Telerehabilitation assessment domains and process in chronic diseases: a scoping meta-review

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Abstract

Background Telerehabilitation (TR) interventions are receiving increasing attention. They have been evaluated in various scientific areas through systematic reviews. However, there is a lack of data on how to standardize assessment and report on their domains to guide researchers across studies and bring together the best evidence to assess TR for chronic diseases.

Aims and Objectives The aim of this study is to identify domains of assessment in TR and to qualitatively and quantitatively analyze how they are examined to gain an overview of assessment in chronic disease and understand the complexity of TR interventions.

Methods A scoping meta-review was carried out on 9 databases and gray literature from 2009 to 2019. The keyword search strategy was based on *"telerehabilitation"*, *"evaluation"*, *"chronic disease"* and their synonyms. All articles were subjected to qualitative analysis using the Health Technology Assessment (HTA) Core Model prior to further analysis and narrative synthesis.

Results Among the 7412 identified articles, 80 studies met the inclusion criteria. Regarding the domains of assessment, the most frequently occurring were *"social aspect"* (n = 63, 79%) (e.g., effects on behavioral changes) and *"clinical efficacy"* (n = 53, 66%), and the least frequently occurring was *"safety aspects"* (n= 2, 3%). We also identified the phases of TR in which the assessment was conducted and found that it most commonly occurred in the *pilot study* and *randomized trial* phases and least commonly occurred in the *design*, *pretest*, and *postintervention* phases.

Conclusions Through the HTA model, this scoping meta-review highlighted the multidisciplinarity and comprehensiveness of TR assessment in the recent literature. Future studies will benefit from approaches that leverage the best evidence regarding the assessment of TR interventions, and it will be interesting to extend this assessment framework to other chronic diseases.

Background

At a time when medical progress is accelerating and life expectancy are increasing, chronic or noncommunicable diseases (NCDs) are also on the rise [1]. The latest WHO reports indicate that NCDs (mainly heart and lung disease, obesity, cancer, and diabetes) are responsible for 16 million premature deaths (before the age of 70) each year (WHO, 2015). As the leading cause of morbidity, disability and mortality in industrialized countries, NCDs constitute a real public health problem, and their prevention, treatment and risk factors have become major international issues. Nondrug interventions, such as rehabilitation, are possible based on a thorough assessment of the patient. *Rehabilitation* is a comprehensive intervention focused on the patient's needs and designed to improve physical and psychological fitness and promote long-term adherence to health-promoting behaviors [2].

At present, due to the use of information and communication technologies (ICT) [3], the use of telemedicine and the potential effectiveness of mobile applications [4–6], *telerehabilitation* (TR) is

increasingly attracting the attention of policymakers, payers, healthcare professionals, patients and the scientific community. TR (a subcategory of telehealth) is the use of ICT to provide clinical rehabilitation services from a distance [7]. TR is emerging as an innovative approach to providing remote care and to deploying rehabilitation [8][9–12] to improve accessibility and continuity of care and to educate patients about adherence and long-term maintenance of the beneficial effects of rehabilitation [13, 14]. TR is an intervention that emerged at the end of the 1990s [15], and it represents a powerful tool for improving the management of daily practice and the creation of networks between health structures (e.g., hospitals or clinics) and services.

However, despite undeniable evidence of the contribution of TR, many TR interventions still fail and rarely achieve technology adoption [16, 17], user engagement and intervention effectiveness [18–20]. Considering the several elements that could explain this failure, it is clear that TR suffers from a lack of exhaustive development in its many dimensions and that there may be a gap between design and reality [21]. Indeed, assessing TR is a complex matter for several reasons: TR is a broad concept that requires multidisciplinary collaborations with many stakeholders [22], who must simultaneously consider the dimensions that characterize TR intervention: technological, clinical and others (i.e., ethical, cost-effectiveness, social) [23][24][25, 26]. In addition, health information systems should be assessed with the same rigor as a new drug or treatment program to prevent decisions about future deployments of ICT in the health sector from being determined by social, economic, and/or political circumstances rather than by robust scientific evidence [27]. Thus, we must be able to evaluate TR interventions while they are being designed, developed and deployed [27]. Thus, in assessing TR, an extensive appraisal including these different dimensions is needed in each phase of the technology's life cycle [27–30].

The aim of this scoping meta-review [31] was thus to systematically map recent research to understand the assessment of TR from a comprehensive perspective. First, in order to identify all the domains of TR assessment for chronic diseases, we used a comprehensive evaluation framework with a multidisciplinary approach: the Health Technology Assessment (HTA) Core Model [32]. The HTA includes several domains and thus appears to be the most complete framework. In addition, we identified the phases of TR interventions in which assessment occurs by mapping out the content of the reviews and grouping the phases of intervention with similar objectives, activities, or results. On this basis, our 2 research questions were as follows:

1. 1. What domains of evaluation have been identified in the literature on TR for chronic disease?
2. 2. What are the assessment domains of the different phases of TR?

Finally, the findings allow us to present a novel way of examining the assessment of TR interventions and could provide a reference and information for policymakers, clinicians and researchers regarding the development of assessment guidelines.

Methods

This study is based on a new method, the scoping meta-review [31]. This method combines the scoping review and meta-review methods. *Scoping reviews* entail reviewing the emerging literature to provide an initial indication of the size and nature of the available literature on a particular topic [33, 34]. *Meta-reviews* involve synthesizing evidence from a set of systematic reviews [35, 36]. We first considered performing a simple scoping review, considering that the field is diverse and complex [37]. However, during the initial extraction of the data, we noticed the existence of numerous systematic reviews on various aspects of TR assessment. Thus, it seemed relevant and feasible to undertake a scoping review of the systematic reviews related to TR assessment approaches [31]. The advantage of relying on systematic reviews is that they can provide a solid and reliable synthesis of work in the field [37].

Protocol

We followed the guidelines of Levac et al. (2010), updated from the initial work of Arksey and O'Malley (2005). In addition, we wrote the protocol using the "Preferred Reporting Items for Systematic reviews and Meta-Analyses Extension for Scoping Reviews" (PRISMA-ScR) [38]. Levac et al. (2010) suggest that the protocol should not be designed as a rigid tool and strictly applied. Thus, in our study, the protocol was used as a guide, and we followed it when necessary [39]. The final protocol is not publicly available; however, it can be made available upon request to the corresponding author.

Eligibility Criteria

The methodological approach of the scoping review allowed for the identification and alteration of the inclusion and exclusion criteria as articles were selected. Inclusion and exclusion were performed first on the basis of article selection through the "title" and "abstract" filters and then by reading the articles in full.

The *inclusion criteria* are studies that (1) are in the systematic literature review format, (2) address at least one of the NCD categories of cardiovascular disease (cardiovascular accidents), cancer, chronic respiratory disease, diabetes, obesity, identified on the basis of the prevalence and importance of the common behavioral risk factors (smoking, poor diet, sedentary lifestyle, harmful use of alcohol) (according to the figures provided by the WHO), (3) address TR in the sense of the definition given in the rationale (see the introduction), (4) include features of the definition of rehabilitation presented in the rationale, (5) contain at least one intervention offering physical activity as part of a multidisciplinary approach, (6) date from 2009 to 2019, (7) are in French or English, and (8) use an adult population 18 + years old.

The *exclusion criteria* are studies (1) that present interventions without technology or limited to a telephone follow-up approach, (2) that are written in a language other than English or French, (3) that present a single study or are opinion papers, draft syntheses, abstract/conference proceedings (oral presentations and posters), chapters, discussions, letters, books available electronically, and theses, (4) where it is impossible to identify the type of intervention performed, (5) that deal with an intervention with technology limited to the physical activity dimension alone (without multidisciplinary approach) or that

do not contain a physical activity dimension, or (6) that deal with methods/requirements without real evaluation related to TR or for which it is impossible to locate the full text.

Information Sources

The field of TR must take into account the growing ICT evolution in health (connected objects, mobile devices, etc.), so we included studies published only between January 2009 and October 2019. We conducted extensive literature searches in the electronic bibliographic databases most likely to contain the type of study we are looking for. The databases are multidisciplinary, covering fields from computer science to health science: MEDLINE (PubMed), Web of Science, Cochrane Library, ABI, Business Source Premier, PsycINFO, Science Direct, Academic Search Premier, and SPORTDiscus. We conducted additional searches in the gray literature (a) by consulting the reference lists of the included studies and (b) by searching repositories of gray literature: CADTH, Directory of Open Access Journals (DOAJ), Occupational Therapy Systematic Evaluation of Evidence (Otseeker), International Prospective Register of Systematic Reviews (PROSPERO), OpenSIGLE (OpenGrey), and the New York Academy of Medicine Library's Grey Literature Report. The research strategy was planned and carried out through structured team discussions and in consultation with a university librarian so that the strategy could be refined in light of the initial results. We exported the final search results to Zotero (5.0.95.1, Roy Rosenzweig Center for History and New Media, Fairfax, Virginia), a bibliographic database. This software facilitated the management of the research, particularly the identification and removal of duplicates.

Search - Identification of Relevant Studies

We identified the keywords through, on the one hand, the medical subject headings (MesH) providing the controlled vocabulary for MEDLINE/PubMed and, on the other hand, other keywords, which we call free vocabulary. Free vocabulary was added based on the expertise of the different team members but also by reading the abstracts in 1st intention if it seemed relevant and necessary. The search strategy was based on the terms "telerehabilitation" AND "evaluation" AND "chronic disease" and all their synonyms (see Additional file 1). Each database was searched individually. The keyword search strategy, based on the use of the Boolean operators AND and OR as well as ti(title) and ab(abstract), is described below.

Selection of Sources of Evidence

To increase consistency among the 5 reviewers, pairs were created to independently evaluate article titles and abstracts for inclusion in the study. Evaluators met at the beginning, midpoint and end of the process to discuss issues and uncertainties related to the selection of potentially relevant studies and to re-evaluate and refine the research strategy if necessary. We then independently reviewed the full papers for inclusion. Disagreements over study selection and data extraction were resolved by consensus and discussion with other reviewers to make a final decision on inclusion if necessary.

Data Charting Process

To begin, the first author developed a data table. We used a conceptual framework to guide the data extraction (Additional file 2). Subsequently, the other coauthors discussed and validated this table to

determine the variables to be extracted. Once this first version was finalized, three members of the evaluation team tested the table by independently collecting data on 3 articles to share their perspectives concerning the dimensions to be collected. Next, two of these reviewers conducted data collection on 10% of the corpus of selected articles and discussed the results, continuously updating the data charting table in an iterative process. We then carried out a second calibration exercise testing the % agreement, with a predetermined level of agreement (70–80%) [38]. The concordance determined by the Kendall concordance coefficient (W) in SPSS software was greater than 80% (mean: 87%; Kendall's W = 0.8697). The first researcher thus finalized the coding alone, and any disagreements and questions were resolved through discussion between the two reviewers. Moreover, by charting the content of the reviews and grouping those with similar objectives, activities, and/or outcomes, thematic analysis could be used to determine whether the reviews focused on certain phases of the technology life cycle rather than others.

Data Items

The data extracted from the articles are as follows: author(s), year of publication, location of study, design of review (narrative review, descriptive review, scoping review, meta-analysis, systematic review, theorical review, etc.), title, type of pathology, fields of technology (m-health, e-health, etc.), definition of technology, tools associated with technology (SMS, apps, web, etc.), end-users, number of studies included (study design and participants), whether type of evaluation allows for consideration of and focus on phases of the technology life cycle (design, pretest, pilot study, randomized trial, postintervention), key findings, and critical appraisal of researcher (if applicable). For each review, we extracted the presence and number of evaluation domains based on the HTA model (see the following paragraph). In accordance with the PRISMA-ScR, we did not perform a quality assessment or quality evaluation, as this is not essential for scoping review methodologies. Thus, the methodological rigor of the published articles was not a criterion for inclusion or exclusion.

Critical Appraisal of Individual Sources of Evidence: The HTA (Healthcare Technology Assessment) Core Model Framework [32]

We needed an analytical framework, a multidisciplinary approach that could include all domains of TR assessment, to know what was being evaluated and to break down the silos of the assessment dimensions. For this purpose, we chose the Health Technology Assessment (HTA) Core Model [32] from among the evaluation frameworks available in the literature [40–44] because it suggests what kinds of information one can find in an HTA report, and its definition encompasses the dimensions of multidisciplinarity and comprehensiveness. The definition of a *health technology assessment* is as follows: *"a multidisciplinary process that summarises information about the medical, social, economic and ethical issues related to the use of a health technology in a systematic, transparent, unbiased, robust manner" (p13)* [32]. The structure of the information collected is as follows: the domains of assessment (the broad framework within which the technology is considered), the topics of assessment (more specific considerations in one of the domains), and the issues raised (even more specific considerations on one of the topics that may be similar to research questions in scientific studies). The structure of the model is based on the combination of these three points to define the different assessment elements and

facilitate a shared understanding of what belongs to HTA. Additional file 2 below provides an overview of the 10 domains described in the HTA core model: health problem and current use of technology, description and technical characteristics of technology, safety, accuracy, clinical effectiveness, costs and economic evaluation, ethical analysis, organizational aspects, social aspects, and legal aspects.

Methods of Handling and Summarizing the Data

A qualitative synthesis of the included studies is conducted to chart the literature on the domains of TR assessment. The data are summarized using descriptive tables of the categories developed from the HTA framework. Additionally, a qualitative inductive and content analysis approach allowed us to bring out other elements of TR assessment (completing the existing framework).

Results

Selection of Sources of Evidence

The search of the 9 databases generated 7412 results (Fig. 1). After elimination of duplicates, 5306 publications remained. The review of the titles and abstracts led to the exclusion of 5174 publications, leaving 132 publications requiring screening on the basis of the full text. Full text screening helped to remove an additional 54 publications, leaving 78 articles. The most common reason for excluding citations during full-text screening was that the studies did not include physical activity in their interventions ($n = 24$). Subsequently, 2 articles were added from the gray literature and manual research. A total of 80 publications remained (Fig. 1), all of which focused on one or more domains of TR assessment and required further analysis.

Characteristics of the Reviews Included and Reports According to the EUnetHTA Template

Year of publication and geographical distribution - Table 1 shows the number of reviews included by year bracket between 2009 and October 2019. Few reviews were published between 2009 and 2013 (n = 14, 18%). Most of the articles were published from 2014 onwards, and more than one-third of the articles (n = 26, 33%) were published from 2018–2019, the last two years studied. The majority of the reviews (n = 31, 39%) were from Europe, followed by North America (n = 25, 31%), Oceania (Australia and New Zealand) (n = 13, 16%), Asia (mainly China) (n = 9, 11%) and South America (n = 2, 3%).

Table 1
Characteristics of the included documents

Characteristics	No. of reviews (n = 80)	Percentage (%)
Year of publication		
2009–2011	7	9
2012–2013	7	9
2014–2015	19	24
2016–2017	21	26
2018–2019	26	33
Location of study		
Europe (with UK)	31	39
North America	25	31
Oceania	13	16
Asia	9	11
South America	2	3
Pathologies concerned		
Diabetes	45	56
Cardiovascular diseases	38	48
Chronic Respiratory Diseases	25	31
Cancers	20	25
Obesity	19	24
Design of the review		
QSR	52	65
QSR and MA	14	18
Umbrella (meta-review)	4	5
Scoping review	4	5
MA	3	4
QSR and meta-synthesis (meta-ethnography)	1	1
Realist review	1	1
MA, meta-analysis; QSR, qualitative systematic review		

Characteristics	No. of reviews (n = 80)	Percentage (%)
Descriptive	1	1
Field of technology (as stated by the authors)		
m-health	33	41
e-health	16	20
Telehealth	16	20
Web (internet)-based intervention	6	8
m-health and e-health	3	4
Telemedicine	2	3
Telerehabilitation	2	3
Digital health intervention	2	3
MA, meta-analysis; QSR, qualitative systematic review		

Pathologies concerned - The main categories of NCDs were cardiovascular diseases (heart attacks), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease or asthma), obesity and diabetes. Fifty-four articles (68%) focused on a single pathology, and 26 (32%) focused on > = 2 pathologies. More than half of the articles dealt with diabetes (n = 45, 56%), followed by cardiovascular disease (n = 38, 48%). One-third of the reviews were on chronic respiratory diseases (n = 25, 31%). A quarter (n = 20, 25%) of the reviews addressed cancer, closely followed by obesity (n = 19, 24%) (see Table 1).

Types of systematic literature reviews - As shown in Table 1, more than 80% of the reviews were additionally derived from qualitative systematic reviews (n = 52, 65%), meta-analyses (n = 3, 4%) or the performance of both at the same time (n = 14, 18%). For the other reviews, we found scoping reviews (n = 4, 5%), meta-reviews (umbrella) (n = 4, 5%), a meta-ethnography and a descriptive review.

Areas of intervention and definitions – In our research, the term "telerehabilitation", according to the definition given in the rationale, was found under different names in each of the included reviews. The most-used terms were rather generic: "m-health" (n = 33, 41%), "e-health" (n = 16, 20%), and "telehealth" (n = 16, 20%) or, more rarely, "web-based intervention/rehabilitation" (n = 6, 8%), "e-health/m-health" (n = 3, 4%), "digital health intervention" (n = 2, 3%), and "telemedicine" (n = 2, 3). The term "telerehabilitation" appeared only twice (3%). Systematic reviews used different definitions corresponding to the field of intervention stated in the research. Despite the sometimes disparate definitions, the numerous reviews nevertheless provided an evaluation of different studies (with different interventions) that may correspond to the definition of TR given in the rationale. In this way, some authors raised the issue of the difficulty of determining the element of effectiveness of the TR interventions evaluated [45].

Types of associated technological tools - We classified the technological tools mobilized into several categories (see Additional file 3). In most studies, a combination of several tools was identified to enable the interventions to be carried out [41, 46–48]. Mobile and internet/website applications were most commonly used, with 51 articles (17% for each). Short message system tools followed, with 47 articles (14%). Often, in addition to these first three tools, phone calls ($n = 39$, 11%), digital devices (e.g., connected objects) ($n = 36$, 11%), and emails ($n = 29$, 9%) were added. Less frequently, it was also possible to identify the following tools: videos/images ($n = 22$, 6%), videoconferences ($n = 14$, 4%), and social networks ($n = 14$, 4%). More rarely, we found that studies used personal health reports ($n = 4$, 1%) or other technological tools, such as logbooks, virtual reality, or digital libraries.

Completeness of the reports according to the EUnetHTA template - Given the number of sources included in the scoping meta-review, the relevant data from each source are provided in Additional File 4. On average, we found a total of 3 HTA domains evaluated per review. Table 2 shows the number of HTA domains appearing in the reviews. Briefly, the most represented domains were *social aspect*, in 79% ($n = 63$) of the reviews, and *clinical efficacy*, in 66% ($n = 53$). *Ethical analysis* and *safety aspects* were both evaluated only in 3% ($n = 2$) of the reviews studied, and *accuracy* was not represented in our data.

Tableau 2

EUnetHTA HTA Core Model Domains included in the reviews

Domains evaluated	No. of domain appearances	Percentage (%)
HTA Core Model domains		
1. Social	63	79
2. Clinical effectiveness	53	66
3. Health problem	46	58
4. Description and technical characteristics of technology	37	46
5. Cost and economic evaluation	14	18
6. Organizational	12	15
7. Legal	12	15
8. Ethical	2	3
9. Safety	2	3
10. Accuracy	-	-

Telerehabilitation Assessment Domains Identified

In this section, we present the TR domains that review authors evaluated. To understand these domains, we mapped them using the principles derived from the EUnetHTA HTA framework (see Methodology). After extracting the domains during the qualitative analysis, we classified them into 9 categories: *social aspects, health problem and current use of technology, description and technical characteristics of technology, costs and economic evaluation, organizational aspects, legal aspects, ethical analysis*, and *safety.* Table 3 shows these domains and the key aspects of their measurement.

Table 3
Description of identified telerehabilitation assessment domains

Domain assessed	Key subjects of measurement
Social aspects	*Major life areas*: Technologies are seen as opportunities to find similar user communities and share experiences among peers [49]. Effect on psychological distress [50], stress management, fatigue [50, 51], knowledge of treatment and chronic disease [52–55]. Encouraging but varied effects on self-efficacy [53, 56, 57]. Effects on behavioral changes in PA, diet, medication adherence, and smoking [53, 57–62]. *Individual*: Ten reviews examine the acceptability of the intervention [63, 64] mainly to the patient as an end user [58, 65, 66], and 15 reviews study satisfaction [58, 67, 68]. Facilitators and individual barriers are also studied [45, 69]. *Communication*: Evaluation of the usability of technologies during the development process [25, 46, 58, 63, 70]. Need for targeted technology [65] and stimulation of user engagement, motivation and involvement over time [68, 71, 72], and the quality of patient-caregiver interaction [64, 65, 68, 73].
Clinical effectiveness	*Health outcomes*: Benefits and unanticipated negative effects of telerehabilitation interventions compared to standard interventions (usual care). Outcomes include postintervention mortality [74, 75], clinical results (blood lipids, blood pressure, hemoglobin A1c, weight, BMI) [20, 47, 53, 58, 76], quality of life [51, 56, 66, 68], anxiety, depression [51, 58, 75, 77–80], and physical functions (exercise capacity, exercise tolerance); presented in the short [47, 54, 81], medium and/or long term [82, 83]. *Patient satisfaction*: Willingness to reuse or recommend the technology [51, 55]. *Comparative accuracy of a replacement technology*: More specific or safer technological intervention than an older or comparable technological intervention (with more features, feedback, educational messages, or combinations of technological tools) [20, 65, 81].
Health problem a current use of technology	*Target condition*: Differences in the effectiveness of the intervention according to the various targeted pathologies, possible differences from one pathology to another [50, 65]. Example of type 1 diabetes and type 2 diabetes [20, 76]. *Utilization*: differences in use between countries or a lack of education in low-income countries [66, 84]. Identification of the applicability and acceptability of telerehabilitation in primary care, general practice and hospital settings [85]. *Other*: Only one study focused on evaluating the actors involved in the design of the technology (i.e., a team of IT developers) [86].
Description and technical characteristics of technology	*Features of the technology*: General information (name, type of device, language, etc.) [48, 67, 86], purpose of using the technology (e.g., to promote behavioral change) [45, 58, 79, 87], technical characteristics (ergonomics, functionalities, interoperability) [88–91]. *Investments and tools required to use the technology*: Type of operating system and its availability [49, 71, 84, 86, 92]; the brand and relevance of technological tools [23, 25, 59]. *Training and information needed to utilize the technology*: Protocols, educational materials, recommendations, and documents developed to make the intervention appropriate for the target population [48, 65, 67, 70, 92–94]. Need to set up feasibility, accessibility and usability studies [89].
Costs and economic evaluation	*Unit costs*: Related to the unit costs of the resources used (e.g., technology acquisition costs or the cost of specific actions) [49, 65, 70, 84, 86, 95, 96]. *Outcomes*: Health cost outcomes by type of telerehabilitation intervention [97], compared to a control group [68], to prevent, predict or minimize exacerbation [98]. *Cost-effectiveness*: Intervention that can be cost-effective under certain conditions [56, 95]. But little studied, "urgent" need to carry out controlled and homogeneous trials [99].

Domain assessed	Key subjects of measurement
Organizational aspects	*Process*: Monitor care outcome processes such as maintenance of the behavioral effects of the intervention [65], clinic attendance, the effectiveness of the chronic disease surveillance system or the compliance of tools used to improve clinic attendance (e.g., SMS reminders) [95]. Interest in having a multidisciplinary team trained in motivational feedback [100]; fund technology-oriented studies and encourage proposals from interdisciplinary groups of researchers [65]. *Structure*: The effects of the implementation of interventions on hospital admissions, the use of health resources [72, 101, 102], clinical workload and workflow, and dependence on technology for work [103]. *Management*: Interest in proposing multiple models of patient management (e.g., integrating alternative models), based on evidence, responding to the needs and profile of patients [68, 77]. Take into account the intentions of future caregivers to integrate technological tools into their practice [65, 89].
Legal aspects	*End-user*: Identify the various target populations [53, 69, 77, 104] and those that are poorly studied [48, 53] in order to carefully examine the possibility of generalizing new modalities of intervention and their potential dissemination. *Privacy of the patient and authorization and safety*: Describe procedures to ensure the security and storage of private data [64] and identify if problems occur in the private sphere [67]. *Legal regulation of novel/experimental techniques*: Adapt the development of new mobile applications to regulations (e.g., medical devices) [89]. *Regulation of the market*: Identify whether reimbursement of intervention systems is possible and by whom [65].
Ethical analysis	*Principal questions about the ethical aspects of technology*: Spreading the use of technologies (e.g., ethical challenges of privacy and data security)[25].
Safety	*Technology-dependent safety risks*: Identify potential problems with the reliability and validity of information entered into the technology by the patient or caregiver; identify the number of adverse effects of interventions in patients [63]. *Use- or user-dependent safety risks*: Identify potential complications that may arise due to certain functionalities (e.g., misinterpretation of information sent) [65].

Additional Non-HTA TR Domain

The HTA framework was not developed specifically for TR, and during the inductive and thematic analysis and by comparing results between reviewers, we found that 95% of the reviews (n = 76/80) evaluated the *"interventional aspect"*. This interventional aspect combines the characteristics of the interventions or their functionalities and the application of recommendations and theoretical foundations to construct these interventions. Therefore, we decided to add this assessment domain to complement the HTA framework.

Characteristics of the intervention - The main characteristics of the intervention can be classified according to the strategies used. An average of 5 strategies was identified per review: educational information (n = 61; 76%), communication with others (n = 53; 66%), self-management (physical activity, diet, medication adherence, smoking) (n = 64; 80%), feedback and self-monitoring (n = 48; 60%), use of prompts/cues (reminders and alerts) (n = 38; 48%), exercise training (n = 32; 40%), psychosocial support (n = 12; 15%), stress management (n = 10; 13%), patient assessment (n = 8; 10%) and others. Additional file 5 gives a sample of the intervention characteristics identified in 10 reviews.

Application of recommendations and theoretical foundations for behavior change -

Clinical recommendations suggest that ongoing behavioral support is necessary for lifestyle changes to be sustainable [58]. Many reviews (n = 31; 39%) present intervention characteristics based on specific theories/conceptual frameworks for designing and optimizing TR interventions [53, 84, 94]. The behavior change theory (BCT) developed by Abraham & Michie (2008) is the most widely used behavior change theory in technological applications (n = 13/31) [41, 60]. The most mobilized BCTs are "goal setting", "self-monitoring of behavior", "information about health consequences", "social support", and "feedback and monitoring". The transtheoretical model [105] and social cognitive theory [106] are the next most applied (n = 10/31). Many other theories are mentioned more sporadically, such as self-efficacy theory, the theory of planned behavior - reasoned action, social ecological theory, social support theory, the self-management model, self-determination theory, the health belief model, and cognitive behavior theory.

Phases of the Telerehabilitation Assessment Process

To answer our second research question, we focused on how the assessment was conducted in the distinct development phases of TR: *design, pretest, pilot study, randomized trial* and *postintervention*. This led us to develop the *telerehabilitation assessment process* (Fig. 2), which illustrates the accumulation of evidence by crossing the assessment domains with the distinct development phases of TR. The domains of assessment (i.e., *health problem and current use of technology, description and technical characteristics of technology, safety, clinical effectiveness, costs and economic evaluation, ethical analysis, organizational aspects, social aspects*, and *legal aspects)* vary in each phase. The results show that assessment is mainly carried out in the *pilot study* and *randomized trial* phases. For example, during the *pilot study* phase, the focus of assessment shifts primarily to the *social aspect*, followed mainly by *clinical effectiveness.* On the other hand, assessment is rarely carried out in the *design, pretest*, and *postintervention* phases. When a TR intervention initiates with the *design* phase, the decisions are made based on the evaluation of the *description and technical characteristics of technology, social aspects, costs and economic evaluation, organizational aspects*, *legal aspects* and *ethical analysis.* The *health problem and current use of technology* and *safety* domains appear in the *pretest* phase. Although there are still few reviews of the postintervention phase, this comprehensive evaluation process can be used to gradually accumulate evidence that could be used to make future decisions.

Discussion

This scoping meta-review was conducted to identify the different domains of TR assessment for chronic diseases and provide a comprehensive view of TR assessment through the analytic framework of HTA. The results indicate that many systematic reviews are generally focused on a limited number of assessment dimensions.

In identifying and summarizing the main domains of assessment, we highlighted the multidisciplinarity and comprehensiveness of the assessment of TR. Our study shows that 9 out of the 10 domains composing the HTA framework have been explored by TR reviews (*social aspects, clinical effectiveness, description and technical characteristics of technology, health problem and current use of technology, costs and economic evaluation, legal aspects, organizational aspects, safety*, and *ethical analysis*). This result reflects the relevance of this framework for our specific analysis.

Much of the focus centered on the domains of *social aspect* and *clinical effectiveness.* Together, they represent 48% of occurrences, though they constitute only 20% of the HTA domains (n = 2/9 domains). This reflects an imbalance in the assessment of the different domains. To date, research in these two domains has relied primarily on randomized controlled trials (RCTs) to assess TR. The performance of an RCT is considered the "gold standard" in research [107], and the RCT is a unique approach of achieving lifestyle changes in patients with chronic diseases [65]. Despite this major interest, some researchers have questioned their usefulness given the complexity of assessing TR interventions [107]. Our results also show that the least frequently occurring domains were *safety* and *ethical analysis.* Although our review highlights some promising emerging results that may help commissioners, developers, and users manage risks and improve patient safety [63, 65], several studies have shown that mobile medical applications (apps) could compromise patient safety [108, 109]. Future research could develop a risk framework that users, developers, and other stakeholders can use to assess the likely risks posed by specific apps in a specific context [110]. Finally, concerning *ethical analysis*, despite the fast-paced growth of TR, only a few articles propose suggestions to practitioners for addressing ethical challenges such as acquiring compliant software, receiving training, creating informed consent procedures, and using an ethical decision-making model [111].

Regarding our choice to mobilize the HTA Core Model, we evaluated its relevance and operationality with respect to TR. This framework had not yet been applied in the field of TR, so we sometimes had difficulty classifying some of the data using the HTA domains. Indeed, there was ambiguity regarding some items that could be classified under multiple domains at the same time. For example, in this framework, the description of the *social aspects* domain includes the effects on behavioral changes in physical activity and diet. These elements could also be classified under *clinical effectiveness* for a health or rehabilitation expert. We can also take a critical view of the results with respect to the frequency of the appearance of certain domains (e.g., the *social aspects* domain is present at a greater frequency than the *clinical effectiveness* domain). Furthermore, with regard to the model, it would be interesting to consider its supplementation or comparison with other validated frameworks. For example, the literature proposes many (more or less comprehensive) approaches to e-health [40], m-health and even telemedicine [38, 105–107] assessment to assist decision makers who want to introduce and use this technology.

Moreover, we identified an additional non-HTA domain, the *interventional aspect*, which defined several attributes of TR intervention assessment. The majority of published reviews (*n* = 76, 95%) examine the different characteristics of interventions that engage the patient and foster the success of TR to promote behavior change and positive health outcomes. A number of reviews provide encouraging evidence about

BCTs and their benefits for the improvement of physical activity outcomes [60]. In contrast to this literature, a recent meta-review highlighted the need for better implementation tools that support patient engagement and identified the necessity of optimizing the design of the self-management resources included in or with guidelines [112]. Thus, a variety of theories offer insight into how patients' perceptions influence their behavior and can be used to design and then evaluate self-management guideline tools.

For our secondary objective, we aimed to identify the phases of TR interventions in which assessment occurs. Our results showed a marked interaction between assessment domains and the distinct development phases of TR. This allowed us to highlight which domain was assessed at which phase, suggesting that it is inappropriate to assess all domains in a single phase. This TR assessment process can capture comprehensive, dynamic and complex evidence, crossing the various domains of assessment with the development phases of TR. While many TR assessments are still quite disconnected from each other and thus fail to create a synergic effect in TR research efforts, this classification could truly structure research in the field, similar to the "phases" of drug discovery and development [113]. Furthermore, through comparison with existing literature, we observed that this TR assessment process is distinct from the e-health evaluation model of Enam et al. (2018) [114]. For example, when e-health intervention is initiated at the *design* phase, the decisions are made solely based on the assessment of the *technological* and *cost* domains of technology development, whereas in this scoping meta-review, they also include *social aspects, organizational aspects, legal aspects* and *ethical analysis.* Therefore, our process proposes an additional specification not present in the evaluation model of e-health interventions in general. This TR assessment process could become cumbersome because of high resource consumption, but it is not a prescription, just a way to show the progression of evidence in TR applications in a reliable manner.

Limitations

The main strengths of this review are the use of the scoping review methodology, which enabled coverage of a very broad range of topics; the comprehensive search strategy developed; and the rigorous quality assessment of each review by two independent researchers. However, there are a number of limitations that must be highlighted. First, a scoping meta-review can only report on literature that has been included in published reviews, meaning some recently published primary research might not be included. Another limitation was that our electronic database searches may have missed relevant citations. This is potentially due (1) to restriction of the search to English and French language publications, and (2) to certain documents that may have been omitted, unknowingly and unintentionally, although we have included and analyzed many journals in this scoping meta-review. Additionally, these TR reviews included only the five major groups of known chronic diseases that represent the highest rate of premature mortality, limiting the generalizability of the results. It would be interesting to see if this TR assessment process could be extended and applied to other chronic pathologies that require TR, such as osteoarthritis or stroke [115, 116].

Finally, this scoping meta-review shows that semantically, the remote delivery of rehabilitation is not homogeneous: the terms used include "m-health", "e-health", "telehealth", "web-based intervention/rehabilitation", "digital health intervention", "telemedicine" and "telerehabilitation". There is a use of multiple 'definitions' and an apparent lack of solidarity in defining TR. How, then, do we – collectively – define TR? The confusion extends to other aspects of the TR domain [117]. According to Scott et al. (2013), it seems important to resolve the semantic issues around "e-health strategies" and identify barriers to TR, such as profession-centric nomenclature. Further discussion can then ensue to ensure that the diversity of TR is understood and that the appropriate mix of specific solutions is brought to bear in response to defined health needs.

Conclusions

This scoping meta-review reported on a large number of reviews that focused on assessing TR intervention for chronic diseases. By proposing and using a comprehensive assessment framework for TR, our results highlighted 10 assessment domains and a list of the main related aspects. The different domains mobilized for assessment are not all studied with the same degree of interest. Furthermore, we showed that each of these assessment domains could appear at different phases of TR development, whereas current research generally focuses on one or a few assessment dimensions. These main contributions allow us to enrich this literature on the assessment of TR and propose new cross-disciplinary and complete method for the assessment of TR interventions.

Due to the challenge of integrating TR into the management of patients with chronic diseases, this framework could guide future studies in obtaining a comprehensive view of the assessment of TR. Thus, improved validation of evaluation methods could facilitate the transferability of results among similar studies and bring together the best evidence to assess TR interventions across a broad range of domains.

Abbreviations

WHO: World Health Organization

 CADTH: Canadian Agency for Drugs and Technologies in Health

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

BC conceived the study. BC, FA, NH, FB and MH participated in the design of the study and the initial syntheses of the results. BC designed the search strategy with input from FA, NH, FB, MH, RO, and ASC and drafted this section of the methods. BC, FA, NH, MH, and FB conducted the title and abstract screening. BC, FA and NH extracted the data and conducted the coding and analyses. All authors were involved in drafting and critically revising the manuscript. All authors read and approved the final manuscript prior to its submission.

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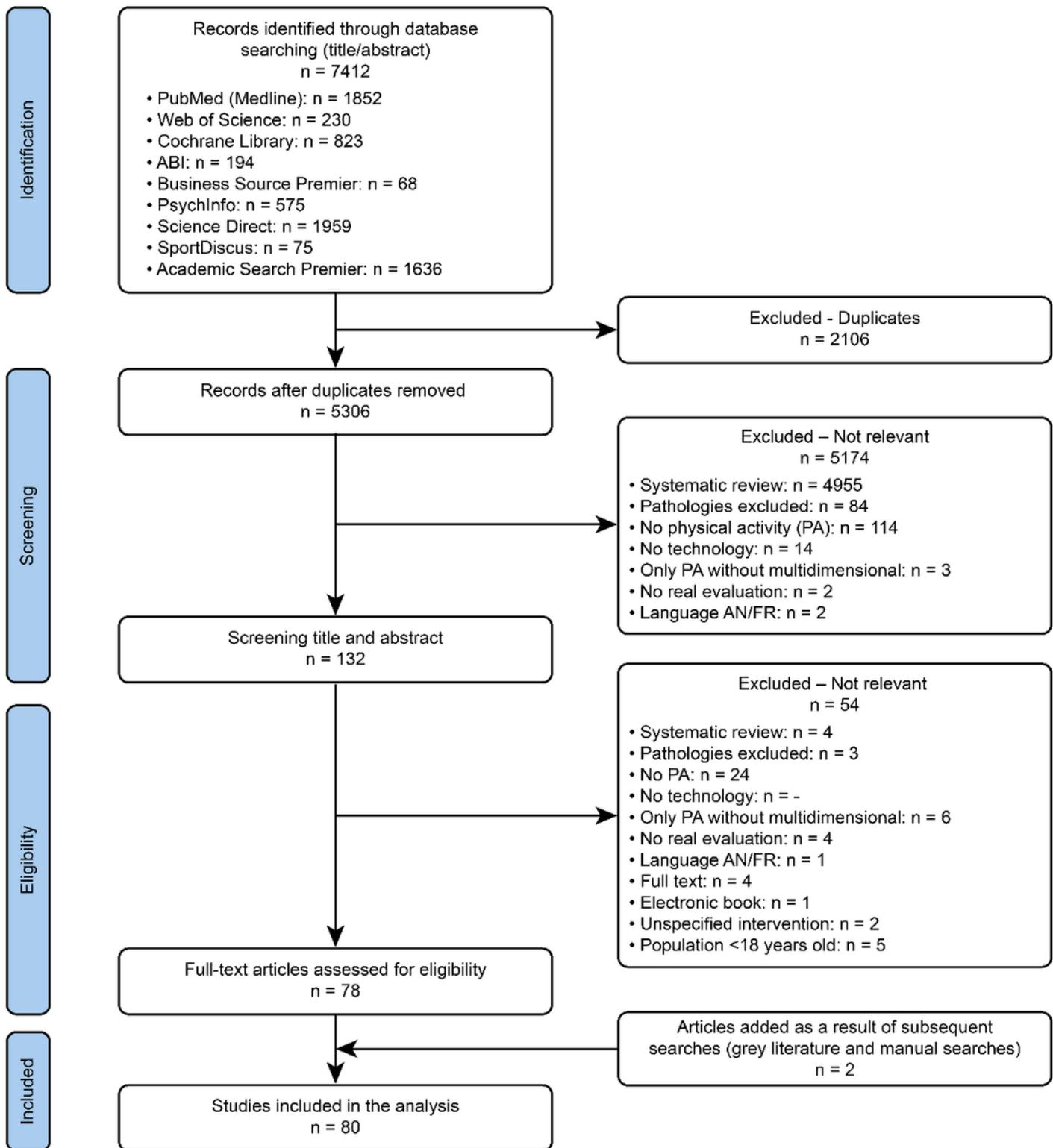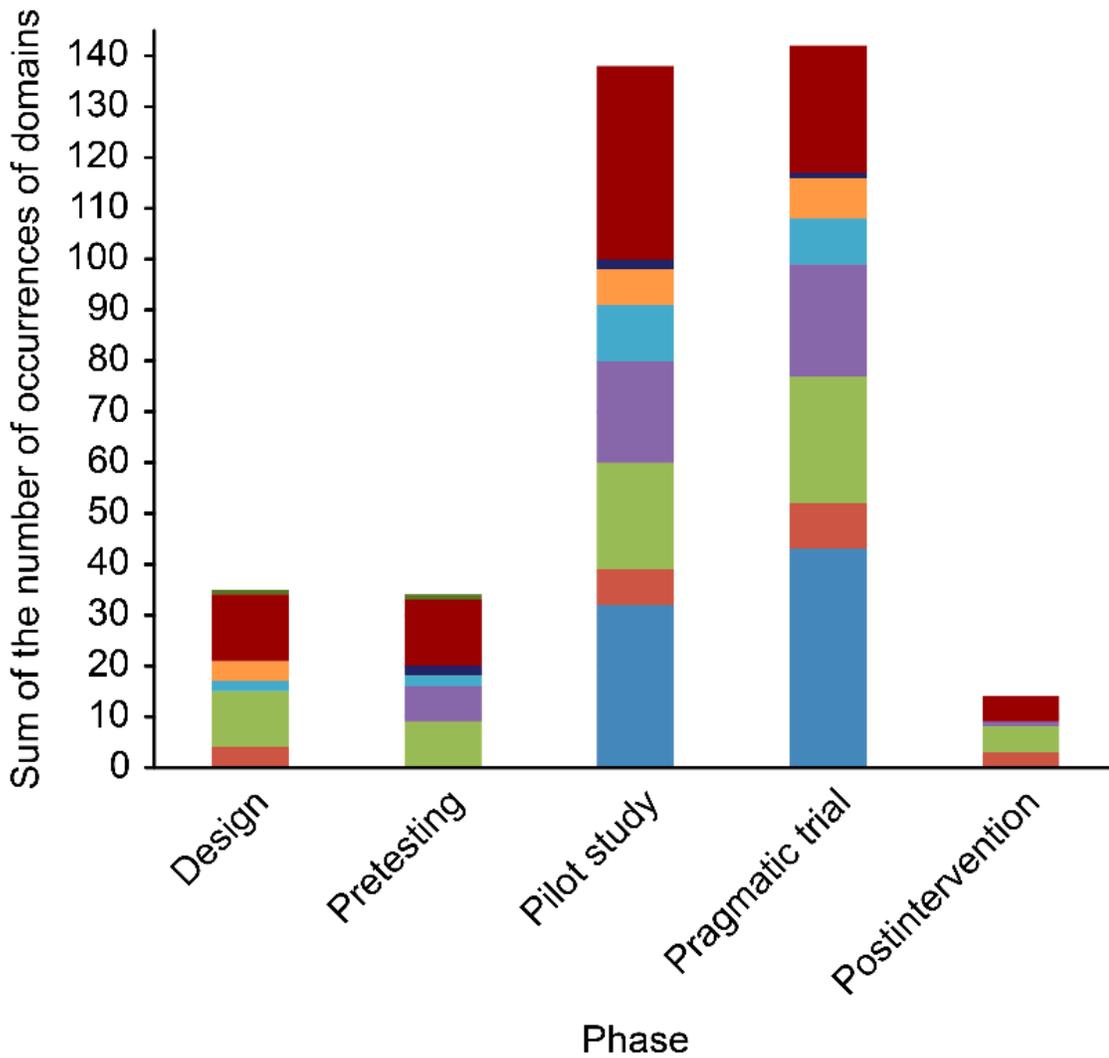
Figures

Figure 1

PRISMA flow chart for the study

Figure 2

Telerehabilitation assessment process

Supplementary Files

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