



Multisensory design REPORT

Hospital at home tool kit

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The nightshades

UNIVERSITY
OF TWENTE.

Understand phase

Introduction & Challenge Framing

Hospital-at-Home (HaH) programs enable patients to receive hospital-level care in their own homes through the use of portable diagnostic and therapeutic devices. While this model increases comfort and autonomy, it also places greater responsibility on patients and informal caregivers to correctly use medical equipment in non-clinical environments. Variability in lighting, sound, space, and daily routines, combined with emotional stress and differing levels of health literacy, creates significant challenges for safe and effective device use.

The current Hospital-at-Home toolkit reveals shortcomings in usability, safety, emotional support, and inclusivity. Devices are largely designed for clinical contexts and rely predominantly on visual interaction, increasing the risk of incorrect use or improper calibration in the home. These limitations can lead to inaccurate measurements, unsafe treatment, and heightened anxiety for patients and caregivers, while the clinical aesthetic of the devices often conflicts with the domestic environment.

Within the context of a multi-sensory design course, this project addresses the redesign of an existing Hospital-at-Home toolkit through the deliberate integration of visual, auditory, and tactile cues. By distributing information and feedback across multiple sensory channels, the design aims to guide correct usage, reduce cognitive load, and support patient autonomy and emotional well-being. The redesigned toolkit should function reliably across diverse home environments while integrating seamlessly into everyday domestic life.

User Insights

Drawing from the conclusions derived from the interview with Dr. Michael van Herwerden from Erasmus MC and from the literature review that was conducted, it is quite evident that Hospital-at-Home kits today have basic problems, like the bulky plastic boxes, which lead to rattling of items and also breakage while shipping. Doctors also don't really like the rigid design of these boxes, as each patient requires a different set of tools in the box.

While patients aged 60 to 80 are expected to do their own tests, any help from family members must come from adults because of legal rules in the Netherlands. Sticking to a medical schedule is a major struggle, as about half of all people with long-term illnesses miss their daily checks (Robinson, 2022). This is often because they simply forget to do them (Unni, 2011). Many older adults experience issues with their sight or hearing, which can make it difficult for them to use standard medical equipment and complex mobile applications (Patel, 2022; AHA, 2009).

Adding to this, when older people bring medical tools into their homes, they often feel like they are losing control because their private space starts to feel like a hospital or a clinic. This change can make the home feel less like a safe place to relax and more like a doctor's office where their daily life is run by medical rules and equipment. Many people feel a sense of resignation, meaning they believe they have no choice but to use these tools to stay alive, which can hurt their self-esteem and sense of independence (Thomson, 2013; Sulis, 2022).

To help with this, the kit should look like a normal home item and use smart sensors to work quietly in the background (Lu, 2024; Philpot, 2025). Finally, using a mix of touch, sound, and light can help those with failing senses stay independent and build a safe daily routine (Wei & Liu, 2025; Lloyd-Esenkaya, 2020).

Understand phase

Research Question

This project explores how multi-sensory design can improve the accessibility and usability of Hospital-at-Home toolkits for people with diverse sensory abilities. It is guided by the following research question:

How might we redesign a Hospital-at-Home toolkit to be more accessible, safe, and usable for people with different sensory abilities in a home environment?

Personas

Three personas were created to visualize the target group for the Hospital-at-Home toolkit.

These are based on the types of personas as described by Engelmann et al. (2023): the one who needs and wants support, the one who accepts their situation with heart failure and reaches out when necessary, and the one who feels neglected by healthcare. The personas were then generated using ChatGPT, with prompts based on the information from the case provider and the three personas from the research. One persona can be seen in Figure 1; the others can be found in Appendix A.

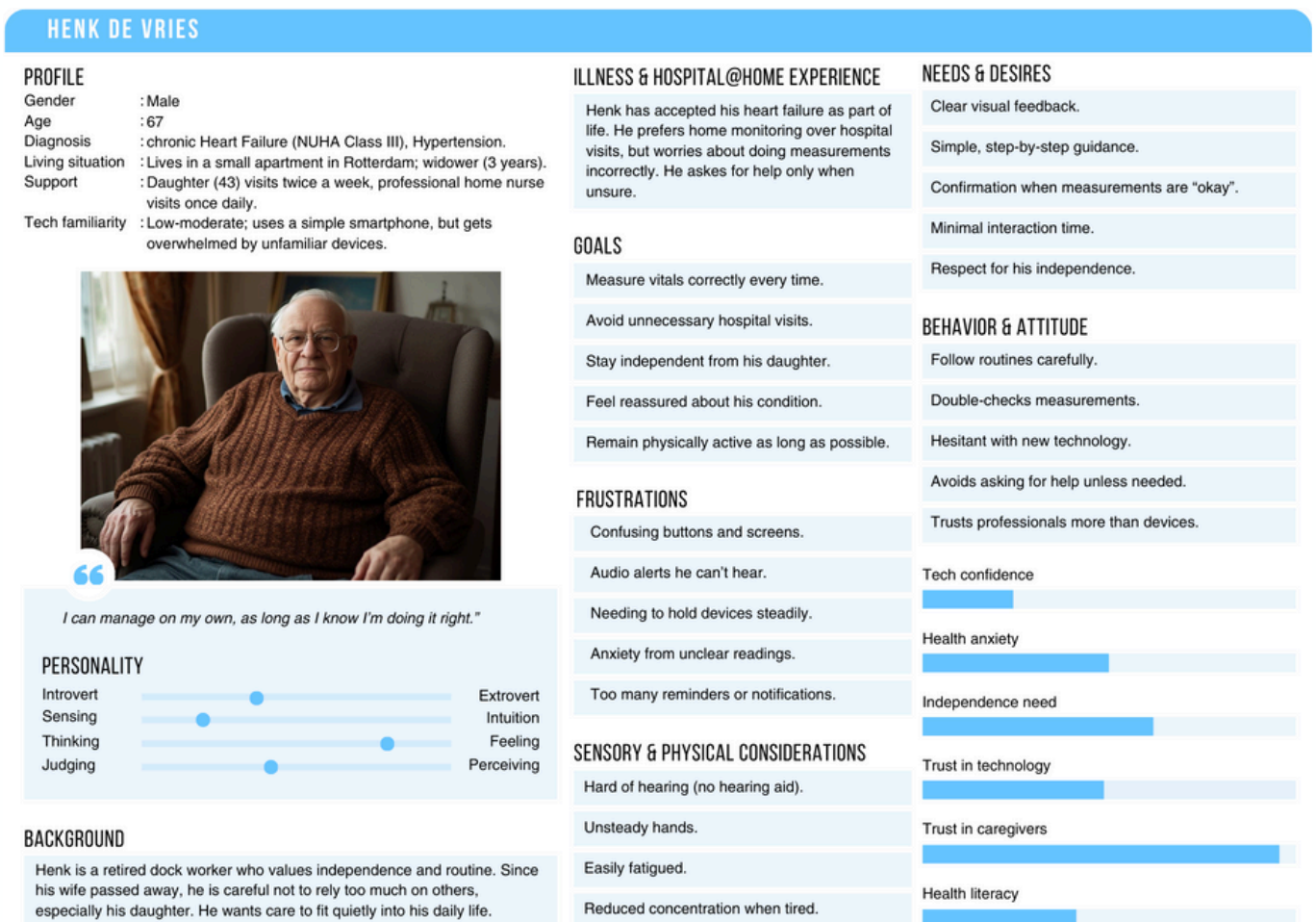


Figure 1: Persona, Henk de Vries

Understand phase

Scenarios

After the meeting with the case provider, scenarios were developed to visualize three cases of problems that occur with the current toolkit. In the sketch (Figure 2), the patient receives the toolkit. In the first scenario, a tool is missing. This could be because different configurations are required for other conditions patients may have. The second scenario shows that the patient struggles to understand which value needs to be submitted in the app. This could be due to the unclear displays and the overload of information provided. The third problem that was mentioned by the case provider was that the tools arrived broken or were dirty. Since the box is quite large, there is room for the tools to get tossed around, which could lead to damage. These three cases lead to a phone call to the hospital, which works counterproductively to the goal of this toolkit, which is to minimize hospital interaction.

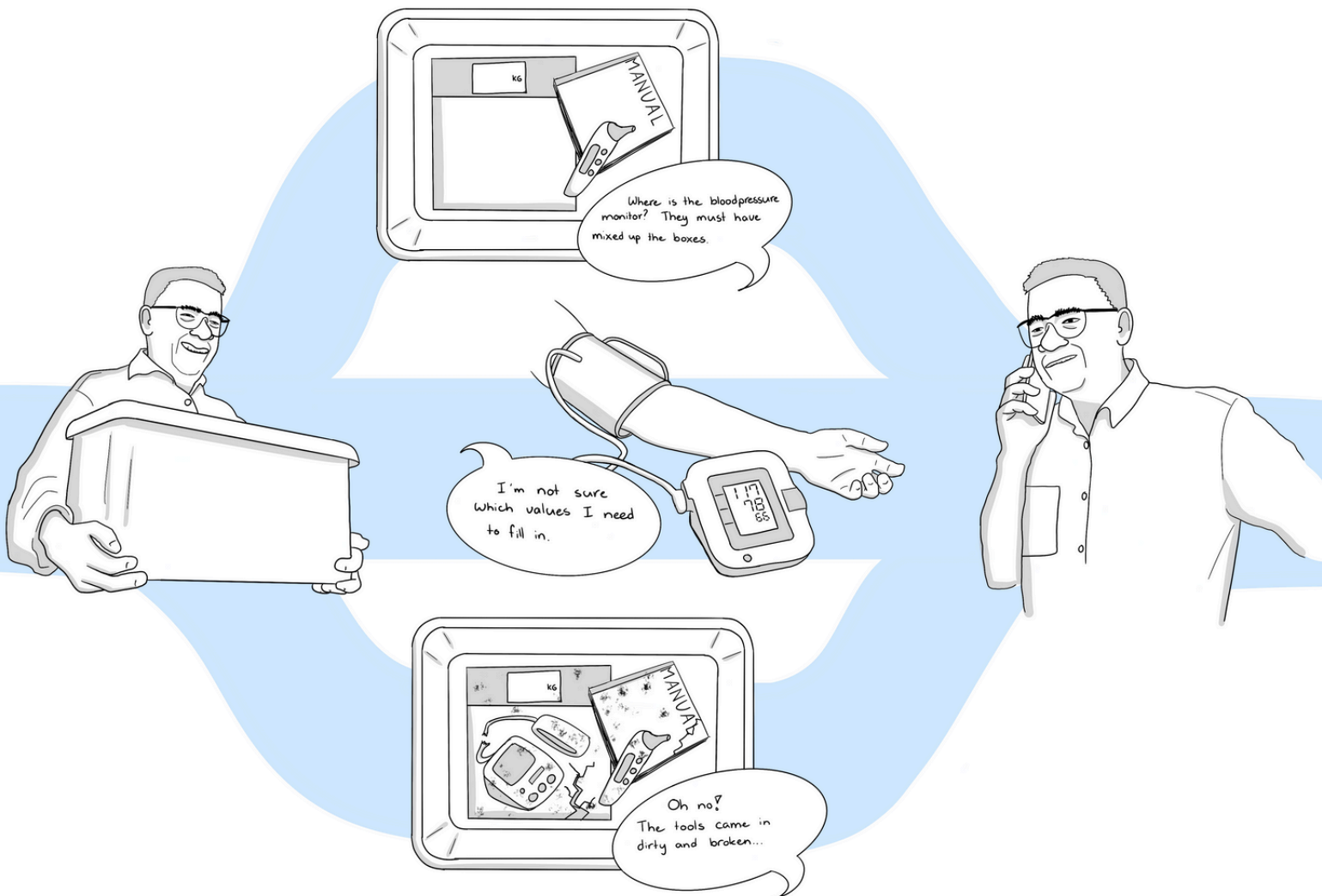


Figure 2: Scenario of current toolkit

Explore phase

Requirements

Five design principles were developed based on the information gathered during the Understand phase and are supported by research, which can be found in Appendix B. The following principles should be considered when designing medical care for older adults with heart failure in a home environment:

1. Misuse prevention
2. Accessibility and independence through multisensory design
3. Integration into the home environment
4. Habit integration into routine through multisensory design
5. Emotional comfort through sensory soothing

Also, a list of design requirements was made, which gives more technical and physical restrictions to the design process compared to the Design Principles. The MoSCoW method was applied to give the requirements a level of importance. The full list of requirements can be found in Appendix C, but some examples are listed below in Table 1.

No.	Requirement	Reasoning
1.2	The toolkit must be usable for users with vision impairments.	Accessibility and independence
1.7	The toolkit should provide consistent interactions across all tools.	Misuse prevention
2.3	The toolkit must be easy to clean and maintain.	Home environment
2.8	The toolkit must use a friendly and reassuring design language.	Emotional comfort
3.8	The toolkit must avoid unnecessary alarming messages.	Habit integration

Table 1: Examples from the requirement list

Ideation

The ideational phase was not linear, but instead followed several iterations before forming a set of definitive elements that could have improved the previous solution, enhancing its usability and overall effectiveness.

Starting from an analysis of the existing product, its content, and how it works, further research focused on how the other senses could be better integrated, allowing the product to be used by a wider range of users and facilitating understanding and use.

Through the study of users and the established design principles, several necessary design aspects were clarified. These included a product that allows better integration of tools within the toolbox; a virtual assistant that could accompany the patient throughout their journey, and an container with appropriate dimensions that supports transportability while becoming a familiar presence in users' lives, distancing itself from the perception of a hospital product.

The development of the first concepts reflected these themes by attempting to transform a purely hospital-based product into one more focused on the home environment, with attention to tactile and formal qualities. The initial ideas aimed to develop these features while retaining aspects of the existing box and improving those identified as critical.

Explore phase

The exploration moved from box concepts to drawer systems, seeking combinations of elements that could best address the identified issues and transform the box into a more organized system. In addition, the integration of a virtual assistant was explored as a way to add continuous support, guidance, and reassurance, improving adherence to the process and the overall perception of product effectiveness.

A turning point occurred after the fishbowl presentation, which allowed gaps, missing functions, and less effective elements to be identified. This moment shaped the thinking that later permeated the final concept: a system that also addressed transportability by combining previous reflections with new possibilities. Subsequent ideas built on these insights, introducing new toolbox systems that blended earlier elements with fresh concepts. As a result, a range of possibilities emerged, from article bags to modular trolley systems. These solutions fit well within the home context, resembling everyday household objects rather than hospital equipment, helping users feel more comfortable and positive when using the product. The focus also shifted toward customization, modularity, and tool organization, helping to define the most appropriate development path.

The product, therefore, incorporates elements that users can touch and recognize, supporting interaction in ways that make it easier to understand for a wide range of users, including those with visual or auditory differences. Accessibility thus becomes a key aspect of the product, aiming to make it suitable for everyone. Sketches from the ideation process can be found in Appendix D.

Patient journey

The patient journey was created based on our persona Henk (see Figure 1). The mapping reflects both our user insights and our own testing of the current Hospital-at-Home toolkit. The full patient journey can be found in Appendix E.

Notably, the patient journey with the current kit relies almost exclusively on visual cues for the sensory experience. In addition, when sounds are incorporated, they are mostly unpleasant. The high-frequency beeping of the thermometer, for example, is likely difficult for Henk, as older adults may not hear sounds at such high frequencies (Gottfriedová et al., 2024). The primary “touch” experience is uninviting, consisting solely of smooth, cold plastic and glass materials from the devices and the transparent box. Furthermore, throughout the current patient journey, Henk experiences a sense of uncertainty. He is instructed on how to use the devices once by his doctor; after that, he is completely on his own, with only the box, the manuals, and the “Digizorg” app, where he has to upload his measurements. Whenever he is unsure how to take a measurement, he needs to look it up in one of the four manuals, which span several hundred pages and use a small font size, making them difficult to read.

Henk’s journey helped us to further identify where the sensory experience of the current kit falls short and should be improved to fulfill our aforementioned five design principles.

Explore/Define phase

Touchpoints

In the original Hospital-at-Home toolkit, patient interaction is largely limited to functional, device-level touchpoints. The patient engages with each medical device individually, such as the scale, blood pressure monitor, ear thermometer, and pulse oximeter, without a unifying system guiding the process. These interactions rely heavily on visual cues, small screens, and auditory beeps, which can be difficult for older adults with reduced vision, hearing, or dexterity.

The storage box itself functions mainly as a container for transport and organization, and does not actively support the measurement process. It offers no guidance on which device to use next, whether a measurement has been performed correctly, or whether all required steps have been completed. Instructions are typically provided through separate paper manuals, which are often cognitively demanding, easy to misplace, or inaccessible for users with visual impairments. As a result, patients must remember measurement routines, interpret feedback independently, and self-assess whether their actions are correct. This fragmentation of touchpoints increases the risk of misuse, creates uncertainty during daily monitoring, and can contribute to stress or reduced confidence when using the kit at home. The touchpoint matrix includes all these points and can be found in Appendix F.

Final Design Description

This design reimagines the Hospital-at-Home toolkit as a supportive, lifestyle-oriented companion rather than a piece of medical equipment. It is tailored to older adults and focuses on both physical and emotional needs through thoughtful mobility, accessibility, multisensory interaction, and a non-clinical, home-friendly aesthetic. The sketches and renders of the final design can be seen in Figures 3 and 5.

Mobility and Flexible Use

At the core is a mobile unit with wheels and a trolley handle, allowing patients to move medical supplies easily without lifting heavy items. The unit can be adapted to suit different situations: it opens fully and features a detachable bottom, enabling the main compartment to hang vertically like a toiletry bag. A fold-out fabric panel brings essential tools to eye level, reducing the need to bend down while saving floor space in the home.

Modular and Home-Like Design

To avoid the sterile feel of traditional hospital equipment, the exterior uses warm, familiar textures inspired by wood, which have been shown to promote positive emotions and reduce stress (Alapieti et al., 2020). Inside, a flexible Velcro-based system allows users or caregivers to customize the layout. Medical devices and compartments can be placed exactly where they are most convenient, adapting to individual treatment plans.

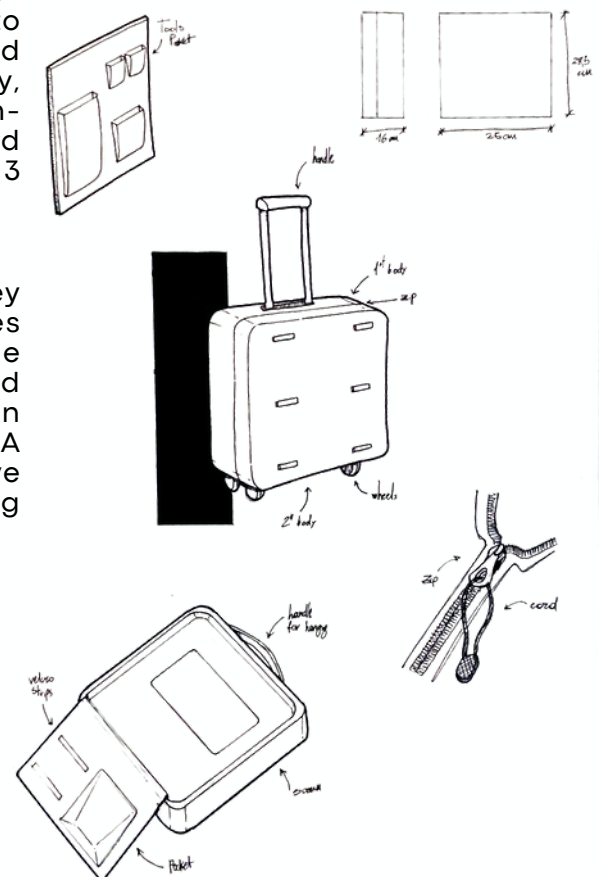


Figure 3: Sketch of final design

Define phase

Accessibility and Multisensory Interaction

The toolkit is designed for users with varying levels of dexterity and vision. Interactions always use at least two senses, combining touch, sound, or visual cues to ensure clarity and confidence. Raised foam borders and tactile stickers help users identify devices by touch, while feedback is provided through gentle vibrations or soothing sounds instead of loud alarms, keeping interactions calm and reassuring.

Safety and Emotional Support

Acting as a digital “buddy”, the system supports users by flagging unusual measurements, offering reminders for routine checks, and helping them find relevant information such as manuals. Patients remain in control of their data at all times by agreeing to either send or redo a certain measurement.

Regarding the design of the buddy, there is currently no consensus in the literature on whether digital healthcare agents should be anthropomorphic in order to increase user acceptance. Anthropomorphic agents may invoke users to project empathic and rational thinking traits onto them, which can result in disappointment if these expectations are not met (Curtis et al., 2021). Conversely, Parmar et al.’s (2018) large-scale user study (N = 308) found that an avatar dressed in medical attire leads to a more positive User Experience. To take these design considerations into account, we designed our buddy as a humanized stethoscope, intended to be cartoonish and encouraging while still clearly set in a healthcare context (see Fig. 4).

The buddy uses a female voice, as this is preferred by users in preventive healthcare contexts (Schillaci et al., 2023).



Figure 4: Avatar of the buddy

To support habit formation without stress, motion sensors and comforting audio cues such as nature sounds or soft domestic hums guide daily routines.

These cues act as gentle, recognizable signals rather than alarms, helping users associate specific sounds with recurring actions over time. Research shows that consistent sensory cues in a stable context can support habit formation while minimizing cognitive and emotional load (Lally et al., 2010; Spence, 2020).



Figure 5: Renders of the final design

Define Phase

Customizable themes like sea or forests further help create a sense of calm, safety, and independence. The use of calming colors such as blue in these themes has been shown to support emotional relaxation, peace, and stress reduction in interior environments (Jalali et al., 2025). Research using EEG measurements shows that exposure to virtual coastal landscape imagery can significantly support stress recovery and emotional regulation, reinforcing the therapeutic potential of nature-based visual themes in home environments (Shi et al., 2025).

Patient journey

The improved patient journey can be found in Appendix E and is visualized as “Opportunities.” The redesigned kit increases Henk’s independence: with wheels underneath, he can move the box on his own, and the velcro pockets allow him to rearrange the devices’ layout as he prefers. The tactile experience is also noticeably softer, using soft polymer, wood textures, and fabric instead of cold plastic. In addition, Henk feels guided and supported by the buddy companion, which leads him step-by-step through measurements with the two devices he feels most unsure about. He can interact with the buddy via voice, and all measurements are read out loud. Rather than relying on high-frequency beeps, the devices vibrate twice when a measurement is completed, and the values are automatically displayed on the buddy screen. This multimodal feedback makes taking measurements more comfortable and easier for Henk to understand. Overall, the redesigned kit fits more naturally into Henk’s home and reduces his previous sense of uncertainty when using the medical devices.

Touchpoints

In the redesigned Hospital-at-Home concept, touchpoints are intentionally integrated into a coherent, guided experience rather than isolated device interactions. The patient’s primary point of contact is no longer an individual medical device, but the mobile care kit as a whole, which acts as a central companion throughout the measurement routine. Interaction begins when the patient approaches the kit, where motion sensing and subtle audio cues help initiate the process in a calm and familiar manner. The system then guides the user step by step, reducing the need to remember sequences or interpret instructions independently.

Each medical device becomes part of a multisensory interaction that combines touch, haptic feedback, sound, and visual cues. Tactile elements such as raised borders, fabric stickers, and textured surfaces support users with visual impairments, while gentle vibrations provide clear feedback during measurement without relying on loud or potentially stressful sounds. The buddy companion serves as an interpretive touchpoint between the patient and the digital system: it explains how to use each device, confirms when measurements are complete, and prompts the user before sending data, reinforcing a sense of control and trust.

Rather than functioning as passive storage, the kit’s physical form is designed as a mobile, foldable, fabric-based unit that supports accessibility by bringing devices to eye level and minimizing physical strain. Through consistent, reassuring touchpoints across physical and digital interactions, the solution transforms routine health monitoring into a supportive daily ritual, reducing misuse, anxiety, and cognitive load while fostering confidence and independence in home-based care. The touchpoint matrix for the solution can be found in Appendix G.

Define Phase

Low-Fi Prototype

The low-fi prototype consists of a physical component that resembles the kit and a digital prototype for the “buddy” companion. The exterior of the kit was constructed from cardboard and painted with acrylic paint, mimicking the blue, soft polymer shell of the final kit. The fabric flap underneath the buddy, as well as the pockets for the medical devices, was sewn by one of the project team members using black fabric.

To distinguish the devices through tactile stickers, four differently colored foam sheets were used - one for each device: red and heart-shaped for the blood pressure monitor, blue and diamond-shaped for the blood oximeter, green and flower-shaped for the scale, and yellow and star-shaped for the ear thermometer. The foam material was cut into a representative shape for each device; these shapes were then sewn onto the outside of the fabric pockets and displayed on the buddy’s digital measurement screens (see Figure 6) to create a coherent experience.

The buddy interface, displayed on an iPad placed inside the cardboard prototype, was designed in Figma (see Figure 6). Here, special focus was placed on large fonts, clear colors, and simple shapes to ensure accessibility for elderly users with limited digital skills. The buddy character was illustrated with two eyes and a mouth to convey three emotional states - calm happiness, excitement, and thinking (see Figure 4). The digital prototype was later exported to the advanced prototyping software ProtoPie, which offers built-in features for text-to-speech, speech recognition, and audio playback. This enabled the interface to be not only visually interactive, but also responsive to audio commands, ensuring a full demo of measuring weight and blood pressure via voice guidance and interaction. Only the automatic sending of the measurements (via Bluetooth) had to be wizarded through timed interactions.

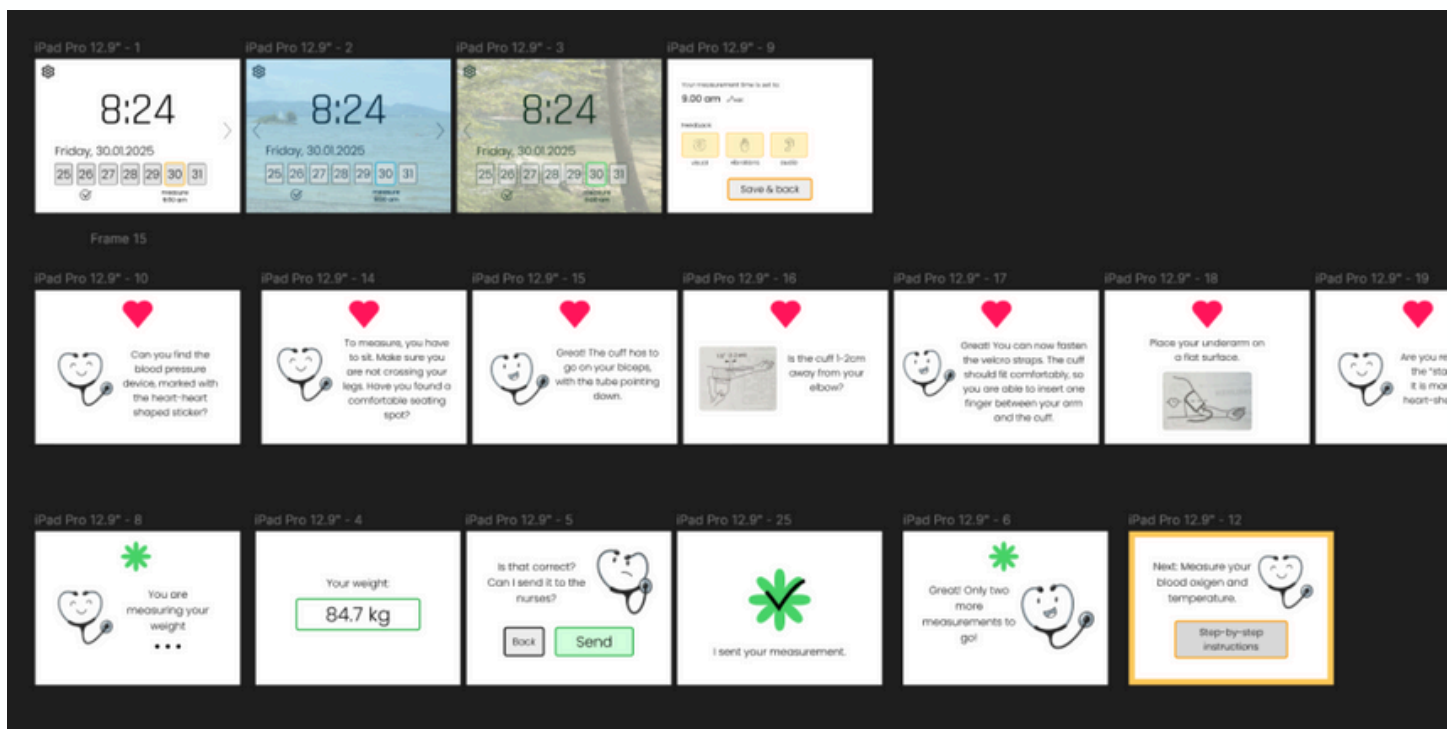


Figure 6: Low - Fi prototype interface

Define Phase

Testing / Improvements

After the final design was presented (via email) to Dr. Michael van Herwerden, feedback indicated that some patients who are not well-versed in handling multiple interaction points might be excluded. Additionally, the materials used in some of the devices within the kit may be prone to corrosion due to the moisture present in bathrooms. It was also noted that the fabric used for the kit could become dirty, and that some patients may have limited space in their homes.

Taking this feedback into account, the incorporation of these suggestions is planned for the next iteration of the product. While it is acknowledged that the current prototype may not be suitable for everyone, the goal is to make it as accessible as possible. It is also understood that the bathroom may not be the ideal location for storing the kit; instead, it is recommended to place it in a less humid area of the home. Finally, improvements are planned to the materials used for the box to make it easier to clean, as well as the addition of lockable wheels to keep the kit stationary, which may help address space constraints.

Conclusion

This report answered the question, "How can multi-sensory design improve the accessibility and usability of Hospital-at-Home toolkits for people with diverse sensory abilities?" By moving away from a focus on screens and using touch and sound, instead, the toolkit becomes easier to use and much less intimidating. This helps the equipment feel like a natural part of the home rather than a clinical medical device. Ultimately, it allows people to manage their own health checks with more confidence and less stress in their own space.



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Appendix

Appendix A - All personas

MARJOLIJN JANSSEN

PROFILE

Gender : Female
Age : 72
Diagnosis : Chronic Heart Failure (NYHA Class II-III), Diabetes type 2.
Living situation : Lives alone in a small terraced house; stairs limit mobility.
Support : Son visits weekly; the district nurse visits 2 to 3 times a week.
Tech familiarity : Moderate; uses a smartphone and tablet, but lacks confidence with new apps.



“

If the toolkit guides me calmly, I can take care of myself.”

PERSONALITY



BACKGROUND

Marjolijn is a retired school assistant who is used to structured routines. She is comfortable with everyday technology and prefers tools that quietly fit into her home and daily rhythm.

ILLNESS & HOSPITAL@HOME EXPERIENCE

Marjolijn uses the hospital@home toolkit weekly. She wants clear guidance, confirmation, and calm feedback. When the system feels distant or unclear, she worries something is being missed.

GOALS

Use the toolkit independently every time.
Feel reassured by clear system feedback.
Avoid mistakes during measurements.
Integrate care into her routine.
Stay at home with confidence.

FRUSTRATIONS

Unclear system responses.
Fear of misusing the device.
Too much visual complexity.
Disruptive alarms or notifications.
Measurements that don't feel "acknowledged."

SENSORY & PHYSICAL CONSIDERATIONS

Mild vision decline.
Sensitive to harsh sounds.
Benefits from tactile confirmation.
Easily stressed by cluttered interfaces.

NEEDS & DESIRES

Multisensory confirmation.
Clear guidance before and during use.
Cal, soothing feedback.
Seamless fit into her home environment.
Feeling "seen" by the system.

BEHAVIOR & ATTITUDE

Intends to measure weekly, but forgets.
Misses measurements when routine changes.
Responds well to repeated gentle cues.
Completes tasks once prompted.
Feels relieved after confirmation.

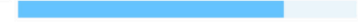
Tech confidence



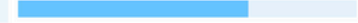
Forgetfulness



Need for reassurance



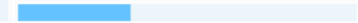
Routine dependence



Stress from alarms



Trust in toolkit



PIETER VAN LEEUWEN

PROFILE

Gender : Male
Age : 58
Diagnosis : Chronic Heart Failure (NYHA Class II), mild COPD
Living situation : Lives with his partner in a rented apartment; partner works full-time and is minimally involved in care
Support : GP and cardiologist; remote monitoring team with infrequent contact
Tech familiarity : High; confident with apps and digital tools



“

I do everything that's asked of me — I just don't know what happens after that.”

PERSONALITY



BACKGROUND

Pieter is used to managing his life independently. Developing heart failure in his late 50s forced him to scale back work earlier than expected, which he found frustrating but manageable. He doesn't see himself as a "patient" and expects healthcare to run reliably in the background; when processes are unclear or silent, he questions their value.

ILLNESS & HOSPITAL@HOME EXPERIENCE

Pieter uses the hospital-at-home kit correctly and has no trouble with the technology. However, the lack of visible feedback makes the monitoring feel opaque, which gradually reduces his engagement and trust despite continued compliance.

GOALS

Avoid hospital admissions.
Maintain control over his daily life.
Understand what happens with his health data
Minimize contact with healthcare providers.
Be treated as a competent, informed patient.

FRUSTRATIONS

Not knowing who is monitoring his data.
Sending measurements without understanding
Generic alerts without explanation.
Having to initiate contact himself when unsure.
Long periods of silence from the care team.

SENSORY & PHYSICAL CONSIDERATIONS

Shortness of breath with exertion.
Chronic fatigue.
Reduced tolerance for cognitive overload.
Sleep disturbances related to breathing issues

NEEDS & DESIRES

Clear visibility of clinical oversight.
Feedback that explains trends, not just thresholds.
Transparency about when action is or isn't needed.
Efficient, factual communication.
A sense of partnership rather than one-way reporting.

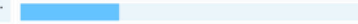
BEHAVIOR & ATTITUDE

Uses the toolkit consistently and correctly
Rarely asks questions unless something feels wrong
Downplays symptoms to avoid "unnecessary" contact
Becomes less engaged when feedback is absent
Values competence and accountability over reassurance

Tech confidence



Health anxiety



Need for independence



Trust in technology



Trust in caregivers



Health literacy



Appendix

Appendix B - Design Principles

Introduction

For our challenge, redesigning the Hospital@Home kit, we found the following 5 Design Principles that should be regarded when designing medical care in a home environment, for older adults with heart failure.

1. Misuse prevention
2. Accessibility and independence through multisensory design
3. Integration into the home environment
4. Habit integration into routine through multisensory design
5. Emotional comfort through sensory soothing

Principles

Misuse prevention

The Hospital-at-Home toolkit is intended to articulate its functions in a manner that clearly supports patient care, without introducing complexity or obstacles into the care pathway, and with built-in safeguards to prevent misuse or improper application.

Preventing misuse is a key consideration for products intended for medical use in the home environment. It is essential that the product is intuitive, easily understandable and accessible to all identified user groups, ensuring that its functions are immediately clear. The problems associated with the use of medical devices do not arise solely from mechanical failures; users can also, often unintentionally, contribute to malfunctions or operational errors (Bogner et al., 1994). Consequently, a prevention-focused design approach must be adopted, carefully considering how a future user will interact with the device, how they will perceive its functions, and how it can be guided and supported to use the toolkit safely and appropriately. An approach for preventing the misuse not only enhances safety but also fosters confidence and efficiency in administering medical care at home.

Accessibility and Independence through Multisensory Design

The hospital-at-home toolkit must make the use of every component (e.g., a blood pressure monitor) accessible by providing feedback and interaction through multiple sensory channels.

Through sensory substitution, users with different sensory capabilities are able to access the same information (Lloyd-Esenkaya et al., 2020). Older adults with heart disease are likely to experience sensory decline, often across more than one modality simultaneously. In prior work on older adults with coronary heart disease, Wei and Liu (2025) propose a cross-modal sensory compensation approach and highlight that combining auditory and visual feedback can support patients with impairments in both. For patients with visual impairments, tactile and auditory support can furthermore mitigate limitations that would occur if feedback was provided only visually. Additionally, to foster inclusivity, users should have the option to interact with the device through multiple channels via multimodal interfaces (Jeseo & Hall, 2025).

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Appendix B - Design Principles

Habit integration into routine through multisensory design

The hospital-at-home toolkit must integrate habit formation through multisensory design to aid the patients in adhering to the actions required for their medical needs.

Patient adherence to medication in long-term conditions is around 50% (Robinson et al., 2022). Three key elements were summarized by Zhu Y et al. (2024) to form habits: implementation intention, positive reinforcement, and cues. Behavior initially needs to be driven through goals and planning. Cues can serve as triggers to form associative memories, which can be done through multisensory design. Lastly, the positive reinforcement refers to rewarding the process of cue-behaviour association (Zhu Y et al., 2024). Research from Haynes et al. (1976) describes how hypertensive steelworkers linked medication intake and blood-pressure testing to their daily habits and rituals. It showed that the experimental group had increased compliance and decreased blood pressure compared to the control group. Indicating that the habits help with adhering to the medical needs. The experimental group was also rewarded for adhering to the medication plan, which connects to the positive reinforcement of Zu Y et al. (2024).

Integration into the home environment

The hospital-at-home toolkit must integrate seamlessly into the patient's home environment, ensuring that healthcare activities and devices coexist naturally with everyday domestic life.

For patients recovering from cardiac failure at home, standard medical equipment can disrupt routines and make the home feel medicalized, potentially reducing engagement. Sulis et al. (2022) demonstrated that embedding sensors and monitoring devices unobtrusively into daily household routines allows clinical interventions to occur naturally, minimizing disruption and preserving the home's residential character. Embedding context-aware sensor technologies into household routines, such as motion, light, or furniture-integrated devices, allows healthcare interventions to blend seamlessly with daily life, supporting usability, acceptance, and sustained engagement (Lu et al., 2024). Furthermore, participatory design studies involved patients in co-design workshops where they provided input on device placement, interface layout, and visual appearance. These sessions guided adjustments to ensure that devices fit naturally within domestic spaces, avoided clinical cues, and aligned with patients' daily routines. This approach preserved the home's non-clinical character and supported emotional well-being and autonomy (Philpot et al., 2025).

Emotional comfort through sensory soothing

The hospital-at-home toolkit must integrate calming, non-clinical multisensory cues to reduce patient and caregiver anxiety and promote emotional well-being.

For patients receiving acute care at home, the clinical appearance and sounds of standard medical equipment can heighten stress, potentially hindering recovery and creating a negative care experience. This principle directly counters that by applying evidence-based multisensory design. It draws on biophilic theory to replace clinical cues with nature-inspired, soothing elements (Yin et al., 2024). Research confirms that somatosensory interactions, such as soft textures and gentle haptic feedback, are effective for stress reduction and emotional regulation (Cheung et al., 2025).

Appendix

Appendix B - Design Principles

References Design Principles

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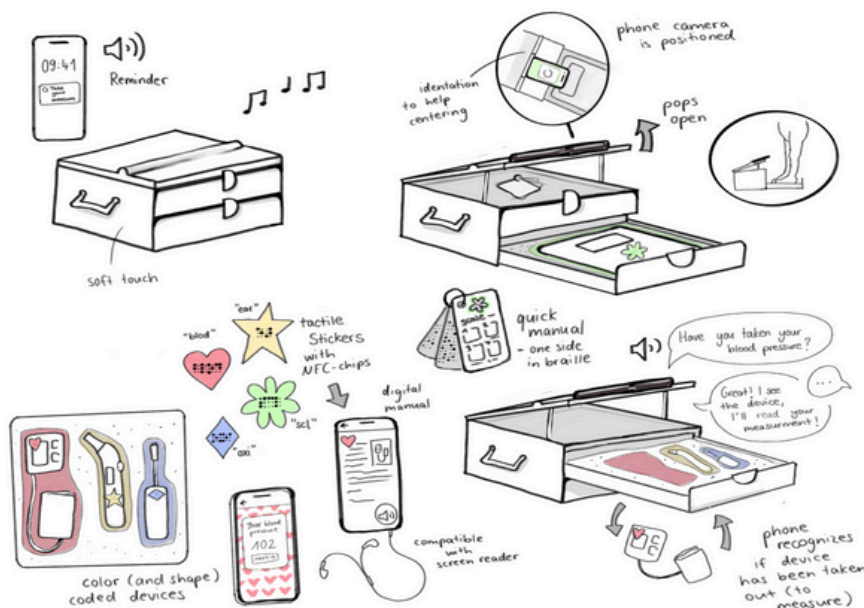
Appendix

Appendix C - Full list of requirements

No.	Requirement	Reasoning
Usability requirements		
1.1	The toolkit must be usable for users with hearing impairments.	Accessibility and independence
1.2	The toolkit must be usable for users with vision impairments.	Accessibility and independence
1.3	The toolkit must be usable for users with mobility impairments.	Accessibility and independence
1.4	The toolkit must include multiple senses.	Design assignment
1.5	The toolkit must be easy to understand without medical knowledge.	Accessibility and independence
1.6	The toolkit must provide clear feedback after each action.	Misuse prevention
1.7	The toolkit should provide consistent interactions across all tools.	Misuse prevention
1.8	The toolkit must guide the patients through the workflow of the tools.	Misuse prevention
1.9	The toolkit could make the type of data output understandable for the user.	Accessibility and independence
1.10	The toolkit could have packaging and materials suitable for older users to open and handle.	Accessibility and independence
Home context requirements		
2.1	The toolkit must have a comfortable and 'familiar' appearance (not "hospital-like").	Home environment
2.2	The toolkit must be easy to store in a home environment.	Home environment
2.3	The toolkit must be easy to clean and maintain.	Home environment
2.4	The toolkit could be usable in different lighting conditions.	Home environment
2.5	The toolkit must provide sounds between the range of 30 dB and 70 dB.	Accessibility and independence
2.6	The toolkit must prevent the user from getting more stress or anxiety.	Emotional comfort
2.7	The toolkit should promote a sense of control and independence.	Emotional comfort

2.8	The toolkit must use a friendly and reassuring design language.	Emotional comfort
2.9	The toolkit must be safe for the user to use unsupervised.	Accessibility and independence
Functional requirements		
3.1	The toolkit must be easily transportable.	Accessibility and independence
3.2	The toolkit must be usable whenever the workflow gets interrupted.	Misuse prevention
3.3	The toolkit should be compact.	Home environment
3.4	The toolkit must be water-resistant.	Home environment
3.5	The toolkit must be shock-resistant.	Home environment
3.6	The toolkit must be a modular system that allows tools to be added, removed, or replaced.	Case requirement
3.7	The toolkit could be usable without an internet connection.	Accessibility and independence
3.8	The toolkit must avoid unnecessary alarming messages.	Habit integration
3.9	The toolkit must provide clear warnings when it is misused.	Misuse prevention
3.10	The toolkit should clearly indicate the battery status.	Misuse prevention

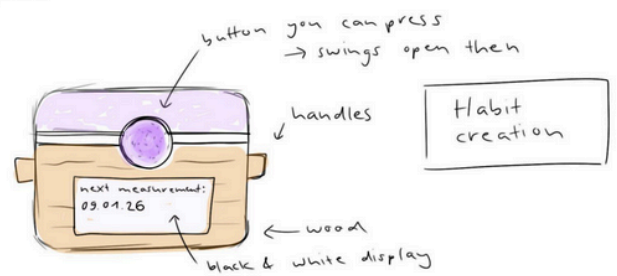
Appendix D - Ideation sketches



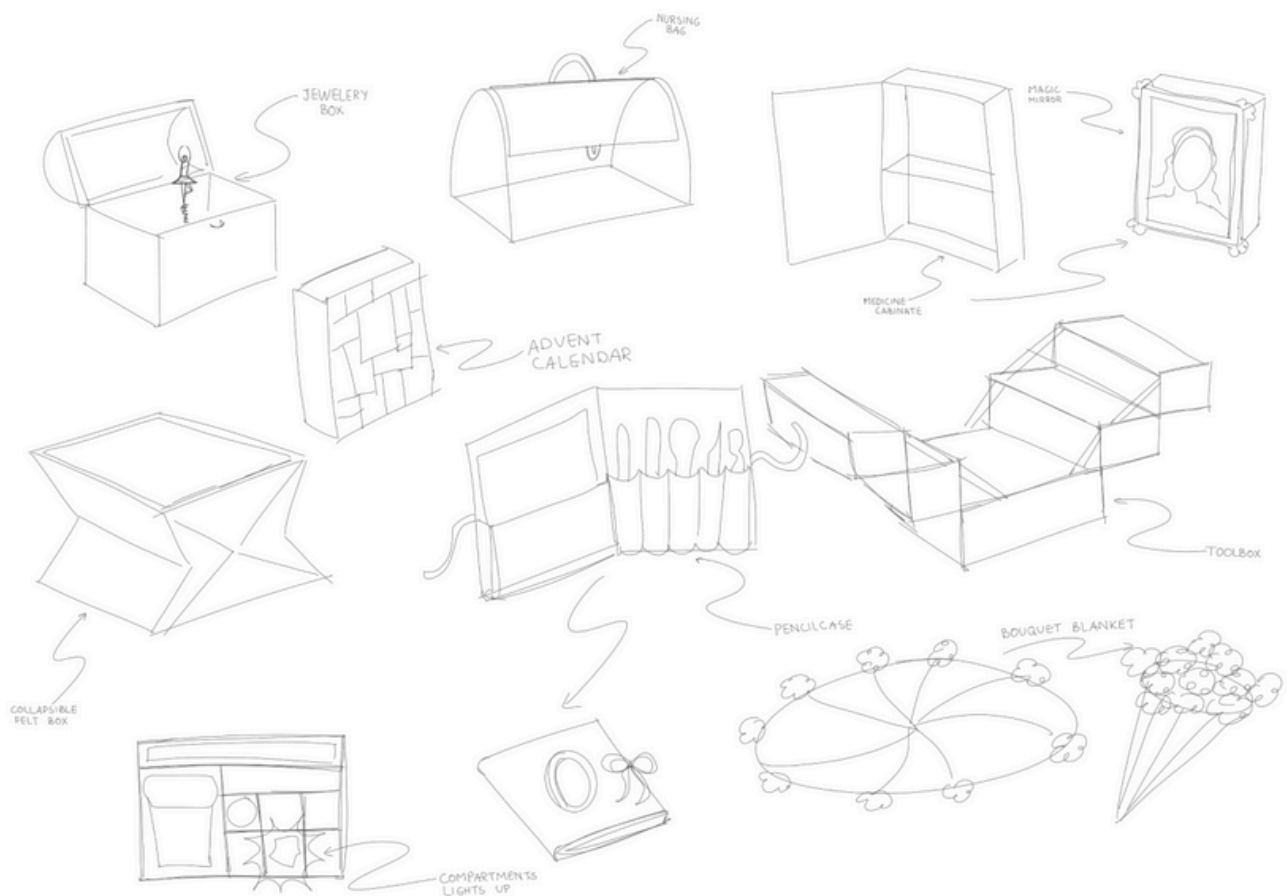
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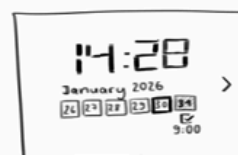
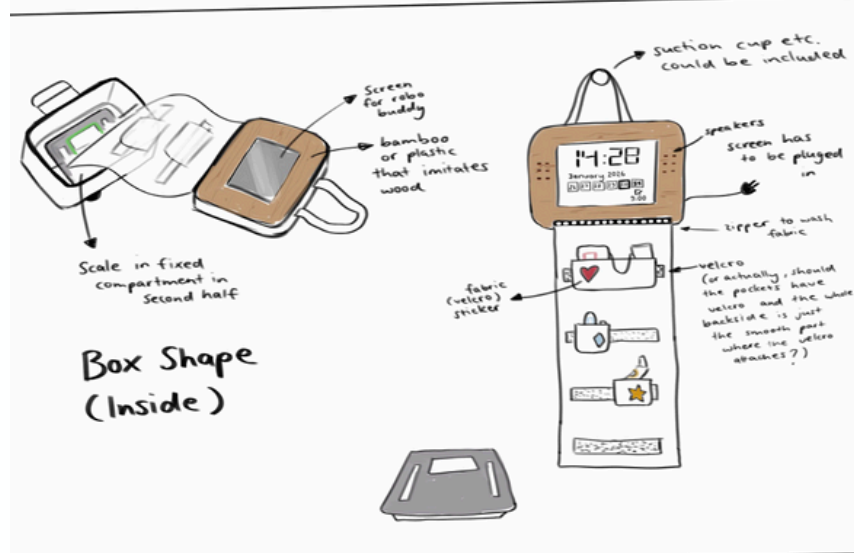
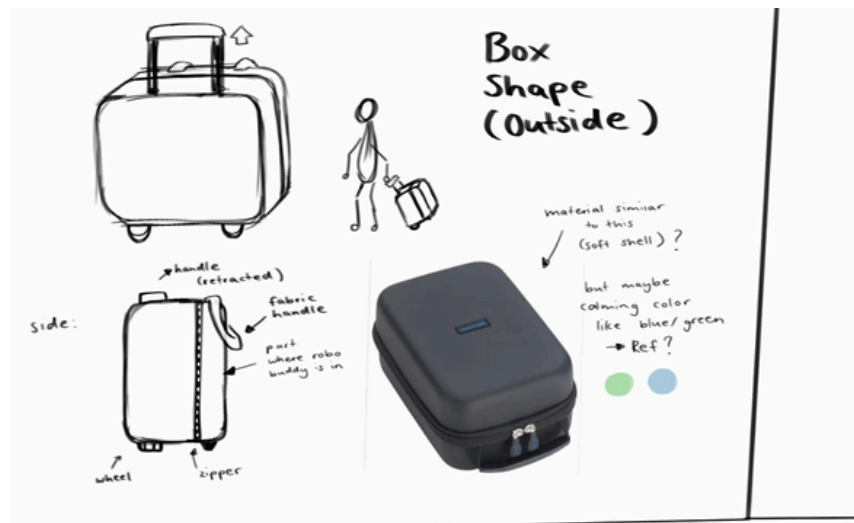
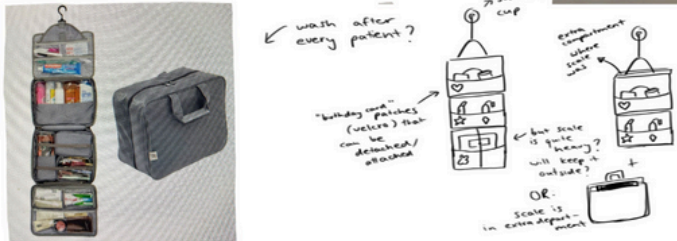
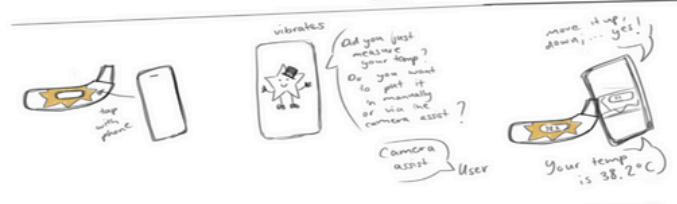
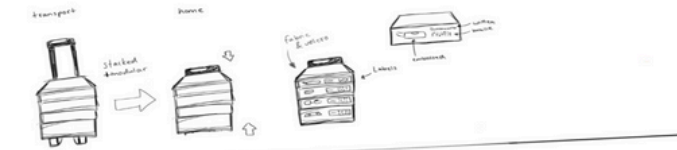
"treasure box"



you have to take measurements?
→ box swings open



Appendix



minimalistic black & white design



beach theme, ...

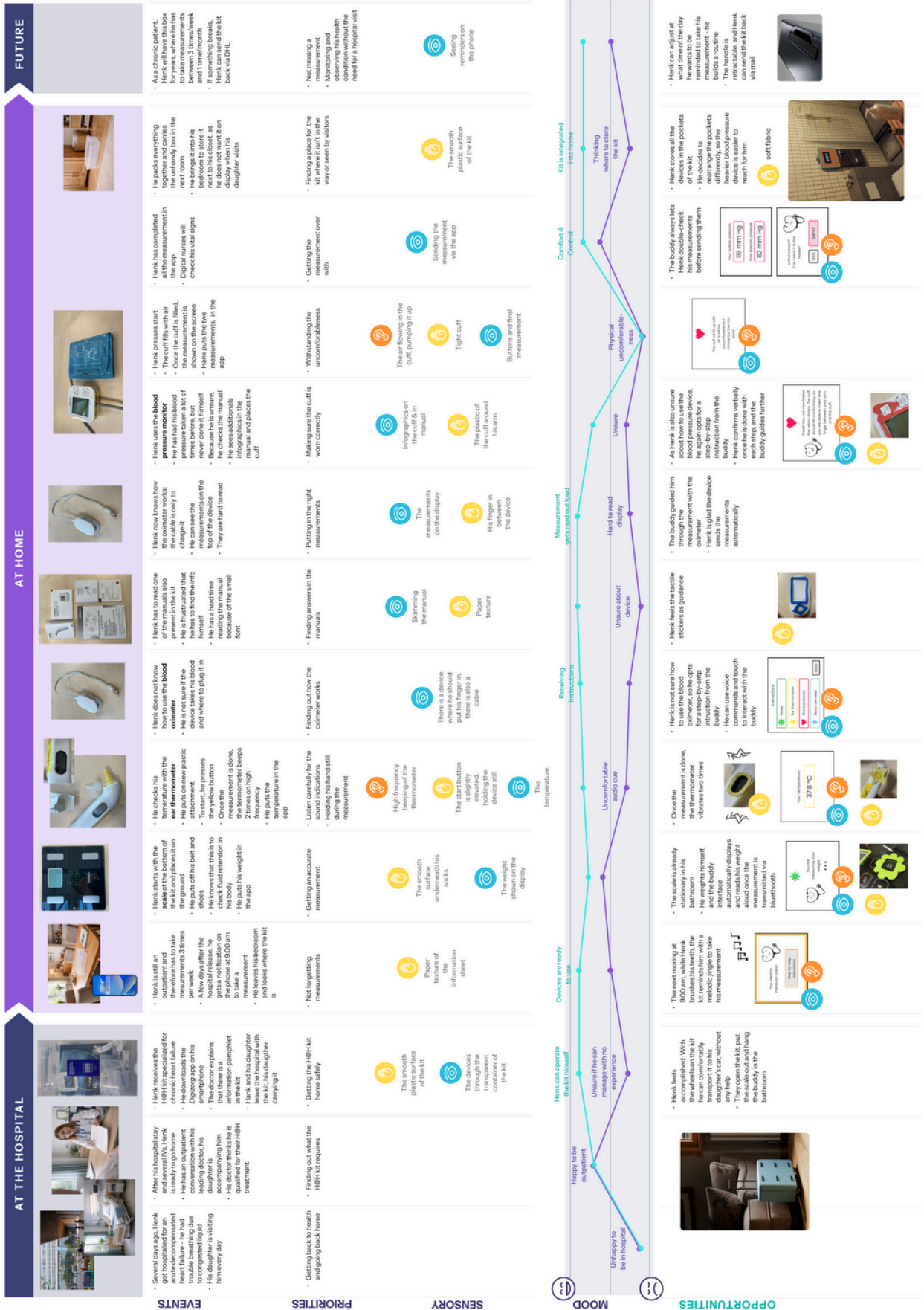
Buddy - To be continued...

Appendix

Appendix E - Patient journey mapping

Patient Journey | The Hospital@Home Kit

Goal: Henk just became an outpatient at Erasmus MC. Now he wants to best control his chronic heart failure condition through the home monitoring system Hospital@Home (H@H).



Appendix

Appendix F - Touchpoint matrix (current toolkit)

Patient Journey Stage	Touchpoint	Channel	Patient Action	Current Issues	Opportunity
Preparing for measurement	Preparing for measurement		Open box, find device and manual	Box is slippery; devices move; manuals loose; clinical appearance; hard to transport	Improve grip, tactile edges, organize compartments, make box more homely and safe; easier transport
Taking weight	Weighing Scale	Visual	Step on scale, press buttons	Unclear where to stand; no confirmation; slippery surface	Add tactile cues for correct stance; provide feedback when measurement starts/completes
Taking blood pressure	Blood Pressure Monitor	Visual	Position cuff, press Start	Cuff placement unclear; visual-only feedback; faint vibration; risk of incorrect measurement	Add guidance for proper cuff placement; confirm start/stop via haptics or sound; reduce misuse and cognitive load
Taking temperature	Ear Thermometer	Visual + Audio	Place thermometer in ear, press button	beep hard to hear; unsure of start/end; hygiene concerns, the cups are stored loosely	Provide placement guidance; storage solution for disposable cups; clear start/stop cues
Measuring oxygen saturation	Pulse Oximeter	Visual	Place finger in oximeter	Finger placement unclear; USB output confusing; visual-only feedback; fragile	Add tactile guidance for proper placement; clarify connectivity; feedback via haptics

Appendix

Understanding instructions	Manuals / Instructions		Read or follow step-by-step	Loose papers; confusing; visual-only; patients may ignore instructions	Make manuals accessible (braille, icons, videos); keep organized; visually appealing; easy to follow
Following measurement sequence	Workflow / Routine	Visual	Decide which device to use first	No guidance on measurement order; sequence disconnected; cognitive load on patient	Provide clear cues for sequence reduce cognitive load; integrate with reminders
Recording / sending data	App	Visual	Enter measurement	connectivity issues; patients unsure if data uploaded	easy to scan; ensure data sync confirmation; simplify digital interaction
Finishing routine	Box / Kit		Put devices back; close box	No confirmation devices stored properly; potential misuse; no feedback on completion	Provide visual/audio feedback when devices stored correctly; prevent misuse; guide workflow completion

Appendix G - Touchpoint matrix (redesigned toolkit)

Patient Journey Stage	Touchpoint	Channel	Patient Action	Current Problem (Original Kit)	Opportunity in Our Concept
Approaching the kit	Mobile hanging kit + Robot Buddy	Visual + Audio	Walk past or approach kit	Kit is passive; patient must remember measurements	Motion sensing activates the system gently; calming soundscape supports habit formation
Preparing for routine	hanging toiletry bag	Tactile	Open the kit	Plastic box feels clinical, slippery, and cold	Soft fabric + zipper feels domestic, familiar, washable, and non-medical

Appendix

Understanding today's task	Robot Buddy calendar	Visual + Audio	Check whether measurements are needed	Patients forget schedules or feel uncertain	Calendar externalizes memory and reduces cognitive load
Learning how to use a device	Robot Buddy manual guidance	Audio + Visual	Listen to or watch instructions	Paper manuals are loose, ignored, or inaccessible	Spoken and visual step-by-step guidance adapts to user needs; reduces misuse anxiety
Finding the correct device	Hanging pockets with tactile stickers	Tactile + Visual	Identify device by touch or sight	visual-only identification	Shape- and texture-based markers support visually impaired users
Reaching devices	Fold-out fabric panel		Access tools at eye level	Bending down is difficult; cluttered box	Ergonomic access supports fatigue, balance, and safety
Taking weight	Floor-level scale	tactile + Haptic	Step onto scale	Slippery surface; unclear stance; no confirmation	Tactile foot zones + vibration confirm correct positioning and
Taking blood pressure	BP monitor with haptic motors	Haptic	Apply cuff and start measurement	Incorrect cuff placement; stressful noise	Haptic-only feedback guides correct use calmly
Taking temperature	Ear thermometer	Haptic	Place thermometer in ear	Beeps hard to hear; tinnitus; unclear start/end	Distinct vibration patterns and audio cues
Measuring oxygen saturation	Pulse oximeter	Haptic	Insert finger in the oximeter	Visual-only positioning; fragile feel	Tactile borders and vibrations guide correct placement

Appendix

During measurement	Robot Buddy + motion sensors	Digital + Audio	Remain still	Incorrect measurements go unnoticed	System detects instability and prompts correction
After measurement	Robot Buddy interpretation	Visual + Audio	Review feedback	No explanation of values	Immediate validation builds trust and understanding
Sending data	Robot Buddy confirmation	Audio + Visual	Choose whether to send	Patients unsure if data is uploaded	Explicit consent preserves autonomy and transparency
Storing device	Velcro pockets + tactile borders	Tactile	Return device to pocket	Devices shift; hygiene issues	Secure, modular storage reinforces routine and order
Completing routine	sound feedback	Audio	Finish session	No closure or reassurance	Calm completion cue reinforces habit loop
Between routines	Hanging kit as home object	Environmental	Live with kit in space	Medicalization of the home	Toiletry-bag form blends into domestic life