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Nazish Saeed, Mirfa Manzoor & Pouria Khosravi

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REVIEW ARTICLE

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An exploration of usability issues in telecare monitoring systems and possible solutions: a systematic literature review

Nazish Saeed[a], Mirfa Manzoor[b] and Pouria Khosravi[c]

[a]Informatics Department, Jonkoping International Business School, Jonkoping, Sweden; [b]Department of Computer Science, Sardar Bahadur Khan Women's University, Quetta, Pakistan; [c]Business School, Queensland University of Technology, Brisbane, Australia

ABSTRACT

Background: The idea of product usability has been discussed in several research areas including product research and development. Usability, in telecare monitoring systems, determines how much the system is effective and efficient for the telecare users. Usability has been considered an important factor in the acceptance of telecare monitoring systems by individuals who encounter challenges in the use of such systems and who possess a limited knowledge of their use.

Objectives: The purpose of this study is to explore the relevant usability issues and identify possible solutions to improve the usability of telecare monitoring systems.

Method: The study is based on eight research questions and to find the answers to those research questions, a systematic literature is performed.

Results: The research findings highlight various usability issues, including the complexity of the interface, difficulty in reading the text, and insufficient provision of instructions. These studies have also suggested solutions to enhance the usability of systems, including development of the technical skills of users, explanations of usability evaluation techniques for telecare monitoring systems, and engaging the appropriate users during the development of telecare monitoring systems.

➤ IMPLICATIONS FOR REHABILITATION

- Successful implementation of telecare monitoring systems can increase the chances of acceptance of telecare monitoring systems by the users.
- Implementing an efficient and effective system will make telecare users more independent at their homes.
- The development of usable telecare monitoring systems can significantly contribute to a basis for clinical and home-based implementation of the telehealth technology to promote remote monitoring for elderly and people with disabilities.
- Considering the usability issues and solutions identified in this study, it will go a long way towards aiding subsequent researchers and developers in the implementation of more usable and valid telecare monitoring systems.

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KEYWORDS
Telecare; telecare monitoring system; usability; systematic literature review

Introduction

Advances in science and technology have helped in the development of electronic communication devices, which are useful in delivering healthcare services over both small and large distances [1–3]. A fast-growing interdisciplinary area referred to as "telehealth" can aid in reducing health care costs [4] and improving the quality of life [5,6] of elderly individuals [7–9] and patients suffering from chronic diseases [1,10,11]. Telecare applications also offer numerous advantages to healthy people by helping them to maintain and improve their health [12,13].

We live in an aging society; according to a United Nations report, by the year 2050, the number of people over the age of 60 will have increased compared to the number of people under the age of 15 [14]. Medical interventions have provided increased longevity and at the same time, fertility rates have declined, causing an imbalance between age groups in the global population. Care of this aging population will be a fundamental problem in the coming decades that demands immediate attention [14]. At the same time, people with disabilities and older people prefer to live independently in their homes, and this can be made possible through technological support. Furthermore, institutional care is expensive and not affordable to everyone [15].

A monitoring function is the most prevalent use of technology in the current era, and can assist older people with cognitive and sensory deficits, mobility issues and manual dexterity [14]. Reminders and advice systems are currently being researched for individuals with cognitive problems [16]. However, monitoring technology faces inherent design problems, and researchers are working on ideas that can be applied to the widest population. One of the more recent developments in monitoring technology is telecare monitoring [17]. The services developed using this technology can help in reducing the severity of harm but cannot prevent accidents. There is a need to develop user-friendly

CONTACT Mirfa Manzoor mirfa.manzoor@ju.se Informatics Department, Jonkoping International Business School, Jonkoping, Sweden

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systems [18] that can be easily operated by users and which possess the ability to prevent accidents.

Telecare monitoring systems should offer confidence to their users; however, this would require a significant improvement in terms of design to meet current needs [19]. For example, in a research study conducted by Lorraine and colleagues [20], the feasibility and acceptability of remote monitoring systems (RMS) for managing chronic heart failure were assessed in older adults. The majority of the participants gave this technology a positive evaluation. However, 71% of the participants reported *difficulty in reading* the health data on the monitor. They wanted to receive their health information in a *written format* rather than displayed on the RMS screen. Older adults also reported problems with their eyesight; they complained that they *could not properly read the visual display* and had to get help from family members.

A number of such examples related to usability issues have been discussed in existing studies [18,21–23], causing people to be deterred from using telecare monitoring systems due to poor usability. Moreover, if telecare monitoring systems are not user-friendly, then they can increase the problems experienced by users. For instance, if the patients are unable to understand and operate a monitoring system, this can lead to serious health consequences for a person who is living independently.

Various monitoring technologies have been adopted to help patients, and particularly older people, to overcome issues in their daily lives. Since telecare monitoring services promise cost-effective outcomes for critical patients [19], it is vital to develop systems and devices that can improve usability, and consider patients' needs and limitations, in order to obtain the best possible results.

Studies have been conducted to introduce monitoring technologies and to investigate the acceptance of these [18,24,25]; however, research into the usability of telecare monitoring systems is scant. Monitoring systems need to be evaluated in terms of their usability, in order to maximize their acceptance and benefits. Thus, the focus of this study is to identify usability issues and provide possible solutions for improving the usability of telecare monitoring systems.

This research study will incorporate the concepts of Moulaert's social innovation theory [26] and Roger's diffusion theory [27] to examine the patterns of the adoption and success of innovation. Social innovation focuses on social sustainability and responsibility, and the innovation process undergoes three important phases: the initiation phase, the development phase, and the scaling phase. The initiation phase involves the identification of the problem and development of a solution. In this study, telecare monitoring systems that are not user-friendly are the identified problem, and the identification of usability issues and the possible solutions represent the development of a solution. The development phase involves the mobilization of resources and testing of solutions. We need to develop telecare monitoring systems that are efficient and easy to use. Furthermore, these systems require thorough testing in different environments to ensure efficient and safe usage by the patient. The scaling phase involves the application and implementation of the idea [28]. To complete the third phase, we require user-friendly telecare monitoring services; this will increase their use and implementation among people from different age groups.

Using a systematic literature review, this study examined the following research questions:

Q1: What are the publication sources in the context of the usability of telecare monitoring systems? This question is motivated by a need to understand the scope of studies by observing where these studies are published.

Q2: How has the publication rate of studies related to the usability of telecare monitoring systems changed over time? This question is motivated by the need to examine progress in the publication of such studies, for example the publication rates of these studies in each year.

Q3: Which usability features or benefits are discussed in these studies? This question is motivated by the need to observe the different usability features used by adopting usability standards such as ISO/IEC 9126-1 and ISO 9241-11.

Q4: Which evaluation methods have been used to assess the usability of telecare monitoring systems? This question is motivated by the need to identify the most commonly used evaluation methods in such studies.

Q5: What types of diseases or problems are targeted by telecare systems? This question is motivated by the need to identify diseases or problems that are targeted by monitoring systems as technological solutions in order to assist people in their routine activities.

Q6: What types of telecare monitoring devices or services have been discussed in these studies? This question is motivated by the need to identify the most commonly used devices or services in these studies.

Q7: What are the usability issues or obstacles, and who has evaluated the usability of telecare monitoring systems? The aim of this question is to analyze who (e.g. patients, doctors, nurses or experts) has evaluated the usability of telecare monitoring systems and which usability issues have been identified by them.

Q8: What solutions have been proposed to overcome usability issues? This question is motivated by the need to find solutions.

By synthesizing the literature on telecare monitoring systems, this study offers several contributions. Firstly, it advances our understanding with regard to the usability and benefits of monitoring systems. Secondly, it furthers an attempt to identify diseases or problems that are targeted by monitoring systems. Finally, it provides insights into usability issues related to monitoring systems and providing solutions to overcome these.

Related work

The systematic literature review is the way toward discovering, assessing and seeing all accessible research to a particular region, on a research question or on a topic of interest [29].

A systematic literature review is a means of identifying, evaluating and interpreting all relevant studies to a specific research question [29]. Systematic literature review is a reproducible and explicit methodology that is used for gaining an overview of the primary studies, their objectives, methodologies and results [30]. Systematic reviews can also demonstrate where knowledge is lacking which can be used to guide future research [31]. According to Kitchenham [29], the reasons to conduct systematic literature review can be to identify the gaps in current research and provide framework. The same reason is adhered in performing systematic literature review in this study.

Since the identification of usability issues and their solutions for improving the efficiency and effectiveness of telecare monitoring systems and to increase the acceptance of these systems for people with disabilities and elderly is a new research area that needed attention, the systematic literature review approach can be helpful, in terms of accumulating a comprehensive review of studies and finding the best practices. Performing systematic literature can make it possible to identify usability issues in the and solutions that are highlighted by the participants in prior studies and also the usability requirements in general discussed for

telecare monitoring systems. Further in this, for performing systematic literature review, a Prisma flow diagram [32] is used that helps researchers to advance the writing process of systematic literature review. In this study, PRISMA flow chart is used to describe the inclusion and exclusion criteria that were followed to find the relevant scientific studies.

Methods

A systematic literature review involves "evaluation and interpretation of all available research relevant to particular research questions or topic area or phenomena of interest" [29]. We conducted our review based on the guidelines offered by PRISMA [32] in four stages (outlined in Figure 1), as used by previous studies (e.g. [33,34])

Search terms

We performed a systematic review of literature from the period 1999 to 2017. Several databases such as Scopus, Cochrane, Embase, Eric, Wiley Online Library and Google Scholar were used to search for relevant studies via a search query. This search query was defined using PICO rules [35]: population, intervention, comparison and outcome. The terms used in the search query were based on the research questions, and thus the scope of the search query was defined by focusing on four themes: (1) telecare monitoring as a target device or service; (2) applications or the software scope of these applications; (3) type of disabilities or disease targeted by the applications; and (4) different usability features. Two different Boolean operators (AND, OR) were used to construct the search query, as can be seen from Table 1.

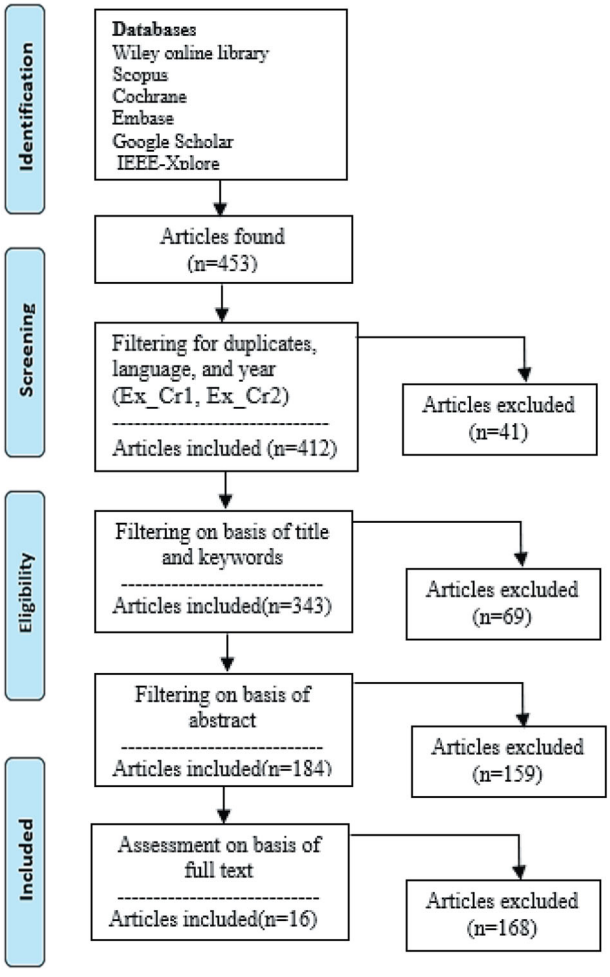

Figure 1. PRISMA flow diagram [32].

Inclusion criteria

Each study found in the databases was assessed using inclusion and exclusion criteria, as follows:

In_Cr1. The paper is focused on telecare monitoring systems.
In_Cr2. The study discusses the usability of telecare monitoring systems.
In_Cr3. The study discusses the end users of the telecare monitoring system.
In_Cr4. The study was published in a peer-reviewed journal or conference proceedings.

Exclusion criteria

Papers that met at least one of the following criteria were excluded:

Ex_Cr1. The study is not written in English.
Ex_Cr2. The paper was published before 1999.
Ex_Cr3. The paper discusses usability in general but does not discuss usability issues or solutions to usability issues.
Ex_Cr4: The papers used methods such as systematic literature reviews and systematic mapping studies.

Data extraction

We obtained 46 articles from Scopus, 118 articles from Wiley Online Library, 12 articles from Cochrane, 78 articles from IEEE-Xplore, 41 articles from Embase database and 158 articles from Google Scholar. The combined results from all databases totaled 453 articles. After removing duplicates and articles not written in English, we were left with 412 articles. Following a review of the title and keywords of these 412 articles, we obtained 343 articles that were related to the study. We then reviewed the abstracts of these articles and selected 184 articles. The remaining 184 articles were read thoroughly, and we obtained 17 articles that could provide answers to our research questions. Figure 1 illustrates this process.

Quality assessment

The purposes of the quality assessment in this study were to evaluate the significance of the results of each of the selected studies and to obtain guidance for the interpretation of findings [29]. Following [18], we adopted six questions for quality

Table 1. Context and search query.

Context	String
Telemonitoring	(telemonitoring OR "telemonitoring system" OR tele-monitoring OR "tele monitoring") AND
Application	(apps or software or device(s) or application(s) or service(s)) AND
Usability	(usability OR understandability OR learnability OR "user experience" OR operability OR attractiveness) AND
Disease	(disease OR care OR patients OR elderly OR illness)

assessment, as shown in Table 2. The score was calculated using the CORE conference ranking exercise [36] and journal citation reports [37]. A study published in a journal with a higher impact factor was assigned a higher score [38]. The maximum score that a study could obtain if it met all the criteria in the form of these six questions was seven points (see Table 2).

A quality assessment of these studies showed that most of the studies provided answers to most of the research questions.

Results

Quality assessment

It was observed that most of the selected studies were significant for this study. The maximum score obtained by the studies was seven points, showing that the selected studies were relevant to this work and that the results produced from these studies can contribute to identifying usability issues and possible solutions. Table 3 below shows the score that each study was awarded.

Results obtained from research questions

The results extracted for each question are as followed:

RQ1. Publication sources for usability in telecare monitoring systems

We found studies from various publication sources that focused on the usability of telecare monitoring systems. From fifteen unique publication sources (journals and conferences), we found 16 papers relevant to this study. We found 10 journal papers [39–48] and five conference papers [49–53]. The selected papers were published in journals that had different focuses of research. Based on the topics covered by these journals, we divided these journals and the corresponding studies into four main categories: informatics, nursing, technology and health. Four studies were published in journals with a focus on informatics [39–41], two in nursing journals [42,43], four in technology journals [44–47], and one study in a health journal [48]. Of the conference papers, three studies were published in conferences with a focus on technology [49,50,52], one on health [51] and one on informatics [53]. Four papers were published by the IEEE [49–52] and one by Springer [53], as shown in Table 3.

RQ2. Change over time of the frequency of research into the use of telecare monitoring systems

Regarding the usability of telecare monitoring systems, the frequency of publication of the studies has changed over time. Figure 2 shows the number of papers published during each year. The highest number of papers (four) was published in 2015 [39,40,46,53]. For 2011 to 2014, we found two studies published in each year. These studies are as follows: 2014 [45,47], 2013 [44,50], 2012 [42,51], and 2011 [41]. We also found one study published in 2017 [48], 2016 [49], 2008 [43] and 2000 [52].

Table 2. Criteria for assessing the quality of the selected studies.

No. Questions	Answer
QAS1: Does the study mention a usability evaluation method?	Yes (+1) / No (+0)
QAS2: Does the study specify usability issues?	Yes (+1) / No (+0)
QAS3: Does the study specify solutions to usability issues?	Yes (+1) / No (+0)
QAS4: Does the study specify the name of telemonitoring services, software or devices?	Yes (+1) / No (+0)
QAS5: Does the study specify the disease for which the telecare monitoring service was used?	Yes (+1) / No (+0)
QAS6: Does the selected study appear in a reputablepublication?	Study with impact factor (+2), study without impact factor but with social science citation indexed (+1), conference (+0.5), other (+0)

Table 3. Publication source of selected studies.

Type of study	Reference	Name of conference/ journal	Research domain	QAS1	QAS2	QAS3	QAS4	QAS5	QAS6	Score
Journal	[39]	International Journal of Medical Informatics	Informatics	1	1	1	1	1	2	7
	[40]	Informatics for Health and Social Care	Informatics	1	1	1	1	1	2	7
	[41]	Applied Clinical Informatics	Informatics	1	1	1	1	1	2	7
	[42]	Journal of Clinical Nursing	Nursing	1	1	1	1	1	2	7
	[43]	Journal of Nursing Management	Nursing	1	1	1	1	1	2	7
	[44]	International Journal of Technology Assessment in Health Care	Technology	1	1	1	1	1	2	7
	[45]	Disability and Rehabilitation: Assistive Technology	Technology	1	1	1	0	1	1	5
	[46]	Patient Preference and Adherence	Technology	1	1	1	1	1	2	5
	[47]	Journal of Telemedicine and Telecare	Technology	1	0	1	1	1	2	6
	[48]	Health Expectations	Health	1	1	1	1	1	2	7
Conference	[49]	IEEE Transactions on Affective Computing	Technology	1	1	1	1	1	0.5	5.5
	[50]	IEEE Transactions on Biomedical Engineering	Technology	1	1	1	1	1	0.5	5.5
	[51]	Engineering in Medicine and Biology Society (EMBC), Annual International Conference of the IEEE	Health	1	1	1	1	1	0.5	5.5
	[52]	Information Technology Applications in Biomedicine, IEEE	Technology	1	0	1	0	1	0.5	3.5
	[53]	International Conference on Bioinformatics and Biomedical Engineering, Springer	Informatics	1	0	1	0	1	0.5	3.5

RQ3. Usability characteristics of telecare systems

In order to assess the usability characteristics of telecare systems, we adopt the ISO 9126–1 and ISO 9241–11 standards [54]. The purpose of these models is to evaluate the quality of the systems. ISO 9126-1 focuses on "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions" and ISO 9241-11 focuses on "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."

The results show that the most discussed characteristics of ISO 9126-1 in evaluating the usability of telecare monitoring systems were understandability, which appeared in 9 studies [40–43,46–48,50,51], and attractiveness, which appeared in six studies [40,42,46,48–50]. Moreover, in the ISO 9241-11 model, the usability characteristic of satisfaction was the most discussed, appearing in seven studies [40,43–47,52], followed by efficiency, which was discussed in four studies [40,46,50,51]. Very few studies have examined the learnability, operability, and effectiveness of telecare monitoring systems. The data extracted from Question 3 can be seen in Table 4.

RQ4. Research methods used to evaluate usability

Various methods have been used for usability evaluation, such as interviews, questionnaire-based surveys, heuristic evaluation and "thinking aloud" (see Table 5). The two most frequently used methods in the selected studies were questionnaire-based surveys [41–44,50] and interviews [45,48]. Other methods included heuristic evaluation and feasibility studies. The duration of the studies/systems used can also be seen in Table 5.

RQ5. Issues for which telecare monitoring systems were used

According to the selected studies, telecare systems are widely used for chronic obstructive pulmonary illnesses, heart failure and chronic diseases [50]. We found three studies discussing chronic obstructive pulmonary disease [39,40,43], three studies of heart failure [41,44,49] and three studies discussing chronic disease [42,50]. Telecare systems are also used for other diseases or problems such as rehabilitation of patients [48,53], comorbidity [51], cystic fibrosis [52], dementia [46] and elder care [45,47]. Further details can be seen in Table 5.

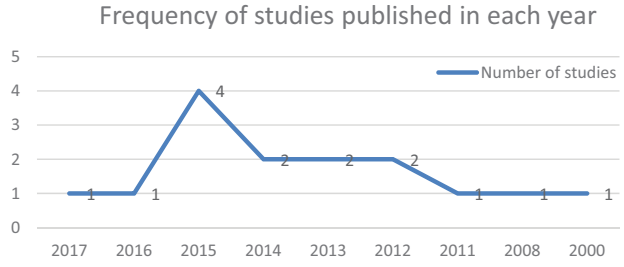

Figure 2. Frequency of publication.

RQ6. Telecare monitoring devices or services

The results show that 13 out of 15 studies have designed, developed or proposed the telecare monitoring services or devices. Various telecare monitoring devices or services are discussed in the studies, for example, the use of smartphones to monitor patients [49] and sensors [50] that can allow the concurrent acquisition of ECG and blood pressure data.

Furthermore, telecare monitoring systems including the AMICA mobile application [40], iVitality Smartphone application [46], a heart patient monitoring system [44], eCAALYX [51] and a telekit internet-based monitoring and treatment system [39] have been used to monitor patients' health conditions on a daily basis. These systems use a local call system that has an integrated response service for the community. These monitoring services also evaluate any changes in physiology. There is a system to help the operator in the call center to identify the intervention that would be appropriate [43] with home telecare contacts [42] and a home monitoring system [55] to assist patients with different diseases. Table 6 below shows a list of systems and the diseases supported by these devices/services.

RQ7. Usability issues and participants in the evaluation of the system

A number of usability issues have been identified in the selected studies: difficulty in using the system, a lack of user-friendliness, a lack of assistance with the system, performance issues, systems not meeting users' needs, and technical errors. We found six studies that discussed the issue of lack of user friendliness, and five studies examining the issue of difficulty in using the system. Few studies discussed issues related to a lack of assistance, system performance, failure of systems to meet the needs of users, and technical errors (see Table 7). This study also presents the primary evaluators and the usability issues highlighted by these evaluators, as shown in Table 7. The results show that most of the studies [40–46,48–50] asked patients to evaluate the usability of the system. The usability issues identified by patients were similar to those listed above: (i) difficulty in using the system [40,42,43,46,48]; (ii) a lack of user-friendliness [40,42,43,46,49,50];

Table 4. Data extracted for RQ3.

	ISO 9126-1				ISO 9241-11		
Ref	Understandability	Learnability	Attractiveness	Operability	Efficiency	Satisfaction	Effectiveness
[49]	no	no	yes	yes	no	no	no
[50]	yes	no	yes	yes	yes	no	no
[51]	yes	no	no	no	yes	no	no
[52]	no	no	no	no	no	yes	yes
[39]	no	no	no	no	no	no	no
[42]	yes	no	yes	yes	no	no	no
[43]	yes	no	no	no	yes	yes	no
[48]	yes	no	yes	no	no	no	no
[46]	yes	no	yes	no	yes	yes	yes
[40]	yes	yes	yes	no	yes	yes	yes
[41]	yes	no	no	no	no	no	no
[53]	no	yes	no	no	no	no	no
[44]	no	no	no	no	no	yes	no
[45]	no	no	no	no	no	yes	no
[47]	yes	no	no	no	no	yes	no

Table 5. Data extracted from RQ4 and RQ5.

Ref	Evaluation method	Duration of the study	Tasks	Users	Health condition
[49]	Pilot study	Three-month	yes	Fifteen patients and medical staff	Heart failure
[50]	Survey	–	yes	Elderly people over 58	Chronic disease
[51]	Study describing the placement and development test outcome from nine volunteers through the CAALYX application	Four weeks	yes	Nine volunteers	Comorbidity
[52]	System modeling approach and case study	–	yes	_	Cystic fibrosis
[39]	Heuristic evaluation	Three to four weeks	yes	Five experts	Chronic obstructive pulmonary disease
[42]	Survey	–	yes	Real users of the system	Chronic disease
[43]	Survey	Six months	yes	Professionals and patients	Chronic obstructive pulmonary disease
[48]	Interview	Eight weeks	yes	Thirteen older participants, three spouses and one carer	Rehabilitation patients
[46]	Think-aloud protocol	Six months	yes	Four participants	Dementia
[40]	Iterative user-centered design methodology	Six-month field trial	yes	Twenty-five elderly users	Chronic obstructive pulmonary disease
[41]	System was assessed in the course of a clinical pilot test and user satisfaction was assessed by usability questionnaire	One week	yes	Twenty-one patients	Heart failure
[53]	Presented a mobile wearable monitoring system and highlighted the key features in simplifying tele-rehabilitation devices	_	_	_	Rehabilitation
[44]	Survey	Fifteen minutes (system used)	yes	Medical experts (n = 34), technical users (n = 39), control group/ participants (n = 44)	Heart failure
[45]	Interviews and development of telecare system	_	_	21 participants	Elderly
[47]	Feasibility study	Six months	_	34 participants (10 males and 24 females)	Elderly

Table 6. Telecare monitoring systems supporting patients with different issues.

		Issues					
Studies	Systems	Chronic diseases	Heart problems	Comorbidity	Rehabilitation patients	Dementia	Cystic fibrosis
[49]	Smartphone	✓					
[50]	Wireless sensor networks for patient monitoring, alarm	✓					
[51]	eCAALYX system			✓			
[52]	Web-based monitoring system						✓
[39]	Telekit internet-based monitoring and treatment system	✓					
[42]	Home telecare contacts	✓					
[43]	Daily monitoring of patient's condition via the local call center with an integrated community response service	✓					
[48]	iPads for videoconferencing and electronic FitBitR devices				✓		
[46]	iVitality and iVitality Smartphone application					✓	
[40]	AMICA mobile application	✓					
[41]	Sensing device that allows the concurrent acquisition of blood pressure and ECG		✓				
[44]	Heart patient monitoring system		✓				
[47]	Home telehealth system that monitors blood pressure and body weight					✓	

(iii) a lack of assistance with the system [48]; and (iv) technical errors. The patients also identified that some of the systems did not meet their requirements [43,45], and were therefore reluctant to use them for long periods. Medical staff, volunteers, usability experts, carers and one study author also identified several usability issues. Table 7 below presents the usability issues identified by the various participants in the selected studies.

RQ8. Solutions for overcoming usability issues

The results show that several solutions are discussed in the selected studies for eliminating the usability issues in the system. For example, the two most commonly discussed issues were difficulty in using the system and a lack of user-friendliness. The former can be resolved by considerations such as: (i) decreasing the complexity [42]; (ii) giving users training on how to use the

Table 7. Types of participants and their evaluations.

	Usability issues identified by the evaluators						
Usability evaluators	Difficulty in using system	Lack of user-friendliness	Lack of assistance/ help feature	Lack of performance	System not meeting needs	Technical errors	Total studies
Patients	[40,42,43,46,48]	[40,42,43, 46, 49,50]	[48]		[43, 45]	[41, 44]	16
Medical staff		[49]				[44]	2
Volunteers	[51]			[51]			2
Experts	[39]		[39]		[43]	[44]	4
Study authors	[55]						1
Carers	[48]		[48]				2

Table 8. Usability solutions discussed in the selected studies.

Usability issues	Possible solutions for usability issues
Difficulty in using the system	• Decrease complexity [42] • Provide education and training on use [30,43,47,55] • Increase user involvement in the design process [56] • Provide clear instructions and tailored technological developments (such as adjustable stands and high-visibility controls) [48]
Lack of user-friendliness	• Decrease complexity [42] • Include easy-to-use features in the system [55] • Design and develop a custom-made user interface [50] • Develop a system that is understandable and only consists of necessary functionalities [51]
Lack of an assistance/help feature	• Design and develop self-explanatory systems [41] • Design and develop a graphical user interface with guidance [53]
Lack of performance	• Design and develop a robust system [41]
Failure of system to meet requirements	• Consider user feedback [49] • Carry out usability evaluations to fulfill users' requirements [46] • Involve users in all phases of development and design[40] • Include key users such as doctors and medical care personnel in the development of telemedical applications [44] • Create links between users and other stakeholders at the earliest stages of design and development [45]
Technical errors	• Heuristic evaluation of the system [39] • Properly test the system [39]

system [43,55]; and (iii) developing systems taking into consideration the concept of ease of use . The second issue can be resolved by: (i) decreasing the complexity [42]; (ii) including easy-to-use features [55]; (iii) designing a custom-made user interface [50]; and (iv) avoiding unnecessary features in the system [51]. The results also show that a number of studies discuss solutions to issue of the system failing to meet the users' needs, for example: (i) understanding user feedback [36]; (ii) usability evaluations [46]; (iii) involving users in the early stages of development [45] (one study suggested involving users in all design and development phases of the system [40]); (iv) including professionals such as carers and doctors/physicians [44]. The selected studies also identified possible solutions to usability issues such as lack of assistance, performance, and technical errors; these can be seen in Table 8.

Discussion

The present study has performed a systematic literature review with the aim of examining the usability of existing telecare monitoring systems. This review has identified several different usability issues and presented possible solutions to those usability issues. A discussion of each research question is given below.

RQ1. What are the publication sources in the context of the usability of telecare monitoring systems?

The wide range of publication sources (16 articles in 15 journals) indicates that there is no preferred source regarding studies related to telecare monitoring systems, and particularly the usability of telecare monitoring systems; numerous research efforts are still being made in this direction. Additionally, telecare technologies have a high level of adaptability, which allows them to be applied in diverse fields.

RQ2. How has the publication rate of studies related to the usability of telecare monitoring systems changed over time?

The selected articles were published between 2000 and 2017. The studies appeared in this study are limited and the possible reasons can be: (i) less research from academic side have been conducted on the usability of telecare monitoring system, and (ii) less development have been seen from the markets side. The year in which the most studies were published was 2015 (four studies out of 16). Although telecare systems are beginning to be widely used, telecare monitoring systems are in the initial stages of development.

RQ3. Which usability features or benefits are discussed in these studies?

A number of characteristics regarding the usability of telecare monitoring systems are examined, but understandability, attractiveness, satisfaction and efficiency [48] were the most discussed characteristics of the usability of telecare monitoring systems. A user-friendly interface is very important in the acceptance of the system by the user. User acceptance largely depends on how effectively this interface meets the needs of the users [52]; in

other words, to ensure the success of the system, it must be accepted by the users. Understandability, that is, the presence of self-explanatory instructions and efficiency in terms of functionalities, is also necessary [51]. These studies also show that systems need to offer user support feedback [49] and a self-explanatory user manual to increase the satisfaction level of users.

RQ4. Which evaluation methods have been used to assess the usability of telecare monitoring systems?

It is interesting to note that studies have adopted various research methods with a focus on the usability of telecare monitoring systems. We did not identify any particular method as having been followed in all the studies, and various types of usability issues were identified. The studies examined or evaluated the usability of the systems via questionnaire-based surveys, interviews, thinking aloud methods, or heuristic approaches. It was observed that the selected studies also mentioned the duration of the study or the examination of the usability of the systems, and most of the studies were performed over three to eight weeks [39,48,49,51], although we also found studies that were performed over six months [43,46,47].

RQ5. What types of diseases or problems are targeted by telecare systems?

Telecare systems are used to monitor users in order to ensure better health conditions for patients with different diseases/issues. Chronic obstructive pulmonary disease, heart failure and other chronic diseases were most often discussed as being supported by telecare monitoring systems. It was noted that some studies discussed the usage of telecare monitoring systems by the elderly [45,47], assisting them in achieving an independent life at home.

RQ6. What types of telecare monitoring devices or services have been discussed in these studies?

Several varieties of telecare monitoring devices or services were used in the selected studies. It was difficult to categorize these devices or services since the devices or services had different functionalities and had been used for different types of diseases/issues. Smartphones are gaining in popularity and have a high level of adaptability, and we found one study of smartphones as telecare monitoring systems. In addition to smartphones, sensing devices [41,50] are also used for telecare monitoring. Telecare monitoring systems have been used for purposes including heartbeat monitoring [44], monitoring health conditions on a daily basis [39], and monitoring of activities at home [45,47]. Most of the systems in these studies were used to assist patients with chronic disease; there is need to focus on other diseases such as heart failure, dementia, and issues related to rehabilitation.

RQ7. What are the usability issues or obstacles, and who has evaluated the usability of telecare monitoring systems?

A number of usability issues have been identified in the selected studies. The main issues were difficulty in using the system [40,42,43,46,48] and a lack of user-friendliness [40,42,43,46,49,50]. The results show that most of these usability issues were identified by the patients using the system. Since the system is designed for a particular type of user, it needs to be easy to use in order to create acceptance by this user. Of the 16 papers selected, six examined the issue of difficulty using the system, showing that telecare monitoring systems are neither user-friendly [42,48] nor straightforward to use. However, the usability of the system is crucial, since it has a high degree of influence over the success of the system. Thus, the system needs to be designed to provide a friendly environment for the user; in this way, the user can develop a positive attitude toward using the system, which may lead to its successful adoption.

The studies also showed that most users with severe chronic obstructive pulmonary disease were elderly and had physical disabilities such as poor eyesight. Such issues make it necessary to use large buttons, in order to prevent errors. These elderly individuals also utilized new portable innovations that are relevant to the consideration of other visual or audio cues [39] but faced challenges such as technical problems in using the applications [41,46], the bulkiness of the system [43], discomfort in using the system [55], and difficulty in adoption of telecare monitoring systems [50].

The participants proposed a user-centred design method that focused on ensuring that system will meet the users' requirements through a proper design process cycle that may also include usability evaluation of the system [45]. In the usage of smartphones for monitoring, one of the main problems was the battery life [49]. Studies have also identified problems including the failure of the system to meet the user's needs, a lack of user-friendliness, difficulty in accessing readings, trouble sending readings and temperature.

The mobile application was hard to utilize for users who were not accustomed to it, due to the excessive number of elements and counterintuitive operations. Moreover, the online portal could not meet the requirements of the users and thus had limited usage. Given the extended loading times of more than sixty seconds per view [51] and the patients' lack of technical competence, the issue of not being able to use and handle the systems implies a low device usability [44].

RQ8. What solutions have been proposed to overcome usability issues?

Various solutions are discussed in the selected studies to solve these usability issues. One study proposed a well-considered design that can be followed to develop effective and efficient system [52]. A higher level of acceptance could be achieved through a better understanding of feedback on the user interface [49] as the users are given education and training. Easy-to-use technology should be included for patients with chronic obstructive pulmonary disease, including those with disabilities [55]. The system should be understandable and should consist of only those functionalities that are necessary [51].

Moreover, there is a need for flexibility and for friendly, simple and self-explanatory interfaces that allow users to interact with the system [50]. Some studies also find that the system should contain only those functionalities which are important [51] and should avoid displaying unnecessary information to users.

For the systems to be effective, it is important to create and assess a system that is easy to utilize on a daily basis. This would increase the ability of the patients to control their diseases and would allow their daily lives to be more satisfying [39]. Usability evaluations [39,46] can help in evaluating the overall functionalities of the system and whether it fulfills the users' requirements [46]; for example, a heuristic assessment can be an effective technique for identifying issues with a system [39].

A system's difficulty is the degree to which it is problematic to appreciate and use; if the invention is easy to use [55], an

individual will be more likely to accept it [44,49]. If a system is difficult to use, this issue can be overcome by training [43,55] to offer information and self-confidence in the use of telecare systems [43].

Conclusion

Telecare monitoring systems (devices and services) are common in healthcare systems. However, there existed limited studies focusing on usability of the telecare monitoring systems. There is need to conduct more scientific studies in this research area.

Telecare monitoring systems should be easy to use in order to enhance the patients' interaction with the system and to encourage them to use these systems in the future. This study identifies the various issues faced by users, challenges and solutions that can increase the usability of telecare monitoring systems. The primary issues faced by users are a complex interface, difficulty in using the display, absence of instructions and a lack of expertise.

This study also found that one of the reasons of low acceptance of telecare monitoring system can be the fact that real users are not part of the design and development process of the telecare monitoring systems. As seen in this study, most of the studies involved the users in product evaluation process after implementing the telecare monitoring systems. Involvement of users in the design and development process is necessary because it can help in understanding the needs of users and avoiding issues mentioned in this study. Moreover, involving users will be helpful in implementing an efficient and effective system that can be accepted by the users and satisfy them which in turns will reduce the healthcare cost and their dependence on others.

Future research

There exist several usability guidelines that have been defined in general, to improve the usability of any website or mobile application or device. However, it is difficult to use such guidelines for telecare monitoring systems because the users of these systems are people with disabilities and elderly who have some unique requirements for using the systems. Therefore, there is a need to define usability guidelines for the telecare monitoring systems (websites or applications or devices) considering the needs of people with disabilities and elderly. In this regard, the future research will focus on collecting primary data involving the users of telecare monitoring systems and the usability experts who are implementing these telecare monitoring systems in order to usability issues and solutions to those usability issues. The collected data will contribute in defining usability guidelines particularly for telecare monitoring systems.

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