eRehabilitation after stroke: the interplay between the effectiveness, the implementation and the context

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Summary & General Discussion

SUMMARY

Aim of this thesis

Stroke is a relatively common condition with a large impact on patients' lives. Rehabilitation treatment aims to support patients in coping with the physical, mental and cognitive consequences of stroke. Although technologies are increasingly available for rehabilitation purposes, the actual use of eRehabilitation in clinical practice after stroke can be improved.

The main aim of this thesis was to gain insight in the interplay between the effectiveness, the implementation, and the context in which eRehabilitation after stroke will be used, as delivered in a specialised rehabilitation facility. To study this interplay, the sub aims were:

1. Identify the (most important) barriers and facilitators of patients, informal caregivers and healthcare professionals regarding the use of eRehabilitation after stroke;
2. Investigate the effectiveness of a multidisciplinary eRehabilitation intervention embedded in conventional stroke rehabilitation, using a hybrid implementation and effectiveness study design;
3. Investigate what works and why in the implementation of a multidisciplinary eRehabilitation intervention in conventional stroke rehabilitation, by using a hybrid implementation and effectiveness study design.

Main findings

In Chapters 2, 3 and 4, the barriers and facilitators perceived by patients, informal caregivers and healthcare professionals for the use of eRehabilitation after stroke were identified and prioritized ***(Aim 1)****.*

Chapter 2 concerned a qualitative focus group study aiming to identify expected barriers and facilitators for the use of eRehabilitation after stroke. Expected barriers/facilitators were investigated by means of eight focus groups; six focus groups with in total 32 stroke patients and 15 informal caregivers, and two focus groups with in total 13 healthcare professionals (rehabilitation physicians, physiotherapists, occupational therapists, psychologists and managers) involved in stroke rehabilitation. Focus groups were audiotaped, transcribed in full and analysed by direct content analysis according to the implementation model of Grol. A total of 14 influencing factors were found, which were classified to five of the six levels of the implementation model: Innovation, Organizational context, Individual patient, Individual professional, Economic & political context. Most quotes from patients, informal caregivers and healthcare professionals were comparable and classified to the level of the Innovation (e.g. content, attractiveness and feasibility of an eRehabilitation intervention). In addition, patients' responses were relatively often classified at the level of the Individual patient (e.g. patients characteristics as fatigue and the inability to understand ICT devices). For the healthcare professionals, relatively many quotes were classified to the level of the Organizational context (e.g. having sufficient time and the shift in tasks and responsibilities in conventional rehabilitation). It was concluded that there was considerable overlap in reported factors between patients/informal caregivers and healthcare professionals

regarding the level of innovation. However, patients/informal caregivers put particular emphasis on factors related to the Individual patient whereas healthcare professionals emphasized the importance of factors related to the Organizational context.

In **Chapter 3**, a large scaled national cross-sectional survey study is described, that aimed to investigate which expected barriers and facilitators that were identified in Chapter 2 are most important in the use of eRehabilitation. Based on the outcomes of the qualitative study, 88 statements about barriers and facilitators potentially influencing the intention to use eRehabilitation were scored on their importance for using eRehabilitation (1-4; unimportant-important). Besides, the survey included one statement about the willingness to use eRehabilitation in the future (yes/no). A one-time online survey was conducted among 125 stroke patients, 43 informal caregivers and 103 healthcare professionals (physicians, physiotherapists, psychologists). The 88 statements were allocated to and grouped into 16 factors of the implementation model of GroI using factor analyses. Next, univariate logistic regression analyses were used to assess the association between the 16 factors (the independent variables) and the intention to use eRehabilitation (the dependent variable). All factors that were positively associated with the intention to use eRehabilitation in the univariate analyses were entered simultaneously in a multivariable logistic regression analysis. This multivariable analysis showed that the intention to use eRehabilitation was positively influenced by perceived benefits for patients (i.e. reduced travel time, increased motivation, increased health-related outcomes), for patients (OR 2.68, 95%CI 1.34-5.33), informal caregivers (OR 8.98, 95%CI1.70-47.33) and healthcare professionals (OR 3.87, 95%CI 1.41-10.64). However, insufficient knowledge about the use of eRehabilitation was associated with a decrease in intention to use eRehabilitation for patients (OR 0.36, 95%CI 0.17-0.74). It was concluded that although differences were found between patients/informal caregivers and healthcare professionals, perceived benefits of the use of eRehabilitation facilitated willingness to use eRehabilitation for patients, informal caregivers and healthcare professionals.

Contextual factors not only concern the local context but also national or cultural aspects. To get more insight in the impact of international and intercultural aspects, in **Chapter 4**, an international comparison between Brazilian and Dutch healthcare professionals (BHP and DHP) regarding factors influencing the use of eRehabilitation was made. The survey used in Chapter 3 was translated into Portuguese and administered to 99 BHPs (physical therapists, rehabilitating physicians and psychologists, nurses, hospital educators, physical education teachers and neurologists). To compare the responses of the BHPs with the DHPs, a top-10 most and a top-10 least important statements for Brazil and The Netherlands was composed by calculating the median importance score of each of the 88 statements in the survey. In the top-10 most influencing statements, four statements were found in both top-10's of the BHPs and DHPs, the other six statements differed. Overlap concerned the ease of use and better health-related outcomes after the use eRehabilitation. Concerning the disagreeing statements of the top-10, most important for BHPs were sufficient support from the rehabilitation centre with respect to resources and time. DHPs rated the feasibility of the use of eRehabilitation for the patient (i.e. a helpdesk and good instructions) as most important for effective use. Top-10 least important statements were mainly similar; eight

statements were found in both the top-10's of BHPs and DHPs, related to problems caused by stroke (i.e. aphasia or cognitive problems) or problems with resources (i.e. hardware and software). Therefore, it was concluded that the use of eRehabilitation after stroke by BHPs and DHPs is partly influenced by different factors but there is also a considerable overlap in less important factors. To develop an effective implementation strategy, barriers and facilitators specific for each county needs be taken into account.

Using the knowledge of the studies described in the Chapters 2, 3 and 4, an eRehabilitation intervention and accompanying implementation strategy was developed and carried out at two locations of a specialized rehabilitation facility. In Chapter 5, the effectiveness of this multidisciplinary eRehabilitation intervention implemented in clinical stroke rehabilitation was investigated ***(Aim 2)****. In Chapter 6, the accompanying implementation strategy was evaluated* ***(Aim 3)****.*

Chapter 5 concerned an observational study with a clinical pre-post design, comparing outcomes of stroke patients admitted in a period where only conventional rehabilitation was offered (control group, n=153) with patients admitted in a period where stroke rehabilitation was combined with eRehabilitation (intervention group, n=165). This multidisciplinary eRehabilitation intervention, named Fit After Stroke @Home (Fast@home), comprised one digital environment with possibilities for cognitive and physical exercise programs, wearable activity-tracking devices and online psycho education, and was delivered alongside conventional rehabilitation. All patients in the intervention group were given access to the psycho education and if beneficial, one or more of the other applications was offered by the treating healthcare professional. Primary outcomes included seven domains of the Stroke Impact Scale (SIS; hand function excluded because of an administration error) and secondary outcomes included measures of health-related quality of life, fatigue, self-management, participation and physical activity. Measurements were done at admission (T0), and three and six months thereafter (T3, T6). Change scores between T0-T3, T3-T6 and T0-T6 were compared between the intervention and control groups by means of analysis of variance and linear mixed models, adjusted for potential confounders including age and type of rehabilitation (inpatient or outpatient). In the intervention group, 82 (50%) patients received the intervention, of whom 54 (66%) used one or more applications. In the first three months of rehabilitation, no differences between the total intervention and control groups were found. Between three and six months, a favourable effect of the intervention was found for the SIS domains Communication (p=0.026) and Physical strength (p=0.010), although the mean change scores were all below the minimally clinically significant difference. No significant differences were found for other outcome measures, between T0-T3, T3-T6 or over all time points. When only those who used the intervention were compared with the control group (per protocol analysis) the favourable effect on the SIS domains Communication (p=0.019) and Physical strength (p=0.008) was confirmed, supplemented with a favourable difference in the domains Memory (p=0.031) and Meaningful activities (p=0.040). The conclusion of this study is that a comprehensive eRehabilitation intervention combining multiple applications, offered alongside conventional stroke rehabilitation, is beneficial regarding the maintenance

of some of the improvements obtained directly after stroke. This was based on small, yet statistically significantly greater improvements of communication and physical strength in the intervention group between three and six months after starting rehabilitation.

In **Chapter 6**, the implementation strategy was evaluated according to the Medical Research Council framework. The objectives were 1) to describe the implementation process of Fast@home (dose, fidelity, adaptations and reach), 2) to explore the mechanisms of impact (participants' responses and interaction with Fast@home) and 3) to identify contextual factors influencing the implementation. The predefined implementation activities included information provision for healthcare professionals and patients, integration of the intervention into conventional rehabilitation, instruction, practical support and motivation of professionals directly involved. Implementation activities were carried out over a 14-month period in a specialized rehabilitation facility. A mixed-methods design was used; qualitative data included field notes made during the implementation and in-depth interviews were conducted after the intervention period was ended with 11 healthcare professionals involved in Fast@home. Quantitative data included the user data of the applications in Fast@home and surveys conducted among 73 patients and 51 healthcare professionals. The surveys comprised questions regarding the use of and satisfaction with the intervention (5 items, range 0-10), the awareness and influence of the implementation activities (7 items for patients, 9 for healthcare professionals, range 0-10) and contextual factors influencing the use of the intervention (9 items for patients, 11 for healthcare professionals, range 0-10). Descriptive statistics were used for quantitative data, thematic analyses for qualitative data. Implementation activities were evaluated by field notes, surveys and user data; mechanisms of impact by surveys; contextual factors by field notes and interviews. All planned activities were delivered, although some less frequently then planned (fidelity), whereas some additional supporting activities were delivered to enhance the implementation in a changing context (adaptations). Of the 51 professionals included in the survey, 31 were trained to deliver the intervention and 25 (75.8%) of those 31 delivered it. Of the 165 patients included in the effect evaluation, 82 (49.7%) received the intervention, of which 54 (65.8%) used it. Concerning the mechanisms of impact, professionals and patients were equally satisfied with the implementation activities (median score 7.0 (IQR 6.0-7.75) versus 7.0 (6.0-7.5)), but patients were more satisfied with the intervention (8.0 (IQR 7.0-8.0) versus 5.5 (4.0-7.0)). The rating of impact on the implementation showed highest scores for, amongst others, personal guidance by professionals (patients) and use of ambassadors and time given for training (professionals). Professionals rated the integration into conventional rehabilitation as insufficient. Contextual factors hampered the implementation, including unexpected financial cutbacks and technical setbacks. It was concluded that main areas for improvement of the implementation of eRehabilitation appear to be related to healthcare professionals' perceptions on the intervention, actual integration of eRehabilitation into conventional rehabilitation, as well as contextual, mostly technical and organizational factors.

GENERAL DISCUSSION

The effectiveness of eRehabilitation is not only influenced by the intervention itself, but also by the implementation strategy and the context in which the intervention is implemented. These latter two aspects often vary from one intervention, organisation or country to the other [1,2]. This complex interplay between the effectiveness, the implementation and the context of an eRehabilitation intervention in stroke care constitutes the focus of the present thesis.

The Fit After Stroke @Home (Fast@home) project is the central study in this thesis. It consisted of the following phases (Figure 1): 1. a thorough and structured investigation of the anticipated barriers/facilitators in the context of the specialised rehabilitation facility. With this information, an eRehabilitation intervention and a tailored implementation strategy were developed, simultaneously with the control period of the effect study. After this, 2. the effectiveness; and 3. the implementation strategy of the eRehabilitation intervention was evaluated. Studying these three different phases in the same clinical setting enabled us to interpret the effect of the intervention in the context in which it was used and evaluated the extent to which the implementation and context influenced the effects.

Considering the results of the studies, this thesis leads to a deeper understanding of how and why eRehabilitation works, compared to merely studying the effectiveness of an eRehabilitation intervention as independent tool. Apart from the relevance of the results for patients and healthcare professionals, the outcomes can be used to inform other stakeholders, including directors, managers and policymakers regarding the future implementation and upscaling of eRehabilitation [3]. This chapter discusses the interplay between the multiple phases of the research projects (the effectiveness, the implementation and the context). Besides, recommendations for future research and clinical practice are given.

Figure 1. Interplay between studies included in this thesis, concerning the context (green, Chapters 2-4), the effectiveness of the intervention (orange, Chapter 5) and the implementation (blue, Chapter 6)

Part 1: The interplay between the effectiveness, implementation and context

1.1 Barriers and facilitators in the context of eRehabilitation

Several studies in this thesis (**Chapters 2-4 and 6**) describe barriers and facilitators regarding the use of eRehabilitation among multiple groups of end-users (patients, informal caregivers and healthcare professionals) at multiple time-points (before and after implementation) in a specialised rehabilitation facility. Up to now, most studies investigating barriers and facilitators for the implementation of eRehabilitation included only one group of end-users and were performed only before [4-6] or during/after [7-11] the use of an eRehabilitation intervention.

1.1.1 Multiple perspectives

By investigating multiple end-users, it was shown that the expected barriers and facilitators for the use of eRehabilitation among different groups of end-users were only similar to a limited extent. All groups of end-users expected that a specific eRehabilitation intervention, the Fast@home intervention, would add value to conventional stroke rehabilitation (e.g. by possibilities for additional online training or information provision). On the other hand, end-users also reported barriers and facilitators that were specific to their personal situation. Patients mainly reported barriers and facilitators related to their personal situation, including reasons to use eRehabilitation (i.e. the potential to reduce travel time and possibilities to continue treatment after discharge) and hampering characteristics related to their stroke (e.g. fatigue and lack of understanding of ICT devices). Healthcare professionals, on the other hand, reported barriers related to the organisation of eRehabilitation and defined some organizational requirements (e.g. tasks and responsibilities of both rehabilitation centre and healthcare professionals, and resources like hardware).

Although differences in expected barriers and facilitators between groups of end-users might seem obvious, more attention for these different perspectives in research and clinical practice is necessary. Only one other study was found to investigate barriers and facilitators for stroke eRehabilitation among more than one group of end-users [12]. In line with our study, differences in barriers and facilitators between end-users were observed. Based on the findings of this and our study, it can thus be concluded that important information will be missed when the perspective of only one group of end-users is taken into account. As a result, not acting on unidentified barriers is likely to lead to a less effective implementation strategy. After all, a proper fit between the implementation strategy and barriers and facilitators as perceived by *all* end-users is crucial for an optimal use of eRehabilitation interventions [13].

1.1.2 Expected versus experienced factors

Next to the exploration of *anticipated* barriers and facilitators prior to the implementation of eRehabilitation (**Chapters 2 and 3**), we investigated which barriers and facilitators were *actually experienced* by healthcare professionals (**Chapter 6**), resulting in interesting differences. Prior to the implementation, healthcare professionals mainly had concerns about the organisation of the eRehabilitation intervention, as discussed above. During

the implementation, healthcare professionals experienced barriers regarding the integration of eRehabilitation into conventional care pathways and the actual delivery of eRehabilitation. These barriers pertained to the eRehabilitation intervention (e.g. lack of proven effectiveness), the implementation process (e.g. insufficient time to become familiar and to use the eRehabilitation intervention during conventional therapy, and insufficient integration in conventional rehabilitation) and the context in which healthcare professionals had to use the eRehabilitation intervention (e.g. financial cutbacks, low priority for the implementation among managers and rehabilitation physicians).

To counteract the additional barriers that were not anticipated, it is recommended to monitor barriers and facilitators at multiple time-points during the implementation phase and act on them directly if needed. Indeed, additional implementation activities were undertaken when new barriers were noticed; e.g. insufficient time to learn how to use the eRehabilitation intervention was solved by additional instructions and more time to get familiar with eRehabilitation. However, these adjustments were done ad hoc and were not formally evaluated at predefined time points. The use and subsequent effect of the eRehabilitation intervention in our study may have been larger if we monitored the use of the eRehabilitation intervention better, performed additional analyses of barriers, and had systematically undertaken actions to improve the use, including an evaluation of the effects of those actions. Although interim adjustments of the implementation strategy are recommended in literature, hardly any study has so far planned or conducted these [14].

1.2 Effect of eRehabilitation

In **Chapter 5**, the effects of the eRehabilitation intervention are evaluated. This evaluation did not show significantly better health-related outcomes in stroke patients for the Fast@home intervention group as compared to those in the control group during the first three months of rehabilitation. Possibly, the additional effect of the Fast@home intervention was not large enough to detect significant differences during the first three months of treatment. This hypothesis is supported by the experience that most progress in stroke rehabilitation is established during the first three months [15,16]. Neither randomized controlled trials [17-22] nor several systematic reviews [23-25] that investigated the effects of adjuvant eRehabilitation among stroke patients reported better outcomes in favour of the intervention groups during the first three months of rehabilitation treatment.

In contrast with the first three months, between three and six months some statistically significantly greater improvements in the intervention group as compared to the control group were observed. The observed mean differences were, however, relatively small, and, if available, did not exceed the minimally clinically important difference. The improvements between three and six months became somewhat larger if only the users of the intervention were compared to the control group. This delayed effect may be explained by a larger contrast between intervention and control group; with the rehabilitation trajectories mostly finished, the effect of doing more exercises at home will be more pronounced. Two studies evaluating the effects of eRehabilitation intervention were identified with a follow-up of six months [19,20]. These studies did no show differences between the intervention and control group at six months. A possible explanation for the lack of effect is that both

studies used mixed-model analyses, meaning that they compared the intervention group and control group over the total period of six months. In our study, the results of the total period of six months were also non-significant. A separate analysis between three and six months was not performed in the two previous studies. However, since eRehabilitation may have more pronounced effects after the first three months, it is recommended for future research to perform separate analyses for the first three months and the period between three and six months.

1.2.1 Use of eRehabilitation

The relatively small proportion of stroke patients using the eRehabilitation intervention in the clinical effect study (64% of the patients who received the intervention; 32% of total intervention group) is partially consistent with literature [7,11,17,20,21,26-29]. Comparisons with previous studies are hampered by the fact that some of these studies did not explicitly report details about adherence. Studies that did mention details, reported the percentage of patients that used the eRehabilitation intervention at least once (range between 66-100% [20,21,26,28,29]) or those who used it for the entire intended period (10%-93%, [7,11,27]). Others reported the duration (on average 12-20 min per day, 1190 minutes in total or for a total of 5 days [7,11,26,27]). Compared to those studies, indeed the percentage of patients using the intervention in our study might be relatively low, but the duration of use (median 19 days) was better than the previously reported average of 5 days [26].

Chapter 6 showed several explanations why relatively few patients used the intervention. This included the attitude of healthcare professionals towards the intervention, extent of integration in the conventional stroke rehabilitation and financial and technical setbacks. Most of the previous studies did not report reasons for non-use. For the few studies where those reasons were given, explanations were partly comparable. This included barriers related to the intervention (e.g. technical errors) and lack of support from the healthcare professionals [21,27,28]. In contrast to other studies, we did not encounter any practical issues with the delivery of the intervention in our study (e.g. patients not attending sessions due to scheduling conflicts or no-shows) or problems with the level of difficulty of the therapy [21,27,28].

To evaluate the effect of the eRehabilitation intervention in this thesis, a pre-test post-test comparison was made. This design allowed the use of data that was already collected. However, traditional study designs where control and intervention conditions as well as assessments are to a large extent predetermined, are not always ideal to study the effectiveness of innovations like eRehabilitation. Designs with a shorter duration are needed, since eRehabilitation technology develops rapidly and may be outdated before the study is finished [30]. The study design used in this study was, despite a limited duration, still relatively rigid and did not allow for interim improvements. Alternative designs that are particularly suitable to evaluate eRehabilitation will be discussed in part 2 of this paragraph 'Implications for future research & clinical practice'.

1.3 Implementation in the clinical context

The Fast@home study was performed in a real-life setting (i.e. in clinical stroke rehabilitation). This means that multidisciplinary teams of healthcare professionals involved in the rehabilitation of a stroke patient jointly decided whether or not to offer the eRehabilitation intervention to a patient. Subsequently, a designated healthcare professional (mostly a physical therapist or occupational therapist) was responsible for the delivery of the intervention. **Chapter 6** showed that a more intensive and better monitored implementation strategy, adapted to emerging needs, could probably have resulted in more stroke patients being offered and using the eRehabilitation intervention. Since the user of the intervention showed greater gains in health–related outcomes compared to the intervention group as a whole (**Chapter 5**), more intensive use of eRehabilitation as a consequence of a better adapted implementation strategy will probably lead to greater effects on health-related outcomes, as is supported by previous research [24].

Previous studies concerning stroke eRehabilitation with a randomized controlled design did not face problems with the implementation of eRehabilitation. The interventions in those studies were offered not fully embedded into conventional rehabilitation; for example, by setting a fixed number of digital consultations next to the conventional consultations [18,31], or by delivering eRehabilitation without the involvement of a healthcare professional [20,21,26,29]. Despite the obvious drawbacks of an evaluation in a real-life setting, the results of our effect study are better transferable to clinical practice.

Despite all the internal efforts to increase the use and implementation of eRehabilitation, external contextual factors may have had a major impact. A strong example is the situation arising during the COVID-19 pandemic starting in the spring of 2020. During this pandemic, it was impossible to deliver conventional face-to-face rehabilitation. The absence of an alternative [38] may have motivated healthcare professionals to use eRehabilitation and resulted in a forced substitution of physical consultations by remote care [39]. Although eRehabilitation was offered as an alternative to conventional stroke rehabilitation and not as a blended approach, it was shown that urgency can support to overcome barriers. The increased use of eRehabilitation during COVID-19 [40] provides the possibility to embrace the positive experiences and increasing competency of the users, focussing on optimal integration of eRehabilitation to prevent healthcare professionals relapse into old habits.

1.3.1 Integration in conventional rehabilitation

The largest challenge in the implementation of eRehabilitation in the clinical setting was found to be the integration of eRehabilitation into conventional rehabilitation. This observation is in line with previous literature [32,33]. Although difficult, it is crucial to offer eRehabilitation integrated into conventional stroke rehabilitation instead of offering it as a full alternative or next to conventional rehabilitation. Some studies even concluded that eRehabilitation can only achieve its full potential when integrated in conventional stroke rehabilitation [32,34]. However, real integration requires conventional care pathways being “redesigned”, meaning that tasks and responsibilities must be reallocated [33,34]. Healthcare professionals have to learn new routines, including prescribing exercises embedded in the personal eRehabilitation

program of the patient, discussing the use and results of digital treatment modalities with patients and collaborate in this use with colleagues of the multidisciplinary team.

For patients, a major benefit of integration is that eRehabilitation is delivered with the support of a healthcare professional. Patients reported to only be interested in eRehabilitation when it would not replace conventional rehabilitation treatment (**Chapters 2 and 3**) and that guidance by their healthcare professional motivated them most to use it (**Chapter 6**). The support of a healthcare professional to explain benefits, guide the first-time use and tailor an exercise program to individual needs was previously found to be essential for effective use of eRehabilitation [11,27,34-37]**.**

For healthcare professionals, the integrated approach results in the possibility to offer treatment modalities in the conventional way to patients who are not capable of using eRehabilitation. To support the integration, the role of the specialized ambassadors within the teams were highly appreciated by healthcare professionals (**Chapter 6**). Moreover, the integration could be improved by instructing professionals other than physical therapist and occupations therapist (i.e. speech therapists, social workers, nurses) in the use of eRehabilitation. The delivery of eRehabilitation was found too extensive for one physical or occupational therapist alone. By involvement of the whole multidisciplinary team, healthcare professionals can support and remind each other about the use of eRehabilitation.

Part 2: Implications for future research & clinical practise

The significant interplay between the effectiveness, the implementation and the context leads to an extensive overlap between the implications for future research and clinical practice, which are therefore described in a single paragraph and visualized in Figure 2.

2.1 Evaluation & designs

Traditional study designs (e.g. randomized controlled trials or a pre-test post-test comparison) are not always most appropriate to evaluate eRehabilitation in a clinical setting, as was mentioned before. In the rapidly developing field of eHealth, in which the context is also subject to change, research designs that have a shorter time frame and allow iterations during the study period are probably more suitable [41,42]. Iterations facilitate the quality, usefulness and relevance for clinical practice [43], whereas shorter studies could decrease the time between research findings and larger scale uptake in clinical practice [41,42]. An overview of 75 study designs to assess the effects of eHealth has recently been published [42]. The results were aggregated into an online “eHealth methodology guide” to support researchers in the field of eHealth to identify the appropriate evaluation approach suitable for a particular study [44].

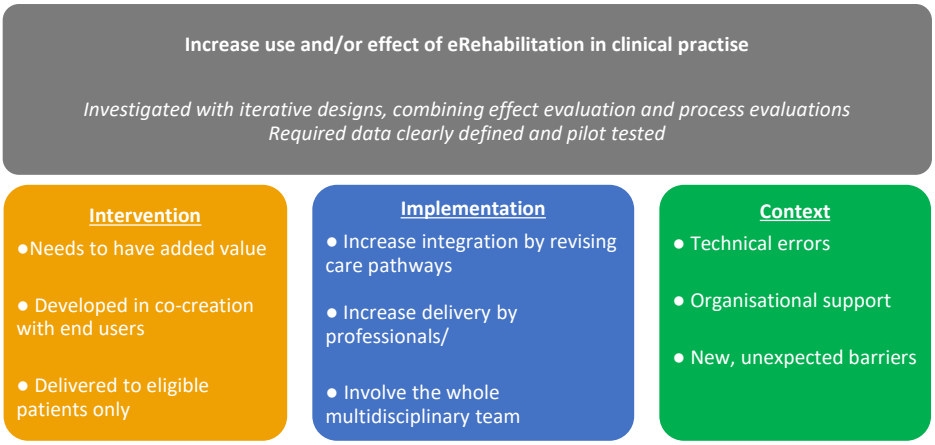

Figure 2. Lessons learned for future use and evaluations of eRehabilitation in the clinical setting

A useful methodology with respect to the iterative process of the development, evaluation and implementation of eHealth interventions, is the roadmap of the Centre for eHealth Research and Disease Management (CeHRes [45]). The CeHRes roadmap can be used as a guideline for eHealth development, implementation and evaluation. In this, each consecutive phase is related to previous phases and active participation of the community (e.g. patients, healthcare professionals, managers) is required to articulate the problem and participate in the problem-solving process. Although not explicitly defined in the study protocol, some aspects from the CeHRes roadmap have been included in our study, such as the use of information of the first stages (**Chapters 2-4**) in the development of the intervention and implementation strategy and the close involvement of end-users throughout the study.

In this thesis, a *hybrid implementation and effect study* was combined with an exploration of the barriers and facilitators in the context in which it is used. This means that the effectiveness of eRehabilitation was investigated together with the implementation strategy, and an exploration of the context in which it is used. Hybrid design increase the usefulness and relevance for clinical practice [43] and offers the possibility to evaluated an eRehabilitation intervention together with the infrastructure and organisation of delivery [46]. This resulted in a more valid assessment of the effectiveness in clinical practice [47]. Besides, insight in the implementation and context is important to interpret the outcomes of the effect evaluation and use of the intervention. We showed that the relatively small effects of eRehabilitation in addition to conventional rehabilitation could be improved by a better adapted implementation strategy which will probably lead to more intensive use of eRehabilitation.

2.2 Clinical use of eRehabilitation

An important aspect that must be considered in future use of eRehabilitation concerns the eligibility of patients. In this project, it was expected that most patients would receive and use the intervention, whereas a small proportion would have cognitive, emotional or motor

impairments hampering its use. Taking the health situation of the patient into account, it was left to the discretion of the treating healthcare professionals to either deliver the intervention or not. In future projects, a clear decision algorithm should underlie such clinical decisions, to obtain insight in the reasons why (not) to deliver the intervention. By means of such information, the process of identifying the patients for whom the eRehabilitation is not feasible or useful can be further refined. An example of a promising tool is the 'Quick scan for your patient's digital skills' [48]. This quick scan enables a healthcare professional to identify whether a patient is capable of using eHealth. In addition, disease specific tools are needed to assess the capability of patients for using eHealth.

Apart from the patients' perspective, improving the commitment of healthcare professionals is important to increase the use of eRehabilitation. This can be achieved by making eRehabilitation an integral part of the rehabilitation treatment, which requires a comprehensive revision of the current care pathways. Support and leadership of the organisation and the rehabilitation teams is needed for such a revision [49,50]. Sufficient integration also includes the continuous monitoring of the use of eRehabilitation, both by the healthcare professionals and patients, in order to act upon non-users and registering the exercises and adherence in electronic medical records.

To monitor the use of eRehabilitation in the clinical setting, a minimal set of data to quantify the use of eRehabilitation is needed. However, the collection of such a set will not be easy, as applications vary widely with respect to their nature [23] and data stored, as well as the ease of extracting data from applications. It is recommended to at least be sure of a good definition and operationalization of the terms 'delivery' and 'use'. For instance, is a patient a user if he/she logged in at least once, if he/she has started a minimum number of sessions, or when the prescribed protocol was fully completed? For each exercise session, a time stamp including date and time is needed of both start and finish. If applicable, this should also include the intensity, number of sets and repetitions, and experiences during and after the exercises, such as pain or exertion scores. To calculate the adherence, a link between what is prescribed and performed is necessary. It is recommended to actually analyse the user data in a pilot phase and determine whether it is sufficient to calculate the delivery, use and adherence. Collaboration with application developers is a prerequisite for successful monitoring the use of eRehabilitation interventions in clinical practise. It should also be considered that once exercises have been repeated many times and can be done without digital support, it does not necessarily mean that the patients is not exercising any more. Depending on the nature of an intervention, abandonment may also mean that digital support is simply no longer necessary.

2.3 Future projects

The lessons learned from the Fast@home study are incorporated in a follow-up project "Ikoefenzelf" (funded by Stimuleringsregeling Ehealth Thuis, [*I exercise by myself*, funded by eHealth at Home Incentive, grand number 1900002]). In this project, an improved version of the Fast@home intervention including more applications and smaller chance of technical errors is used. It is widely implemented in multiple specialized rehabilitation facility, including the multidisciplinary team as a whole. The use of this intervention can be

continued in primary care, for instance by a physical therapist working in primary care. In this follow-up project, a healthcare insurance company is involved, to explore how the use of eRehabilitation as part of the regular therapy can be reimbursed in the near future.

CONCLUSION

This thesis gained insight in the interplay between the effectiveness, the implementation and the context of eRehabilitation after stroke. An eRehabilitation intervention and accompanying implementation strategy were developed based on anticipated barriers and facilitators identified in the context of the specialised rehabilitation facility. The use of the eRehabilitation intervention led to small but significantly greater improvements in the intervention group on the long term. These improvements were even more pronounced if only the users of the intervention were compared with the control group. However, between admission and three months, no between group differences were seen, only a limited number of patients used the intervention and all change scores were below minimal clinical important difference.

Reasons for the limited use were found in the lack of implementation and contextual factors. Especially the full integration of Fast@home in clinical care pathways appeared challenging. To increase the delivery of eRehabilitation, it should be an integral part of the rehabilitation care pathways, which requires a comprehensive revision of the current care pathways, including the electronic medical records.

To gain better insight in the clinical effectiveness of eRehabilitation, effect evaluations should be combined with process evaluations investigating the implementation strategy. It is recommended to include the organisation of care delivery and barriers and facilitators in the context rather than investigating eRehabilitation as an independent intervention. Besides, iterative designs allowing adaptations of both the intervention and implementation strategy and a minimum set of data in order to perform proper analyses of the use of eRehabilitation, are important. Future project should include these recommendations, to increase the use and effectiveness of eRehabilitation.

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