Barriers and facilitators of implementing robotic systems in nursing care

A Systematic Review

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Abstract

Background and Purpose

Economic and demographic developments led to the application of robots in medicine and healthcare [1]. The purposes of using robots in this field are to support older individuals in maintaining their independence [2], to reduce the need of care, support and therapy in order to relieve caregivers [3] and to improve medical procedures (e.g. surgeries or diagnostics) [4, 5]. According to these purposes health care robots can be classified in telepresence and assistance robots, social-interactive robots, robots for medical interventions, and rehabilitation robots [1].

The multidisciplinary project* 'MobIPaR' (Mobilization of Intensive Care Patients) aims to develop and pre-test such a rehabilitation robot, more specifically an auto-adaptive robotic solution for periodic leg movement that supports early mobilization of intensive care unit (ICU) patients. In order to prepare the development of a meaningful implementation protocol, we carried out a systematic review to identify barriers and facilitators for implementing robotics in nursing.

Methods

The systematic review considers studies where robotic systems have been implemented. Robotic systems include

telepresence and assistance robots, social-interactive robots (SIR) and training devices, and tools for movement performance, mobility, and independence. The search strategy aims to identify studies available in English or German language published in the last 15 years (2002-2017). The following sources were searched: electronic search in the databases Medline (via PubMed), CINAHL, Community Research and Development Information Service (CORDIS). Technische Informationsbibliothek (TIB), International Journal of social robotics, Journal of Robotics, International Journal of Robotics Research, and Robotics and Autonomous Systems. The review includes all types of study designs and project reports, quantitative as well as qualitative. Relevant search terms for the topics 'nursing/health care' and 'robotics' were used. Data extraction and analysis follows the CICI Framework, barriers and facilitators are classified according to the dimensions of context, implementation and setting [6].

Results

After removal of duplicates the database search revealed 6141 records. 5996 were excluded in the Title/Abstract screening and 145 publications were screened in full text. Finally, 24 studies were included. Currently we are in the stage of data extraction.

Conclusion

Results will be used for planning the implementation strategy of the robotic device in daily routine, together with the multidisciplinary team.

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Keywords — Nursing science, Robotics in nursing, Implementation barriers, Implementation facilitators, Complex Interventions

I. INTRODUCTION

The Federal Ministry of Education and Research (BMBF) is currently funding several projects in the field of robotics in healthcare [7]. This demonstrates the actuality and the innovativeness of this topic.

This article will give a short overview about robotics in healthcare and present the BMBF funded multidisciplinary project 'MobIPaR' (Mobilization of Intensive Care Patients), which aims to develop and pretest a rehabilitation robot. Further the article describes the methodology and preliminary results of a systematic review, which is currently carried out under the scope of this project.

II. BACKGROUND AND PURPOSE

A. Robotics in Healthcare

The development and application of robots in medicine and healthcare has increased due to economic and demographic changes (e.g. staff shortages and increased cost pressure) [1]. "Robotics for medicine and healthcare is considered the domain of systems able to perform coordinated mechatronic actions (force or movement exertions) on the basis of processing of information acquired through sensor technology (...)" [4]. The purposes of using robots in this field are diverse. Amongst others some aims include the support of older individuals in maintaining their independence with regard to rehabilitation or activities of daily life [1, 2], the improvement of medical procedures (e.g. diagnostics or surgeries) [3, 4] or is to reduce the need of care, support and therapy in order to relieve caregivers [3].

A few examples include PARO, a social-interactive robot, which is used in dementia care [1, 4], the Care-O-bot, developed by Fraunhofer Institute for Manufacturing Engineering and Automation, is now available in his 4th generation and suitable for different scenarios like supporting health care staff in hospitals or assist humans in tasks of daily living [8]. The da Vinci® Surgical System is powered by robotic technology and is used for minimal invasive surgery [9].

B. Early Mobilization

Prolonged immobility and best rest are important risk factors for functional decline in intensive care unit (ICU) patients. Both may be associated with acute complications and

long-term disability. To reduce this risks early mobilization is a safe and feasible intervention [10, 11]. Early mobilization is defined as the onset of physical therapy within the first two to five days after admission of critically ill patients on ICU [12]. However, there are often barriers which prevent the application of early mobilization in those patients. This includes patient-related barriers (e.g. hemodynamic instability or patient safety) or institution-related barriers (e.g. time constraints, insufficient equipment and inadequate staff training) [13, 14].

C. Project MobIPaR

The multidisciplinary project 'MobIPaR' aims to overcome those barriers of adoption of early mobilization by developing and pretesting an auto-adaptive robotic solution for periodic leg movement in ICU patients, which can be classified as a rehabilitation robot. The primary objective of the overall project is to provide an acceptable, feasible and safe device to support frequent early mobilization and to significantly reduce the physical burden of the involved health care professionals. The University of Applied Sciences Rosenheim supports the development, implementation and evaluation within the scope of the medical research council's (MRC) framework for complex interventions [15] from a nursing science perspective.

In order to prepare the development of a comprehensive implementation protocol that builds upon best currently available evidence, we are carrying out a systematic review to identify barriers and facilitators of the implementation of robotic systems in nursing care.

III. METHODS

The systematic literature search aimed to identify published studies available in English or German language that were published in the last 15 years (2002-2017). An initial search in Medline (via PubMed) was undertaken followed by an analysis of the text words contained in the titles and abstracts. Medical subject headings (MeSH) terms and free text terms have been combined. A second search used all identified search terms with adaptions specific to the respective database. A search of the reference lists of all relevant publications was performed in order to identify further studies.

After the initial search, the systematic search was performed in the following databases: Medline (via PubMed), CINAHL, Community Research and Development Information Service (CORDIS), Technische Informationsbibliothek (TIB), International Journal of social robotics, Journal of Robotics, International Journal of Robotics Research, and Robotics and Autonomous Systems.

The search string is divided in two main groups. Group 1 included terms with the topic of nursing and care and group 2 the topic of robotics with its synonymous terms (Fig.1).



Fig. 1 exemplary search strategy PubMed and CINAHL

To enable a comprehensive overview on this new topic, the review considers all types of study designs (quantitative and qualitative), as well as research reports, if they include original data. Inclusion criteria for the interventions were the implementation and application of robotic technology in inpatient (long-term care or acute care settings) or outpatient care settings. Studies investigating surgical procedures or diagnostics, clinical outcomes of robotics in nursing care, robotics in other fields, brain-computer interfaces and the development of robotics are not considered for inclusion.

A data extraction form was developed and piloted, comprising of three parts. The first part covers general information, including the reference, study design and intervention characteristics e.g. if an implementation was reported, including a classification of the robot, and if barriers and facilitators were described. If information of at least one of these characteristics or the study design was not reported, the study was excluded. The second part of the data extraction form contains study details in accordance with the template for intervention description and replication (TIDieR Checklist [16]). This includes a short description of the intervention, the aim of the intervention with its underlying problem, and information about what kind of material was used, how the intervention was delivered, the setting and the target population [16]. The results were aggregated as the description of barriers and facilitators as primary outcome. For this purpose we used the CICI framework to categorize the results in meaningful clusters [6]. Barriers and facilitators are classified according to the dimensions of context, implementation and setting (Fig 2).

Context	Geographical	a da
	Epidemiological	
	Socio-economic	
	Socio-cultural	
	Political	
	Legal	
	Ethical	
	Implementation theory	
tion	Implementation process	
nenta	Implementation strategies	
nplen	Implementation agents	
-	Implementation Outcomes	
etting		

Fig.2. Dimensions of barriers and facilitators (CICI Framework)

As a variety of study designs are included, we used different instruments for critical appraisal of the study quality according to the individual study design (Table1).

Study design	Critical Appraisal Tool
Mixed-method studies, Quantitative descriptive studies, quantitative non randomized studies	Mixed Methods Appraisal Tool (MMAT) Version 2011 [17]
(Systematic) Literature Reviews	CASP Tool for systematic Reviews [18]
Case studies, Interview studies, Focus Group	CASP Qualitative tool [19]
Case report, Practical experience	Joanna Briggs for Text and Opinion [20]

TABLE I. CRITICAL APPRAISAL TOOLS

All identified records were assessed by two independent reviewers using 'Covidence' (www.covidence.org), an online software, which enables researchers to accelerate their systematic reviews by offering different features, like uploading citations and full texts, screening title and abstract and full texts, create customized forms for data extraction, risk of bias and the function of exporting into common formats to further work with preferred software.

For the purpose of the review we use aggregated data from individual studies. A descriptive and narrative synthesis is planned.

IV. PRELIMINARY RESULTS

Until now, all full-texts have been read by two independent researchers and the phase of data extraction has started. Therefore, only preliminary results can be presented.

After removal of duplicates, the database search revealed 6141 records for title/abstract screening. Additionally, we identified eight studies by cross-referencing and manual search. 145 publications remained for full-text screening. 121 studies didn't meet the inclusion criteria and 24 studies were included in the data synthesis. (Fig. 3).



Fig. 3 PRISMA Flow Chart

Data extraction and quality assessment was completed for 23 publications. Most of those publications dealt with the implementation of telepresence and assistance robots (n=10), rehabilitation robots (n=3) and others robotic systems like ambient assisted living (AAL), telemedicine/-monitoring, medication delivery or assistive devices. Settings were nursing homes, personal living environments of participants or hospital units. Studies were mostly conducted in European countries (Austria, France, Italy, Denmark, Finland, Sweden, Netherlands, Germany, UK), the USA and Japan.

Barriers and facilitators, which have been described in the publications, were categorized within the dimension of context in the domains of epidemiological, political, legal, socio-economic, socio-cultural and ethical. Within the dimension of implementation, in the domains of implementation process, implementation strategies, implementation agents and implementation outcomes. For now, only barriers and facilitators, which have been mentioned at least twice will be listed here.

High costs [21–26], high time consumption [23, 27] and the question of reimbursement [28–30] were categorized as socio-economic barriers. The non-acceptance of end users [24, 31–33] and poor attitudes and mistrust towards using technologies [30, 31, 33, 34] as socio-cultural barriers. Ethical considerations included the stigmatization as being frail and dependent [21, 25, 26, 31], the fear of dehumanization of society [21, 25, 32], low data security [26, 32] and the invasion in individual's privacy [21, 25, 26, 35]. Within the domain of implementation agents the mistrust of caregivers, that the application of robotics in nursing will change or replace their professional role [22, 34] was One socio-cultural facilitator, which was mentioned several times is the acceptance of end-users [26, 28, 33]. Facilitating implementation strategies are an adequate training and information for involved stakeholders [29, 30, 33, 37, 38] and a continuous support and maintenance of the device [30, 35, 39].

V. DISCUSSION AND OUTLOOK

The preliminary results show that there is a need for an adequate implementation strategy in order to meet potential barriers and facilitate the implementation process of new robotic devices, such as the MobIPaR-device.

Since data extraction is not yet completed and the results have not yet compared by two researchers, the description of barriers and facilitators in the studies is just preliminary and even not generalizable. Furthermore, this review builds upon best currently available evidence without further restrictions of study designs, this might entail that no high evidence studies (e.g. randomized controlled trials) are available.

The next steps include the completion of data extraction and critical appraisal of all publications and the aggregation of the results of both researchers. Based on the results, we can derive suitable agents for the implementation process. For example: The reasons for non-acceptance of end-users can be further assessed and those results in turn might help to find solutions for this barrier. Otherwise if adequate training seems to be a facilitator, a training schedule adapted to the needs of the stakeholders can be developed for our device.

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