Evaluation of mHealth interventions in wound care: A systematic review highlighting the involvement of informal caregivers

Giannis Polychronis¹*, Maria Noula¹, Christos Petrou¹, Zoe Roupa¹

¹Department of Health Sciences, University of Nicosia, Cyprus

Article Info

Article type: Review

Article History:
Received: 2024-03-24
Accepted: 2024-04-07
Published: 2024-04-19

* Corresponding author:
Giannis Polychronis
Department of Health Sciences, University of Nicosia, Cyprus
Email: polychronis.g@unic.ac.cy

Keywords:
Informal Caregivers
Mobile Health Interventions
Wound Care
Systematic Review

ABSTRACT

Introduction: Contemporary wound care (WC) complexities strain healthcare systems and challenge informal caregivers (ICs), especially in home settings. Mobile health applications (mHealth apps) offer real-time solutions, and telemedicine's rise emphasizes its potential to address these challenges. The aim of this study was to systematically evaluate and synthesize existing literature on mHealth app interventions for WC, with a specific emphasis on understanding the involvement, impact, and contributions of ICs in these interventions.

Material and Methods: This study followed the PRISMA guidelines for systematic reviews. Articles were sourced from three databases (PubMed, Cochrane Library, and CINAHL), focusing on WC via mHealth with IC involvement. Quality assessment tools, including the Newcastle-Ottawa Scale and the Cochrane Collaboration tool, were used to ensure high research standards.

Results: Upon meticulous examination of the articles, a mere six accurately aligned with the primary objectives of the research. Modern strides in healthcare technology have undeniably augmented both patient care and education. Several studies from different nations have delved into various wound categories, including pressure ulcers, diabetic foot ulcers, surgical wounds, and burns. The participant count in these scholarly investigations fluctuated between 15 and 70. Remarkably, among these six, only a single study concentrated on ICs.

Conclusion: Wound management requires an integrated technology, education, and IC training approach. Our review suggests that research on mHealth app interventions for ICs in WC needs to be more represented in global literature. Given this gap, we advocate for enhanced joint efforts to ensure that WC advances with digital healthcare without overlooking the IC population.

INTRODUCTION

In contemporary healthcare systems, the complexities surrounding wound care (WC) have emerged as a paramount concern [1]; this concern not only deteriorates patients’ quality of life but also imposes a substantial financial and logistical strain on healthcare infrastructures [2]. As patients increasingly shift from well-established hospital environments to home-based care, there must be a discernible deficiency in the expertise required for optimal home care [2, 3].

Central to this dynamic are informal caregivers (ICs): individuals who, without formal compensation, offer care to their dependent loved ones. Despite their critical role as the primary facilitators of at-home trauma care, these ICs often find themselves navigating the intricate maze of healthcare with scant resources and training [4].

A transformative prospect emerges in the digital epoch, propelled by the swift progression of technological innovation. MHealth apps have risen as pioneering tools, harnessing the omnipresence of smartphones to furnish ICs with real-time, tailored solutions [5]. The global pivot towards telemedicine—a trend profoundly intensified by the COVID-19 pandemic—further highlights the
potential of mHealth platforms [6].

Nonetheless, this metamorphosis from conventional caregiving methods to a digitized paradigm presents its own set of challenges. While there is a palpable enthusiasm surrounding these innovations, barriers persist, including technological unfamiliarity and apprehensions about data authenticity. Therefore, the research community must prioritize the needs and perspectives of ICs. As we usher in an era of mHealth applications, the insights and experiences of these ICs must remain at the forefront [7], both in the ideation and during the rigorous stages of development and evaluation. ICs play a significant and often underrepresented role in the effectiveness and outcomes of mHealth interventions for WC, and their active involvement can enhance the overall efficacy of these interventions in global settings.

MATERIAL AND METHODS

The present study was based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [8]). In the context of the current research, the following procedural steps were rigorously adhered to about the methodology implemented.

Search strategy

A rigorous bibliographic search was conducted across several databases (PubMed, Cochrane Library, and CINAHL) to identify pertinent articles. Boolean operators were employed in the search strategy, with "AND" utilized to integrate primary concepts and "OR" to encompass synonyms and associated terms. The focal keywords for this investigation included "Wounds," "apps," and "informal caregivers." Table 1 systematically represents the search terms explicitly used for the CINAHL database through the EBSCO platform. This ensures a meticulous literature search within that specific resource. Furthermore, citations from the selected articles were rigorously examined to identify and include any pertinent additional studies, guaranteeing a comprehensive and all-encompassing exploration of the existing literature. During the articles search process, no language restrictions were set. Instead, specific filters were applied, emphasizing peer-reviewed articles and those published between 2013 and 2023. An unfiltered search was concurrently executed to ensure inclusivity and comprehensiveness, capturing any potentially relevant and appropriate studies that might be overlooked. The snowball method further complemented this approach, enhancing the article discovery process.

Inclusion and exclusion criteria

Table 2 outlines the studies’ inclusion and exclusion criteria. It is important to emphasize that, to align with this study’s objectives, flexibility was granted to the population criteria, ensuring that no study was excluded, even if it made only minimal references to ICs.

Table 1: Search strategy

<table>
<thead>
<tr>
<th>Category</th>
<th>Search Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM (mesh terms), DE (Subject terms)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Inclusion and exclusion criteria

<table>
<thead>
<tr>
<th>Criteria Type</th>
<th>Study Design</th>
<th>Population</th>
<th>Intervention</th>
<th>Outcome Measures</th>
<th>Publication Date</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusion</td>
<td>Randomized controlled trials (RCTs), quasi-experimental studies, observational studies, and qualitative studies</td>
<td>Studies that focus on patients undergoing WC via mHealth interventions, with involvement or feedback from ICs</td>
<td>mHealth interventions designed explicitly for WC (e.g., mHealth apps, telemedicine platforms)</td>
<td>Studies that evaluate any aspect of mHealth interventions for WC and provide data or insights from ICs</td>
<td>Studies published in the last ten years</td>
<td>Studies published in English or with English translations</td>
</tr>
<tr>
<td>Exclusion</td>
<td>Case reports, letters to the editor, opinion pieces, and reviews without primary data</td>
<td>Studies exclusively focusing on formal healthcare providers without the involvement of ICs</td>
<td>Digital health interventions are not mobile-based or not explicitly designed for WC.</td>
<td>Studies that do not provide outcomes related to the role or impact of ICs in the mHealth intervention</td>
<td>Studies published more than ten years ago</td>
<td>Studies without an English version or translation</td>
</tr>
</tbody>
</table>
Data charting process
In the study selection process, two primary researchers, G.P. and Z.R., examined the titles and abstracts of the articles retrieved through the strategic search. These articles were subsequently assessed based on specific criteria, including Study Design, Population, Intervention, and Outcome Measures. A third researcher, M.N., independently reviewed the shortlisted articles to ensure rigor and mitigate potential biases. In instances where there was a discrepancy or disagreement regarding the eligibility of a study, a resolution was achieved through a structured dialogue between the researchers.

Analysis
The data gleaned from the selected studies were subjected to a rigorous analysis to discern prevalent themes, methodologies, and findings. Particular attention was dedicated to comprehending the architectural design and efficacy of mHealth app-based interventions and the pivotal role played by ICs. Moreover, the challenges encountered by ICs in the assimilation and execution of these digital instruments were explored. Notably, owing to the pronounced heterogeneity among the studies, conducting a meta-analysis was deemed infeasible.

Presentation of results
The findings were meticulously organized and showcased in an ordered fashion, including a systematic review tableau and an elaborate discussion section. This discussion accentuated each study’s relevance to the review’s central aim. While the contributions of the studies were acknowledged, a more pronounced emphasis was placed on identifying the existing gaps within the academic literature.

Quality Assessment
The quality and validity of each study were rigorously assessed using distinct criteria, including study design, methodology, and analytical rigor. Recognizing the importance of objectivity and consistency, studies that met high research quality standards were more significant in the analysis and discussions. The Newcastle-Ottawa Scale (NOS) for Observational Studies was employed to appraise non-randomized, mainly observational studies. The NOS framework evaluates the selection of study groups, their comparability, and the reliability of outcome or exposure methods. Studies are scored on a scale 9, with those scoring seven or above considered superior quality [9]. Furthermore, the Cochrane Collaboration tool was utilized for randomized controlled trials (RCTs). This tool identifies potential biases across various domains: selection, performance, detection, attrition, reporting, and other possible biases. Each domain’s risk is classified as “Low risk,” “High risk,” or “Unclear risk,” adhering to the guidelines of the tool [10]. These standardized tools ensured a comprehensive and objective quality assessment, affirming that the review’s conclusions are grounded in high-quality research.

RESULTS
A meticulous literature search was executed to unearth studies pertinent to WC via mHealth app-based interventions aimed at ICs. The search strategy yielded 387 articles from the three databases. An additional 17 studies were identified through citation searching and general internet searches. After a rigorous review process, which evaluated the relevance and methodology of the studies, only six articles were deemed to align closely with the research’s primary objectives. The PRISMA Flow Diagram is presented in Fig 1.

![Fig 1: PRISMA Flow Diagram](image)

The figure was created using the online tool developed by Haddaway et al. for custom diagram generation [11]. This tool allows for the precise visualization of complex data sets, enhancing the clarity and impact of our analysis.

In recent years, the confluence of technology and healthcare has exhibited significant advancements in patient care and education. This systematic review of six included articles underscores this trend (Table 3). Two pilot studies [12, 13] conducted in England and Portugal stand prominent among these. Regarding the nature of wounds, the mentioned studies [12, 13] and another study [14] from Switzerland primarily centered on pressure ulcers. In contrast, other studies [15, 16] from Iran and the USA specifically delved into diabetic foot ulcers. Another study [17] from Taiwan adopted a more comprehensive approach, exploring a gamut of injuries, encompassing ulcers, skin grafts, burns/frictions, pressure ulcers, and trauma. The sample size of these studies demonstrated variability, with one of those studies [12] involving a modest group of 15 participants and one other [17] examining a more
extensive cohort of 70 patients.

Table 3: Details of the included articles

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Publication Year/Country</th>
<th>Methodology</th>
<th>Sample size/Participants</th>
<th>Type of wounds/Primary focus on ICs</th>
<th>Purpose of Study</th>
<th>Results</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>[13]</td>
<td>2022/England</td>
<td>Pilot study of mixed methods</td>
<td>32 ICs²</td>
<td>PUs¹/Yes</td>
<td>Evaluation of a mHealth app³ (iCare) for PUs¹ prevention training aimed at ICs².</td>
<td>Positive reception and effect on the knowledge and confidence of the ICs².</td>
<td>A significant increase in ICs²’s knowledge of PUs¹ was found using the iCare app.</td>
</tr>
<tr>
<td>[12]</td>
<td>2020/Portugal</td>
<td>A descriptive study with user test</td>
<td>15 participants (8 Nurses, 2 Doctors, and 5 Direct Action assistants)</td>
<td>PUs¹/No</td>
<td>The investigation of the “ActiveRest” project aims to develop a protective layer of fabric to prevent PUs¹.</td>
<td>Introduction of the “ActiveRest” project with an integrated monitoring system.</td>
<td>Developed a layer protector integrated with sensors and a mHealth app³ for real-time monitoring for PUs¹ prevention purposes.</td>
</tr>
<tr>
<td>[16]</td>
<td>2021/Iran</td>
<td>Clinical trial</td>
<td>60 Patients (or a close family member)</td>
<td>Diabetic foot ulcers/No</td>
<td>The impact of teaching methods (and multimedia teaching) on self-care was evaluated.</td>
<td>Both methods (teach-back and multimedia teaching) effectively enhanced self-care in people with diabetes.</td>
<td>Supportive programs are essential for preventing and controlling foot ulcers in diabetic patients.</td>
</tr>
<tr>
<td>[15]</td>
<td>2023/United States of America</td>
<td>Prospective observational study</td>
<td>Twenty-five patients (wound scans were obtained by patients 40.0% and 60.0% by ICs²).</td>
<td>Diabetic foot ulcers/No</td>
<td>To evaluate the feasibility of the “Healthy.io Minuteful for Wound Digital Management System” as a patient-centered remote solution for monitoring lower extremity wounds.</td>
<td>Patients of diverse demographics were enrolled in a study over a few months. Their wound conditions, recovery stages, and smartphone availability varied. Both patients and ICs² contributed to wound scans. The digital wound management system prompted changes for some and had high satisfaction overall.</td>
<td>The app is a feasible means of remote wound monitoring for use by patients and/or their ICs².</td>
</tr>
<tr>
<td>[14]</td>
<td>2020/Switzerland</td>
<td>Qualitative study</td>
<td>Fifteen patients with spinal cord injuries and 12 healthcare professionals specialized in spinal cord injury.</td>
<td>PUs¹/No</td>
<td>This study aims to explore and identify the perceived benefits of a co-designed self-management mHealth app³ tailored for individuals with spinal cord injuries and to understand the potential barriers that may hinder its adoption.</td>
<td>Participants perceived the app as helpful for those with spinal cord injuries, serving as both a guide and an emergency resource. However, user motivation and misuse concerns could hinder its adoption.</td>
<td>Trust-building, tailored solutions, and solid organizational backing are essential to overcome barriers. Though co-design is beneficial, it does not ensure widespread use, highlighting a need for more targeted research.</td>
</tr>
</tbody>
</table>
McKeown et al. [13] explored the acceptability and impact of the iCare app, designed to educate ICs about pressure ulcer prevention. Their findings revealed a positive reception of the mHealth app, with a notable effect on IC knowledge and confidence, emphasizing the potential of mHealth apps in health education. Similarly, the ActiveRest project, introduced by Martins et al. [12], addressed the challenges of immobility and the risk of pressure ulcers. This project featured a textile mattress guard with an integrated monitoring system, highlighting the potential of remote monitoring in patient care. One of the studies [16] assessed the impact of teach-back and multimedia teaching methods on self-care for patients with diabetic foot ulcers. Their research underscored the effectiveness of both methods in enhancing self-care among individuals with diabetes, further emphasizing the importance of supportive programs in preventing and controlling foot ulcers. Another study [15] evaluated a patient-centered remote wound management system for monitoring lower extremity wounds. Their findings revealed that the system prompted early changes in wound management for a significant number of patients, with 94% finding the system functional. This study underscores the potential of remote monitoring systems in enhancing patient care and outcomes. One study [14] delved into the perceived benefits and challenges of a co-designed self-management mHealth app for spinal cord injury patients. Their qualitative study identified specific use cases highlighting the app’s benefits for different audiences. However, they also uncovered challenges that might impede the app’s adoption, providing insights into the complexities of integrating technology into patient care. Lastly, one study [17] evaluated a mHealth app’s effectiveness based on self-regulation theory, focusing on patients’ knowledge of WC, dressing change skills, and anxiety. Their trial found that the experimental group, which used the mHealth app, exhibited significantly higher WC knowledge levels, improved WC skills, and reduced anxiety levels compared to the control group. This study provides compelling evidence for the potential of mHealth apps in health education, especially in areas requiring specialized care and knowledge [17].

In conclusion, integrating technology in healthcare, primarily through mHealth apps and remote monitoring systems, offers promising avenues for enhancing patient care, education, and outcomes. However, while these tools provide numerous benefits, addressing the challenges and barriers to their widespread adoption is essential.

### Quality assessment

According to the Newcastle-Ottawa Scale (NOS) for Observational Studies (Table 4), various research studies have been evaluated for their methodological quality. McKeown et al. [13] received a score of 6, which suggests that the study is of moderate quality. On the other hand, Martins et al. [12] scored a 3 indicating potential methodological limitations that might affect the robustness of the findings. Similarly, Keegan et al. [15] were awarded a score of 4, pointing towards possible limitations in their research approach. Lastly, Amann et al. [14] scored 5, denoting it as a moderate-quality study.

<table>
<thead>
<tr>
<th>Publication/Ref</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>McKeown et al. [13]</td>
<td>6/9</td>
</tr>
<tr>
<td>Martins et al. [12]</td>
<td>3/9</td>
</tr>
<tr>
<td>Keegan et al. [15]</td>
<td>4/9</td>
</tr>
<tr>
<td>Amann et al. [14]</td>
<td>5/9</td>
</tr>
</tbody>
</table>

In the research conducted by Satehi et al. [16], various biases were carefully assessed. A significant concern arises from selection bias, which is perceived to be a high risk due to the employment of convenience sampling. As a result, the findings might not be universally applicable to all People with Diabetes suffering from diabetic foot complications in the involved hospitals, let alone broader populations. Regarding performance bias, the risk is low, as the study took commendable steps to ensure consistent care across all participant groups. Detection bias, however, remains a nuclear. Despite using single-blinding, which can mitigate certain biases like...
placebo effects, it does not necessarily shield against detection bias. Often, a double-masked design, where participants and evaluators are unaware of treatment assignments, is the gold standard to reduce such bias [18].

Chang et al. [17] assessed several biases in the study. The study showed a high risk of selection bias despite efforts to reduce it, primarily because methodologies like convenience sampling and precise inclusion/exclusion criteria introduced the possibility of such bias. The research took great care to minimize differences in care between participant groups, so performance bias was viewed as being at a low risk in contrast. By carefully addressing and reporting on participants who might have discontinued or were not followed up with, the research successfully managed attrition bias, ensuring this had the most negligible impact possible. Fig 2 shows the use of Cochrane Collaboration’s Tool for RCTs, created with the Risk-of-bias VISualization (robvis) tool [19].

![Fig 2: Cochrane Collaboration’s Tool for RCTs](image)

In our review of six studies using established quality assessment tools, four were observational or pilot studies and evaluated using the Newcastle-Ottawa Scale (NOS). Their scores ranged from 3 to 6 out of a possible 9, suggesting varying methodological quality, with none reaching the high-quality threshold of 7 or above. The other two studies were controlled trials assessed using the Cochrane Collaboration tool. Both studies displayed concerns in several bias domains, indicating potential methodological issues. While these studies offer valuable insights, their methodological limitations should be considered when interpreting their findings.

**DISCUSSION**

The domain of WC, mainly when approached from the perspective of mHealth app-based interventions targeting ICs, needs to be more adequately explored. An in-depth scrutiny of existing studies underscores the fact that their focus, while pertinent, does not precisely coincide with the objectives of our review. For instance, one of the studies [14] assessed the advantages of a mHealth self-management application tailored to individuals with spinal cord injuries. Although the study does delve into the mHealth app’s function as a guide for ICs, its predominant focus remains on the patients. Nevertheless, it offers insights about ICs derived through patients, justifying its inclusion in our review. Similarly, one of the studies [12] introduced the ‘ActiveRest’ project, emphasizing a fabric layer protector incorporated into a mHealth app. The primary objective was real-time surveillance rather than direct IC intervention or training. Although the study ambiguously references ‘Direct Action assistants,’ making it unclear if ICs were part of the study cohort, the results suggest that this mHealth app could benefit ICs. Consequently, this research was deemed fitting for our review. In the work of Satehi et al. [16], the primary emphasis needed to be more squarely on ICs. However, it warrants inclusion in our review because the participant inclusion criteria for the same study [16] explicitly stated the “ability to read and write inpatient or a close family member.” This implies that a literate family member could participate if a patient lacked the requisite skills. Friesen et al. [20] undertook a study on interventions related to WC. Notably, their focus was not on ICs but a distinct sample of eight nurses. Although their findings mentioned benefits for patients and ICs, we chose not to include this study in our review because of its precise sampling method.

One of the research [17] also lacks an exclusive concentration on ICs. To be precise, the study identifies its participants as ‘Patients or family members.’ Furthermore, one of the studies [15] noted that patients and their ICs received instructions on utilizing a digital management system. The results revealed that patients conducted 40% of the wound scans, while 60% were performed solely by ICs. This study is the sole comprehensive research that accurately describes ICs percentage to patients. On the other hand, one study [13] distinctly aligns with the primary objective of our review. Their research appraised a mHealth smartphone app expressly crafted for pressure ulcer prevention training targeting ICs. This study’s pronounced impact in bolstering ICs’ pressure ulcer knowledge perfectly complements our review’s essence. Participants acquired new knowledge and adapted their care methodologies, evincing the mHealth app’s immediate practicality and efficacy.

Although each study offers invaluable insights into the broader realm of wound prevention and management, it is McKeown et al. [13] that zeroes in on our review’s core interest: the potential of mHealth app-based interventions in educating and steering ICs toward practical WC. The fusion of
technology into healthcare, especially in Wound Prevention and Management, has captured considerable interest in contemporary times. Nonetheless, the focus on the IC demographic must be more conspicuously present, highlighting a substantial research void that should captivate the scholarly community. Responding to this research gap, a researcher [21] conducted a systematic review examining home-based chronic WC training for patients and their ICs. Our findings align with this review. In that recent study [21] on WC among ICs, the scope was expanded to encompass various interventions, not just those related to mHealth apps. Of the 16 studies that met their criteria, only one [16] addressed mHealth app interventions.

**CONCLUSION**

In summary, wound prevention and treatment necessitate a comprehensive strategy encompassing technology, education, and ongoing training for ICs. Although the methodologies employed by mHealth technology into healthcare, especially in Wound Prevention and Management, has captured considerable interest in contemporary times. Nonetheless, the focus on the IC demographic must be more conspicuously present, highlighting a substantial research void that should captivate the scholarly community. Responding to this research gap, a researcher [21] conducted a systematic review examining home-based chronic WC training for patients and their ICs. Our findings align with this review. In that recent study [21] on WC among ICs, the scope was expanded to encompass various interventions, not just those related to mHealth apps. Of the 16 studies that met their criteria, only one [16] addressed mHealth app interventions.

**REFERENCES**


5[2]: 635-45.


