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Emerging Digital Technologies Used for Fall Detection in Older Adults: A Scoping Review

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ADMINISTRATIVE INFORMATION

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 06 November 2023 and was last updated on 06 November 2023.

INTRODUCTION

Review question / Objective This scoping review aimed to explore an overview of emerging digital technologies in fall detection for older people. The findings provide critical insights into the potential future role of digital technologies in healthy aging for older adults in different settings.

Background The proportion of the ageing population (aged 60 years and older) is projected to increase from one billion in 2020 to 1.4 billion in 2030, constituting 16.7% of the overall population. Additionally, it is anticipated that the elderly population will be tweaked to 2.1 billion by 2050 (Naja et al., 2017; Organization, 2021). In pursuit of the objectives outlined in the United Nations Decade of Healthy Ageing, countries must employ innovative solutions to address the healthcare requirements of current and future older populations.

Nearly 30% of individuals aged 65 have experienced at least one fall yearly. In 2015, approximately 2.9 million reported falls, tragically resulting in 33,000 fatalities. Even more concerning, 61% of older adults experienced a fall at some point during their first year of residency (Bharathkumar et al., 2020; Hawley-Hague et al., 2014). These alarming numbers underline the urgency of detecting falls and highlight the potential for substantial improvements in healthy ageing and overall quality of life among the ageing population (Kane, 2001; Loveys et al., 2022).

In recent years, Smart technologies have begun to reshape the global landscape of elderly health care. Those emerging technologies refer to systems that analyse their environments and take actions to achieve specific goals with a degree of autonomy for older adults (Grigorescu et al., 2021).

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Digital devices or systems such as sensors, signal robots, or smart homes are pivotal in ageing healthcare. They can create programs and solve problems using digital technologies incorporated with machine learning (ML) algorithms to simulate human intelligence. These devices and systems are frequently programmed to replicate human cognitive functions related to understanding human behaviour and conditions (Oyibo et al., 2023; Tanwar et al., 2022). Those digital technologies can manifest in software systems operating within virtual spaces, such as conversational agents and facial recognition systems, or hardware systems navigating physical environments, such as robots (Ohneberg et al., 2023). ML algorithms, including neural networks and deep learning, and computer vision, which involves tasks like image classification and object tracking, as well as pattern detection and natural language processing, among others (Lee and Yoon, 2021; Loveys et al., 2022; Van Roy et al., 2021).

Many older adults will likely reside in residential homes, nursing homes or care centres with assisted living or living alone for prolonged durations. Predicting and assessing the risks of falls becomes increasingly vital. A rise in health issues stemming from physical accidents and timely detection of falls is a significant enhancement in healthy ageing (Gharti, 2020; Tanwar et al., 2022). There is a growing interest in a monitoring system designed to provide a rapid response in emergency situations by closely observing their daily lives within their private spaces. Therefore, emerging digital technologies for fall detection have been lauded for early access to prevent accidental morbidities. Also, emerging fall detection interventions have been devised to bolster the well-being and independence of older people, extend the reach of care services, enhance their efficiency, and relieve the burden on caregivers (Chen, 2020; Linn et al., 2021). They can deal with service disparities, particularly in remote areas but high demand (Pilotto et al., 2018). Additionally, they can enhance the efficiency of information systems and data analysis for individuals to detect falls. The widespread application of digital technology to detect falls has accelerated the processing of related elderly healthcare research (Ma et al., 2022; VandeWeerd et al., 2020). Indeed, it is crucial to emphasize that research in this field is still in the developmental stage. The extensive utilization of digital technologies to detect falls has expedited research into the elderly population.

Rationale Previous research mainly focusses on employing a specific type of Artificial intelligence (AI) technology in older adults in healthcare and did not focus on fall detection. Also, those reviews provided deep insights into the potential benefits of AI technologies in serving older adults in general such as disease diagnosis, vital signs monitoring and emotion detection(Ma et al., 2022; Neves et al., 2023; Ohneberg et al., 2023). A mini-view was conducted, including 20 studies using fall detection monitoring systems based on the Internet of Things (IoT) and mobile-based application devices in indoor environments for older people. They mentioned methodology quality and system accuracy may not be accurate when aimed at older people in their living environment, such as homes or nursing homes or communities, in their study limitations. Therefore, fall detection systems must be developed in actual fall situations with lively environments and high model performance (Adamek et al., 2022). Also, it is important to explore different digital technologies that serve varying functions when detecting falls for older adults in their living environment.

The comprehensive application of emerging technologies for identifying accidental falls among the elderly has rarely been studied with empirical evidence. This scoping review aimed to explore an overview of emerging digital technologies in fall detection for older people. The findings provide critical insights into the potential future role of digital technologies in healthy ageing for older adults in different settings.

METHODS

Strategy of data synthesis Emerging technologies and related research have been conducted in health services and technology disciplines, and scientific findings have been published in different literature repositories. This scoping review was performed using the following databases: Embase, Medline (OVID), CINAHL, Coherence and IEEE Explore. The search terms "older people", "aged", "aging adult", "elder", "old person*", "old population", "old adult*", "old men", "old women", "Older", "senior*", "senile", "fall", "falling", "accidental fall", "Fall detection systems", and "Fall detection devices", "Monitoring", "Ambulatory" "ALGORITHMS", "WEARABLE ELECTRONIC DEVICES", "Fall detection technology" were systematically used with four controlled vocabularies from MeSH, Emtree, CINAHL heading and ageLINE with English synonyms in each database (Appendix 2). The search of literature published between 2013 and September 30, 2023, emerging technologies that support the detection of falls among older adults. The second phase of this review involved exploring grey literature through Google Scholar, followed by

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the third phase, which entailed a manual search of the reference lists within the identified studies and relevant reviews.

Eligibility criteria This study included older adults with a mean age of 60 years or older living in nursing homes, care homes, residential homes, respite care homes, and all skilled and ambulatory care facilities. The technologies /devices or systems that include AI techniques for fall detection, monitoring, and intervention delivery. The technologies can focus on physical capacity, psychological, social, environmental capacities, or health protection. AI techniques include machine learning or machine learning (e.g., neural networks, deep learning, reinforcement learning, classification algorithms, random forest, support vector machines, fuzzy logic, and genetic algorithms). Digital technologies may also involve pattern detection, computer vision, sensors, process automation, and robotics. Peer-reviewed journal articles refereed full-length conference papers, Randomized controlled trials or experiments, Observational studies, Cohort studies, pre-and post-evaluation clinical studies, Pilot studies and Feasibility and acceptability studies were included.

The exclusion criteria for studies are as follows: Studies that included populations with a mean age of less than 65 years were excluded. The technology's hardware form or software was not a basis for exclusion, but the technology needed to incorporate digital technologies to be included. Studies with no direct or indirect focus on fall detection were excluded. Studies focused on outcomes not identified in the inclusion criteria, such as cost-effectiveness, were excluded. Furthermore, studies where the technology was not evaluated in older people's everyday living environments, such as hospital or emergency care settings, were excluded. Theses, dissertations, other non-peer-reviewed literature, review articles, opinion pieces, protocols, laboratory experiments, qualitative studies, and review articles were excluded. Methodological quality was not used as a basis for exclusion. We have screened studies for inclusion in two stages (abstract screen full-text review) with training beforehand.

Source of evidence screening and selection In the compilation of the database search, all search articles were exported into The EndNote 20 database to remove duplicate articles and to screen titles and abstracts. A full-text review was conducted using Covidence systematic review software (www.covidence.org). Two researchers (SPKM, SDM) independently examined full-text articles against the eligibility criteria. When it was unclear if the concept or context was based on populations that included emerging digital technology, the third researcher contacted for concessions and searched for additional information for sensitivity (e.g., peer-reviewed articles on the intervention developer websites). The researchers agreed moderately in the initial ratings (k=0·40) and achieved consensus on a final list of included papers alongside three research team members (SPKM, BOL, and YCT). For studies with unclear reporting components or full-text findings, original authors were contacted via e-mail for clarification.

Data management Data extraction was conducted based on the recommendations of the Joanna Briggs Institute (JBI) methodological format (Munn et al., 2020; Peters et al., 2020). Two researchers (SPKM and BOL) conceptualized the study and developed the research protocol. SPKM and SDM created detailed variables and extracted data from a full-text review based on the study characteristics of interest. Data extraction was independently carried out on each article by two researchers, and disagreements were resolved through discussion with the other two researchers. Extraction data were input into a standardized Excel sheet through Covidence software.

Reporting results / Analysis of the evidence The results were reported in a structured narrative synthesis. The application of emerging digital technologies and the roles played among the elderly population to detect falls were grouped thematically. The following variables were listed: Authors, year, country, study setting, study design, nature and types of included digital technology to detect falls and model performance.

Presentation of the results Table 1. (a) Methods of fall classifications, (b) various technologies, devices, and systems used in fall detection, and (c) different technologies and methods utilised for fall data storage in included studies.

Figure 1 PRISMA flow diagram for included studies.

Figure 2. (a) Number of studies based on countries, (b) Number of studies based on study setting, (c) Number of studies based on publication year, (d) Number of studies based on study designs.

Figure 3. (A) Number of studies based on Raw data input methods, (B) Number of studies-based fall display devices, (C) Number of studies based used methods for fall notifications, (D) Number of studies-based health care response (usable populations) and (F) Number of studies-based models' performance.

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Figure E. Number of studies based on AI approaches and algorithms.

Language restriction Article published in English.

Country(ies) involved Taiwan.

Other relevant information No.

Keywords Fall, Fall detection, systems, device, Digital technology, older adults.

Dissemination plans After this review, we will publish results in the scientific conference and journal articles as reference materials.

Contributions of each author

Author 1 - Ching Teng Yao - conceptualization and draft manuscript.
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