Healthcare professionals' perspectives on development of assistive technology using the Comprehensive Assistive Technology model

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Abstract

Background: The implementation of technology in healthcare shows promising results and provides new opportunities in rehabilitation. However, the adoption of technology into daily care is largely dependent on the acceptance rate of end-users.

Objectives: This study aims to gather information from healthcare professionals on the development of assistive technology that match users' needs using the Comprehensive Assistive Technology model.

Methods: In total 27 healthcare professionals (12 occupational therapists, 8 physiotherapists, 3 nurses, 2 allied health directors, a physician and a speech therapist) attended one of four online focus group discussions. These focus group discussions were structured using a question guide based on three predefined scenarios. Recordings were transcribed and data was analyzed using a thematic analysis (NVivo).

Results: Major themes identified in this study were safety, price and usability. Healthcare professionals focused on both functional capabilities of the user, as well as behavioral aspects of usability and attitude towards technology. Furthermore, the need for assistive devices that were catered towards the limitations in activity and user experience, was highlighted extensively.

Conclusion: Based on information gathered from healthcare professionals a user-centered approach in development of safe, low-cost devices that maximize both functional outcomes and user acceptance, could potentially increase the adoption of new technology in rehabilitation.

Keywords: Healthcare professionals; Technology; Rehabilitation; Qualitative research; Focus Group Discussions.

1. Introduction

Over the last decade, research on sensor-based technology and robotics in the field of rehabilitation has become more and more relevant [1-3]. Literature has shown that the use of rehabilitation technology, which ranges from large robotic devices to smaller, more sensor-based technology, can have a positive outcome on several aspects of rehabilitation [2], but the impact on activities of daily living remains unclear [4]. When looking at rehabilitation robots, mixed results are present. Some studies show a benefit of these devices compared to routine physical treatment [5-7], while others show no added effect of robotics compared to conventional therapy [8, 9]. On the other hand, wearable sensor devices have proven relevant in terms of monitoring movement disorders and giving feedback to the wearer, this for both upper limb rehabilitation [10-12] and balance and gait training [13, 14].

Furthermore, the adoption of technology in rehabilitation has also proven relevant for a wide variety of patients in a telehealth setting. Fritz et al. (2022) reported significant improvement in disability, pain intensity, pain interference, physical function and sleep disturbance for persons with chronic low back pain after telehealth physical therapy [15]. Cerdán-de-Las-Heras et al. (2021) investigated the effect of telerehabilitation in idiopathic pulmonary fibrosis and found an increase in exercise capacity after 3 months of telerehabilitation [16]. Similarly, Campbell et al. (2022) found a decrease in symptoms in mild traumatic brain injury patients after six weeks of telerehabilitation [17].

Nonetheless, the implementation of technological devices for rehabilitation depends heavily on the acceptance rate of the end-users [18-20]. Regarding the perspective of healthcare professionals, cost and reimbursement models were stated as important [21]. In addition, maintenance requirements, a user-friendly device interface, patient safety and ease and time required to fit the device were also identified as relevant conditions [21-23]. Finally, a study by Langer et al. (2019) states that trust in rehabilitation technology is a priority in accepting these devices, this for both patients and therapists [20]. Many recent innovations are predominantly driven by the functional outcomes the devices obtain but have little focus on the behavioral aspect of usability and user experience. Consequently, adopting a human centered approach in development of healthcare technology is important to guarantee an ample adoption in rehabilitation [19, 24]. Human centered design (HCD) can be defined as an iterative, multidisciplinary and people-focused approach to designing products, services or systems [25]. It can be seen as a set of tools for discovering opportunities and generating innovative solutions focused on the needs of people [26].

In line with HCD, several theoretical frameworks have been developed. One relevant framework is the Comprehensive Assistive Technology (CAT) model [27]. This model describes the complex interaction of four components (e.g., Person, Activity, Context and Assistive Technology) in a dynamic framework aimed at finding the place of assistive technology in the lives of persons with disabilities. Within this framework, the assistive technology is seen as an external enabler for the person to perform an activity in a certain context. In other words, the person, activity and context influence the selection and success of the assistive technology [27, 28]. This modelling framework has several relevant application areas: identification of accessibility barriers, analysis of existing assistive technology systems, design synthesis for new assistive technology and end-user assessment, device provision and outcome measurement.

Based on the principles of HCD [25, 29], this study aimed to gather information from healthcare professionals on the development of assistive technology for rehabilitation that match the users' practices, needs and preferences. This paper focuses on the design of three pre-defined scenarios aimed at improving health outcomes, innovate care and optimize the work environment. These scenarios were developed as a result of brainstorming sessions with healthcare professionals of two Belgian hospitals and embedded in a VLAIO (Vlaams Agentschap Innoveren en Ondernemen) TETRA project called SAIRE (Smart devices and Artificial Intelligence for Rehabilitation). This project aims to implement smart devices and artificial intelligence (AI) in healthcare, more specifically in a rehabilitation setting.

The first scenario, a smart walker, involves the implementation of measurement and feedback technology added to any sort of walking aid. During the brainstorming session, the healthcare professionals expressed the need for a device that can be mounted on different types of walking aids and measures certain parameters during gait. Additionally, the device should be able to give feedback to the patient to correct the gait pattern.

The second scenario described by the healthcare professionals was a smart brace system to aid in the rehabilitation of patients suffering from spatial neglect after brain injury. The healthcare professionals described a portable device worn on the affected side which is able to attract the attention of the patient and register if the patient is able to direct the attention to stimuli presented by the device.

The third and last scenario, a smart intravenous (IV) stand is a motorized IV stand able to automatically follow the patient. The healthcare professionals described that a motorized IV stand could potentially be useful for both patients and therapist, as patients would be able to

walk handsfree and therapist could direct more attention to the patient without being concerned about a correct position of the IV stand during therapy.

2. Methods

2.1. Study design

As aforementioned, this explorative qualitative study was part of a larger VLAIO TETRA project called SAIRE between Vrije Universiteit Brussel, Erasmus University College Brussels and Odisee University College for applied sciences (see https://www.saire.be/ for information on the project). Data was collected from focus group discussions with healthcare professionals from different healthcare centers in Belgium. Protocol details were registered (registration number: NCT04833088) and ethical approval was obtained from the medical ethics committee of the University Hospital Brussels and the local Ethical committees of the participating hospitals (BUN: 1432021000461).

2.2. Participants

Dutch speaking healthcare professionals from the rehabilitation units of five healthcare centers were recruited for this study. All healthcare professionals had working experience with patients who use walking aids or other supportive devices. Before the start of the study, all participants received an information document and signed the informed consent. Additionally, all participants completed a short form focusing on demographic information.

2.3. Procedure

Considering the COVID-19 pandemic, all focus group discussions were conducted online using Microsoft Teams or Zoom. Each focus group discussion was led by one moderator (J.V.) and one assistant (R.D.). The moderator facilitated the discussion and ensured that all participants were involved. The assistant made sure the time limit of 90 minutes was respected and took field notes during the conversation. All discussions were recorded with permission of the participants. Data collection was completed when data saturation was reached.

2.4. Question guide

The focus group discussions started with an introduction in which the moderator presented himself and the observer and explained the purpose of the study. Secondly, the participants were asked to shortly introduce themselves and describe any previous experience with assistive technology or technology in healthcare. Thirdly, a short presentation was given that created a global picture of the scenarios. Finally, the discussion between the participants and the

moderator started following a question guide (table 1). If necessary, side questions were used to refocus the conversation and avoid off-topic discussions.

2.5. Data analysis

The recorded focus groups were transcribed verbatim using Word (Microsoft, USA) and all participants were pseudonymized to replace personally identifiable information. A thematic content analysis was performed by R.D. and J.V. using NVivo (QRS International, USA). For this analysis the six steps of Braun and Clarke (2006) were followed [30, 31]. Firstly, the researchers familiarized themselves with the data through repeated reading of the data. Secondly, the initial codes were generated as the researchers begin to take notes on relevant data items. For this next step, the researchers scanned the collated data and took note of all themes that were potentially of relevance to form a thematic map. The fourth step in the thematic analysis involved reviewing the themes. This review was done both within each theme, as between different themes. All codes within a theme were checked to ensure a proper fit within the theme, and all individual themes were assessed in relation to the entire data set, to see whether the thematic map accurately represented the data. In the fifth step, the researchers defined each theme. Additionally, for each theme, the importance to the broader study topic was described. Lastly, the final analysis was written based on all previous steps. The researchers first analyzed the data separately. Afterwards, both researchers compared their analysis and adjusted until agreement was reached. Disagreements were resolved by consensus. Finally, credibility of results was assessed through member checking [32].

In line with the aforementioned CAT model, this qualitative thematic analysis identified relevant elements in the development of assistive technology for rehabilitation. For each scenario, the data provided by the healthcare professionals is reported in line with the four components of the CAT model (e.g., Person, Activity, Context and Assistive Technology).

3. Results

Four focus group discussion were organized with healthcare professionals from five different healthcare centers in Belgium. An overview of the characteristics of the participants is presented in table 2.

In total 27 healthcare professionals (twelve occupational therapists, eight physiotherapists, three nurses, two allied health directors, one physician and one speech therapist) took part in the focus group discussion (four groups of five, seven, eight, and seven participants respectively). Of the 27 participants, 20 were female and seven were male with a mean age of

35.44 ± 9.70 yrs (range: 20-56 yrs). Thirteen participants mainly worked with patients with neurological disorders, nine with patients with musculoskeletal disorders, six with elderly, 2 with patients with psychological disorders and one with patients with respiratory disorders.

3.1. Analysis across scenarios

3.1.1. Person

After analysis of the overall data gathered across the three scenarios, an important focus on the functional capabilities of the patients and the possible limitations these patients experience during functional tasks and activities of daily living can be seen. Nonetheless, a major focus on the behavioral aspects of technology acceptance and attitude towards technology was also extensively discussed across all scenarios. The healthcare professionals often were skeptical towards adoption of the assistive technology as they were not convinced that the functional outcomes gained from using such a device always outweigh the cost of the device. Similarly, they expressed concerns on the use of complex devices that require complicated steps to set-up. A focus on usability and ease-of-use was noticed across all scenarios. Healthcare professionals suggested different functionalities to ensure easy access to comprehensible data provided by the assistive device for both the healthcare professionals and the patients.

3.1.2. Activity

Regarding the activities performed by the users, the importance of linking the activity level with the capabilities of the individual patients was often discussed. Across all scenarios, healthcare professionals expressed the need for devices that can target the specific needs of individual patients and are adjustable towards these needs. As activities performed by the patients often involve a complex interaction of cognitive and motor systems which are influenced by the capabilities of the individual patients, it was suggested that the assistive technology should be easily adjustable towards the specific activities the user needs to perform, but also wants to perform.

3.1.3. Context

Healthcare professionals mainly focused on the physical context in which the devices will be used. Within this physical environment, the main focus of the healthcare professionals was on the use of the device in a hospital setting, as well as in a home-based setting. Both these settings came with their own opportunities and challenges for use mentioned by the healthcare professionals. Only few suggestions were made towards the societal and institutional context in which the assistive devices operate.

3.1.4. Assistive technology

As aforementioned, the healthcare professionals suggested low-cost devices that are adjustable towards the specific needs of individual users and are easy to use. By implementing these elements in development, the healthcare professionals expressed confidence that a good adoption of the devices could be ensured.

In the following sections the results for each scenario are reported. Table 3 gives an overview of the results.

3.2. Analysis of the smart walker scenario

3.2.1. Person

Healthcare professionals mentioned that a variety of patient populations experience difficulties during walking and are at an increased risk of falling. Based on the pathology, different problems will occur. Older adults for example often take smaller steps and have a narrower gait pattern and base of support. Furthermore, the healthcare professionals mentioned an asymmetrical and slow gait pattern, crossing of the legs during gait, reduced stride length, abnormal heel strike and toe off, etc.

"… because that's the thing you often see with elderly. They have a narrower step width and base of support during walking …" (Participant 3, focus group 1)

Related to the use of a walking aid (e.g. walker, crutches, etc.), the healthcare professionals expressed concerns about the distance of the walking aid relative to the patient. The healthcare professionals described that patients tend to walk further away from their walker in difficult or challenging situations. Furthermore it was mentioned that patients often place to much pressure on the handles of their walking aid. In view of this, it was described that patients who place more pressure on the walker tend to need more support and are at higher risk of falling. Patients tend to walk more tensed or strained when they are afraid or feel less confident during gait.

"… people that put a lot of pressure on the handles, which is a sign of being more tense … that they are insecure." (Participant 1, focus group 4)

3.2.2. Activity

As aforementioned, gait difficulties were described intensely by the healthcare professionals. It was mentioned that patients often require feedback on different gait parameters during walking and this feedback is currently given to the patient during therapy by the healthcare professionals.

"Most of the time, we pretend to be a metronome and for example say left, right, left, right, … in a certain rhythm." (Participant 5, focus group 3)

However, the healthcare professionals suggested the possibility of real-time feedback given to the patient by their assistive device. This way the healthcare professionals can focus on different aspects of rehabilitation while still ensuring a correct gait pattern for the patient. Furthermore, if the assistive device is able to give feedback to the patient, it provides opportunities for patients to rehabilitate outside of their physical therapy in a home setting. The healthcare professionals also highlighted the possible motivational aspect of easily accessible data and comprehensible feedback. When patients can check their progression in an easy and comprehensible manner, they might be more motivated to move on their own without supervision of the healthcare professionals.

3.2.3. Context

Related to the influence of the context in which patients experience gait difficulties, healthcare professionals describe that the physical context of the hospital setting can influence the patients' gait, as the small hospital rooms create a challenging environment which could potentially lead to falls. But similarly, at home a lot of obstacles (e.g. a coffee table, a rug, etc.) are present that create potentially dangerous situations.

"… but now I'm talking about the obstacle course of the hospital room again … a patient will never walk the same way in their room, compared to the corridor for example." (Participant 9, focus group 3)

On the other hand, healthcare professionals mention that providing a way for patient to receive feedback in a home context, might motivate patients to exercise more outside of therapy.

"Maybe during the weekend, it can be a motivation to start moving on their own without therapy." (Participant 1, focus group 2)

3.2.4. Assistive technology

Regarding the assistive technology as an enabler for the activity, the healthcare professionals described a smart walker system that supports gait and can provide different types of feedback on different gait parameters. The potential added effect of both visual and auditory cues on gait parameters were highlighted.

"It would be good if you could project something visually as well, for example where they should place their feet." (Participant 5, focus group 3)

The following gait parameters were suggested as potentially relevant for inclusion in the smart walker system: position of the feet relative to the walker, stride length, step width, base of support and gait speed. Additionally, the healthcare professionals suggested the possibility of measuring the differences between the left and the right side of the body during gait.

But as mentioned earlier under the human component of the CAT model, individual patients experience different problems during walking so a one-size-fits-all design is not applicable. Considering this, the healthcare professionals stated the importance of adjustable feedback and the ability to specify the feedback given by the smart walker towards the needs of the individual user.

"... but if you could adjust this based on the patient who is walking with it, that would be good." (Participant 5, focus group 3)

Furthermore, to ensure good adoption of the device in daily care, the healthcare professionals highlighted the importance of ease of use. Both therapist and patients should be able to easily utilize the walker and extract data from the device without excessive connections to other devices or cumbersome steps to acquire data.

"But if it really has to be used in a rehabilitation setting or a clinical setting, then you have to translate this into a good dashboard or an app or something that is very user-friendly." (Participant 3, focus group 4)

3.3. Analysis of the smart brace scenario

3.3.1. Person

With regard to the second scenario, the healthcare professionals described that patients after severe stroke potentially suffer from a wide range of comorbidities related to their stroke, of which one is spatial neglect.

"People with major cerebral infarction or cerebral bleeding often suffer from a number of combined disorders, of which one is neglect." (Participant 3, focus group 4)

The complex nature of neglect was intensely discussed, and it was described as an umbrella term that incorporates different physical and cognitive symptoms.

Additionally, it was mentioned that patients who suffer from neglect often do not realize they are neglecting one side of the body. To them they have no problem. For example, patients who only finish one side of their plate while eating, and do not realize the other half of the plate is still full of food.

"… when you're eating and, the classic reaction of only eating from one side of the plate." (Participant 2, focus group 4)

3.3.2. Activity

Healthcare professionals highlighted the inability of patients who suffer from spatial neglect to direct their attention towards one side of the body or the spatial environment. This often results in a reduced usage of the affected side of the body compared to the unaffected side.

"… because we see that all the attention goes towards the good side and they lose attention for the neglect side" (Participant 5, focus group 3)

Furthermore, the healthcare professionals expressed concern regarding the inattention as this could result in injury of their affected side. For example, if the arm is constantly hanging without any support. Over time, this could result in damage to the shoulder joint. Moreover, the healthcare professionals also mentioned the risk of patients injuring their affected side due to collision with objects or getting stuck. For example, patients in a wheelchair getting their hand or fingers caught in the wheels of their wheelchair.

"This is potentially dangerous when people use a wheelchair […] their hand getting caught in the wheel" (Participant 3, focus group 1)

3.3.3. Context

Healthcare professionals focused on two aspects of context while discussing the second scenario. Related to the physical context, healthcare professionals described the stimuli-rich environment patients often rehabilitate in. This overload on information might influence the ability of patients to direct their attention towards specific points during therapy. It might be beneficial for patients to rehabilitate in an environment with only few stimuli, and gradually build up towards a more complex environment.

"… but in daily practice, there are constant changes to the amount of stimuli those people experience […] it's strictly the environment that is making the difference" (Participant 1, focus group 4)

Furthermore, the healthcare professionals heavily focused on the social context in which patients with neglect function. As aforementioned, these patients often do not realize they are neglecting one side of their body so healthcare professionals or other people have to remind the patients. Healthcare professionals mentioned that it is important for family members or other people closely related to the care of the patients to support the patients outside of therapy to maintain attention to both sides of the body.

"… a third party will always have to be involved […] a therapist, a roommate or a nurse …" (Participant 5, focus group 3)

3.3.4. Assistive technology

The assistive technology described by the healthcare professionals involved a smart brace system worn on the affected side that is able to direct the attention of the patients towards their affected side using different types of stimuli. The healthcare professionals suggested three different types of stimuli: auditory, tactile and visual stimulation. Considering this, several healthcare professionals added that a combination of the different stimuli might be beneficial to attract the attention of the patient in as much ways as possible.

"It would be good if this was auditory, as well as visual and sensory at the same time. This way you can direct the attention to that side as much as possible." (Participant 4, focus group 3)

Moreover, the healthcare professionals stated that the possibility for the therapists to adjust the parameters of stimulation (e.g. intensity, timing and type of stimulation) might prove beneficial in personalizing therapy towards the needs and preferences of the patients. The healthcare professionals discussed both the time schedule during which the patient is stimulated, as well as the frequency at which stimuli are given. The possibility to implement a time schedule in the device to ensure that patients are not stimulated during rest periods (e.g., during sleep), and more frequently stimulated during therapy time was suggested.

When discussing the usefulness of the smart brace during rehabilitation, the healthcare professionals stated that the device could be a useful tool for patients to rehabilitate without the supervision of a therapist. The brace can easily be used to aid the patient in directing attention to the neglected side when completing activities of daily living. During therapy, the patient receives extra stimulation added to their treatment and after therapy, the device can still stimulate the patient to maintain attention to the affected side without the help of a healthcare professional. To achieve a good effect, it was suggested that the patient wears the brace for long periods of time during the day to maximize the period in which the patient is stimulated.

"I think we should go for as long as possible during the day, because we know it has little effect otherwise." (Participant 5, focus group 3)

Ease of use, for both patients and therapists, was another important element discussed by several healthcare professionals. The brace should be easy to use and adjustable to the size of the patient. Additionally, low maintenance and easy to wash were mentioned.

"The easier to use, the better right? For every party involved." (Participant 3, focus group 3)

In terms of ease of use, easily accessible data was also specified. The healthcare professionals suggested the possibility of a smart watch system which directly shows the data, without connecting to external devices.

3.4. Analysis of the smart IV scenario

3.4.1. Person

Within the last scenario, the healthcare professionals described the burden of hospitalized patients while using an IV-stand. These IV-stand are often difficult to maneuver and might increase the risks of falls in certain patients. As patients who have been hospitalized for long periods of time experience some form of muscle weakness or reduced functional capacity, they might require support during walking. But due to the IV-stand they are not able to use certain forms of walking aids or constantly require support of a healthcare professional. This could result in increased sedentary behavior, which further limits the patient's recovery.

"... people who have limited mobility [...] they seek support, or they see an IV-stand and hold on to that for support." (Participant 6, focus group 2)

3.4.2. Activity

The activity described by the healthcare professionals for the last scenario mainly involved walking in the corridors of the hospital and the hospital rooms. This both during therapy time with support of a healthcare professional, as well as outside of therapy. Healthcare professionals discussed how patients and therapists maneuver the IV stand and how this might limit the functional capacity of the patient or the amount of support a therapist can give. For example, in the pediatric ward, parents are not able to hold their child while walking independently as they have to maneuver the IV-stand with one hand.

"In the pediatric ward, [...] I sometimes have a feeling that parents, nurses or even us, have our hands full with the child [...] and then you still have to carry the IV-stand with you as well." (Participant 2, focus group 1)

3.4.3. Context

First, the healthcare professionals mainly focused on the physical context in which an IV-stand is used. The healthcare professionals extensively described how patients walk with the IV-stand in the complex environment of the hospital. The corridors of the hospital are often narrow and crowded which might make it difficult to navigate. Additionally, the maneuvering of the IV-stand in smaller rooms like toilets or hospital rooms was highlighted. Within this physical

context, it was mentioned that patients often bump into objects or even other people with their IV-stand. This in turn creates dangerous situations as people might trip over the IV-stand.

"To me the most difficult part of the IV stand is the base. It's often very big causing the therapist or the patient to trip over it frequently." (Participant 6, focus group 3)

Secondly, the institutional context was briefly mentioned as healthcare professionals described the laws surrounding the mandatory brake system required on IV-stands.

3.4.4. Assistive technology

For this last scenario, a motorized smart IV system was suggested able to automatically follow the patient during walking. By incorporating an automatic following function, patients can walk handsfree in the corridors of the hospital. This might improve the physical activity level of the patients as they are no longer limited by the burden of maneuvering the IV-stand. But as aforementioned, patients who are hospitalized for longer periods of time often experience some sort of reduced functional capacity, it was proposed to incorporate a fall detection and risk assessment system. This could either be through an alarm signal installed on the IV stand or through a connection with the central alarm system of the ward.

"… so when he falls and can't reach the bell […] it gets forwarded…" (Participant 3, focus group 1)

Furthermore, the healthcare professionals specified that the auditory signal used for fall detection might be useful in other situations as well. It also seemed relevant as a warning signal in terms of problems with the IV leads (e.g., tangling of the cables), connection problems with the sensor or registration from obstacles (e.g. a door that swings open or objects on the floor).

Related to the narrow corridors and small rooms mentioned earlier, the position of the smart IV stand relative to the patient was an important element discussed by the healthcare professionals. It was specified that both next to the patient as well as behind the patient are good positions to follow the patient. But the healthcare professionals warned that difficulties might come up in narrow corridors and small rooms when the IV stand follows alongside the patient. This might pose difficulties in developing the smart IV-stand due to the complex environment of the hospital.

"I would say behind the patient, because narrow corridors might make it impossible to stay next to the patient." (Participant 5, focus group 2)

Lastly, the healthcare professionals expressed concern regarding the correct tracking of the patient. Since traction or tangled IV leads should always be avoided, this must be considered

during development. A system was suggested that ensures the IV stand maintains a safe distance from the patient and automatically adjust its position when risk of traction or tangled leads occurs.

"… at the top there is some sort of loop [..] and this loop instantly registers … ow there is traction on the leads…" (Participant 5, focus group 2)

4. Discussion

This study aimed to gather information from healthcare professionals on the development of assistive technology based on three predefined scenarios using the CAT model. The results gathered from this study shows that the focus of healthcare professionals in development of assistive technology is predominantly on a user-centered approach where safety and ease of use for both patients and healthcare professionals are a core concept. Furthermore, the device should be low cost, as this could potentially facilitate adoption in therapy.

This study further highlights the importance of a human-centered approach in development of assistive technology. HCD has been used in a wide variety of healthcare settings and has proven to be effective in developing therapy modalities, assistive devices and many other aspects of healthcare. For example, Krainer et al. (2022) investigated the design requirements for a telerehabilitation platform for stroke patients [33]. In this study, an iterative process was described that focuses on user's needs during development with the goal of maintaining a continuous user-driven approach. Krainer reported that the HCD process was time-consuming and required intense communication between developers and researchers. Nonetheless, they were able to design a telerehabilitation system that fulfills the requirements of the therapists involved in the process [33]. A study by Gagnon et al. (2021) applied the HCD approach for development of an immersive and interactive platform for cognitive assessment and rehabilitation [34]. Gagnon et al. (2021) adopted a multidisciplinary approach to development in which the need for the platform was determined through active discussions with healthcare professionals and viability was tested through collaborations with clinical sites. Additionally, two preliminary acceptability studies using the platform were performed and reported positive results on acceptability and tolerability of healthy participants [34]. This further highlights the importance of adopting a HCD approach to ensure high levels of technology acceptance. When looking into the results of this study, a predominant theme of ease of use and usability was present across all focus group discussions and all scenarios. As aforementioned, the adoption of technology in healthcare is heavily dependent on the acceptance of the end-users [18-20]. Vaezipour et al. (2019) states that a user-centered approach is required to support the

development of rehabilitation technologies that maximize both user acceptance and functional outcomes [18]. This is also in line with other literature on the assessment of technology acceptance and usability. One of the most important models related to technology acceptance and usability is the Technology Acceptance Model (TAM) by Davis (1985), which assumes that the perceived ease of use and perceived usefulness are the primary factors influencing an individual's intention to use new technology [35]. The TAM suggests that the acceptance of technology by users can be increased if development and efforts to improve the technology are driven by the attitude of the users towards the technology. In other words, this model provides a direct link between acceptance of technology and the technology's perceived usability and ease of use [36]. Lin et al. (2016) presents the design of a wearable instrumented vet for posture monitoring and verified usability using a TAM-based questionnaire [37]. This study reports a negative correlation between technology anxiety and perceived ease of use. Furthermore, positive correlations were found between perceived ease of use and perceived usefulness, perceived ease of use and attitudes towards using the device, perceived usefulness and attitudes towards using the device, and lastly between attitude and the behavioral intention of using the device [37]. In line with the results from the current study, these findings all highlight the importance of ease of use and usability as the driving force for development of assistive technology to ensure ample adoption into healthcare.

4.1. Strengths, limitations and recommendations for future research

An important strength of this study was the use of focus group discussions to gain insight into the thoughts and opinions of the healthcare professionals. Based on Guest et al. (2016) who reported that 90% of the themes can be discovered in three to six focus groups [38], the number of focus groups organized was sufficient to gain enough insight in the topics researched in this study. Furthermore, our study invited several different healthcare disciplines to join the focus group discussions. This gives us an overview of the opinion of different disciplines which strengthens potential adoption in daily care.

One of the limitations of this study was related to the sample selection. For this study only healthcare professionals were invited to participate in the discussions. Having representation of patients would enrich the analysis by providing insights in the needs and recommendations of an important group of end-users. Furthermore, all focus group discussions were organized online which posed some difficulties in ensuring that all participants were equally engaged in the discussions.

In summary, several important overarching themes were identified while discussing the development of assistive technology: (1) ease of use and technology acceptance, (2) the price of technology and lastly, (3) safety. These themes could provide interesting topics in future research on the development of assistive technology in healthcare. Based on the findings of this study, three devices will be developed and tested. Initial testing will be done in a laboratory setting to assess the effectiveness and ease of use of the devices. Finally, all devices will be tested in a larger clinical setting.

5. Conclusion

The results of this study gain insights into the needs and recommendations of healthcare professionals related to the development of assistive technology for use in healthcare and provide a comprehensive overview of perspectives. Overall, a user-centered approach is recommended to ensure that user-acceptance and functional outcomes are maximized. Assistive technology should be safe, low cost and easy to use for both patients and healthcare professionals, as this could potentially increase the adoption of new technology in healthcare.

6. Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committees of the University Hospital Brussels in collaboration with Algemeen Ziekenhuis Sint-Maria Halle (B1432021000461).

7. Informed consent statement

Informed Consent was obtained from all subjects involved in the study.

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9. Declaration of interest

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11. Tables

Table 1: Question guide used during the focus group discussions

Question type	Question
Opening	What is your function in the hospital?
Introduction	Do you have any experience with the use of assistive technology in healthcare?
Presentation of the smart walker	
Key	For whom do you think the device is most useful?
	What should the device be able to do?
	What should the device be able to measure?
	What other features might be useful for this device?
	What are potential barriers in use or problems that come to mind?
Presentation of the smart brace	
Key	For whom do you think the device is most useful?
	What should the device be able to do?
	What should the device be able to measure?
	What other features might be useful for this device?
	What are potential barriers in use or problems that come to mind?
Presentation of the smart IV stand	
Key	For whom do you think the device is most useful?
	What should the device be able to do?
	What should the device be able to measure?
	What other features might be useful for this device?
	What are potential barriers in use or problems that come to mind?
Ending	From everything that was mentioned, what is the most important element for you?
	Are there any remarks?

Table 2: Characteristics of healthcare professionals

Characteristics of health care professionals (n= 27)		
Sex (n, %)	Male	7 (25.9%)
	Female	20 (74.1%)
Age (mean yrs ± SD) + range		35.4 ± 9.7 yrs (range: 20-56 yrs)
Profession (n,%)	Occupational therapist	12 (44.4%)
	Physiotherapist	8 (29.6%)
	Nurse	3 (11.1%)
	Physician	1 (3.7%)
	Allied health director	2 (7.4%)
	Speech therapist	1 (3.7%)
Experience with (n, %)	Musculoskeletal disorders	9 (33.3%)
	Elderly	6 (22.2%)
	Neurological disorders	13 (48.2%)
	Respiratory disorders	1 (3.7%)
	Psychological diseases	2 (7.4%)

Abbreviations: SD: standard deviation

Table 1: Summary of the analysis of the three scenarios using the CAT model

CAT model	Results
General analysis across scenarios	
Person	Functional outcomes and behavioral aspects
Activity	Activity linked to the individual capabilities of person
Context	Main focus on physical context
Assistive technology	Safe, low cost, easy to use
Analysis of the smart walker scenario	
Person	Gait difficulties, increased fall risk, different per pathology
Activity	Require feedback during gait
Context	Hospital, home setting
Assistive technology	Gait support, different types of feedback, adjustable feedback
Analysis of the smart brace scenario	
Person	Comorbidities related to stroke, patient attitude towards neglect
Activity	Inability to direct attention, injury due to inattention
Context	Stimuli-rich environment, social context
Assistive technology	Different type of stimuli, adjustable parameters
Analysis of the smart IV scenario	
Person	Difficulties maneuvering IV stand, increased sedentary behavior
Activity	Handsfree gait impossible
Context	Crowded corridors, small rooms
Assistive technology	Motorized, tracking of user, risk assessment and fall detection

Abbreviations: CAT model: Comprehensible Assistive Technology model