



Review article

Usability in telemedicine systems—A literature survey

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ABSTRACT

Introduction: The rapid development of sensors and communication technologies enable the growth of new innovative services in healthcare, such as Telemedicine. An essential ingredient in the development of a telemedicine system and its final acceptance by end users are usability studies. The principles of usability engineering, evaluations and telemedicine are well established, and it may contribute to the adoption and eventually deployment of such systems and services. An in-depth usability analysis, including performance and attitude measures, requires knowledge about available usability techniques, and is depending on the amount of resources. Therefore it is worth investigating how usability methods are applied in developing telemedicine systems. Our hypothesis is: with increasing research and development of telemedicine systems, we expect that various usability methods are more equally employed for different end-user groups and applications.

Method: A literature survey was conducted to find telemedicine systems that have been evaluated for usability or ease of use. The elements of the PICO framework were used as a basis for the selection criteria in the literature search. The search was not limited by year. Two independent reviewers screened all search results first by title, and then by abstract for inclusion. Articles were included up to May 2015.

Results: In total, 127 publications were included in this survey. The number of publications on telemedicine systems significantly increased after 2008. Older adults and end-users with cardiovascular conditions were among largest target end-user groups. Remote monitoring systems were found the most, in 90 publications. Questionnaires are the most common means for evaluating telemedicine systems, and were found in 88 publications. Questionnaires are used frequently in studies focusing on cardiovascular diseases, Parkinson's disease and older adult conditions. Interviews are found the most in publications related to stroke. In total 71% of the publications were trial-orientated and the remaining process orientated. An increase in telemedicine research, development and applications is found worldwide, with the majority of publications conducted in America.

Discussion and conclusion: Monitoring patients in their homes can lead to better healthcare at lower costs which implies an increased demand of new healthcare strategies like telemedicine. We expected that with the increase in telemedicine research and development, a greater range of usability methods would also be employed in the included publications. This is not the case. Researchers employed questionnaires as a preferred usability method for each type of telemedicine system and most end-users. However, in process-orientated studies a greater range of usability evaluations were applied, with fewer differences found in the amount of publications for each evaluation method. Questionnaires enable researchers to evaluate a system quickly on end users, as it requires less expertise on the evaluation method compared to the other methods. They are easily distributed and are customizable. The use of questionnaires is therefore an evaluation method of choice for a variety of telemedicine systems and end-users.

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1. Introduction

The rapid development of sensors and communication technology enables the proliferation of new innovative services in healthcare, such as Telemedicine. Telemedicine often can be differentiated into three modalities: 1) consultation, 2) remote

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monitoring and 3) remotely supervised treatment or training. Consultations are remote meetings between a healthcare professional and client (e.g. older adults, focussing on healthy aging) may rely on the use of interactive video, chat, diagnostic images or data sharing. External monitoring of a client’s condition can be done either at home (i.e. at a fixed location) or ambulatory (portable). Methods for monitoring include: questionnaires, diaries, medical dispenser counters and physiological sensors. Sensors can be worn on-body or are installed inside the end-user’s home. Training (and “medical education”) can be given web-based, targeting individual end-users or groups in remote locations to improve their health. The latter also provides insights into the client’s own medical data for e.g. self-managing their condition.

An essential ingredient in the development of a telemedicine system and its eventual acceptance by end-users (e.g. patients and care-professionals) are usability studies. Usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness (accuracy and completeness), efficiency (resources needed for effectiveness) and satisfaction (comfort and acceptability) in a specified context of use [1]. Foundations for usability evaluations were established in the 1990s by ISO (ETR 095, Human Factors; guideline for usability evaluations of telecommunication systems and services) and research. Effectiveness and efficiency are part of the performance of the system. Both parameters can be measured objectively, by assessing how users achieve certain goals with the developed product by performing specific tasks. Satisfaction, which is captured subjectively in attitude measures, comprises what the user thinks of the system and its components. Performance and attitude measures do not have to be related in any way. Measuring usability requires awareness and knowledge of the user, their goals, and environments. It must be driven by clear objectives. Identifying which user characteristics, tasks and environmental aspects influence usability is called a usability context analysis. The ETR 095 guide for usability evaluations presents guidelines for performing a usability analysis, based on ISO standards, earlier work by the MUSIC project and others. It provides a clear and solid framework, which can also be applied to any telemedicine system. [2–4].

The World Health Organisation has adopted the following description of telemedicine: “The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities” [5,6]. However, in this manuscript a compact version of this definition is in use, where we exclude the “education of care providers”, as we are only focussing on clients.

The principles of usability engineering, evaluation and telemedicine are well established, which may contribute to the adoption and eventually deployment of telemedicine systems and services. An in-depth usability analysis, including performance and attitude measures, requires knowledge about available usability techniques (e.g. knowledge about the toolbox of methods that can be used), and is depending on the amount of resources (e.g. time and money). For example, questionnaires are a popular usability tool as they provide a “quick fix” (cheap and easy to implement) for research methodology, where observational methods require more extensive amount of resources [7]. Therefore it is worth investigating how usability methods are applied in developing telemedicine systems.

Our hypothesis is: *with increasing research and development of telemedicine systems, we expect that various usability methods are more equally employed for different end-user groups and applications.*

Table 1
MeSH/Emtree terms for the literature search.

Term OR	AND
Telemedicine	(usability OR ease-of-use)
Teletreatment	
Telerehabilitation	
Teleconsultation	
Telehealthcare	
Telemanagement	
Remote physiological monitoring	
Remote patient monitoring	
Homecare management	
Telehomecare	
Telenurse	
Telehealth	
Telemonitoring	

This literature survey answers the above by searching in databases for all telemedicine systems (with no year restriction) where a usability or ease-of-use analysis is applied to. A thorough analysis of the literature is performed and outcomes are presented and discussed. The process for performing the literature search is presented in Section 2, including the inclusion and exclusion criteria, selection method and data analysis. The results of the literature search are described in Section 3, and discussed in Section 4. Finally, a conclusion is given in Section 5.

2. Methods

2.1. Literature search

A literature survey was conducted by two independent reviewers in using the following databases: IEEE, Pubmed/Ovid Medline, Embase, Scopus, Springerlink and Web of Science. The MeSH, Emtree terms and the combinations that were used are listed in Table 1. The search was not limited by year and only the title and abstract were screened. Publications were included up to May 2015.

2.2. Selection criteria

The elements of the **PICO** (Population (P), Intervention (I), Control(C), Outcome (O)) framework [8] were used as a basis for the selection criteria in the literature search:

P: End-users (adults) of a telemedicine system. It must include end-users (e.g. care-professionals or patients) of the system. **I:** Using Information Communication Technology (ICT) for telemedicine purposes (a complete architecture or parts of it) in a home environment, targeting systems that *support independent living*. **C:** A control group is not required for this research. **O:** Usability evaluations on the applied telemedicine architecture or parts of it, including trials or tests focusing on the target population.

Excluded were publications:

- That were non-peer-reviewed conference and journal publications.
- With no inclusion of system usability evaluation methods (or aspects of it).
- Which did not cover a telemedicine system architecture or parts of it (e.g. did not include a Body Area Network (BAN), back-end system, web portal or interface).
- That only included software and/or hardware engineering/development or performance tests.
- Where the system was not tested on an intended target group for the developed system.
- Where solutions were presented which only focused on children.
- Non-English articles.
- Review articles.

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