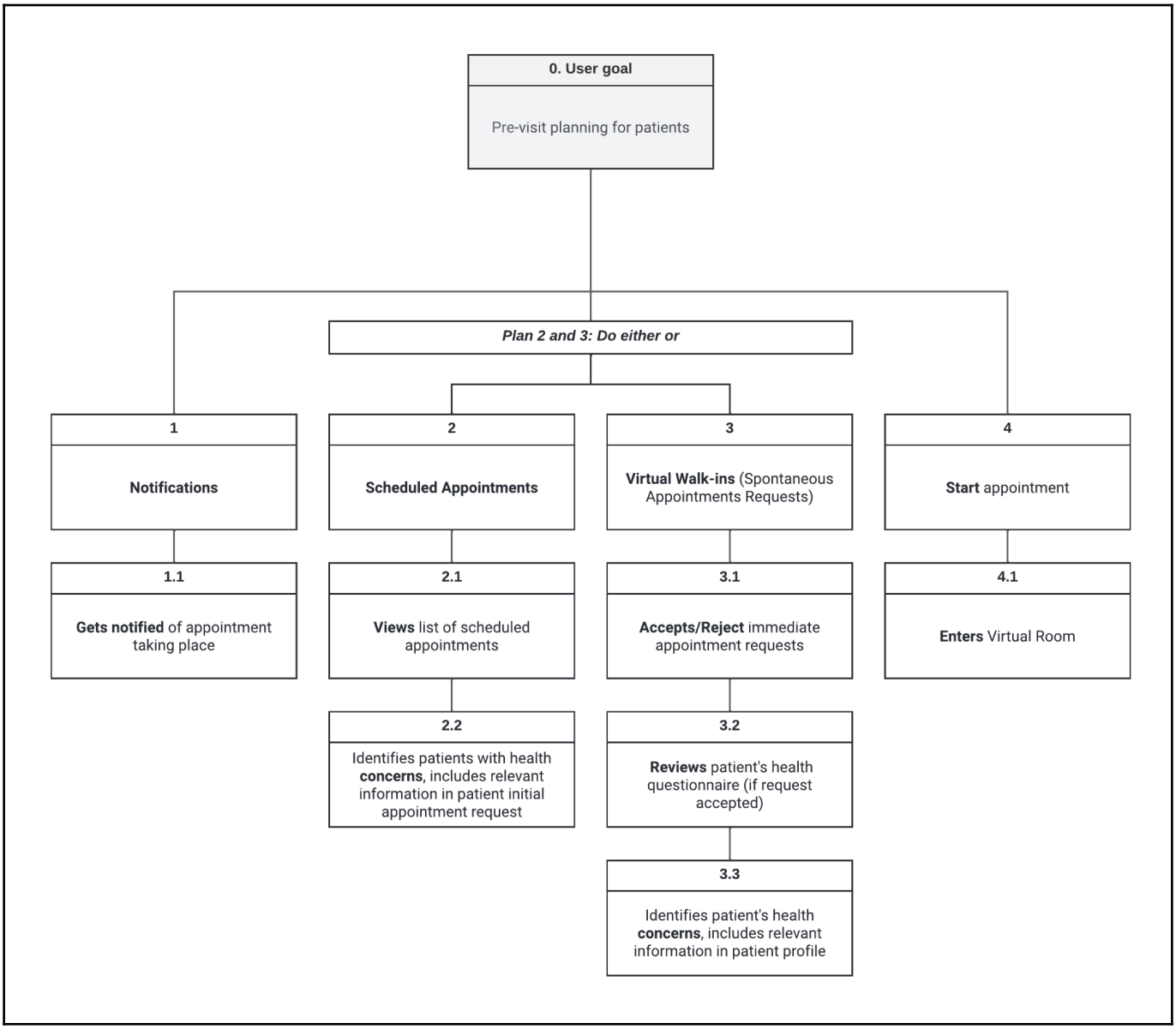
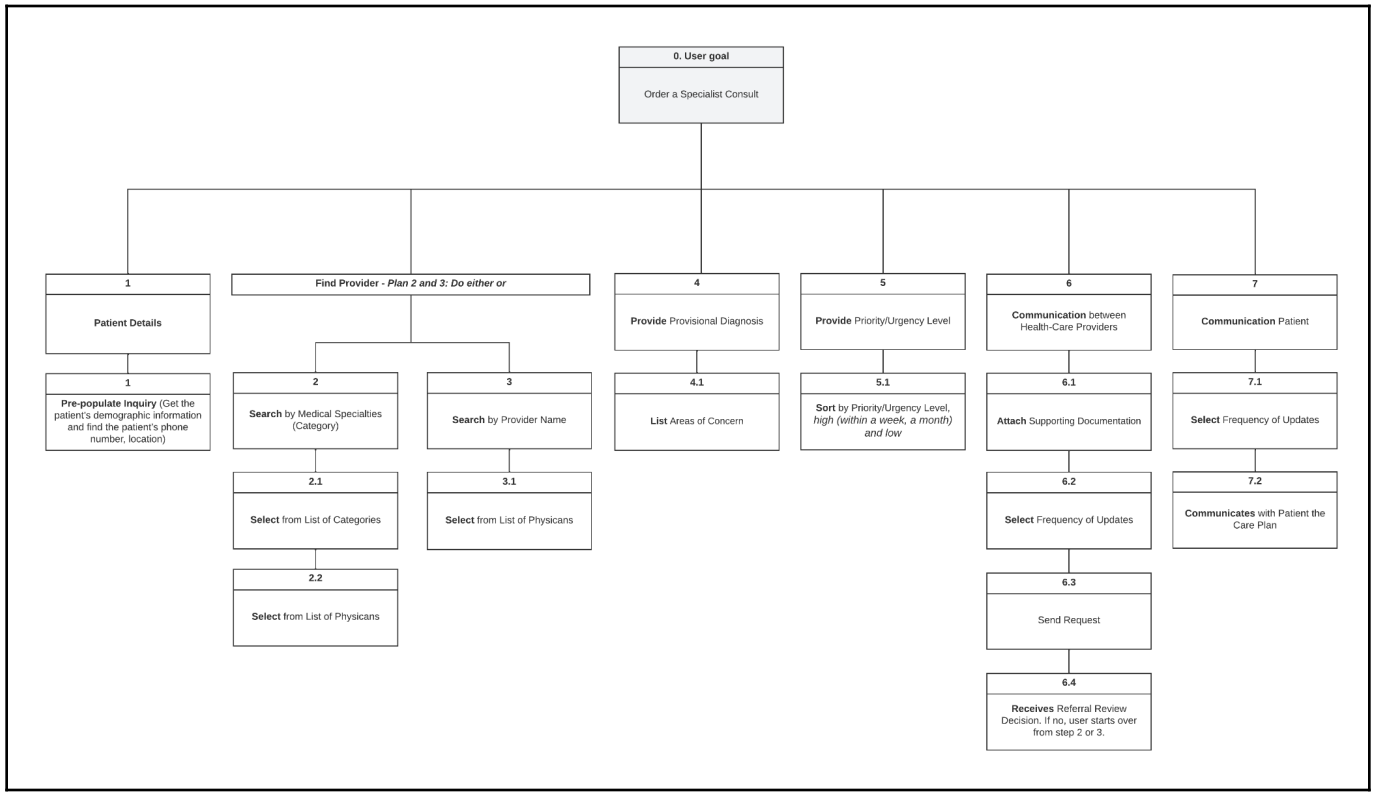
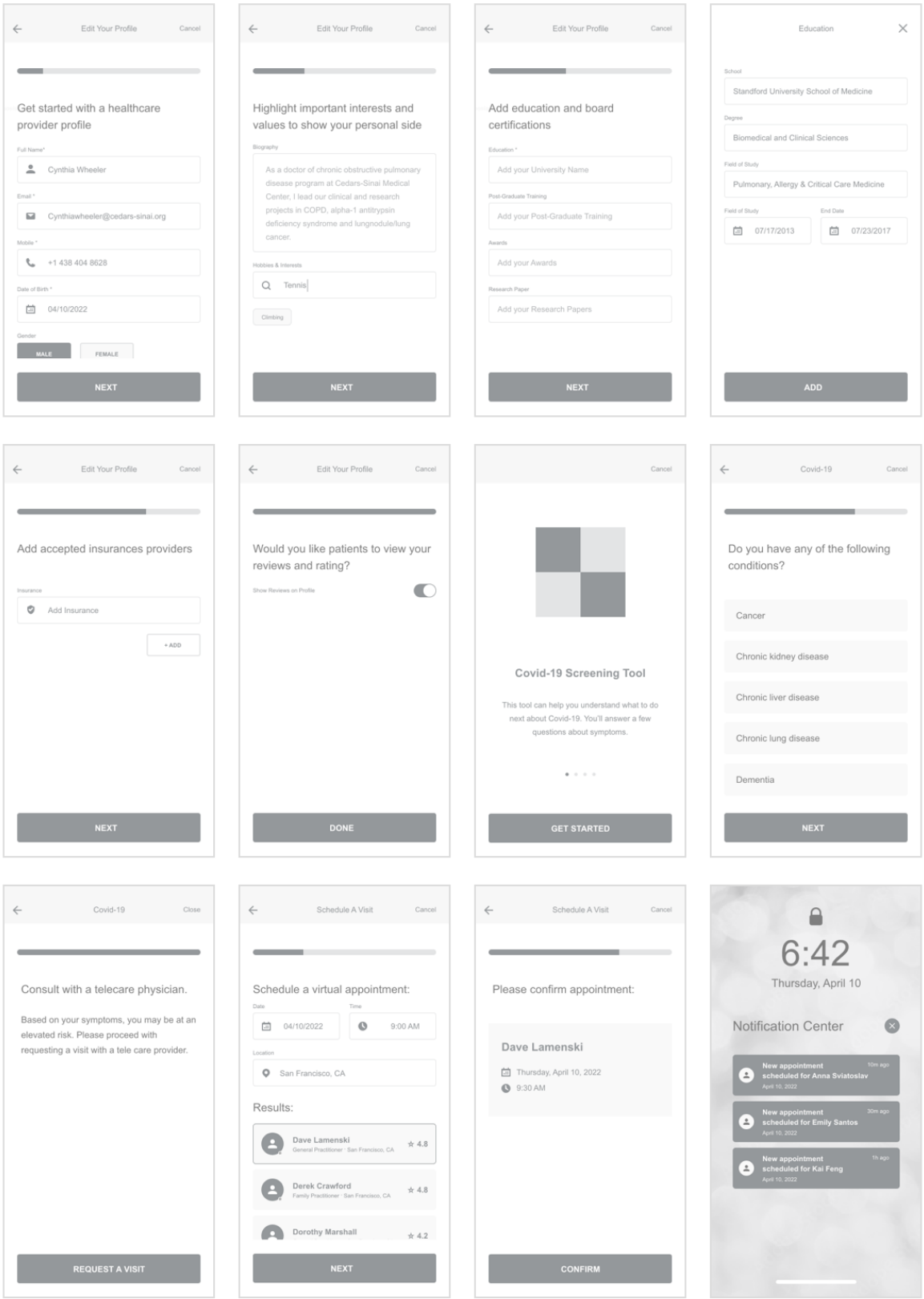
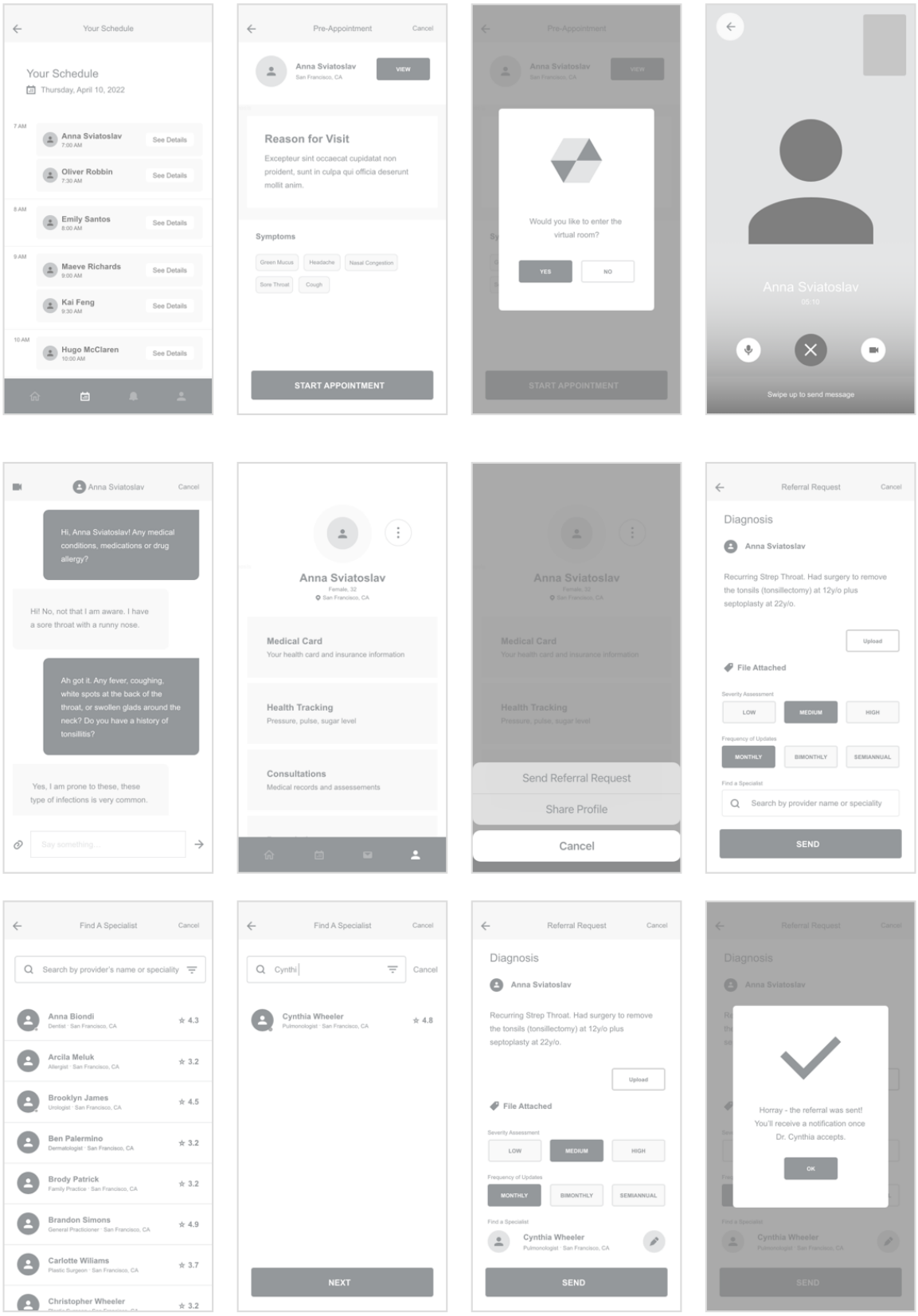


Figure 4. Medical Provider Patient Referral



Appendix 3 - Prototype


Edit Your Profile
Cancel
Get started with a healthcare provider profile
Full Name*
Cynthia Wheeler
Email *
Cynthiawheeler@cedars-sinai.org
Mobile *
+1 438 404 8628
Date of Birth *
04/10/2022
Gender
MALE
FEMALE
NEXT
Edit Your Profile
Cancel
Highlight important interests and values to show your personal side
Biography
As a doctor of chronic obstructive pulmonary disease program at Cedars-Sinai Medical Center, I lead our clinical and research projects in COPD, alpha-1 antitrypsin deficiency syndrome and lungnodule/lung cancer.
Hobbies & Interests
Tennis
Climbing
NEXT
Edit Your Profile
Cancel
Add education and board certifications
Education *
Add your University Name
Post-Graduate Training
Add your Post-Graduate Training
Awards
Add your Awards
Research Paper
Add your Research Papers
NEXT
Education
School
Standford University School of Medicine
Degree
Biomedical and Clinical Sciences
Field of Study
Pulmonary, Allergy & Critical Care Medicine
Field of Study
07/17/2013
End Date
07/23/2017
ADD
Edit Your Profile
Cancel
Add accepted insurances providers
Insurance
Add Insurance
+ ADD
NEXT
Edit Your Profile
Cancel
Would you like patients to view your reviews and rating?
Show Reviews on Profile
DONE
Cancel
Covid-19 Screening Tool
This tool can help you understand what to do next about Covid-19. You'll answer a few questions about symptoms.
GET STARTED
Covid-19
Cancel
Do you have any of the following conditions?
Cancer
Chronic kidney disease
Chronic liver disease
Chronic lung disease
Dementia
NEXT
Covid-19
Close
Consult with a telecare physician.
Based on your symptoms, you may be at an elevated risk. Please proceed with requesting a visit with a tele care provider.
REQUEST A VISIT
Schedule A Visit
Cancel
Schedule a virtual appointment:
Date
04/10/2022
Time
9:00 AM
Location
San Francisco, CA
Results:
Dave Lamenski
General Practitioner · San Francisco, CA
4.8
Derek Crawford
Family Practitioner · San Francisco, CA
4.8
Dorothy Marshall
4.2
NEXT
Schedule A Visit
Cancel
Please confirm appointment:
Dave Lamenski
Thursday, April 10, 2022
9:30 AM
CONFIRM
6:42
Thursday, April 10
Notification Center
New appointment scheduled for Anna Sviatoslav
10m ago
April 10, 2022
New appointment scheduled for Emily Santos
30m ago
April 10, 2022
New appointment scheduled for Kai Feng
1h ago
April 10, 2022


Your Schedule
Your Schedule
Thursday, April 10, 2022
7 AM
Anna Sviatoslav
7:00 AM
See Details
Oliver Robbin
7:30 AM
See Details
8 AM
Emily Santos
8:00 AM
See Details
9 AM
Maeve Richards
9:00 AM
See Details
Kai Feng
9:30 AM
See Details
10 AM
Hugo McClaren
10:00 AM
See Details
Pre-Appointment
Cancel
Anna Sviatoslav
San Francisco, CA
VIEW
Reason for Visit
Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim.
Symptoms
Green Mucus
Headache
Nasal Congestion
Sore Throat
Cough
START APPOINTMENT
Pre-Appointment
Anna Sviatoslav
San Francisco, CA
VIEW
Would you like to enter the virtual room?
YES
NO
START APPOINTMENT
Anna Sviatoslav
05:10
Swipe up to send message
Anna Sviatoslav
Cancel
Hi, Anna Sviatoslav! Any medical conditions, medications or drug allergy?
Hi! No, not that I am aware. I have a sore throat with a runny nose.
Ah got it. Any fever, coughing, white spots at the back of the throat, or swollen glads around the neck? Do you have a history of tonsillitis?
Yes, I am prone to these, these type of infections is very common.
Say something...
Anna Sviatoslav
Female, 32
San Francisco, CA
Medical Card
Your health card and insurance information
Health Tracking
Pressure, pulse, sugar level
Consultations
Medical records and assessements
Anna Sviatoslav
Female, 32
San Francisco, CA
Medical Card
Your health card and insurance information
Health Tracking
Pressure, pulse, sugar level
Send Referral Request
Share Profile
Cancel
Referral Request
Cancel
Diagnosis
Anna Sviatoslav
Recurring Strep Throat. Had surgery to remove the tonsils (tonsillectomy) at 12y/o plus septoplasty at 22y/o.
Upload
File Attached
Severity Assessment
LOW
MEDIUM
HIGH
Frequency of Updates
MONTHLY
BIMONTHLY
SEMIANNUAL
Find a Specialist
Search by provider name or speciality
SEND
Find A Specialist
Cancel
Search by provider's name or speciality
Anna Biondi
Dentist · San Francisco, CA
4.3
Arcila Meluk
Allergist · San Francisco, CA
3.2
Brooklyn James
Urologist · San Francisco, CA
4.5
Ben Palermino
Dermatologist · San Francisco, CA
3.2
Brody Patrick
Family Practice · San Francisco, CA
3.2
Brandon Simons
General Practicioner · San Francisco, CA
4.9
Carlotte Wiliams
Plastic Surgeon · San Francisco, CA
3.7
Christopher Wheeler
3.2
Find A Specialist
Cancel
Cynthi
Cancel
Cynthia Wheeler
Pulmonologist · San Francisco, CA
4.8
NEXT
Referral Request
Cancel
Diagnosis
Anna Sviatoslav
Recurring Strep Throat. Had surgery to remove the tonsils (tonsillectomy) at 12y/o plus septoplasty at 22y/o.
Upload
File Attached
Severity Assessment
LOW
MEDIUM
HIGH
Frequency of Updates
MONTHLY
BIMONTHLY
SEMIANNUAL
Find a Specialist
Cynthia Wheeler
Pulmonologist · San Francisco, CA
SEND
Referral Request
Cancel
Diagnosis
Anna Sviatoslav
Horray - the referral was sent!
You'll receive a notification once Dr. Cynthia accepts.
OK
Cynthia Wheeler
Pulmonologist · San Francisco, CA
SEND

Appendix 4 - Survey Questions

Q1. What gender do you identify yourself with?

Male
Female
Prefer not to answer
Other [please specify]

Q2. What is your age?

20 - 30 years old
35 - 40 years old
40 - 50 years old
50 - 60 years old
60 - 70 years old
70+
Other

Q3. In the last two months, have you had an appointment with a doctor, nurse, or other health professional by video or by phone?

Yes
No

IF Q3 = Yes SKIP to Q5

Q4. Last experience with Tele-health:

Less than 3 months
3 to 6 months
6 months to a year
More than a year
None

Q5. What's your comfort level with using Telehealth Apps:

Very comfortable
Comfortable
Somewhat Comfortable
Neutral
Somewhat Uncomfortable
Uncomfortable
Very uncomfortable

Context and limitation awareness Screen

Follow the steps in order. Remember this is a prototype, some options might not be available. Don’t forget to speak your thoughts out loud as you go through the prototype.

Q7. Scenario

View Textbox 1.

Please rate from [1] Extremely Difficult to [7] Extremely Easy.

Overall, how difficult or easy was the task to complete?

Q8. What did you think of the layout of the content?

[free form]

Q9. How would you describe your overall experience with this product?
[free form]

Q10. Was there anything that could be improved? Please explain
[free form]

Q11. Was anything unnecessary? If so, what was it?
[free form]

On a scale from 1 to 7, please rate the following sentences from [1] Strongly Disagree to [7] Strongly Agree.

Q12. The way I interact with this system is pleasant.
Q13. I like using the system.
Q14. The system is simple and easy to understand.
Q15. This system is able to do everything I would want it to be able to do.
Q16. The app performed the way I expected.

Appendix 5 - Participants Profiles

Medical Provider Profile

Id	Participant Description
1	39-year-old, Male, Single, High-School Degree, Employed full-time
2	52-year-old, Male, Single, College Degree, Self-Employed
3	42-year-old, Female, Single, College Degree, Self-Employed
4	48-year-old, Male, Single, High-School Degree, Employed full-time
5	39-year-old, Male, Married, College Degree, Employed full-time
6	44-year-old, Male, Married, High-School Degree, Employed full-time
7	44-year-old, Male, Married, College Degree, Self-Employed
8	36-year-old, Male, Married, Post-Graduate Degree, Employed full-time
9	42-year-old, Female, Married, Post-Graduate Degree, Self-Employed
10	35-year-old, Female, Single, College Degree, Employed full-time
11	35-year-old, Male, Married, High-School Degree, Employed full-time
12	32-year-old, Male, Single, College Degree, Employed full-time
13	48-year-old, Female, Married, College Degree, Employed full-time
14	36-year-old, Male, Married, College Degree, Employed full-time
15	25-year-old, Female, Married, Post-Graduate Degree, Employed full-time

Pre-Assessment

Id	Participant Description
1	44-year-old, Female, Married, High-School Degree, Unemployed
2	58-year-old, Male, Married, High-School Degree, Employed full-time
3	35-year-old, Female, Single, College Degree, Employed full-time
4	35-year-old, Female, Married, College Degree, Employed full-time
5	48-year-old, Male, Married, College Degree, Employed full-time
6	36-year-old, Male, Single Post-Graduate Degree, Employed full-time
7	33-year-old, Male, College Degree, Self-Employed
8	37-year-old, Male, Single, High-School Degree, Employed full-time
9	39-year-old, Male, Married, High-School Degree, Employed full-time
10	44-year-old, Male, Married, High-School Degree, Employed full-time
11	25-year-old, Female, Married, Post-Graduate Degree, Employed full-time
12	35-year-old, Male, Married, High-School Degree, Employed full-time
13	48-year-old, Male, Single, High-School Degree, Employed full-time
14	38-year-old, Female, Single, College Degree, Self-Employed
15	41-year-old, Male, Single, College Degree, Employed full-time

Referrals

Id	Participant Description
1	32-year-old, Male, Single, High-School Degree, Employed full-time
2	37-year-old, Male, Married, Post-Graduate Degree, Employed full-time
3	37-year-old, Male, Married, College Degree, Employed full-time
4	24-year-old, Female, Married, Bachelor Degree, Employed full-time
5	41-year-old, Female, Married, College Degree, Self-Employed
6	38-year-old, Female, Single, College Degree, Self-Employed
7	25-year-old, Female, Married, Post-Graduate Degree, Employed full-time
8	45-year-old, Male, Married, High-School Degree, Employed full-time
9	39-year-old, Female, Married, High-School Degree, Employed full-time
10	56-year-old, Male, Married, College Degree, Employed full-time
11	48-year-old, Female, Married, College Degree, Self-Employed
12	37-year-old, Male, Married, Post-Graduate Degree, Employed full-time
13	40-year-old, Male, Married, High-School Degree, Employed full-time
14	39-year-old, Male, Married, College Degree, Employed full-time
15	32-year-old, Male, Single, College Degree, Self-Employed

Covid-19 Assessment

Id	Participant Description
1	41-year-old, Female, Married, College Degree, Employed full-time
2	44-year-old, Male, Married, High-School Degree, Employed full-time
3	29-year-old, Female, Single, High-School Degree, Employed full-time
4	40-year-old, Female, Single, College Degree, Self-Employed
5	35-year-old, Female, Single, College Degree, Employed full-time
6	48-year-old, Male, Single, High-School Degree, Employed full-time
7	35-year-old, Male, Married, High-School Degree, Employed full-time
8	33-year-old, Male, Single, College Degree, Unemployed
9	25-year-old, Female, Married, Post-Graduate Degree, Employed full-time
10	37-year-old, Male, Single, High-School Degree, Employed full-time
11	40-year-old, Female, Married, College Degree, Self-Employed
12	47-year-old, Female, Married, College Degree, Employed full-time
13	40-year-old, Male, Single, College Degree, Employed full-time
14	43-year-old, Female, Single, Post-Graduate Degree, Employed full-time
15	38-year-old, Male, Single, College Degree, Self-Employed

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