A Renewed Framework for the Evaluation of Telemedicine

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***Abstract*— The aim of this paper is to present a renewed framework for the evaluation of telemedicine that provides better insight into the real potential of telemedicine and as such fosters implementation in daily clinical practice. This study first evaluates the current literature on the use of the framework proposed by Dechant et al., 1996. Physical rehabilitation is used as casus. After screening, 40 relevant papers were included. Results show that the technology used and the clinical purposes are diverse and that the majority of the technology used was not implemented in daily clinical practice. The staged approach to the evaluation of telemedicine proposed by Dechant et al., 1996 was rarely applied. From the papers included it becomes clear that the following aspects are important to consider in the evaluation of telemedicine: (1) the type of telemedicine in terms of technology used, its level of maturity and its clinical purpose and (2) the way the telemedicine is implemented in daily clinical practice (service configuration).**

Keywords-Telemedicine; evaluation; framework.

I. INTRODUCTION

It is widely acknowledged that telemedicine has great potential in healthcare to overcome the problems related to our ageing community, to increase the quality and accessibility of care, and to restrain the rise of imperative healthcare costs. The current state is that the amount of evidence regarding the effectiveness of telemedicine is growing [1][2]. However, even proven effective telemedicine services often fade away and are not implemented into healthcare [3][4][5]. It deserves a further analysis to what factors impede the uptake of these services and what is needed to speed up its implementation [6][7]. One of the questions directly related to this, is whether the evaluation studies currently being performed provide sufficient evidence to convince healthcare professionals, policy makers and insurance companies.

An evaluation framework is the first step to secure a proper evaluation. Currently, only a few evaluation frameworks are available. The most common evaluation framework is the stage model of drug evaluation [8]. This model has been developed by the Food and Drug Administration and provides guidelines for demonstrating the safety and efficacy of new drugs as a prerequisite for marketing. In 1996, an analogous model for evaluation of new technologies was proposed by Dechant et al.[9]. In this framework, the type of assessment is tailored to the development life cycle of the technology. This so-called staged approach differentiates between telemedicine evaluation at application (stage 1-2) and global level (stage 3-4). Evaluation of a telemedicine service starts with an evaluation of the technical efficacy (accuracy and reliability) of the application and evaluation of the primary objective of the service in terms of access, quality or cost (stage 1-2). During the subsequent deployment a comprehensive evaluation is necessary, using multiple endpoints such as accessibility, quality and cost of care (stage 3). The last step of evaluating a telemedicine service is to examine whether the overall evaluation of a technology in one system, applies in other settings (stage 4). An advantage of this evaluation framework is that it takes into account the iterative process of the development of the technology. However, considering the fast development of new technology the obsolete of this evaluation framework could be a disadvantage.

Proper evaluation is essential to convince the various stakeholders of the added value of telemedicine and to come to sustainable implementation in daily clinical practice. Therefore, the aim of this paper is to create and present a renewed framework for evaluation of telemedicine starting from the framework proposed by Dechant et al. [9] that provides better insight in the real potential of telemedicine and as such fosters implementation in daily clinical practice. In section II the methods of this paper are described. Section III addresses the results in four topics; telemedicine service, added value, use of an evaluation framework and refinement of the evaluation framework. Section IV describes the discussion. The acknowledgement and references close the paper.

II. METHODS

To present the current state of the evaluation of telemedicine for physical rehabilitation, a computerized literature search of the Medline and Scopus databases were conducted in January 2014. The search strategy and keywords used for both databases are shown in Table 1. In addition to this search, the online versions of three journals in telemedicine (Journal of Telemedicine and Telecare, Journal of Telemedicine and e-Health and International Journal of Telemedicine and Applications) were manually searched for additional relevant references.

TABLE I. SEARCH STRATEGY

For Medline database	
Step 1	teletreatment OR telerehabilitation OR telehealth OR telecare OR ehealth OR telemedicine [MeSH Terms] OR therapy, computer assisted [MeSH Terms] OR ambulatory monitoring [MeSH Terms] OR computer [MeSH Terms] OR Technology [MeSH Terms] OR Internet [MeSH Terms] OR telecommunication [MeSH Terms]
Step 2	physical therapy* OR physiotherapy OR exercise [MeSH Terms] OR physical therapy modalities [MeSH Terms]
Step 3	home OR home based* OR outpatient OR home care services [MeSH Terms]
Step 4	1 AND 2 AND 3
For Scopus database	
Step 1	teletreatment OR telerehabilitation OR telehealth OR telecare OR ehealth OR telemedicine OR computer assisted therapy OR ambulatory monitoring OR telecommunication
Step 2	Physical therapy OR physiotherapy OR exercise
Step 3	home OR outpatient
Step 4	1 AND 2 AND 3

Papers were included when: (1) they were designed as an evaluation study; (2) they concerned patients and not healthy subjects; (3) the telemedicine intervention utilized remote treatment by means of ICT; (4) the treatment focused on physical rehabilitation or exercising and (5) they were written in English, German or Dutch. Papers were excluded when: (1) no results of the evaluation were provided; (2) they only gave a description of the telemedicine service or the proposed evaluation; (3) no healthcare professionals were involved in the service delivery; (4) they concerned patients with mental illnesses; (5) they were duplicates of other already included paper and (6) they were published before 01-01-2000.

Potential eligibility of the papers was first identified from the titles and abstracts identified during the searches. Two reviewers (CSvdV and SMJK) read all titles and/or abstracts independently. If an abstract did not give sufficient information about the study, the full-text paper was obtained for further review. Then the reviewers evaluated full-text papers independently and reached consensus about whether or not the papers should be included. Papers were not blinded for authors and journals.

To gain insight into the evaluations performed in the studies, a data extraction form was developed to systematically describe:

- the technology used in the telemedicine service;
- the clinical aim for which the telemedicine service is used;
- the way the telemedicine service was implemented in daily clinical practice i.e. service configuration;
- the outcome of the evaluation study on the domains accessibility, quality of care and cost of care as suggested by Dechant et al.[9],
- and whether or not the author refers explicitly to an evaluation framework as a starting point.

After assessing all full-text papers, the reviewers reached consensus and completed the data extraction form. The outcome of the data extraction form will be presented in the results section. Based on these results, the evaluation framework proposed by Dechant et al. [9] is refined, to involve all aspects and to increase the use of it as the standard framework for evaluation of telemedicine services.

III. RESULTS

Based on our literature search, we started with a set of 1511 citations. These were analyzed and 1413 citations were excluded following screening. We retrieved 98 potentially relevant papers in full text. We excluded 62 of these based on the pre-specified inclusion and exclusion criteria. Main reasons for exclusion were that technology used did not utilize remote treatment and the participants of the evaluation study were healthy subjects. The literature search provided us with 36 papers. The manual search of the online version of the journals in telemedicine by screening of titles, abstracts and full-texts left us with 4 relevant papers in full text. In total, we retrieved 40 relevant papers.

A. Telemedicine service

Technology used: Various technologies are described in the 40 papers included. In 24 (60%) papers, a videoconference system (synchronous communication technologies) was used to enable contact between the patient and healthcare professional. This was used to have remote face-to-face contact during exercising [10-25] or a scheduled face-to-face contact [26][27][[28][29][30][31][32][33]. In six (15%) papers, patient and professional had contact by an asynchronous communication technology, such as email on a weekly basis [29][34][35][36] or as short messaging technology after an exercise session [37][38].

In 26 (65%) papers, sensor-based technologies were used for a variety of reasons. In more detail: in eight papers to guarantee secure exercising [25][32][33][38][39][40][41][42]; in seven papers to monitor patient's progression or adherence [27][34][35][36][38][46][47]; in three papers to deliver automatic and professional feedback to the patients [43][44][45] and in nine papers to detect the motions of a patient [11][12][16][26][28][29][30][31][48]. Exercise-application are used in 18 (45%) papers to activate patients to perform exercises and to rehabilitate in their own environment [22][26][27][28][29][30][31][33][35][36][37][41][43][44][45][47][48][49] and in four (10%) papers, virtual reality or game technologies are used to stimulate the patient to execute the requested exercises [11][12][16][22]. In 72.5% of the included papers the telemedicine service used two or more of above mentioned technologies.

Clinical purpose: Clinical purpose is an important characteristic to describe a telemedicine application and was hardly addressed in the included papers. Based on the technology used three different clinical purposes can be identified:

- Consultation (27.5%): to enable a real-time one-to-one or group based contact between patient and healthcare professional during the rehabilitation session [10][13][14][15]17][18][19][20][21][23][24];
- Safety (20%): to enable a safe environment to rehabilitate independently. In these cases, during a remote rehabilitation session, ECG or saturation level was monitored [25][32][34][38][39][40][42][46];

- Remote supervision and exercising (52.5%): to remotely supervise the patient using sensor-based technology and to enable the patient to exercise by means of a technology supported exercise-application [11][12][16][22][26][27][28][29][30][31][33][35][36][37][41][43][44][45][47][48][49].

Service configurations: This characteristic of the telemedicine application was in most included papers not addressed. In 15 papers telemedicine was delivered to the patients as a follow-up treatment [10][12][14][15][19][20][23][24][26][32][34][37][38][40][41] after a period of conventional rehabilitation patients prolonged their rehabilitation at home by means of telemedicine. In the remaining 22 papers, the telemedicine technology was evaluated as being an autonomous treatment. In none of the included papers telemedicine was delivered as addition or (partially) replacement of the conventional treatment.

B. Added Value

Telemedicine has the potential to increase the accessibility of care, to increase the quality of care and to decrease the costs of care. This added value of telemedicine is widely accepted and determined by the characteristics of telemedicine: technology used, clinical purpose and service configuration. To evaluate the true potential of telemedicine it is important to relate the outcome of the evaluation to the hypothesized added value of the telemedicine services beforehand.

Accessibility: All telemedicine services have the potential added value to increase the accessibility of healthcare, because technology used allows remote contact among patient and healthcare professional. From a patient point of view increase accessibility means no geographical obstacles or absence of work [33][39]. Accessibility was not directly parameterized as outcome in the evaluation of the telemedicine intervention. However, 25 of the included papers assessed the patients' experience in terms of satisfaction and usability. Overall it can be stated that patients are satisfied with the telemedicine interventions and the interventions evaluated are "easy to use". Next to the accessibility for the patient, there is also accessibility from the healthcare professional's point of view what can be defined as the ability to treat more patients simultaneously or to treat patients from a larger geographical area. In none of the included papers these potential added value was addressed.

Quality of care: Telemedicine services that support remote supervision and actuate patients to exercise in their own environment have the potential added value to increase the quality of healthcare as these telemedicine services give patients the ability to excise more often, independently from the availability of a healthcare professional or treatment facilities. In 21 of the included papers the evaluated telemedicine services gave patients the ability to rehabilitate independently. Quality of care was assessed in nineteen of these papers. Eleven studies used a prognostic cohort and concluded that telemedicine services induced positive changes [28][29][31][33][34][38][40][42][45][48][49]. The other 8 studies were Randomized Controlled Trials (RCT). Seven of these RCT-studies found telemedicine services at least as effective as conventional care [26][35][41][43][44][46][47]. Only 1 of these RCT-studies concluded that telemedicine was more effective as conventional care [30]

Costs of care: Telemedicine services delivered as (partial) replacement of the conventional treatment have the potential added value to reduce costs. From a healthcare professional point of view cost can be reduced when the technology used give the professional the ability to increase the efficiency of the treatment. Only four of the included papers investigated the costs relating to the evaluated telemedicine service. One service was implemented as follow-up treatment [14] and the other three as autonomous treatments [33][43][44]. Given the results of these 4 papers it can be stated that the efficiency of the treatment can be increased by a decrease in preparation and consultation time [43][44] or by lowering travel costs for professionals [14] and patients [33][44].

C. Use of an evaluation framework

The evaluation framework proposed by Dechant et al. [9] was only used in two of the included papers [43][44]. Both papers were stage 4 evaluation studies. Applying the four stages of the evaluation framework proposed by Dechant et al. [9] to categories, the included papers, show that most papers (55%) present the results of a stage 1-2 evaluation. The included papers focused mainly on clinical effectiveness (45%), feasibility (42,5%), user-experience (7,5%) and adherence (5%).

D. Refinement of the evaluation framework

The staged approach to the evaluation of telemedicine purpose by Dechant et al.[9] is rarely applied in the included papers. From the reviewed papers, it becomes clear that the following aspects are important to consider in evaluation:

- The type of telemedicine application in terms of which technology used and its level of maturity and clinical purpose for which it is being used.
- The context in which the telemedicine application is being used such as the service configuration

Once having these defined the main outcome criteria and the design of the evaluation can be defined. Taking this into account and looking at the framework proposed by Dechant et al. [9], the stages of evaluation are well defined but their content can be further refined in the following way:

Stage I: The first stage of telemedicine evaluation focuses on the feasibility and usability of the technology used in an experimental design with a small number of subjects or even case studies. This type of evaluation design allows researchers to gain detailed information which can be used for further improvement of the telemedicine service. The telemedicine service is evaluated as a standalone service and evaluation endpoints focus on feasibility and usability of the technology used.

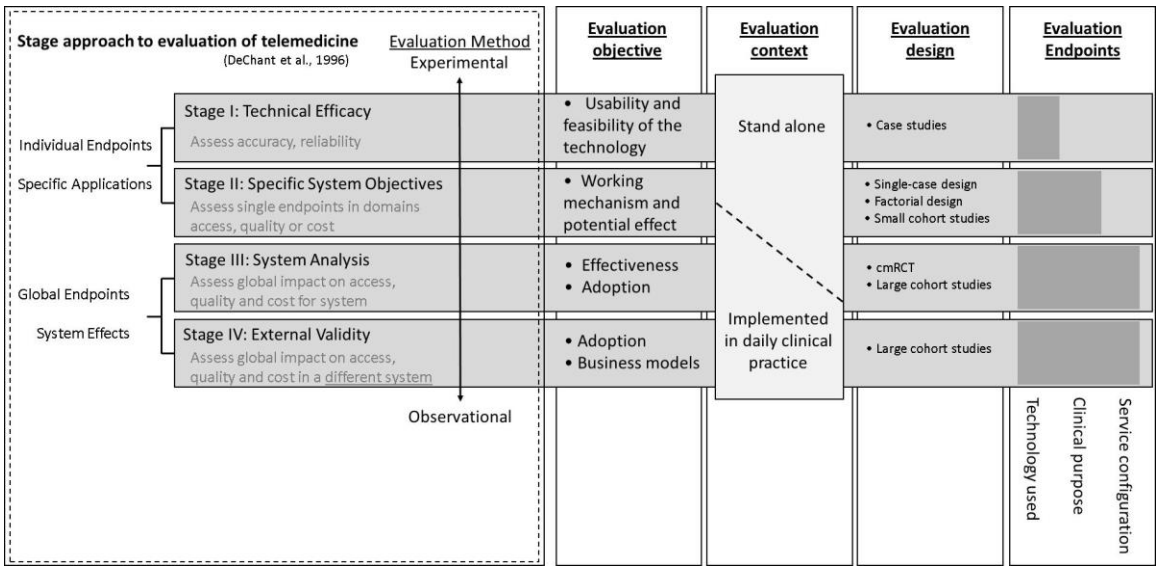

Figure 1. The refinement of the staged approach to evaluation of telemedicine.

Stage II: The technology used in the second stage is stable and evaluation is focused on gaining an initial idea about the potential added value for clinical practice and possible working mechanisms. For this, evaluation can be performed using the telemedicine service as a standalone service. Designs that can be used focus on studying processes in often small groups of subjects rather than on examining the effectiveness. Suitable designs are cohort studies with a small sample size (n<50) or single-case design (or N = 1 designs) [50]. The evaluation endpoints within this stage should focus on the potential added value of the telemedicine service mapped on both the technology used and the clinical purpose that is supported.

Stage III: This stage starts when earlier studies indicate that the telemedicine service has potential and focuses on showing the effectiveness of the telemedicine service and/or adoption of the service by its end-users. In order to identify these aspects, it is important that the telemedicine services are evaluated in the way they will be implemented in daily clinical practice. Although, randomized controlled trials (RCTs) are considered the gold standard for evaluating the safety and effectiveness of medical interventions their characteristics do not fit well with the evaluation of telemedicine services [50]. An alternative for a conventional RCT might be the "cohort multiple randomized controlled trial" (cmRCT) being introduced by Relton et al.[51]. The evaluation endpoints at this stage should not only focus on a previously defined value expected for each technology used and the clinical purpose that is supported but also take into account the way the telemedicine service is being implemented in daily clinical practice.

Stage IV: The fourth stage evaluation elaborates the adoption as addressed in stage III. To ensure further implementation, involvement of every stakeholder (healthcare professionals, patients, technology providers, insurance companies and policy makers on a local and national level) is important. This means that evaluation here should focus on the business models and concrete business cases. Without information on the cost and effectiveness of telemedicine services, decision makers run the risk of introducing services that are not cost-effective for society [53]. This evaluation can only be performed in an adequate way when the service is implemented in daily clinical practice as only in this case the true added value can be evaluated. The studies performed in this stage are large-scale cohort studies (n≥50) [54]. As addressed in stage III the evaluation endpoints in this stage should focus on the expected value of the telemedicine service depending on the application that is being used (technology used and clinical purpose) but also on the way it has been implemented in daily clinical practice (service configuration).

The refinement of the staged approach.to evaluation of telemedicine are presented in Figure 1.

IV. Discussion

The aim of this paper was to create and present a renewed framework for telemedicine evaluation that provides better insight in the real potential of telemedicine services and as such fosters implementation in daily practice. For this the use of the evaluation framework proposed by Dechant et al. [9] was analyzed using the current state of the evaluation of telemedicine service for physical rehabilitation as casus. Focusing on the characteristics of telemedicine for physical rehabilitation it can be concluded that the technology used and the clinical purpose were diverse and the majority of the telemedicine was not implemented in daily clinical practice. The level of maturity of the evaluated telemedicine was low and therefore most evaluations focused on feasibility, user-experience and adherence (stage 1-2 evaluation). In the following years, the level of maturity of telemedicine will increase and it is expected that more stage 3-4 evaluations will be published.

It is desirable that these evaluation studies relate the outcome of the evaluation to the hypothesized added value of the telemedicine beforehand to evaluate the true potential, focusing on accessibility of care, quality of care and costs of care [51, 55-59].

Based on the results, a refined version of the staged approach to the evaluation of telemedicine [9] for physical rehabilitations were presented and created, which of course need to be further validated in other cases to see whether this framework is useful and is generalizable for telemedicine evaluation in general.

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