Virtual Coaching Activities for Rehabilitation in Elderly

Call: H2020-SC1-2016-2017

Grant Agreement Number: 769807

Deliverable

D1.9 vCare cost effectiveness study

Deliverable type:	Report
WP number and title:	WP1: Clinical Concept and Piloting
Dissemination level:	Confidential
Due date:	August 2022
Lead beneficiary:	OSA/BCB
Lead author(s):	Rocio Del Pino (OSA/BCB)
Co-authors:	Iker Ustarroz (OSA), Massimo Caprino (CCP), Juan Carlos Gómez Esteban, Iñigo Gabilondo (OSA/BCB), Agnese Seregni (CCP), Peppino Tropea (CCP), Andreea Lacraru (UMFCD), Gabriel Olteanu (UMFCD).
Reviewers:	Massimo Caprino (CCP), Emanuel Sandner (AIT)

This project vCare has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769807.

Document history

Version	Date	Author/Editor	Description
0.1	04.05.2022	Rocio Del Pino (OSA/BCB)	Initial schedule
0.2	03.06.2022	Rocio Del Pino (OSA/BCB)	First draft
0.3	01.07.2022	Rocio Del Pino / Iker Ustarriouz (OSA/BCB)	Revision
0.4	20.07.2022	Gabriel Olteanu (UMFCD)	UMFCD costs
0.5	25.07.2022	Massimo Caprino (CCP)	CCP costs
0.6	29.07.2022	Gabriel Olteanu (UMFCD)	Clinical results
0.7	29.07.2022	Peppino Tropea and Agnese Seregni (CCP)	Clinical results
0.8	01.08.2022	Iker Ustarroz (OSA)	Cost-effectiveness
1.0	03.08.2022	Massimo Caprino (CCP)	First revision
1.1	09.08.2022	Emanuel Sandner (AIT)	Second revision
2.0	22.08.2022	Rocio Del Pino (OSA/BCB)	Third revision
2.1	23.08.2022	Gabriel Olteanu (UMFCD)	Clinical results
2.2	24.08.2022	Rocio Del Pino (OSA/BCB)	Final revision

Table of Contents

List of Tables

List of Figures

Abbreviations

ACC: accelerometry

ADL: activities of daily living

ARAT: Action Research Arm Test; CG: control group

CES-D: Center for Epidemiologic Studies Depression Scale

CG: Control group

CPET: Cardiopulmonary Effort Test

ECG:Electrocardiogram/Electrocardiography

EG: experimental group

EQ-5D: EuroQoL five-dimensional

FIM: Functional Independence Measure

HADS: Hospital Anxiety and Depression Scale

HF: Heart Failure

ICER: incremental cost-effectiveness ratio

IHD: Ischemic Heart Disease

IQR: Inter Quartile Range

LAMP: Low Activities of daily living Monitoring Program

LDL: Low-Density Lipoprotein

MoCA: Montreal Cognitive Assessment

MLHFQ: Minnesota Living with Heart Failure Questionnaire

NA: Data not available

PAEE: Physical activity energy expenditure

PAL: Physical activity level

PeakVO2: Peak oxygen consumption

PHQ: Patient Health Questionnaire

PD: Parkinson’s disease

POMA: Performance-oriented mobility assessment

QALY: quality-adjusted life years

QoL: Quality of Life

RCT: Randomized controlled trial

SF-36: Health-related quality of life

SUS: System Usability Scale

Telerehab: Telerehabilitation

UEQ: User Experience Questionnaire (UEQ)

VAT: Ventilatory anaerobic threshold

VO2Max: Maximal Oxygen Consumption/Maximal Oxygen Uptake/Maximal Aerobic Capacity

UPDRS: Unified Parkinson's Disease Rating Scale

6MWT: 6-minute walk test

10MWT: 10-meter walk test.

1 Executive Summary

Telerehabilitation in neurological and cardiological diseases is an alternative rehabilitation that improves quality of life and health conditions of patients and enhances the accessibility to health care. However, despite the reported benefits of telerehabilitation, there is a need to study its implementation impact in the health care system. This two-fold document therefore provides:

(1) A **systematic literature review** about telerehabilitation costs in neurological and cardiological diseases performed for one year (finished in January 2021), and
(2) A **comparative analysis** of the cost of rehabilitation towards telerehabilitation in the premises of the three clinical centres participating in the vCare study.

First, a **systematic review** is presented, which aims to investigate the costs and results of telerehabilitation in neurological and cardiological diseases. MEDLINE and EMBASE databases were searched from 2005 to 2021, for studies that assess the costs and results of telerehabilitation in comparison to traditional rehabilitation (centre-based programs) in neurological and cardiological diseases. A narrative synthesis of results was carried out. A total of 8 studies (865 participants) out of 430 records were included. Three studies were related to costs and results of telerehabilitation in neurological diseases (specifically in Stroke) and five studies assessed the telerehabilitation in cardiological diseases (chronic heart failure, coronary heart disease, acute coronary syndrome, and cardiovascular diseases). The duration of the telerehabilitation ranged from 6 to 48 weeks. Studies included 4 methods of evaluation: cost-analysis, cost-benefit, cost-effectiveness, or cost-utility. Four studies found significant cost/savings per person between €564.40 and $2352 while most of the studies found no statistically significant cost-effectiveness differences between the telerehabilitation performed and the rehabilitation performed at the clinic. Just one study found quality-adjusted life years (QALY) significant differences between groups. Telerehabilitation is a good alternative to traditional centre rehabilitation which increases the accessibility to rehabilitation to more people either due to the geographical situation of the patients or the limitations of the health systems. According to this systematic review, telerehabilitation seems to be clinical-effective and cost-effective option as traditional rehabilitation, even if generally, telerehabilitation was less costly. More research is needed to evaluate health-related quality of life and cost-effectiveness in other neurological diseases such as Parkinson's disease (PD).

Second, the document presents the **costs analysis of using vCare vs traditional rehabilitation** for the four diseases (stroke, PD, heart failure and ischemic heart disease) and the cost-effectiveness of both the traditional and vCare-based rehabilitation in PD was calculated.

2 LITERATURE REVIEW

2.1 TRADITIONAL REHABILITATION (AT THE CLINIC) VS TELEREHABILITATION

Telerehabilitation can be defined as “the delivery of rehabilitation services at a distance by means of electronic information and communication technologies” (Rosen, 1999). The use of technology allows communication between clinicians and patients and can be used to supply continuity of care at home, mostly for chronic disease patients after a comprehensive assessment performed by the clinician / professional. Telerehabilitation guidelines have been described to provide discipline specific standards and requirements to rehabilitation professionals (Richmond et al., 2017). Among its benefits, it can provide treatment access to rural areas and an earlier start of rehabilitation (Peretti, Amenta, Tayebati, Nittari, & Mahdi, 2017).

Rehabilitation is prescribed to enhance the patient’s quality of life and reduce the impact of a health condition, focusing on certain aspects based on the patient’s needs, goals, and preferences. For acute and chronic patients, such as neurological and cardiological diseases, early access to rehabilitation is crucial for symptoms recovery, and long-term continuity of care in many cases (Feigin et al., 2020; Piepoli et al., 2014). Specifically, cardiac rehabilitation has demonstrated efficacy on cardiological diseases in improving quality of life and reduction of mortality (Bellmann et al., 2020). Moreover, stroke rehabilitation was also reported to be beneficial for the patients (Stinear, Lang, Zeiler, & Byblow, 2020).

In most countries, rehabilitation is not integrated as a standard of care in the public health system, and this situation worsens in low- and middle-income countries (World Health Organization, 2017). The World Health Organization reported that several unmet needs exist regarding access to rehabilitation, due to the lack of funding and policies at a national level, the lack of available rehabilitation services outside urban areas, and the high out-of-pocket expenses (World Health Organization, 2017). Moreover, in the past years, the prevalence of diseases with health complications is increasing, and consequently, there is an increment in the demand for rehabilitation services (Jamison, 2018). In light of this, the integration of rehabilitation as an essential service in the health system is included as one of Europe's priorities for health system strengthening (Skempes et al., 2021).

Telerehabilitation may overcome the actual lack of accessibility to rehabilitation programs for the majority of the patients in need, mostly in remote or rural areas without medical facilities. Moreover, COVID-19 pandemic has reflected the great contribution of telerehabilitation as a means of treatment accessibility, not only in isolated areas but also when physical attendance is not possible (Bettger & Resnik, 2020). In this scenario, telerehabilitation has emerged as a valuable solution for providing health care to patients.

Despite the reported benefits of telerehabilitation (Bellmann et al., 2020; Stinear et al., 2020), there is a need to study the impact of the implementation of telerehabilitation in the health care system.

2.2 SYSTEMATIC REVIEW IN CARDIOLOGICAL AND NEUROLOGICAL DISEASES

A systematic review has been carried out to investigate the costs and effects of telerehabilitation in neurological and cardiological diseases.

2.2.1 Methods

This review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist (PRISMA). This study is focused on telerehabilitation through a virtual coach in four different pathologies: Stroke and PD as neurological diseases, and Heart Failure and Ischemic heart disease as cardiological diseases.

2.2.1.1 Study selection and procedures

The study included all empirical studies that met the following inclusion criteria: (1) The study reported telerehabilitation versus traditional centre-based rehabilitation on neurological or cardiological diseases; (2) Studies published from 2005 to 2021; (3) Studies published in a peer-reviewed English or Spanish language journal. (4) Studies focused on the costs and effects of rehabilitation and virtual rehabilitation. No limits were set on the ages of participants. The exclusion criteria were as follows: (1) Duplicated studies; (2) Abstracts or conference papers; (3) Study protocols or systematic reviews; (4) Studies with inpatient participants; (5) Studies with participants with other diseases different from neurological or cardiological diseases. Protocol review will be made publicly available on the "FigShare"[1] online hosting site, with DOI provided upon manuscript acceptance. The search was performed in MEDLINE and EMBASE databases in cooperation with a trained librarian and the search was finished in January 2021. The keywords used for each search are detailed by topics in Table 1 and the specific keyword strategy is explained in the supplementary Table 1. Seven searches were performed in MEDLINE[2] and 4 searches were performed in EMBASE[3] using specific keywords. The used keywords are organized by topics related to cost, telerehabilitation and cardiological and neurological rehabilitation (see Table 1). Three experienced reviewers screened separately the search results using the inclusion and exclusion criteria explained above, following the subsequent steps: title and abstract screening, followed by full-text screening. When the judgments of any of the reviewers were not similar, the discrepancies were explained, and a common decision was taken. The bibliographic databases yielded 430 references in total (Fig. 1).

[1] See: https://figshare.com/
[2] See: https://www.nlm.nih.gov/medline/medline_overview.html
[3] See: https://www.embase.com/

Table 1: keywords organized by topics.

Keywords related to cost	Keywords related to telerehabilitation	Keywords related to cardiological rehabilitation	Keywords related to neurological rehabilitation
Costs and cost analysis	Telerehabilitation	Cardiac rehabilitation	Stroke rehabilitation
Cost	Virtual rehabilitation	Heart rehabilitation	Parkinson rehabilitation
Cost-benefit analysis	Virtual reality	Cardiac rehabilitation	Neurorehabilitation
Cost-utility	User-computer interface	Heart rehabilitation	Neurological rehabilitation
Cost effectiveness	Clinical competence	Heart failure	
Hospital costs	Computer simulation		
Cost control	Computer-assisted instruction		
Cost utility analysis	Virtual training		
Cost minimization analysis	Virtual rehabilitation system		
Cost effectiveness analysis			

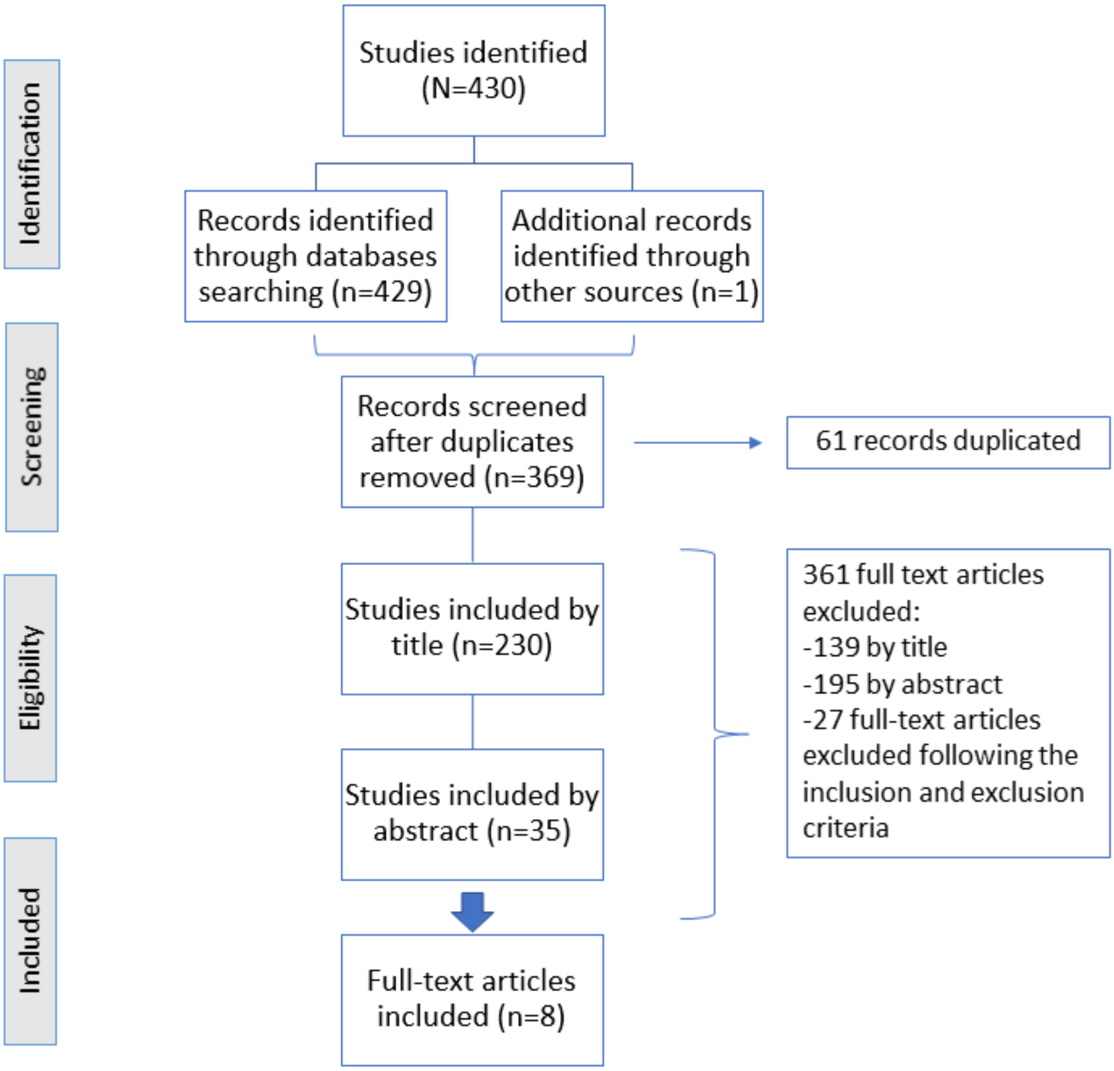


Figure 1. Flow diagram showing the process of study selection.

2.2.1.2 Data extraction and outcome

The three reviewers used a preformatted Excel sheet to extract data for the prespecified relevant data and outcomes for each included article: (1) Neurological or cardiological disease; (2) Total sample size; (3) Percentages of males; (4) Sample size included in the telerehabilitation or control group; (5) Age of each group; (6) Objective of the study; (7) Methods (randomization, outcome measurement, type of cost analysis, time of rehabilitation, type of rehabilitation); and (8) Results.

Risk of bias assessment was performed using the Cochrane risk of bias tool (Chandler, Higgins, Deeks, Davenport, & Clarke, 2017), which deals with the following sources of bias: (1) selection bias (random sequence generation and allocation concealment); (2) performance bias (blinding of participants and outcome assessors); (3) attrition bias (incomplete outcome data); (4) reporting bias (selective reporting); and (5) other sources of bias.

Four different modalities have been found in the literature search for neurological and cardiological diseases when addressing the costs and/or effects of telerehabilitation: cost-effectiveness, cost-utility, cost-benefit, and cost-analysis.

Cost-effectiveness analysis is a systematic method of comparing two or more interventions by measuring their costs and consequences (health outcomes), where the consequences of each are measured in the same common units related to the clinical objective of the interventions (e.g., life-years gained or hospital stays) (Cho et al., 2007).

Cost-utility analysis is similar to the cost-effectiveness analysis, but instead of measuring its incremental effects in units related to its objective or commonly used in the clinic (i.e. blood pressure or detected cases), effectiveness is measured in quality-adjusted life years (QALY), which encompasses life expectancy and quality of life. This measure of effectiveness makes it possible to compare different programs or interventions, as it is not specific to a specific intervention (Drummond, Michael F.; O´Brien, Bernie J.; Stoddart, Greg L.; Torrance, 2001).

Cost-benefit analysis measures and compares the net costs of a healthcare intervention with the benefits that arise as a result of the intervention, where both net costs and benefits are expressed in monetary units (Berger, Bingefors, Hedblom, Pashos, & Torrance, 2003).

Finally, cost minimization analysis or cost-analysis can be performed when, regardless of the units in which health outcomes are measured, they are the same in the different options compared (Sacristán, Ortún, Rovira, Prieto, & García-Alonso, 2004). Therefore, cost-analysis only compares costs.

2.2.2 Results

The literature search retrieved 430 records, which were reduced to 369 after removing the duplicated ones (Fig 1). A meticulous title- and abstract screening was done. After the title screening, 230 records were included by title criteria inclusion, and after analysing the abstract, 195 manuscripts were excluded, thus 35 studies were included by abstract (15 studies were related to neurological diseases, 15 studies were related to cardiological diseases, and 5 studies were classified as “others”). Finally, 8 full texts were eligible for our systematic review (Table 2 and 3). Figure 1 shows the details of the screening process. Three of the final studies included were related to neurological diseases while the rest of studies (5 out of 8) were related to cardiological diseases. The aim of these studies was to examine the efficacy and the cost of a telerehabilitation program compared to standard care.

Table 2. Summary of study characteristics.

Study	Disease	Sample size			Age (years) M±SD		Objective	Methods		
		Sample (%males)	Telerehab group	Control group	Telerehab group	Control group		Type of study	Outcome measurement	Type of analysis
Neurological diseases										
Housley et al. (Housley et al., 2016)	Stroke	20 (95%)	20	-	67.0 ±11.4	-	-Examine the efficacy of home-based, tele robotic-assisted device to: -improve functional ability -reduce depression -increase access to -monitor participant utilization of cost-efficient rehabilitation when compared to the cost of clinic-based therapy.	Single group	-ARAT -10MWT -6MWT -FIM -CES-D. -Costs	Cost-analysis
Llorens et al. (Lloréns et al., 2015)	Stroke	30 (56.6%)	15	15	55.5 ±9.6	55.6± 7.2	-Evaluate the clinical effectiveness of a virtual reality-based telerehab program in the balance recovery of hemiparetic individuals post-stroke in comparison to an in-clinic program. -Compare the subjective experiences. -Contrast the costs.	RCT	-Berg -Balance Scale -POMA -SUS -Intrinsic Motivation Inventory -Costs	Cost-benefit
Bendixen et al. (Bendixen et al., 2009)	Chronical diseases (including stroke)	230 (NA)	115	115	72.4±9.4	71.7± 9.6	-Investigate the health-related cost analyses between the telerehab program (LAMP) and standard care.	Retrospective quasi-experimental design	-Hospital Beds days of care -Clinic Visits -Emergency room visits -Nursing home care unit -cost analysis	Cost-effectiveness

Cardiological diseases										
Hwang et al. (Hwang et al., 2019)	Chronic heart failure	53 (75%)	24	29	68.0±14.0	67.0± 11.0	-Investigate the cost-utility of home-based telerehab program versus traditional centre-based rehab program.	RCT	-Health care costs -QALY (EQ-5D)	Cost-Utility
Maddison et al. (Maddison et al., 2019)	Coronary heart disease	162 (85.8%)	82	80	61.0 ±13.2	61.5± 12.2	-Compare the effects and costs of remotely monitored exercise-based cardiac telerehabilitation (REMOTE-CR) with centre-based programmes (CBexCR) in adults with coronary heart disease.	RCT	-VO2 peak -exercise adherence –motivation -quality of life -hospital service -medication costs -QALY (EQ-5D)	Cost-Utility
Kraal et al. (Kraal et al., 2017)	Acute coronary syndrome or revascularisation procedure	90 (88.8%)	45	45	60.5±8.8	57.7± 8.7	Examine the effect of home-based exercise training with telemonitoring guidance compared to regular centre-based exercise training on physical fitness and physical activity levels	RCT	-PeakVO2 -VAT -PAEE -PAL -ACC -MacNew -HADS -PHQ -QALY (SF-36)	Cost-Utility
Kidholm et al.(Kidholm et	Cardiovascular diseases	141 (78%)	72	69	62.4±12.3	62.6± 11.7	To assess the cost-utility of a cardiac telerehabilition program.	RCT	-QALY (SF-36) -Costs of the intervention	Cost-Utility

al., 2016)										
Frederix et al. (Frederix et al., 2015)	Coronary artery disease & chronic heart failure	139 (82%)	69	70	61.0±9.0	61.0± 8.0	To evaluate the cost-utility analysis of a comprehensive cardiac telerehabilitation programme.	RCT	-Health care costs -QALY (EQ-5D) -VO2 peak -Cardio-pulmonary exercise testing -Body mass index	Cost-Utility

Note. Abbreviations: ACC: accelerometry; ARAT: Action Research Arm Test; CES-D: Center for Epidemiologic Studies Depression Scale; EQ-5D (EuroqOL five-dimensional); FIM: Functional Independence Measure; HADS: Hospital Anxiety and Depression Scale; LAMP: Low Activities of daily living Monitoring Program; NA: Data not available; PAEE: Physical activity energy expenditure; PAL: Physical activity level; PeakVO2: Peak oxygen consumption; PHQ: Patient Health Questionnaire; POMA: Performance-oriented mobility assessment; QALY: Quality-adjusted life years; RCT: Randomized controlled trial SF-36: Health-related quality of life; SUS: System Usability Scale; Telerehab: Telerehabilitation; VAT: Ventilatory anaerobic threshold;; 6MWT: 6-minute walk test; 10MWT: 10-meter walk test.

Table 3. Summary of Telerehabilitation characteristics and study results.

Study	Disease	Telerehab duration & type			Results		
		Duration (weeks)	Type		Telerehab Cost-savings/person	Significant differences	Clinical and QALY results
Neurological diseases							
Housley et al.(Housley et al., 2016)	Stroke	12	Home-based robotic rehab device	Not lived guided	$2352	yes	Home-based robot therapy expanded access to post-stroke rehabilitation for 35% of the people no longer receiving formal services and increased daily access for the remaining 65%.
Llórens et al.(Lloréns et al., 2015)	Stroke	6	Home-based telerehab vs in-clinic rehab.	Not lived guided	$654.72	-	No significant differences were found between the groups in any balance scale or in the feedback questionnaires. No significant differences in usability and motivation between groups.
Bendixen et al.(Bendixen et al., 2009)	Chronical diseases (including stroke)	48	Standard care + telerehab vs standard veterans administration care	Not lived guided	-	no	Telerehab increased clinic visits and decreased hospital and nursing home stays.
Cardiological diseases							
Hwang et al.(Hwang et al., 2019)	Chronic heart failure	12	Online group-based exercise vs traditional centre-based program	Live guided	$1590	yes	No significant differences in QALY.
Maddison et al.(Maddison et al., 2019)	Coronary heart disease	12	Exercise-based cardiac telerehab vs centre-based programme	Live guided & not lived guided	£2341	Partially yes	Medication costs were significantly lower in telerehab group No significant differences in hospital service utilization costs.

							No significant differences in QALY.
Kraal et al.(Kraal et al., 2017)	Acute coronary syndrome or revascularisation procedure	12	Home-based training with telemonitoring guidance vs centre-based training	Not lived guided	€3160	no	Telerehab was more cost-effective [between 97% and 75% (willingness-to-pay of 0€ and 100,000€ per QALY, respectively)]. Telerehab was associated with a higher patient satisfaction and appears to be more cost-effective.
Kidholm et al.(Kidholm et al., 2016)	Cardiovascular diseases	12	Cardiac telerehab vs Healthcare centre-based rehab	Not lived guided	€-1700	no	The incremental cost-utility ratio for telerehab was 400,000€ per QALY gained
Frederix et al.(Frederix et al., 2015)	Coronary artery disease & chronic heart failure	24	Internet-based +conventional centre-based rehab vs conventional centre-based rehab	Not lived guided	€564.40	yes	Incremental cost-effectiveness ratio of €-21707/QALY

Note. LAMP: Low Activities of daily living Monitoring Program; Live guided: guided and synchronized telerehabilitation monitored by clinicians; Not live guided: telerehabilitation not live guided by clinicians; QALY: Quality-adjusted life years; Telerehab: Telerehabilitation.

Regarding the risk of bias assessment results, all the included studies reported adequately the random sequence generation and complete outcome data. Almost all studies reported the allocation concealment, blinding of participants, personnel and outcome assessment, and selective reporting properly except for the following studies: Housley et al. (2016) did not include a control group and therefore, no random sequence, allocation concealment or blinding could be achieved; Bendixen et al. (2009) did not describe the allocation concealment and blinding; Hwang et al. (2019) specified that neither subject nor treating therapist blinding could be possible in their study due to the nature of the interventions; in Maddison et al. (2019) the participants could not be blinded to treatment allocation but personnel who performed the VO2 max testing were blinded to treatment allocation at 12 weeks; and in the study by Kidholm et al. (2016) there is not enough information about blinding personnel and outcome assessment. Figure 2 summarizes the risk of bias assessment results, with red, green, and yellow colours indicating high, low, and unclear risk of bias, respectively.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Neurological diseases							
Housley et al., 2016					+	+	?
Lloréns et al., 2015	+	+	+	+	+	?	?
Bendixen et al., 2009	+	-	-	-	+	?	?
Cardiological diseases							
Hwang et al., 2019	+	+	-	+	+	+	?
Maddison et al., 2019	+	+	?	+	+	+	?
Kraal et al., 2017	+	+	+	+	+	+	?
Kidholm et al., 2016	+	+	?	?	+	+	?
Frederix et al., 2015	+	+	+	+	+	+	?

Figure 2. Risk of bias assessment summary according to the Cochrane risk of bias tool: red, green, and yellow colours indicate high, low, and unclear risk of bias, respectively.

Among the 8 publications reviewed, one study included cost analysis, another performed a cost-benefit analysis, another included cost-effectiveness, and the 5 cardiological studies conducted cost-utility analysis.

Concerning the variables included, the cost-utility used QALY as the outcome measure of quality of life adjusted by year, measured through the EQ-5D questionnaire or the SF-36 questionnaire. The cost-effectiveness study used clinic visits, hospital stays, and nurse home stays while the studies that analysed the cost-analysis and cost-benefit included the costs such as cost of the intervention. On the other hand, specific measures of clinical effectiveness such as maximum aerobic capacity, body mass indices, adherence to treatment or motivation among others are also used to assess the effectiveness of the telerehabilitation program performed versus the traditional rehabilitation program.

The duration of the telerehabilitation ranged from 6 to 48 weeks, being 12 weeks the most common period to perform the telerehabilitation. The predominant type of rehabilitation was “not live guided” by clinicians which means that the telerehabilitation was not guided by clinicians when the patient was performing it.

2.2.2.1 Telerehabilitation in neurological disorders

Regarding the neurological studies which included costs and effects of telerehabilitation (Table 2), we only found studies that focused on telerehabilitation after stroke. Two of the studies were specifically related to cost and effects of telerehabilitation with stroke patients and one of the selected studies included chronically ill people and disabled elders that included stroke patients, and also diagnoses of arthritis, hypertension, and diabetes (Bendixen, Levy, Olive, Kobb, & Mann, 2009). Authors did not specify the sample of patients included for each diagnosis, therefore, we used the total sample to analyse this specific study (Bendixen et al., 2009).

The sample size of the neurological studies included between 20 and 230 participants (between 56.6% to 95% were males). The mean age of the telerehabilitation group ranged between 55.9±9.6, and 72.4±9.4. Only one study performed a two-arm study with a randomized controlled trial (Lloréns, Noé, Colomer, & Alcañiz, 2015). In other studies, Housley et al. (2016) followed a single group study design, and Bendixen et al. (2009) carried out a retrospective quasi-experimental design.

Regarding results, Housley et al. (2016), reported cost reductions of $2,352 per person from the telerehabilitation group compared to clinic-based therapy. Their study showed an average cost-saving of 64.97%. The main savings were related to the elimination of the repeated in-person therapist costs and the absence of mileage reimbursement. Regarding clinical effectiveness, patients from telerehabilitation showed clinical improvements but there was no control group to compare with. Lloréns et al. (2015), reported lower costs in telerehabilitation (reductions of $654.72 per person), but no significant differences were found in clinical results between telerehabilitation and in-clinic rehabilitation, showing both modalities having significant improvements. Bendixen et al. (2009), detected no significant costs differences between both treatments, showing the telerehabilitation group slightly increased clinic visits post-intervention but slightly reduced hospital and nursing home stays.

2.2.2.2 Telerehabilitation in cardiological disorders

Regarding the cardiological studies, 5 studies were selected. These studies included telerehabilitation in chronic heart failure, cardiovascular diseases, coronary artery disease, and acute coronary syndrome or revascularization procedure. The sample size ranged from 53 and 162 patients, and most of the patients were male (between 75% to 88.8%). The mean age of patients was ranged from 60.5±8.8 to 68.0±14.0. The methodology followed in all 5 studies was two-arm randomized controlled trials.

Regarding cost comparisons between telerehabilitation and traditional care, some studies report significantly lower costs in telerehabilitation, with reductions of $1,590 (Hwang et al., 2019), and €564.40 (Frederix et al., 2015) per person. In contrast, Kraal et al. (2017), and Maddison et al. (2019) found no significant differences between treatment costs, nevertheless, home-based training had slightly lower costs (€3160 and £2341 per person, respectively) compared to centre-based training. Kidholm et al. (2016), found that telerehabilitation was not significantly cost-effective compared to traditional care, but was more expensive and showing no significant improvement in the quality of life of the patients compared to traditional care.

Frederix et al. (2015) shows a significant incremental cost-effectiveness ratio of €-21.707/QALY, showing a reduction in the number of rehospitalizations. The other studies found no significant differences in QALY between groups.

2.2.3 Systematic review discussion

The systematic review revealed that after 430 manuscripts were retrieved, only eight analysed the costs and effectiveness of neurological and cardiological telerehabilitation. Telerehabilitation was more cost-effective than traditional rehabilitation. Half of the studies found significant differences in cost/savings per person between the telerehabilitation performed and the traditional one at the clinic (Frederix et al., 2015; Housley et al., 2016; Hwang et al., 2019; Maddison et al., 2019).

Although there are several reviews regarding telerehabilitation in neurological (i.e., stroke patients) (Johansson & Wild, 2011; Tchero, Teguo, Lannuzel, & Rusch, 2018) and cardiological diseases (i.e., heart failure) (Subedi, Rawstorn, Gao, Koorts, & Maddison, 2020), just a few studies met our inclusion and exclusion criteria, specifically, few studies were focused on telerehabilitation and included cost evaluations. To our knowledge, this study is the first systematic review that focused on the economic evaluation of telerehabilitation in both, neurological and cardiological diseases.

2.2.3.1 Neurological diseases

As part of the vCare project, the systematic review performed was focused on neurological diseases in general, and on Stroke and Parkinson's disease in particular. However, only 3 studies were found that included costs and clinical results of telerehabilitation in patients after stroke. None of these studies included QALY assessment but included costs, feedback questionnaires, clinical visits, and home stays among others. Housley et al. (2016) was the only neurological study that found significant differences in telerehabilitation cost/saving per person compared to traditional rehabilitation at the clinic. Llórens et al. (2015) also found lower costs of the telerehabilitation program, but they did not specify if the differences were statistically significant. Bendixen et al. (2009) after examining healthcare costs at 12 months of the telerehabilitation (LAMP) intervention, found no significant differences in costs, the telerehabilitation group did more visits to the clinic while decreased hospital stays and also nursing home stays.

Regarding clinical results, in general, patients indicated positive feedback on the telerehabilitation performed after stroke and showed significant improvements in balance and gait. However, Llórens et al. (2015) did not find significant differences in the feedback questionnaires, usability, or motivation between the telerehabilitation group and the traditional rehabilitation at the clinic.

2.2.3.2 Cardiological diseases

Telerehabilitation in cardiological diseases is also relevant because cardiac rehabilitation is an essential component to improve physical, psychological, and social functioning (Balady et al., 2007; Subedi et al., 2020), but few studies have focused on assessing the economic evaluation or the cost-effectiveness differences between telerehabilitation and traditional rehabilitation. After an exhaustive literature review, we found five studies that met our criteria and included costs and clinical outcomes carried out in cardiological diseases such as heart failure or acute coronary syndrome. These studies analysed rehabilitation cost-utility, including QALY measured with the EQ-5D or SF-36. Three of the cardiological rehabilitation studies found significant differences in cost/savings per person, although most of the studies did not find statistically significant differences in QALY between groups of rehabilitation. Specifically, the cost-effectiveness study carried out by Frederix et al. (2015) was the only study that found significant differences in QALY between groups, and the intervention group being more effective. However, the intervention group of this study was different from other studies reviewed since the experimental group performed a telerehabilitation program in addition to centre-based cardiac rehabilitation while the control group just performed the centre-based rehabilitation itself (Frederix et al., 2015). In addition, Frederix et al. (2017) performed a two year follow-up study finding statistically significant clinical differences between the telerehabilitation group and the centre-based rehabilitation. Generally, the telerehabilitation group significantly increased their physical activities, their perceived health-related quality of life, and the QALY at follow-up (Frederix, Solmi, Piepoli, & Dendale, 2017). Although the authors found that telerehabilitation in addition to the standard centre-rehabilitation was more effective but also more costly than the standard centre-rehabilitation alone. On the other hand, Hwang et al. (2019) and Kidholm et al. (2016) revealed non-significant differences in QALY between groups, concluding that telerehabilitation might be as effective as traditional rehabilitation. Hwang et al. (2019) found that telerehabilitation was significantly less costly. Maddison et al. (2019) also found no difference in QALY, even if medication costs were lower in the telerehabilitation group. However adverse events were higher during treatment in the telerehabilitation group (Maddison et al., 2019). Kraal et al. (2017) showed similar QALY between groups, but almost all components were lower in the telerehabilitation group. They also found similar treatment adherence and clinical improvements in both groups, but patients had higher satisfaction in the telerehabilitation group (Kraal et al., 2017).

2.2.3.3 Duration of the telerehabilitation

The telerehabilitation time ranged from 6 to 48 weeks in the studies reviewed (neurological and cardiological diseases). This difference could be a limitation in making a comparison between them. However, most of the cardiological studies reviewed performed telerehabilitation for 12 weeks.

2.2.3.4 Strengths and limitations

There is an increased interest in healthcare spending in Europe and worldwide, specifically in telerehabilitation and care for elders. Chronic illness contributes to disability, diminishes quality of life, and deteriorates health and therefore, increases long-term care costs (Public Health and Aging: Trends in Aging—United States and worldwide, 2003). Traditional care and rehabilitation imply inpatient care, skilled multidisciplinary clinicians, outpatient's clinics, and/or home health visits. As life expectancy is increasing, the availability of cost-effective telerehabilitation programs is not only important for neurological, cardiological, or chronic diseases, but also for active aging. Moreover, telerehabilitation could expand the access to perform rehabilitation for people that could not have access to traditional clinic care either for personal, geographical, economic reasons or due to the public health system (Housley et al., 2016; Jia, Cowper, Tang, Litt, & Wilson, 2012). Moreover, in the COVID-19 pandemic, telerehabilitation has emerged as a valuable tool for the continuity of care at home, offering professionals a rapid learning experience in implementing telerehabilitation with their patients in a satisfactory manner (Buabbas, A. J., Albahrouh, S. E., Alrowayeh, H. N., & Alshawaf, 2022; Signal, Martin, Leys, Maloney, & Bright, 2020).

Our systematic review showed that comparing not just costs but also the cost-effectiveness of different interventions is crucial for making evidence-based decisions regarding telerehabilitation implementation in healthcare systems. Telerehabilitation seems to be as effective as traditional rehabilitation but can be less costly. Patients who performed telerehabilitation presented greater satisfaction and adherence to treatment and rehabilitation. However, few studies reported economic evaluation of the rehabilitation performed, and in those that included it, costs varied across different intervention designs. Future clinical trials should include cost-effectiveness analysis as a relevant measure to decide if telerehabilitation is a good option to be implemented in public health systems. In addition, future research should also consider comparing different telerehabilitation interventions to determine which are the ones that best meet the needs of each disease.

2.2.4 Conclusions of the systematic review

In conclusion, telerehabilitation is a suitable alternative to traditional rehabilitation care in post-stroke patients and in cardiological diseases, especially in remote or underserved areas. Larger cost evaluation studies are needed to evaluate the effectiveness and the health-related quality of life of patients who performed telerehabilitation.

3 ESTIMATE THE EFFECTIVENESS, UTILITY, AND RESULTS OF VCARE

The clinical results are explained in detail in D1.8. Here we summarize the relevant results of clinical data and utility of using vCare.

Clinical and common outcomes:

- Quality of Life: EuroQoL5d-5L
- Usability: System Usability Scale (SUS) and User Experience Questionnaire (UEQ)

Specific clinical outcomes per pathology:

Stroke	Parkinson	Heart Failure	Ischemic Heart
MoCA FIM NIHSS FAC MAS ADL	MoCA UPDRS I UPDRS II UPDRS III UPDRS IV H&Y Schwab & England activities of Daily Living Scale	MLHFQ HADS scale Fagerstrom test for nicotine dependence VO2Max LDL	HADS scale Fagerstrom test for nicotine dependence VO2Max LDL

Note: ADL: activities of daily living FAC: Functional Ambulation Classification; FIM: Functional Independence Measure; HADS: Anxiety and in-hospital depression; H&Y: Hoehn and Yahr; LDL - Low-Density Lipoprotein; MAS: Modified Ashworth Scale; MLHFQ: Minnesota Living with Heart Failure Questionnaire; MoCA: Montreal Cognitive Assessment; NIHSS: National Institutes of Health Stroke Scale; VO_2Max - Maximal Oxygen Consumption/Maximal Oxygen Uptake/Maximal Aerobic Capacity; UPDRS: Unified Parkinson's Disease Rating Scale.

3.1 STROKE

A total of 20 subjects affected by stroke were recruited in the CCP Pilot Phase. As previously mentioned, 10 patients belonged to the experimental vCare group (EG) and 10 to the control group (CG). Subjects showed mild impairment as documented by median NIHSS of 2.5 (IQR 2.0–4.3), and median FIM score of 111.0 (IQR 99.5–121.3). The subjects obtained an average Equivalent Score scale of 2 (IQR 1–3) in the global cognitive efficiency test (MoCA), which indicates normal cognitive functioning.

Patients that concluded the study protocol experienced, on average, a treatment period of 40.69 ± 12.46 days.

The results both in the EG and in the CG reflected a slight deviation of the clinical outcome measures between T0 to T1, shown in Figure 3 where T1 was measured about 6-10 weeks after the beginning of the pilot (T0). Generally speaking, the EG showed a trend in improvement in most of the clinical scales, while the CG shows a less consistent pattern. In particular, on the NIHSS scale, both groups tend to improve slightly, showing a reduction of the baseline score, even though the control group is more impaired neurologically from the start. Next, on the functional scales (FIM and FAC) while both groups show a tendency to improvement, this trend is more accentuated in the EG especially for FIM scale. Finally, from the cognitive point of view, both groups mainly show stable cognitive scores (see values for MOCA scale).

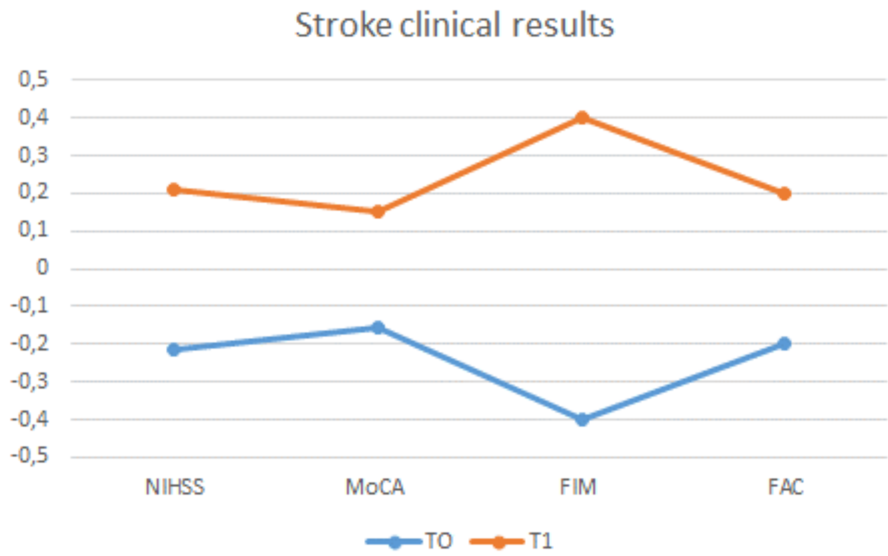


Figure 3. Differences between T0 (pre-intervention) and T1 (post-intervention) of the vCare Stroke group.

Concerning the quality-of-life assessment, the EG displays the tendency to an improvement of quality of life in the areas: anxiety, mobility and usual activities, most likely because of continuous access to monitoring and rehabilitation treatments. The CG instead, while showing some reduction of anxiety, tends to be stable (pain, usual activities, self-care) or even worse (mobility) when exposed to 'conventional' home rehabilitation treatment.

Five patients out of ten assessed the usability of the vCare solution with a SUS score greater than 68 points. In particular, three of these five subjects evaluated the usability as "best imaginable", with a score higher than 85. Remarkably, among these, one patient rated the usability with the maximum SUS score of 100 points. The remaining two patients who assessed the usability provided an unacceptable usability score of around 50 (poor usability) and 20 (worst imaginable usability) points. The 3 patients who drop-out didn't evaluated the usability.

The TAM questionnaire results showed a mean score of 33.1 ± 4.1 for perceived usefulness (42 means strongly agree), a mean score of 31.9 ± 12.5 for perceived ease of use and, a mean total score of 65.0 ± 14.0 (84 means strongly agree).

3.2 Parkinson

PD patients were randomly selected for each group (10 PD vCare group and 10 control group) and all patients were evaluated with the same clinical protocol that measures quality of life, cognitive general status, motor symptoms, functional disability for PD, and capabilities for performing activities of daily living. Specifically, the usability and the experience of using vCare was only assessed in the vCare group. Figure 4 shows the Z scores differences between time 0 (pre-intervention) and time 1 (post-intervention) of the vCare PD group (higher values mean better performance). Statistically significant differences were found between the pre-post intervention measures in general cognitive status, in quality-of-life measures (mobility, self-care, daily chores, and pain/discomfort), and marginally significant differences in daily activities (*p*=.05). The results showed a significant improvement of cognitive status, better quality of life and better capabilities of daily living in the PD vCare group.

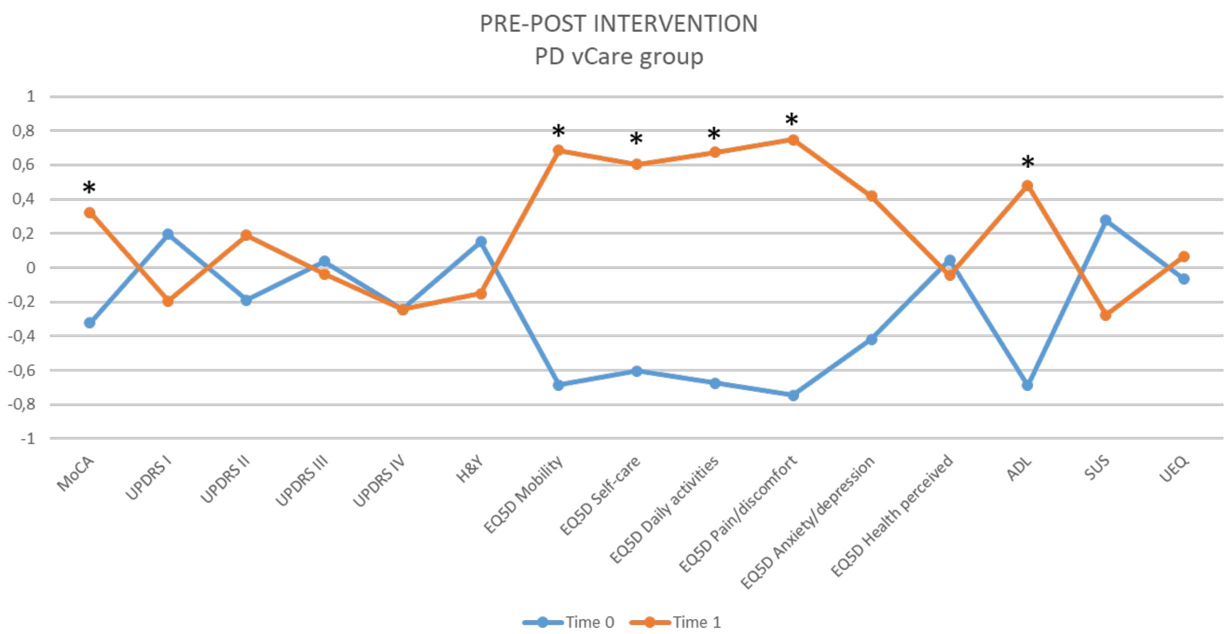


Figure 4. Differences between time 0 (pre) and time 1 (post-intervention) of the vCare PD group.
Note: *: *p<.05*

3.3 HEART FAILURE

30 patients were enrolled and randomly distributed as follows: 10 patients in the vCare group, 10 patients in the ambulatory group and 10 patients in the control group. The initial evaluation was similar for all groups, performed by a cardiologist and consisted in a clinical and paraclinical examination at time T0 (enrolment time) where they completed the questionnaires on quality of life, anxiety and depression and capability for performing activities of daily living. At the end of the rehabilitation program T1 (post-intervention) the same evaluations were repeated, except for the vCare group in which questionnaires for assessing the usability and the experience of vCare were applied. We observed statistically significant differences between the pre-intervention and post-intervention measure. An increase of approximately 15% in the quality of life and a tendency of decrease in depression. In terms of usability and user experience the highest value was 88 and the lowest was 50. In Figure 5 are compared the Z-scores from T0 (enrolment time) and T1 (post-intervention). LDL values were obtained in hospital's laboratory, by analysing the blood samples at T0 and T1. VO_2max values were obtained using the CPET (cardiopulmonary effort test) which required a special mask for assessing the performance of the heart and lungs at rest and during exercise. Minnesota Living

with Heart Failure Questionnaire (MLHFQ), HAD-Scale (Anxiety and Depression) and Fagerstrom are questionnaires and in their cases was calculated a total score based on the patient's answers.

In terms of interpretation of Figure 5, higher values for MLHFQ, HADs (Anxiety and Depression), Fagerstrom and LDL-cholesterol mean a worse performance (a higher level of anxiety, depression, dependence of nicotine, LDL-cholesterol levels in the bloodstream). In contrast, for VO_2max, higher values mean a better performance.

Therefore, all results obtained at T1 are significantly improved when compared to the values obtained at T0 with an improvement in effort capacity (objectified by VO_2max), lipid profile, anxiety, and depression (a decrease in both conditions), nicotine dependence (with a significant decrease compared to T0) and in quality of life.

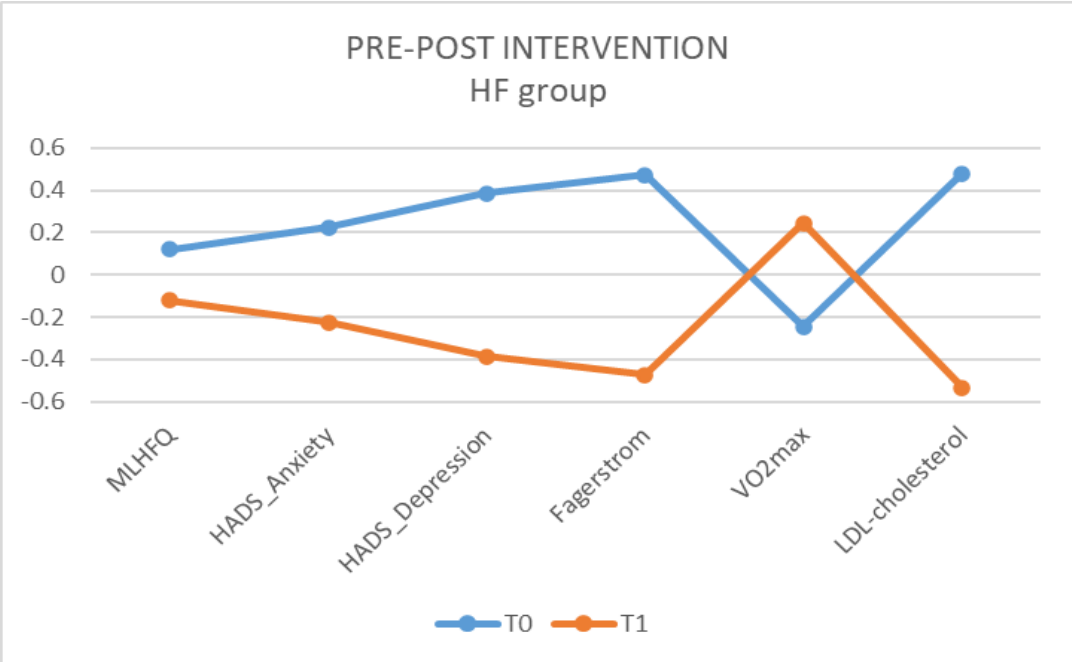


Figure 5. Differences between T0 (pre) and T1 (post-intervention) of vCare HF group.

3.4 Ischemic Heart Disease

20 patients were enrolled and randomly distributed as follows: 10 patients in the vCare group and 10 patients in the control group. The initial evaluation was similar for all groups, performed by a cardiologist and consisted in a clinical and paraclinical examination at time T0 (enrolment time) where they completed the questionnaires on quality of life, anxiety and depression and capability for performing activities of daily living. At the end of the rehabilitation program T1 (post-intervention) the same evaluations were repeated, except for the vCare group in which questionnaires for assessing the usability and the experience of vCare were applied. We noticed statistically significant differences between T0 and T1, especially in terms of quality of life. Thus, an increase of approximately 20% in the quality of life and a decrease of depression by approximately 15% were observed. In terms of usability and user experience the highest value was 75 and the lowest was 44. In Figure 6 are compared the Z-scores from T0 (enrolment

time) and T1 (post-intervention). LDL values were obtained in hospital's laboratory, by analysing the blood samples at T0 and T1. VO_2max values were obtained using the CPET (cardiopulmonary effort test) which required a special mask for assessing the performance of the heart and lungs at rest and during exercise. HAD-Scale (Anxiety and Depression) and Fagerstrom are questionnaires and in their cases was calculated a total score based on the patient's answers.

In terms of interpretation of Figure 6, higher values for HADs (Anxiety and Depression), Fagerstrom and LDL-cholesterol mean a worse performance (a higher level of anxiety, depression, dependence of nicotine, LDL-cholesterol levels in the bloodstream). In contrast, for VO_2max, higher values mean a better performance.

Therefore, all results obtained at T1 are significantly improved when compared to the values obtained at T0 with an improvement in effort capacity (objectified by VO_2max), lipid profile, anxiety and depression (a decrease in both conditions), nicotine dependence (with a significant decrease compared to T0) and in quality of life.

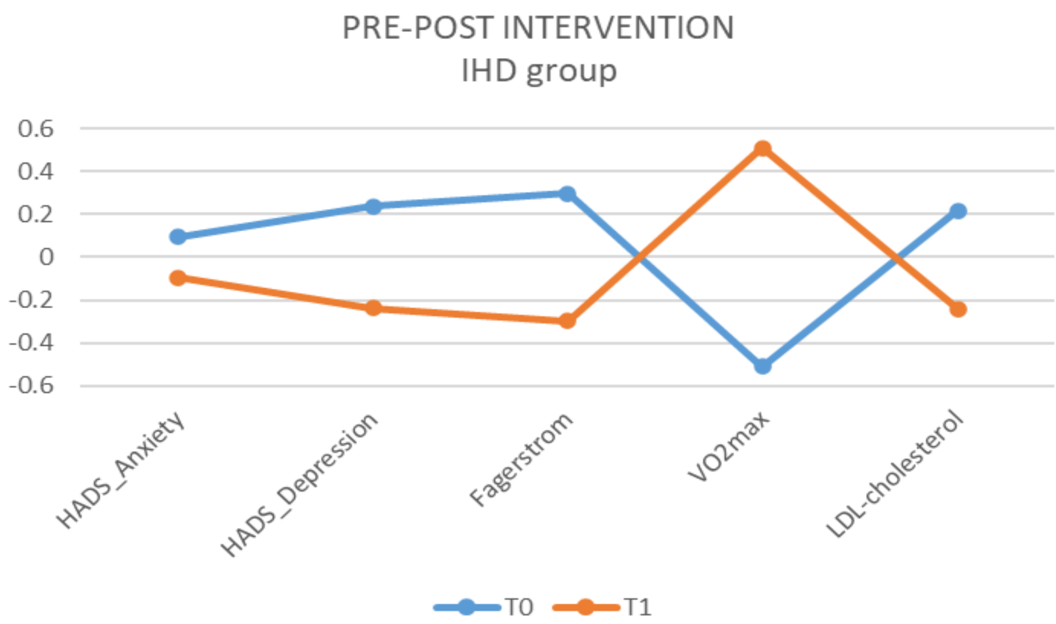


Figure 6. Differences between T0 (pre) and T1 (post-intervention) of vCare IHD group.

4 COST ANALYSIS OF VCARE VS TRADITIONAL REHABILITATION

4.1 STROKE

The rehabilitation @home for stroke patients enabled by the vCare system was mapped according to the structure of a rehabilitation pathway at the clinic, as foreseen by the clinical guidelines approved by the heathcare authority.

Within the vCare project the indication for the patient at home was to perform 6 days of rehabilitation every week, 4 alternative days for motor session and 2 for cognitive session. In the case of planned session (like for instance the execution of serious gaming by the Rehability suite), the duration of each session leasts a maximum of 45 minutes. The traditional rehabilitation is guided by a clinician (physiotherapist or neuropsychologist) while, with the vCare system, the virtual coach guided the patient, supported by a telephone consultation which usually was taking place once a week.

With this information, the use and consumption of resources for both types of rehabilitation were quantified. Information on the unit cost of each of these resources was extracted from the *Hospital Information System,* directly linked with the regional information system of Lombardia region, which provided the payment to the accredited private hospitals. Finally, the cost of treatment of the traditional and vCare-based rehabilitation was calculated.

Both types of rehabilitation perform two consultations at the beginning and at the end of the process, which usually lasts 2 months. Motor rehabilitation was performed (as indication) 4 times a week while neuropsychological rehabilitation is performed 2 times a week for the whole rehabilitation period. In the traditional rehabilitation plan, logopaedic rehabilitation is also included, which was not addressed by the vCare project. Both rehabilitations (traditional and vCare-based) include a face to face clinical, neurological, neuropsychological, and motor pre-post evaluation [Time 0 and Time 1 (day 60)]. During the traditional rehabilitation time no face-to-face consultation is needed while during the vCare rehabilitation, a telephone follow-up consultation is performed 4 times a month.

The cost of subsequent consultations is half the cost of a first consultation, according to corporate criteria. The cost of telephone consultations is a half of the cost of a face-to-face consultation, according to evidence-based calculations. The cost of motor rehabilitation corresponds to a physiotherapist rehabilitation session while the cost of neuropsychological rehabilitation corresponds to the cost of a neuropsychological consultation. Occupational therapy was included as part of traditional rehabilitation in the period before the discharge, while in the vCare project was considered as continuous, addressed by the e-learning services which are always available.

Table 4 and Table 5 show the structure of the regular rehabilitation vs the vCare rehabilitation for one week and the costs of both rehabilitations, respectively.

Table 4. Structure of both rehabilitations for Stroke (one sample week).

		Regual rehabilitation			vCARE tele rehabilitation			
		Motor rehabilitaion	Cognitive rehabilitaion	Occupational therapy	Motor rehabilitaion	Cognitive rehabilitaion	Occupational therapy (eLearning)	Telephone consultation
Weekly programme	Monday							
	Tuesday							
	Wednesday							
	Thursday							
	Friday							
	Saturday							

Table 5. Costs per patient of both rehabilitations for Stroke.

Resource Use	Regular rehablitation	COST (Hospital Information System)	TOTAL COST Regular Rehabilitation	vCare telerehabilitation	COST (Hospital Information System)	TOTAL COST vCare
Face-to-face neurological Consultation (First)	1	€ 230	€ 230	1	€ 230	€ 230
Face-to-face neurological Consultation (Successive)	1	€ 115	€ 115	1	€ 115	€ 115
Face-to-face NPS Consultation	1	€ 120	€ 120	1	€ 120	€ 120
Face-to-face Motor Consultation	1	€ 103	€ 103	1	€ 103	€ 103
Motor Rehabilitation	44	€ 52	€ 2.270	44	€ 52	€ -
NPS Rehabilitation	20	€ 60	€ 1.200	20	€ 60	€ -
Occupational treatment	10	€ 52	€ 516	10	€ 52	€ -
Telephone Consultation (1 hour a week)	0	€ -	€ -	8	€ 26	€ 206
vCare System Costs					vCare Cost	
Avatar voice (AIT)				350 €/year	29,17€ per month	€ 58
Rehability (Imaginary)				60€ (100 patients a month)	60 € per month	€ 120
vCare maintenance (SIMAVI)				25 € (100 patients a month)	25 € per month	€ 50
Devices				2140€ all the devices/3 months of use	178,34 € per month	€ 357
Desing of motor session				Physiotherapist 2 hour	51,6 per hour	€ 103
Desing of cognitive session				Neuropsychologist 2 hour	60 per hour	€ 120
Installation/Uninstallation				50€/hours technician x 4hours	50 per hour	€ 200
			€ 4.555			**€ 1.783**

In this context, the cost of 2 months of traditional rehabilitation is €4.555,20 while the use of the vCare system for 2 months costs €1.783,43. This difference is based on the fact that the physical presence of the professional is not necessary when performing rehabilitation using the vCare system, since the professional designs and configure the rehabilitation program using the KIOLA platform and the games, sessions, difficulty and time to perform the exercises are defined in REHABILITY.

4.2 PARKINSON

As explained in deliverable D1.8, the telerehabilitation for PD patients performed by the vCare system followed the same structure as of a traditional rehabilitation at the clinic. The patient performed 4 days of rehabilitation, 2 alternative days for motor session and 2 for cognitive session every week. The duration of each session least a maximum of 45 minutes (Rehability game session). The traditional rehabilitation is guided by a clinician (physiotherapist or neuropsychologist) while the vCare system, the virtual coach guided the patient. The patient pathway for traditional rehabilitation and the one that would be followed with vCare were reviewed and validated. With this information, the use and consumption of resources for both types of rehabilitation were quantified. Information on the unit cost of each of these resources was extracted from the *Organización Sanitaria Integrada Ezkerraldea-Enkaterri-Cruces* (OSI EEC) Economic Information System (OSAKIDETZA). Finally, the cost of treatment of the two alternatives was calculated.

Both types of rehabilitation perform three consultations at the beginning and at the end of the process, which lasts 3 months. Motor and neuropsychological rehabilitation is performed 4 times a week for 12 weeks. Both rehabilitations include a face to face clinical, neurological, neuropsychological, and motor pre-post evaluation [Time 0 and Time 1 (day 91)]. During the traditional rehabilitation time no face-to-face consultation is needed while during the vCare rehabilitation, a telephone follow-up consultation is performed 2 times a month.

The cost of subsequent consultations is half the cost of a first consultation, according to corporate criteria. The cost of telephone consultations is 0.4 of the cost of a face-to-face consultation, according to corporate criteria. The cost of motor rehabilitation corresponds to neurological rehabilitation sessions of the OSI EEC Rehabilitation Service. The cost of neuropsychological rehabilitation corresponds to the cost of a neuropsychological consultation.

Table 6 and Table 7 show the structure of the regular rehabilitation vs the vCare rehabilitation for one month and the costs of both rehabilitations, respectively.

Table 6. Structure of both rehabilitations for PD.

Weeks		Regular Rehabilitation		vCare telerehabilitaton			
		Motor Rehabilitation	Cognitive Rehabilitation	Motor Rehabilitation	Cognitive Rehabilitation	Telephone neurological consultation	Telephone neuropsychological consultation
Week 1	Monday						
	Tuesday						
	Wednesday						
	Thrusday						
	Friday						
	Saturday						
	Sunday						
Week 2	Monday						
	Tuesday						
	Wednesday						
	Thrusday						
	Friday						
	Saturday						
	Sunday						
Week 3	Monday						
	Tuesday						
	Wednesday						
	Thrusday						
	Friday						
	Saturday						
	Sunday						
Week 4	Monday						
	Tuesday						
	Wednesday						
	Thrusday						
	Friday						
	Saturday						
	Sunday						
Week 5	Monday						
	Tuesday						
1 Month		9	9	9	9	2	2

Table 7. Costs per patient of both rehabilitations for PD.

Resource Use	Regular rehablitation	COST (Hospital Information System)	TOTAL COST Regular Rehabilitation	vCare telerehabilitation	COST (Hospital Information System)	TOTAL COST vCare
Face-to-face neurological Consultation (First)	1	124,03	124,03	1	124,03	124,03
Face-to-face neurological Consultation (Successive)	1	62,01	62,01	1	62,01	62,01
Face-to-face NPS Consultation (First)	1	194,84	194,84	1	194,84	194,84
Face-to-face NPS Consultation (Successive)	1	97,42	97,42	1	97,42	97,42
Telephone NPS Consultation	0	0	0	1	77,94	77,94
Telephone NPS Consultation (Successive)	0	0	0	5	38,97	194,85
Face-to-face Motor Consultation (First)	1	121,98	121,98	1	121,98	121,98
Face-to-face Motor Consultation (Successive)	1	60,99	60,99	1	60,99	60,99
Telephone Motor Consultation (First)	0	0	0	1	48,79	48,79
Telephone Motor Consultation (Successive)	0	0	0	5	24,4	122,00
Motor Rehabilitation	27	63,68	1.719,23	27	63,68	0,00
NPS Rehabilitation (First)	1	194,84	194,84	1	194,84	0,00
NPS Rehabilitation (Successive)	26	97,42	2.532,92	26	97,42	0,00
vCare System Costs					vCare Cost	
Avatar voice (AIT)				350 €/year	29,17€ per month	87,51
Rehability (Imaginary)				60€ (100 patients a month)	60 € per month	180,00
vCare maintenance (SIMAVI)				25 € (100 patients a month)	25 € per month	75,00
Devices				2140€ all the devices/3 months of use	178,34 € per month	535,02
Desing of motor session				Physiotherapist 1 hour	30,96 per hour	30,96
Desing of cognitive session				Neuropsychologist 1 hour	47,43 per hour	47,43
Installation (OSA/BCB)				36,46€/hours technician x 4hours	36,46 per hour	145,84
Uninstallation (OSA/BCB)				36,46€/hour technician x 1hours	36,46 per hour	36,46
			5.108,26			**2.243,07**

Note: NPS: Neuropsychological; values in Euros

The cost of 3 months of traditional rehabilitation is €5108.26 while the use of the vCare system for 3 months costs €2243.07. This difference is based on the fact that the physical presence of the professional is not necessary when performing rehabilitation using the vCare system, since the professional designs and configures the rehabilitation program using the KIOLA platform and the games, sessions, difficulty and time to perform the exercises are defined in REHABILITY. In traditional rehabilitation, the professional is physically with the patient while the rehabilitation is being done.

4.3 Heart failure

Patients suffering from heart failure performed a cardiac rehabilitation program using the vCare system and following the structure of the conventional rehabilitation. The duration of the sessions varied between 30-45 minutes with a frequency of 2-3 times per week. The activities included in the cardiac rehabilitation program consist in aerobic training and resistance training. The traditional rehabilitation is guided and performed under strict observation of a physiotherapist (specialised in cardiopulmonary rehabilitation) and cardiologist. In contrast, the rehabilitation using the vCare system is guided by a virtual coach. The virtual coach sends different notifications if the activity is too easy for the patient, in this case the recommendation is to increase the intensity, or if the activity is too difficult and in this case the recommendation is to decrease the intensity or stop the activity. These notifications are very important because they help preventing possible accidents that may occur during the physical activity. We reviewed both types of cardiac rehabilitation, traditional rehabilitation and rehabilitation using vCare system and extracted the information regarding the resources used in both scenarios. Information on the unit cost of each of these resources were collected from 'Bagdasar-Arseni' Clinical Emergency Hospital. Finally, the cost of treatment of the two alternatives was calculated.

In both scenarios, the clinician performs one consultation (at the beginning of the treatment) and a control (at the end of the treatment). Also, blood samples are collected at the beginning and at the end in order to evaluate the effect on the lipid profile. The costs for ECG are reduced while using the vCare system compared to the traditional rehabilitation (2 for vCare and 12 for traditional rehabilitation), because the patient is performing the activity at home, thus this evaluation is only performed at the hospital at the beginning and the end of the treatment period.

Table 8 and Table 9 show the structure of the regular rehabilitation vs the vCare rehabilitation for one month and the costs of both rehabilitations, respectively.

Table 8. Structure of both rehabilitations for HF.

Weeks		Regular Rehabilitation		vCare telerehabilitation	
		Motor Rehabilitation		Motor Rehabilitation	
		Aerobic Training	Resistance Training	Aerobic Training	Resistance Training
Week 1	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 2	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 3	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 4	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 5	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
1 Month		15	15	15	15

Table 9. Costs per patient of both rehabilitations for HF

Resource Use	Regular rehabilitation	COST (Hospital Information System)	TOTAL COST Regular Rehabilitation	vCare telerehabilitation	COST (Hospital Information System)	TOTAL COST vCare
Blood samples	2	58.00 €	116.00 €	2	58.00 €	116.00 €
Chest X-Ray	1	6.46 €	6.46 €	1	6.46 €	6.46 €
Echocardiography + Doppler	1	11.00 €	11.00 €	1	11.00 €	11.00 €
ECG	12	16.80 €	201.60 €	2	16.80 €	33.60 €
ECG Stress Test	2	27.20 €	54.40 €	2	27.20 €	54.40 €
Cardiology Consultation	1	7.20 €	7.20 €	1	7.20 €	7.20 €
Cardiology Control	1	5.00 €	5.00 €	1	5.00 €	5.00 €
Aerobic Training Sessions	45	8.50 €	382.50 €	45	8.50 €	0
Resistance Training Sessions	45	8.50 €	382.50 €	45	8.50 €	0
vCare System Costs					vCare Cost	
Avatar voice (AIT)				350 €/year	29,17 € per month	87.51 €
Rehability (Imaginary)				60 € (100 patients a month)	60 € per month	180.00 €
vCare maintenance (SIMAVI)				25 € (100 patients a month)	25 € per month	75.00 €
Devices				775€ all the devices/3 months of use	64,59 € per month	193.77 €
Desing of motor session				Physiotherapist 1 hour	16 € per hour	16.00 €
Installation (UMFCD)				9€/hours technician x 4hours	9 € per hour	36.00 €
Uninstallation (UMFCD)				9€/hour technician x 1hours	9 € per hour	9.00 €
			1,166.66 €			**830.94 €**

The cost of 3 months of traditional cardiac rehabilitation is 1166.66€ while the use of the vCare system for 3 months costs 830.94€. This difference is based on the fact that the physical presence of the professional is not necessary when performing rehabilitation using the vCare system, since the professional designs and configures the rehabilitation plan using the KIOLA platform and the motor games, sessions, difficulty, heart rate adaptations and time to perform the exercises are defined in REHABILITY. In contrast, in traditional rehabilitation, the professional is physically with the patient while the cardiac rehabilitation is performed.

4.4 Ischemic Heart Disease

Patients suffering from ischemic heart disease (mostly after a myocardial infarct) performed a cardiac rehabilitation program using the vCare system and following the structure of the conventional rehabilitation. The duration of the sessions varied between 20-30 minutes with a frequency of 2-3 times per week. The activities included in the cardiac rehabilitation program consist in aerobic training and resistance training. The traditional rehabilitation is guided and performed under strict observation of a physiotherapist (specialised in cardiopulmonary rehabilitation) and cardiologist. In contrast, the rehabilitation using the vCare system is guided by a virtual coach. The virtual coach sends different notifications if the activity is too easy for the patient, in this case the recommendation is to increase the intensity, or if the activity is too difficult and in this case the recommendation is to decrease the intensity or stop the activity. These notifications are very important because they help preventing possible accidents that may occur during the physical activity. We reviewed both types of cardiac rehabilitation, traditional rehabilitation and rehabilitation using vCare system and extracted the information regarding the resources used in both scenarios. Information's on the unit cost of each of these resources were collected from 'Bagdasar-Arseni' Clinical Emergency Hospital. Finally, the cost of treatment of the two alternatives was calculated.

In both scenarios, the clinician performs one consultation (at the beginning of the treatment) and a control (at the end of the treatment). Also, blood samples are collected at the beginning and at the end in order to evaluate the effect on the lipid profile. The costs for ECG are reduced while using the vCare system compared to the traditional rehabilitation (2 for vCare and 12 for traditional rehabilitation), because the patient is performing the activity at home, thus this evaluation is only performed at the hospital at the beginning and the end of the treatment period.

Table 10 and Table 11 shows the structure of the regular rehabilitation vs the vCare rehabilitation for one month and the costs of both rehabilitations, respectively.

Table 10. Structure of both rehabilitations for IHD

Weeks		Regular Rehabilitation		vCare telerehabilitation	
		Motor Rehabilitation		Motor Rehabilitation	
		Aerobic Training	Resistance Training	Aerobic Training	Resistance Training
Week 1	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 2	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 3	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 4	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
Week 5	Monday				
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday				
	Sunday				
1 Month		15	15	15	15

Table 11. Costs per patient of both rehabilitations for IHD

Resource Use	Regular rehablitation	COST (Hospital Information System)	TOTAL COST Regular Rehabilitation	vCare telerehabilitation	COST (Hospital Information System)	TOTAL COST vCare
Blood samples	2	58.00 €	116.00 €	2	58.00 €	116.00 €
Chest X-Ray	1	6.46 €	6.46 €	1	6.46 €	6.46 €
Echocardiography + Doppler	1	11.00 €	11.00 €	1	11.00 €	11.00 €
ECG	12	16.80 €	201.60 €	2	16.80 €	33.60 €
ECG Stress Test	2	27.20 €	54.40 €	2	27.20 €	54.40 €
Cardiology Consultation	1	7.20 €	7.20 €	1	7.20 €	7.20 €
Cardiology Control	1	5.00 €	5.00 €	1	5.00 €	5.00 €
Aerobic Training Sessions	45	8.50 €	382.50 €	45	8.50 €	0
Resistance Training Sessions	45	8.50 €	382.50 €	45	8.50 €	0
vCare System Costs					vCare Cost	
Avatar voice (AIT)				350 €/3 months of use	29,17 € per month	87.51 €
Rehability (Imaginary)				60 € (100 patients a month)	60 € per month	180.00 €
vCare maintenance (SIMAVI)				25 € (100 patients a month)	25 € per month	75.00 €
Devices				575€ all the devices/3 months of use	47,92 € per month	143.76 €
Desing of motor session				Physiotherapist 1 hour	16 € per hour	16.00 €
Installation (UMFCD)				9€/hours technician x 4hours	9 € per hour	36.00 €
Uninstallation (UMFCD)				9€/hour technician x 1hours	9 € per hour	9.00 €
			1,166.66 €			**780.93 €**

The cost of 3 months of traditional cardiac rehabilitation is 1166.66€ while the use of the vCare system for 3 months costs 780.93€. This difference is based on the fact that the physical presence of the professional is not necessary when performing rehabilitation using the vCare system, since the professional designs the rehabilitation plan using the KIOLA platform and the motor games, sessions, difficulty, heart rate adaptations and time to perform the exercises are defined in REHABILITY. In contrast, in traditional rehabilitation, the professional is physically with the patient while the cardiac rehabilitation is performed.

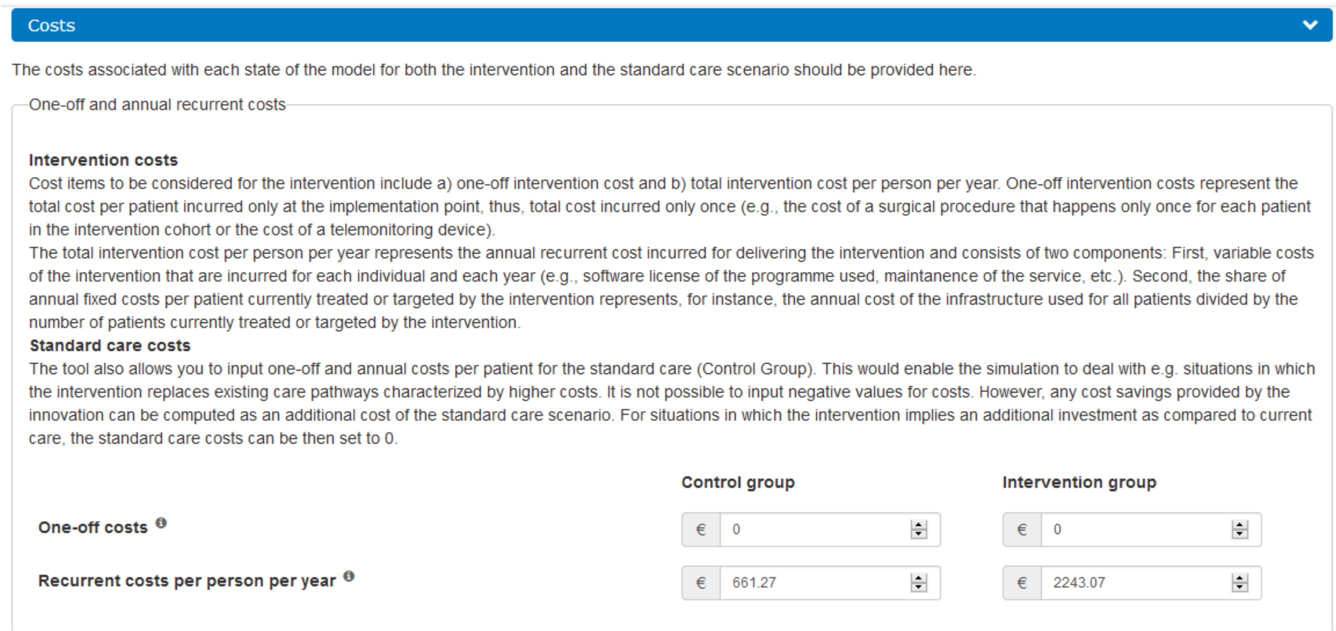
For both use cases (Heart Failure and Ischemic Heart Disease) the protocol for traditional rehabilitation is the same (aerobic training exercises + resistance training exercises), the only difference is the intensity, duration and frequency of the exercises. These parameters are linked to the biological and clinical status of the patient, thus the cost for traditional rehabilitation is the same for both cardiological diseases.

5 Cost-effectiveness of Parkinson's Disease pilot

A micro-cost study has been carried out to quantify the consumption of resources that would be needed in conventional rehabilitation since Osakidetza-Basque Health Service does not provide conventional rehabilitation for this type of pathology, PD.

The costs per patient in the control group (regular/conventional rehabilitation) are €5,108.26 per rehabilitation period and €2,243.07 for the vCare intervention group (telerehabilitation). There are no implementation or unique costs (One-off-costs). All resource consumption has been included in the cost per patient. Social or additional costs have not been taken into account.

Currently, these patients receive follow-up consultations, but no rehabilitation. This follow-up (consultations) has a cost of €661.27. The total cost of the rehabilitation would include motor therapy and neuropsychology, which would mean a total cost of €5,108.26.


Costs

The costs associated with each state of the model for both the intervention and the standard care scenario should be provided here.

One-off and annual recurrent costs

Intervention costs
Cost items to be considered for the intervention include a) one-off intervention cost and b) total intervention cost per person per year. One-off intervention costs represent the total cost per patient incurred only at the implementation point, thus, total cost incurred only once (e.g., the cost of a surgical procedure that happens only once for each patient in the intervention cohort or the cost of a telemonitoring device).
The total intervention cost per person per year represents the annual recurrent cost incurred for delivering the intervention and consists of two components: First, variable costs of the intervention that are incurred for each individual and each year (e.g., software license of the programme used, maintanence of the service, etc.). Second, the share of annual fixed costs per patient currently treated or targeted by the intervention represents, for instance, the annual cost of the infrastructure used for all patients divided by the number of patients currently treated or targeted by the intervention.
Standard care costs
The tool also allows you to input one-off and annual costs per patient for the standard care (Control Group). This would enable the simulation to deal with e.g. situations in which the intervention replaces existing care pathways characterized by higher costs. It is not possible to input negative values for costs. However, any cost savings provided by the innovation can be computed as an additional cost of the standard care scenario. For situations in which the intervention implies an additional investment as compared to current care, the standard care costs can be then set to 0.

	Control group	Intervention group
One-off costs	€ 0	€ 0
Recurrent costs per person per year	€ 661.27	€ 2243.07

Figure 7. Costs for PD. Information extracted from MAFEIP tool.

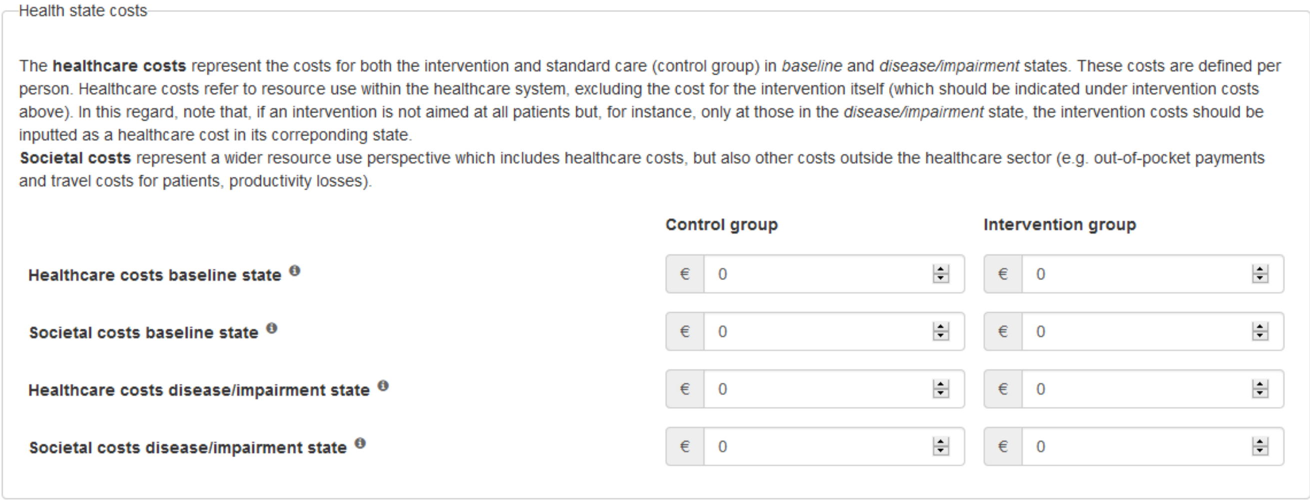


Figure 8. Health state costs for PD. Information extracted from MAFEIP tool.

Regarding the utilities, values from 0 to 1 have been obtained for the health states provided by the patients through the EQ-5D-5L quality of life survey, following the methodology published by Ramos-Goñi et al. (2017).

ID	Baseline	EQ5D Mob	EQ5D Self-Care	EQ5D Actv	EQ5D Pain	EQ5D Anxiet	Post Interve	EQ5D Mob	EQ5D Self-Ca	EQ5D Actv	EQ5D Pain	EQ5D Anxiety
PD01		4	4	4	5	3		2	1	1	4	2
PD02		3	2	3	5	2		1	1	1	3	1
PD03		4	3	3	4	2		2	2	2	1	2
PD04		3	3	3	4	5		3	3	2	1	1
PD05		4	4	3	4	1		2	1	3	1	2
PD06		4	4	3	4	2		3	3	3	1	3
PD07		3	2	2	4	4		1	1	1	2	2
PD08		4	3	3	5	2		4	2	2	4	2
PD09		4	3	4	5	5		2	2	2	2	2
PD10		3	2	3	3	4		2	2	2	2	3
PDC01		4	4	4	4	4		4	4	4	4	4
PDC02		3	3	3	1	2		3	3	3	1	2
PDC03		4	4	5	4	4		4	4	5	4	4
PDC04		3	2	3	3	1		3	2	3	3	1
PDC05		2	2	1	3	1		2	2	1	3	1
PDC06		2	2	2	1	2		2	2	2	1	2
PDC07		2	1	2	1	2		2	1	2	1	2
PDC10		3	3	3	3	3		3	3	3	3	3

Table 12. Quality of life pre-post-intervention data base for PD.

ID	PRE	POST
PD01	-0,0582848	0,5897916
PD02	0,3392365	0,8988509
PD03	0,3218019	0,7412205
PD04	0,2052686	0,8034117
PD05	0,2917834	0,7863568
PD06	0,211044	0,670991
PD07	0,2907151	0,8412776
PD08	0,1854813	0,3299586
PD09	-0,167752	0,6632375
PD10	0,430176	0,6164435
PDC01	-0,0648995	-0,0648995
PDC02	0,717785	0,717785
PDC03	-0,0829082	-0,0829082
PDC04	0,7006447	0,7006447
PDC05	0,7648556	0,7648556
PDC06	0,7412205	0,7412205
PDC07	0,7912441	0,7912441
PDC10	0,5698419	0,5698419

	PRE	POST
PD	0,20	0,69
PDC	0,52	0,52

Table 13. Quality of life pre-post-intervention calculation data base for PD.

Utilities

To estimate the impact of the intervention in terms of health outcomes, utility weights associated with *baseline* and *disease/impairment* states should be provided here. Following the common practice, the tool identifies measures of preference-based Health Related Quality of Life (HRQoL) and life expectancy as preferred categories of health outcome on intervention level. The EQ-5D questionnaire is recommended for calculating utility since the conceptual basis of the EQ-5D is the holistic view of health (i.e. not only including the medical aspect, but also physical, emotional and social functioning of the patient). Nevertheless, other instruments such as SF-36, SF-12 or SF-6D can also be used to account for utility. In such cases, these scores should be mapped into the respective EQ-5D values (Please refer to the MAFEIP User's Guide Manual for more information on mapping utility scores to EQ-5D values).
When none of these methods have been used in your study to assess health outcomes, you may also use other variables as a proxy for quality of life (e.g. patient scores on satisfaction with life).

Health-related quality of life (HRQoL)

The HRQoL as expressed through a quality-of-life weight (utility) represents a particular health outcome. The utility measures summarize both positive and negative effects of an intervention into one value between 0 (indicating death) and 1 (which is equal to perfect health condition) so that the higher the value, the higher the quality-of-life associated with that health outcome. If you do not use utility measures in your intervention, you can utilize other variables as a proxy for quality of life. Such scores should be mapped into a 0-1 range.

	Control group	Intervention group
Utility of baseline state	0.52	0.2
Utility of disease/impairment state	0.52	0.69

Figure 9. Utilities weights associated with baseline and disease/impairment state for PD. Information extracted from MAFEIP tool.

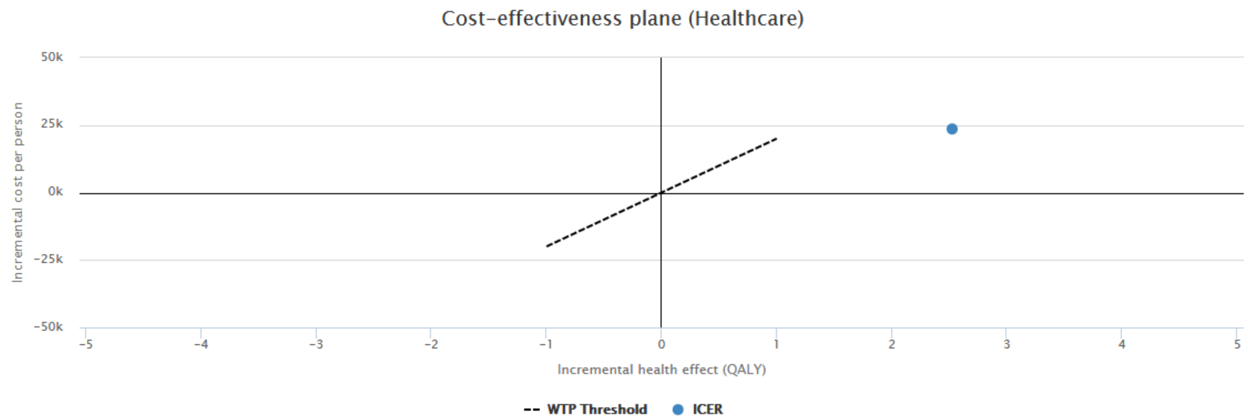
The intervention group had a mean health status of 0.2 at baseline, with some patients even having a health status worse than death (negative). After the intervention, it has gone on to have an average health status of 0.69. The control group has not suffered variation in their health status since these patients currently do not receive treatment.

Cost-effectiveness analysis for PD

The cost-effectiveness plane represented below shows the difference in costs and results per patient. The incremental cost-effectiveness ratio (ICER), represented by the blue dot, is the ratio between the variation in costs and results. This cost-effectiveness analysis has been performed the MAFEIP tool following the European recommendations.

For a cost of €661.27 for the current treatment, and a cost of €2,243.07 for telerehabilitation, given a threshold of €20,000 per QALY (Vallejo-Torres, García-Lorenzo, Serrano-Aguilar, 2018) telerehabilitation is shown as a cost-effective alternative.

Incremental cost and HRQoL effects	
Incremental cost (Healthcare)	23523.87
Incremental effects	2.528
Incremental cost-effectiveness ratio (Healthcare)	9304.71



WTP Threshold: ○ €15K/QALY ◉ €20K/QALY ○ €30K/QALY ○ €50K/QALY ○ €80K/QALY

Figure 10. Cost-effectiveness for PD

If conventional rehabilitation were performed and if the improvement in quality of life would not have been greater than through telerehabilitation, telerehabilitation would be the dominant alternative since it would be the most effective one, and the least expensive alternative.

6. CONCLUSIONS

Telerehabilitation in Parkinson's patients has been shown to be cost-effective compared to conventional rehabilitation, which recommends its implementation. A study with a larger number of patients should be performed to confirm the results obtained in the PD pilot study. In addition, it is important to highlight that vCare is not only a motor and cognitive telerehabilitation tool, it is a virtual coach system that includes telerehabilitation, as well as an artificial intelligence and machine learning system that makes it possible for the rehabilitation and the avatar to adapt and personalize itself to each patient.

Like in the case of Parkinson’s patients, telerehabilitation in stroke patients has been shown to be cost-effective compared to conventional rehabilitation, with a cumulative saving of about €2.500 for patient, which is in line with some evidenced from the systematic review reported at the beginning of the document which shows a significant cost/savings per person between €564.40 and $2352. Moreover, it has to the noted that in the actual Italian environment, traditional rehabilitation at home is seldom provided by the National Healthcare system. Sometimes, depending on the availability of the local healthcare authority, a package of 10 session at home is provided, for motor rehabilitation. But usually there is no availability of professionals, or the waiting list is too long to guarantee the continuity of care. In this sense, telerehabilitation at this stage has to be considered as additional cost, even if a specific working group, driven by Ministry of Health, is working on the topic, to allow the prescription of telerehabilitation services, under the premise of a specific traceability of the exercises, like vCare provides, both the motor and the cognitive component.

For UMFCD in both use cases (HF and IHD), it’s shown a difference regarding the costs for cardiac rehabilitation with a lower cost when using the vCare system. This cost difference doesn’t affect the quality of the rehabilitation program because patients benefited of a personalized schedule which is set by a physiotherapist in the professional portal. In terms of clinical effectiveness, the vCare solution improved the lipid profile, the effort capacity measured in VO_2 max (ml/kg/min) and the scores obtained using the quality of life questionnaire. In Romania, there is a strong need for the implementation of telerehabilitation services, because currently hospitals are overcrowded with difficult cases that require the utmost attention from medical staff. With the help of the vCare system, the patient is monitored 24/7 during the execution of prescribed exercises, as well as at rest and in daily activities.

Overall, the vCare pilots demonstrate that vCare is a clinically and cost-effective tool compared with the clinical results from the control group that followed the traditional rehabilitation at the clinic. The vCare system seems to be an optimal tool to be used as a virtual coach and telerehabilitation tool.

7. Limitations

The cost-effectiveness analysis according to the main outcome, the quality of life, has been performed just for one of the four pilots due to different issues and complications that have appeared during the pilot phase. The minimum time to measure the quality of life after an intervention should be a minimum of 12 weeks. Therefore, this deliverable only shows the cost-effectiveness analysis of the PD pilot (OSA/BCB).

PD pilot limitations

The sample of patients was small, and some data needed for calculating the cost-effectiveness analysis such as quality of life was only available for one of the four pathologies included in the vCare project (Parkinson's). These conditions led to the results obtained in telerehabilitation.

It should be taken into account that the difference in quality of life between the control group and the PD vCare intervention group was the maximum possible since the patients in the control group (conventional rehabilitation) had only received a follow-up of their disease because Osakidetza-Basque Health Service does not offer rehabilitation for this type of pathology. It would be necessary to perform conventional rehabilitation on the control group to compare them with the results obtained with telerehabilitation.

CCP Stroke Use case

CCP has suffered some limitations in running the pilot because of the pandemic situation, which has slowed down the direct contact with patients, both for clinical evaluations and for on-site support at home. In addition, as the solution was intended to be provided in terms of continuity of care, after discharge, during 2019-2022 CCP suffered a reduction of bed-occupancy, also because of the restructuring works of the whole hospital.

UMFCD Heart Failure Use Case

There have been some limitations regarding the pilot that need to be mentioned. Between January and February 2022, the activities performed at Bagdasar-Arseni Clinical Hospital have been suspended, due to pandemic situation. This aspect impacted all the activities including also the enrolment of the patients and the examination in the hospital.

Another limitation was represented by the delay in receiving some of the devices required for the configuration and deployment of the vCare system. The pandemic situation in recent years has led to this delay in delivering the necessary devices for the pilot phase given the worldwide delivery problems.

Noteworthy, a significant shortfall of internet connection infrastructure or inadequate and unsafe home environment forced us to exclude a considerable number of subjects. Indeed, for many of them or for their relatives and/or caregivers the effort required to participate in the study would have been too burdensome. This shows that the inclusion criteria might have been set too lax.

UMFCD Ischemic Heart Disease Use Case

The Ischemic Heart Disease Use Case was initially the responsibility of the Danish partners (AU). Due to the refusal of the Danish Ethical Committee, the case has been transferred on 15.03.2022 to UMFCD.

During this entire period, we have encountered difficulties and delays in the electronic equipment purchases. We received 15 Orbbec Cameras on 12.04.2022 and 12 Set Top Boxes on 18.05.2022. This big delay (mainly due to delivery problems caused by the pandemic situation) resulted in a shorter time for conducting the ischemic heart disease pilot.

Another limitation was the refusal of otherwise eligible patients, situation that limited the enrolment process and the deployment of the devices.

REFERENCES

Balady, G. J., Williams, M. A., Ades, P. A., Bittner, V., Comoss, P., Foody, J. A. M., … Southard, D. (2007). Core components of cardiac rehabilitation/secondary prevention programs: 2007 update - A sci. statement from the Am. Heart Assoc. exercise, cardiac rehabilitation, and prevention comm., the council on clinical cardiology; the councils on cardiovascular nursing, epidemiology and prevention, and nutrition, physical activity, and metabolism; and the Am. Assoc. of Cardiovasc. and Pulmonary Rehabil. Circulation, 115(20). https://doi.org/10.1161/CIRCULATIONAHA.106.180945

Bellmann, B., Lin, T., Greissinger, K., Rottner, L., Rillig, A., & Zimmerling, S. (2020). The Beneficial Effects of Cardiac Rehabilitation. Cardiology and Therapy, 9(1). https://doi.org/10.1007/s40119-020-00164-9

Bendixen, R. M., Levy, C. E., Olive, E. S., Kobb, R. F., & Mann, W. C. (2009). Cost effectiveness of a telerehabilitation program to support chronically ill and disabled elders in their homes. Telemedicine and E-Health, 15(1). https://doi.org/10.1089/tmj.2008.0046

Berger, M. L., Bingefors, K., Hedblom, E. C., Pashos, C. L., & Torrance, G. W. (2003). Health Care Cost, Quality, and Outcomes. International Society for Pharmacoeconomics and Outcomes Research. Department of Pharmacy, Faculty of Pharmacy, Medicinska vetenskapsområdet, Uppsala University: Lawrenceville NJ. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-65251

Bettger, J. P., & Resnik, L. J. (2020). Telerehabilitation in the age of covid-19: An opportunity for learning health system research. Physical Therapy. https://doi.org/10.1093/ptj/pzaa151

Cho, S., Khasanshina, E. V., Mathiassen, L., Hess, D. C., Wang, S., & Stachura, M. E. (2007). An analysis of business issues in a telestroke project. Journal of Telemedicine and Telecare, 13(5). https://doi.org/10.1258/135763307781458930

Drummond, Michael F.; O´Brien, Bernie J.; Stoddart, Greg L.; Torrance, G. W. (2001). Métodos para la Evaluación Económica de los Programas de Asistencia Sanitaria. Ediciones Díaz de Santos.

Feigin, V. L., Vos, T., Nichols, E., Owolabi, M. O., Carroll, W. M., Dichgans, M., … Murray, C. (2020). The global burden of neurological disorders: translating evidence into policy. The Lancet Neurology. https://doi.org/10.1016/S1474-4422(19)30411-9

Frederix, I., Hansen, D., Coninx, K., Vandervoort, P., Vandijck, D., Hens, N., … Van Driessche, N. (2015). Effect of comprehensive cardiac telerehabilitation on one-year cardiovascular rehospitalization rate, medical costs and quality of life: A cost-effectiveness analysis. European Journal of Preventive Cardiology.

Frederix, I., Solmi, F., Piepoli, M. F., & Dendale, P. (2017). Cardiac telerehabilitation: A novel cost-efficient care delivery strategy that can induce long-term health benefits. European Journal of Preventive Cardiology, 24(16). https://doi.org/10.1177/2047487317732274

Housley, S. N., Garlow, A. R., Ducote, K., Howard, A., Thomas, T., Wu, D., … Butler, A. J. (2016). Increasing Access to Cost Effective Home-Based Rehabilitation for Rural Veteran Stroke Survivors. Austin Journal of Cerebrovascular Disease & Stroke, 3(2).

Hwang, R., Morris, N. R., Mandrusiak, A., Bruning, J., Peters, R., Korczyk, D., & Russell, T. (2019). Cost-Utility Analysis of Home-based Telerehabilitation Compared with Centre-based Rehabilitation in Patients with Heart Failure. Heart Lung and Circulation, 28, 1795–1803. https://doi.org/10.1016/j.hlc.2018.11.010

Jamison, D. T. (2018). Disease Control Priorities, 3rd edition: improving health and reducing poverty. The Lancet. https://doi.org/10.1016/S0140-6736(15)60097-6

Jia, H., Cowper, D. C., Tang, Y., Litt, E., & Wilson, L. (2012). Postacute Stroke Rehabilitation Utilization: Are There Differences Between Rural-Urban Patients and Taxonomies? Journal of Rural Health, 28(3). https://doi.org/10.1111/j.1748-0361.2011.00397.x

Johansson, T., & Wild, C. (2011). Telerehabilitation in stroke care - A systematic review. Journal of Telemedicine and Telecare. https://doi.org/10.1258/jtt.2010.100105

Kidholm, K., Rasmussen, M. K., Andreasen, J. J., Hansen, J., Nielsen, G., Spindler, H., & Dinesen, B. (2016). Cost-Utility Analysis of a Cardiac Telerehabilitation Program: The Teledialog Project. Telemedicine and E-Health, 22(7). https://doi.org/10.1089/tmj.2015.0194

Kraal, J. J., Elske Van Den Akker-Van Marle, M., Abu-Hanna, A., Stut, W., Peek, N., & Kemps, H. M. C. (2017). Clinical and cost-effectiveness of home-based cardiac rehabilitation compared to conventional, centre-based cardiac rehabilitation: Results of the FIT@Home study. European Journal of Preventive Cardiology, 24(12). https://doi.org/10.1177/2047487317710803

Lloréns, R., Noé, E., Colomer, C., & Alcañiz, M. (2015). Effectiveness, usability, and cost-benefit of a virtual reality-based telerehabilitation program for balance recovery after stroke: A randomized controlled trial. Archives of Physical Medicine and Rehabilitation, 96(3). https://doi.org/10.1016/j.apmr.2014.10.019

Maddison, R., Rawstorn, J. C., Stewart, R. A. H., Benatar, J., Whittaker, R., Rolleston, A., … Gant, N. (2019). Effects and costs of real-time cardiac telerehabilitation: Randomised controlled non-inferiority trial. Heart, 105(2). https://doi.org/10.1136/heartjnl-2018-313189

Peretti, A., Amenta, F., Tayebati, S. K., Nittari, G., & Mahdi, S. S. (2017). Telerehabilitation: Review of the state-of-the-art and areas of application. JMIR Rehabilitation and Assistive Technologies. https://doi.org/10.2196/rehab.7511

Piepoli, M. F., Corrà, U., Adamopoulos, S., Benzer, W., Bjarnason-Wehrens, B., Cupples, M., … Giannuzzi, P. (2014). Secondary prevention in the clinical management of patients with cardiovascular diseases. Core components, standards and outcome measures for referral and delivery: A Policy Statement from the Cardiac Rehabilitation Section of the European Association for Cardiovascular Prevention & Rehabilitation. Endorsed by the Committee for Practice Guidelines of the European Society of Cardiology. European Journal of Preventive Cardiology, 21(6). https://doi.org/10.1177/2047487312449597

Public Health and Aging: Trends in Aging—United States and worldwide. (2003). From the Centers for Disease Control and Prevention. Public health and aging: trends in aging--United States and worldwide. JAMA : The Journal of the American Medical Association, 289(11). https://doi.org/10.1001/jama.289.11.1371

Ramos-Goñi JM, Pinto-Prades JL, Oppe M, Cabasés JM, Serrano-Aguilar P, Rivero-Arias O. Valuation and Modeling of EQ-5D-5L Health States Using a Hybrid Approach. Med Care. 2017 Jul;55(7):e51-e58. doi: 10.1097/MLR.0000000000000283. PMID: 25521503; PMCID: PMC7659432

Rosen, M. J. (1999). Telerehabilitation. NeuroRehabilitation, 12, 11–26. https://doi.org/10.3233/NRE-1999-12103

Sacristán, J. A., Ortún, V., Rovira, J., Prieto, L., & García-Alonso, F. (2004). Evaluación económica en Medicina. Medicina Clinica. https://doi.org/10.1157/13059336

Skempes, D., Kiekens, C., Malmivaara, A., Michail, X., Bickenbach, J., & Stucki, G. (2021). Supporting government policies to embed and expand rehabilitation in health systems in Europe: A framework for action. Health Policy. https://doi.org/10.1016/j.healthpol.2021.06.014

Stinear, C. M., Lang, C. E., Zeiler, S., & Byblow, W. D. (2020). Advances and challenges in stroke rehabilitation. The Lancet Neurology. https://doi.org/10.1016/S1474-4422(19)30415-6

Subedi, N., Rawstorn, J. C., Gao, L., Koorts, H., & Maddison, R. (2020). Implementation of telerehabilitation interventions for the self-management of cardiovascular disease: Systematic review. JMIR MHealth and UHealth, 8(11). https://doi.org/10.2196/17957

Tchero, H., Teguo, M. T., Lannuzel, A., & Rusch, E. (2018). Telerehabilitation for stroke survivors: Systematic review and meta-analysis. Journal of Medical Internet Research. https://doi.org/10.2196/10867

Vallejo-Torres, L., García-Lorenzo, B., & Serrano-Aguilar, P. (2018). Estimating a cost-effectiveness threshold for the Spanish NHS. Health economics, 27(4), 746–761. https://doi.org/10.1002/hec.3633

World Health Organization. (2017). Rehabilitation in health systems.