REVIEWS

Technologies for fall prevention in the hospital setting: A scoping review

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ABSTRACT

Objective: To identify scientific evidence about the main technologies used to prevent falls in hospitalized patients.
Methods: A scoping review was carried out. Studies available in English, Portuguese, or Spanish, aiming to identify technologies to reduce the risk of falls in hospital settings in the adult and elderly population, were included. No time limit was applied.
Results: Thirty articles were included in the review. The countries with the highest number of studies on the subject were the United States and Brazil. The technological solutions found include mobile applications, protocols, and software. From this list, the main technological solutions were mobile applications.
Conclusions: Technologies such as mobile applications offer portability and ease in transmitting information, becoming a tool to enhance the quality of healthcare practices. The use of technological solutions to provide medical care for the elderly population is promising as such tools assist in critical training and guide patients to achieve healthy living. Technology helps in interpersonal and professional relationships. Further studies exploring new solutions or technologies are needed to build upon the existing knowledge of strategies to improve healthcare quality.

Key Words: Accidental falls, Technology, Patient safety

1. INTRODUCTION

Falls are among the main causes of adverse events in the hospital setting that directly impact the increase in patient hospitalization. A fall is defined as an unplanned descent to the floor or extension of the floor, which may occur during the presence or absence of a caregiver, possibly causing injuries.[1]

The World Health Organization (WHO) characterizes this event as a public health problem and estimates that about 646,000 fatal falls occur per year, alerting institutions and researchers as the second leading cause of death from unintentional injury. It is estimated that more than 80% of fall-related deaths occur in low- and middle-income countries, also reflecting the costs of prolonged hospitalization, human resources, and health compromise.[2]

In this context, the need for interventions aimed at coping with falls in hospitals is evident, with emphasis on health education and creation of technologies that facilitate the identification of risk factors, the prevention of falls, and the reduction of damages, contributing to a safe care and a positive safety climate.[3]

The WHO also points out that preventive strategies should emphasize education, training, creation of safe environments, prioritization of new research related to the theme, and estab-

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lishment of effective policies and protocols to reduce risks.[2]

Studies have shown that falls can be avoided through isolated or combined interventions. Individualized education programs for teaching patients and companions and staff training on basic prevention and risk reduction care can reduce fall rates.[4–7]

Another agent that directly influences the effectiveness of the interventions is teamwork. All professionals directly or indirectly linked to patient care must understand the importance of identifying, evaluating, interpreting, and predicting risky situations and adopting solutions to prevent falls. Attitudes like this can reduce by up to 12% the episodes of falls in a hospital.[8]

Therefore, health education favors an environment of involvement and discussion of patient co-responsibility, enhancing the patient's ability to adopt fall prevention strategies, perceive risks, enhance the patient's self-efficacy and awareness, and, consequently, increase adherence to preventive measures. In addition to being an economic strategy, health education is easily accessible and adaptable to different settings and populations.[9]

Thus, although national and international experimental studies highlight strategies for preventing falls, there is still a literature gap on the use of technological solutions combined with medical interventions and on how these technologies have been created, described, and used in the hospital setting.

Given the above, it is important to gather and synthesize the scientific evidence on the technologies used to prevent falls in hospital settings, in adult and elderly populations, which are the most affected by falls that, in turn, increase in the number of hospitalizations, morbidity, and mortality.

The results of this review can help health professionals, researchers, and teams that deal with health programs and policies have a descriptive view of the technologies used and how they can be applied in a practical scenario. Thus, the present review aimed to identify scientific evidence about the main technologies used to prevent falls in hospitalized patients.

2. Method

A scoping review was carried out to summarize evidence from the literature on technologies developed to assist nurses, other healthcare professionals, patients, and companions in preventing falls in the hospital setting.

The six steps of the Joanna Briggs Institute guidelines for scoping reviews[10] were used as a methodological framework: 1) identification of the research objective and question; 2) identification of relevant studies; 3) study selection using pre-defined criteria; 4) data extraction and charting; 5) collation, summarization, and reporting of results; and 6) presentation and dissemination of the results and their implications.

The research question for the development of this review was: "What are the main technologies available for preventing falls in hospitalized patients?" This question was established using the PICO framework (where P stands for population/problem – hospitalized patients, I for intervention/indicator – technologies, C for comparison – not applicable to scoping reviews, and O for outcome – fall prevention).[11]

The search for primary studies was carried out during February and March 2021 in the following databases: Cumulative Index to Nursing and Allied Health Literature (CINAHL), Latin American and Caribbean Health Sciences Literature (LILACS), Medical Literature Analysis and Retrieval System Online (MEDLINE), Brazilian Nursing Database (BDENF), and Web of Science (WOS). The descriptors used for the search were extracted from the Health Sciences Descriptors (DeCS) belonging to the Virtual Health Library (BVS) and from the Medical Subject Headings (MeSH) of the National Library. The following descriptors were used in English or Portuguese depending on the database: "accidental falls", "patient safety", and "technology". The descriptors were combined using the Boolean operator "AND" to achieve a greater breadth of the search.

Full text articles on fall prevention in the hospital setting, in adult or elderly subjects, available in English, Portuguese, or Spanish, were included. No time limit was applied. Experience reports, editorials, pictorials, and gray literature were excluded.

The search resulted in 4,306 records, of which 2,000 were available, and 1,966 were written in English, Portuguese, or Spanish and published in the period 2006–2020. The titles were read for the refinement of the search, and 2,340 articles were excluded as they did not fit the review's objective and eligibility criteria.

The second stage of refinement took place through the reading of 100 full-text articles resulting in the selection of 30 articles. Figure 1 shows the study selection process.

A descriptive synthesis of important study characteristics (title, authors, year of publication, country of origin, type of technology investigated, journal, and study design) was undertaken (see Table 1). The level of evidence was classified using the Joanna Briggs Institute (2014) tool, which includes five levels: level 1 (very high) corresponds to experimental studies: systematic reviews and randomized clinical trials,

level 2 (high) quasi-experimental studies, level 3 (moderate) observational analytical cohort and case-control studies, level 4 (low) descriptive observational studies – cross-sectional, case series, and case studies, and level 5 (very low) expert opinion and bench-research articles.

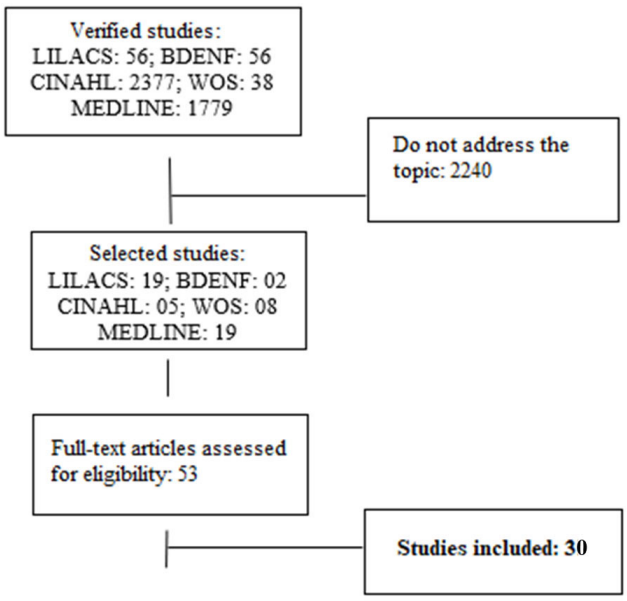

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart of study selection

3. Results

The sample consisted of 30 articles developed between 2006 and 2020, 9 of which were published in the United States (30%), 8 in Brazil (26.7%), 4 in Germany (13.3%), 3 in China (10%), 2 in the United Kingdom (6.7%), 1 in Switzerland (3.3%), 1 in Japan (3.3%), 1 in Austria (3.3%), and 1 in Australia (3.3%).

Fifteen articles were retrieved from CINAHL (48.4%), 9 from MEDLINE (32.3%), 4 from WOS (12.9%), 2 from LILACS (6.4%), and none from BDENF. The articles were published in the following journals: 3 Age and Aging, 2 Revista Brasileira de Enfermagem, 2 BMC Medical Informatics and Decision Making, Revista da Escola de Enfermagem da USP, J. Phys. Res., Revista Gaúcha de Enfermagem, Journal of Gerontological Nursing, J. Med. Internet Res., Int. J. SPHM, J. Nurs. UFPE on line, Advanced Emergency Nursing Journal, AJN, MEDSURG Nursing, Nursing Informatics, Applied Ergonomic, Assistive Technology, International Journal of Medical Informatics, PlosOne, Stud. Health Tech. Informat., Connecting Health and Humans, Sensors, Z Gerontol. Geria., J. Med. Syst., JMIR AGING, and Rev. Brazil Geriatric. Gerontol. The following research designs were used: 12 cross-sectional studies (40%), 9 methodological studies (30%), 3 descriptive studies (10%), 2 clinical trials (6.7%), 2 experimental studies (6.7%), 1 quasi-experimental study (3.3%), and 1 observational study (3.3%).

Studies with a level 4 of evidence were the most frequent (16 studies, 53.33%), followed by level 5 (9, 30%), level 1 (4, 13.33%), and level 2 (1, 3.33%). No study was rated as level 3.

Among the technological solutions identified, 8 studies used mobile applications (apps) (24.2%), 6 developed assisting devices (18.2%), 5 described the creation of protocols for fall prevention (15.1%), 5 developed software programs (15.1%), 2 consisted of checklists (6.2%), 2 were scales (6.2%), 2 consisted of questionnaires(6.2%), 1 described a game (3%), 1 was about a falls prevention program (3%), and 1 was about a video (3%).

Thirty articles were selected after critical and reflective analysis. Table 1 summarizes the characteristics of the selected articles.

4. Discussion

The incorporation of technological solutions to provide safe and harm-free medical care and improve healthcare quality has been expanding. The main objective of these resources is to help health professionals identify potential risk situations (scales), remember necessary actions (checklists), systematize their actions (apps and software), and learn about risk management and adverse events prevention (educational games, videos, and booklets).

Commonly used fall prevention interventions include risk assessment protocols, hazard alerts, environmental modification, ancillary equipment, educational materials for staff/patients/companions, medication management systems, staff transfer assisting tools, hourly surveillance of risk for falls, and bedside shift change reports. Preventive interventions are considered useful, but they need to be used consistently by the health team.[25]

The review's findings reinforce the evident prominence apps have had in hospital settings. Advances in telephony have made the use of smartphones extremely common, and mobile apps (software applications developed for use on smartphones) have been used for healthcare purposes. Bed and bedside sensors help monitor patients by detecting movements when the patient gets off the bed. Healthcare is often offered to many patients simultaneously, making constant surveillance impossible, especially by nurses who spend the longest time caring for patients. Therefore, adopting tools that allow constant surveillance increases the possibility of reducing the response time of professionals to alarms while providing hospitals with baseline information for quality improvement.[20, 30–32, 39]

Table 1. Synthesis of the characteristics of the studies included in the review from LILACS, BDENF, CINAHL, MEDLINE and WOS, in order of year of publication. Fortaleza, CE, Brazil, 2021

Title/Authors/Year/Country	Technological solution	Journal	Study design	Level of evidence
Construction and content validation of checklist for patient safety in emergency care *Amaya et al., 2016 (Brazil)* [13]	Checklist	Rev. Gaúcha Enferm.	Methodological	5
Development of mobile application to identify fall risk in the elderly *Nuñez Filha; Pinto; Leite, 2018 (Brazil)* [14]	Mobile application (Android and JAVA)	J Phys Res	Methodological	5
Safe Embrace: technological innovation for elderly safety in the use of toilets *Niwa; RadoviciI; CiosakI, 2018 (Brazil)* [15]	Device for preventing falls in the elderly while using the toilet	REBEn	Descriptive	4
The implementation of a hospital's fall management protocol: results of a four-year follow-up *Correa et al., 2012 (Brazil)* [16]	Hospital fall management protocol	REEUSP	Descriptive	4
Analysis of risk prediction capability and validity of Morse Fall Scale Brazilian version *Urbanetto et al., 2016 (Brazil)* [17]	Morse Fall Scale	Rev Gaúcha Enferm.	Methodological	5
Building and validating an educational video for elderly individuals about fall risks *Sá et al., 2020 (Brazil)* [18]	Educational video for fall prevention	REBEn	Methodological	5
Fall prevention in a Swiss acute care hospital setting reducing multiple falls *Schwendimann et al., 2006 (Switzerland)* [19]	Protocol of interventions to prevent multiple falls	Journal of Gerontological Nursing	Quasi-experimental	2
Using a medical intranet of things system to prevent bed falls in an acute care hospital: a pilot study *Balaguera et al., 2017 (USA)* [20]	Bed alarms to alert staff when the patient tries to get out of bed via mobile device	J Med Internet Res	Cross-sectional	4
Partnering with the patient to reduce falls in a medical surgical unit *Rochon; Salazar, 2019 (USA)* [21]	Falls prevention program	Int J SPHM	Cross-sectional	4
A prototype of knowledge-based patient safety event reporting and learning system *Kang et al., 2018 (China)* [22]	Reporting system to identify the profile of contributing factors to adverse events	BMC Medical Informatics and Decision Making	Randomized clinical trial	1
Assessment Instrument for Falls among the hospitalized Elderly (hospital AIFE): nurse analyzing vulnerability and mobility *Oliveira et al., 2016 (Brazil)* [23]	Instrument for Assessing Vulnerability to Falls in Hospitalized Elderly (IAQI in Portuguese)	J Nurs UFPE on line	Descriptive-exploratory	4
Development and implementation of the Memorial Emergency Department Fall Risk Assessment Tool *Flarity; Pate. Finch, 2013 (USA)* [24]	Memorial ED Fall Risk Assessment Tool for assessing the risk of falls	Advanced Emergency Nursing Journal	Cross-sectional	4
Using a fall prevention checklist to reduce hospital falls: results of a quality improvement project *Johnston; Magnan, 2019 (USA)* [25]	Hospital fall prevention protocol	AJN	Cross-sectional	4
Evidence-based practice: a falls prevention program that continues to work *Dacenko-Grawel; Holm, 2008 (USA)* [26]	SFH Fall - Hospital Fall Prevention Protocol	MEDSURG Nursing	Cross-sectional	4
Enhancing patient safety using clinical nursing data: a pilot study *Choi; Choi, 2016 (USA)* [27]	Hospital fall prevention protocol	Nursing Informatics	Cross-sectional	4
Iterative user centered design for development of a patient-centered fall prevention toolkit *Katsulis et al., 2016 (USA)* [28]	Fall prevention toolkit	Applied Ergonomic	Observational	4
Autoregressive-moving-average hidden Markov model for vision-based fall prediction—An application for walker robot *Taghvaei; Jahanandish;Kosuge, 2017 (Japan)* [29]	Assistive walker sensor (real-time fall prediction algorithm)	Assistive Technology	Cross-sectional	4
REFINE (REducing Falls in In- patieNt Elderly) using bed and bedside chair pressure sensors linked to radio-pagers in acute hospital care: a randomised controlled trial *Sahota et al., 2014 (United Kingdom)* [30]	Bed and bedside chair pressure sensors linked to radio-pagers	Age and Ageing	Randomized clinical trial	1
Development and alarm threshold evaluation of a side rail integrated sensor technology for the prevention of falls *Hilbe et al., 2010 (Austria)* [31]	BUCINATOR - a bed exit alarm system	International Journal of Medical Informatics	Methodological	5
Detection of falls using accelerometers and mobile phone technology *W.Lee; Carlisle, 2011 (United Kingdom)* [32]	Detection of falls (signals of movement) mediated by mobile technology	Age and Ageing	Experimental	1
A Stroop Stepping Test (SST) using low-cost computer game technology discriminates between older fallers and non-fallers *Schoene et al., 2014 (Australia)* [33]	Stroop Stepping Test (SST) - a computer game	Age and Ageing	Cross-sectional	4
Evaluation of reliability and validity of the Hendrich ii fall risk model in a Chinese hospital population *Zhang et al., 2015(China)* [34]	Hendrich II Fall Risk Model (HFRM) questionnaire to predict falls in hospitalized elderly patients	PlosOne	Cross-sectional	4
Design a learning-oriented fall event reporting system based on Kirkpatrick model *Zhou; Kang; Cong, 2017 (USA)* [35]	Event reporting system integrated into the Kirkpatrick Model	Stud Health Tech Informat	Methodological	5
Transforming the Fall-Injury Risk Assessment Tool from paper to electronic *Hyrkas et al., 2009 (USA)* [36]	Paper-to-electronic fall injury risk assessment	Connecting Health and Humans	Cross-sectional	4
A prototype of knowledge-based patient safety event reporting and learning system *Kang et al., 2018 (China)* [37]	Patient safety event reporting and learning system	BMC Medical Informatics and Decision Making	Methodological	5
INBED: a highly specialized system for bed-exit-detection and fall prevention on a geriatric ward *Jähne-Raden et al., 2019 (Germany)* [38]	Hardware and software for modular wireless movements (central wearable device)	Sensors	Methodological	5
Development and pilot study of a bed-exit alarm based on a body-worn accelerometer *Wolf et al., 2013 (Germany)* [39]	Bed exit alarm based on an accelerometer	Z Gerontol Geria	Methodological	5
An environmental-adaptive fall detection system on mobile device *Chang et al., 2011 (Germany)* [40]	Handheld fall detection sensor system that transmits data to mobile devices	J Med Syst	Experimental	1
Descriptive evaluation and accuracy of a mobile app to assess fall risk in seniors: retrospective case-control study *Rabe et al., 2020 (Germany)* [41]	Mobile application to assess the risk of falls in the elderly	JMIR AGING	Retrospective case-control	4
Development of an application for mobile devices to evaluate the balance and risk of falls of the elderly *Sampaio; Castilho; Carvalho, 2017 (Brazil)* [42]	Mobile application to assess the risk of falls in the elderly	Rev. Bras. Geriatr. Gerontol.	Cross-sectional	4

Notes. Source: created by the authors.

Checklists are an important safety strategy as they help professionals remember all actions necessary to offer safe care. In nursing practice, checklists allow the early identification of risks and the anticipation of adverse events, facilitate the adoption of corrective measures for systemic failures, enable the documentation of healthcare actions, and contribute to implementing patient safety measures.[13]

Another important strategy is the adoption of scales, which is highly recommended due to the possibility of identifying the risk for falls early. Scales help professionals create a co-responsibility environment through the Hawthorne effect, which must be considered since the act of approaching the patient and applying daily risk assessments itself contributes to a positive change in the attitude of individuals (patients/companions and professionals) who, in turn, become vigilant of their attitudes and surrounding conditions.[17,23,24]

Patient safety is a topic that generates great concern in hospital settings. It corresponds to a healthcare quality attribute that deserves attention and is an indicator of the effectiveness of healthcare practices, causing organizations to seek strategies for quality management and safe care. Among these strategies are technologies to facilitate and improve information flows, healthcare quality improvement instruments, and tools to guide patients, family members, and caregivers. It is known that the patient's situation while hospitalized, is distressing due to the hospital environment, so the better the relationships or even the bond built between the patient and the professional, the better the healthcare quality and the clinical condition of the patient, which are related to fall prevention in the hospital setting.[43]

In 2013, in the United States, direct medical costs due to falls corresponded to 31 billion dollars. In 2014, the cost increased by 32.8 million, with more than 800,000 elderly people hospitalized for falls. In Brazil, falls rank second in terms of frequency of hospitalizations and public spending. In 2016, 49,884,326.00 Brazilian reais were spent on hospitalizations and 20 million on medicines to treat elderly patients with femur fractures resulting from falls.[23]

Given the above, strategies must be urgently implemented to promote health and reduce the risk for falls, especially in the elderly population. Health promotion can be achieved by training the population to improve their quality of life and health, disseminating knowledge about disease prevention, and facilitating participation in the control of this process. Healthcare professionals also need to be trained to deal with possible adverse events and reduce them and the consequent public health expenditures.[44]

Health professionals, especially nurses, are primarily responsible for developing behavioral measures and providing guidance on how to prevent situations that may increase the risk for falls. Educational technologies are of paramount importance respect. Among the possibilities, educational materials such as booklets, folders, leaflets, serial albums, apps, board games, or augmented reality can be used, corroborating the findings identified.[43]

Healthcare professionals must be trained to use the available technological innovations appropriately in an associated manner with the theoretical-practical contents and consider the multidisciplinary team's needs. Therefore, educational technologies have been considered tools that facilitate dialogue. They allow strengthening the bond between the professional and the patient, enhancing the consistency of the theoretical component due to ease of use and significant learning, and contributing to the exercise of criticality-oriented skills necessary for improved patient quality of life of patients.[45]

One limiting factor of the present study was the low level of evidence of the studies included in the review, which hampers the impact of the scientific evidence reported. Thus, developing future studies with robust designs is necessary to qualify and support technological solutions to prevent falls in the hospital setting.

5. Conclusion

This study reinforces the need to improve interpersonal and professional relationships between patients, healthcare professionals, family members, and caregivers since this relationship is often ineffective due to failures in the training and continuing education processes. Besides, many professionals face difficulties when interacting with the patient or cannot provide information in a way that the patient can understand. Furthermore, communication should not be carried out solely based on recommendations, as its effectiveness is improved by training and by adopting strategies to enhance meaningful learning.

The technological solutions identified through this study include apps, technological devices, protocols, software, scales, questionnaires, videos, programs, and games. From this list, the most reported technological solutions were apps. The use of technological solutions during healthcare provision is valid and practical due to the ease of acquisition of such tools by professionals and patients, allowing greater clarification of informative contents and portability.

Conflicts of Interest Disclosure

The authors declare that there is no conflict of interest.

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