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Adoption of Information and Technology Communication in Ulcer Pressure Prevention: A Narrative Review

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Abstract

Patients who have immobilization and bedrest prone to have poor blood circulation to the area that contact the bed. This condition is triggering pressure ulcer that may impact on patients' recovery process, burden, and conformity. In 4.0 industry, information, and communication technology (ICT) has implemented in many healthcare activities, including in the prevention of pressure ulcer. ICT provides a solution to prevent this unwanted condition in bedrest patients through many forms, but has not been mapped yet, especially for nursing**.** The purpose of this study is mainly to synthesize previous findings related to the adoption of ICT in pressure ulcer preventions. This study is a literature review which using several databases, namely Pubmed, Google Scholar, JMIR, IEEE, and Sage Journals. We used the PRISMA framework as a guideline to select the eligible articles that must be included to our study. We implemented Mixed Method Appraisal Tool to ensure the quality of articles in this review. Then, the data is synthesized and visualized in tabular**.** We gathered 2,081 articles from literature searching and obtained 12 eligible articles to be synthesized. Our Findings revealed that ICT adoption in ulcer pressure prevention was further than expected which the implementation of artificial intelligence (AI) was dominated in our findings. We also found that several technologies, such internet of things (IoT), were also implemented to send the patient's data related to pressure ulcer periodically and provided the information for healthcare provider to formulate preventive interventions. Detection of pressure ulcer among patients may be done precisely by tomography technique in one study. Various ICT implementations in pressure ulcer prevention were promising to be adopted by healthcare providers, including nurses.

Keywords: - ICT, Pressure ulcer, Prevention

Introduction

Decubitus or pressure ulcers are undesired conditions that often occur in patients who have difficulty with physical mobility, such as those who require total bed rest or have decreased consciousness. The global prevalence of pressure ulcer incidents is quite high, reaching 41% (Barakat-Johnson *et al.*, 2019). Pressure ulcers are tissue damage conditions that can extend to the surrounding muscle tissue due to friction between bony prominences and the patient's bed surface. Patients with decreased consciousness, malnutrition, and poor blood perfusion generally have an increased risk of pressure ulcer or decubitus incidents while on bed rest (Kottner *et al.*, 2020).

Several instruments have been developed to identify the risk of pressure ulcer incidents in patients, such as the Braden Scale, Waterlow, and Norton. These instruments generally combine various assessment dimensions, including sensory perception, skin moisture, friction, nutrition, mobility, weight and height, age, gender, and other factors that differ among each instrument. The goal is to determine a combination of risk factors that can trigger the occurrence of pressure ulcers or decubitus (Gurkan *et al.*, 2022). However, the accuracy of pressure ulcer identification is highly dependent on

the proficiency of healthcare professionals, including nurses, who use these instruments. If healthcare professionals lack skill, scoring errors may occur and lead to incorrect conclusions (Crunden *et al.*, 2022; Du *et al.*, 2021).

Although studies on scoring errors in pressure ulcer risk assessment are still limited, efforts to improve the precision of risk determination are being made by incorporating rapidly evolving information technology. Health Information Technology (HIT) is widely used today and offers a combination of technology and information in healthcare (WHO, 2021). HIT can be defined as the combination of information and communication technology (ICT) science, health science, and mathematics in purpose to create or achieve better health care quality and outcomes (Han & Lee, 2021). HIT serves as an alternative to enhance the quality of healthcare services in various segments, including promotion, prevention, treatment, and rehabilitation. It provides benefits such as more comprehensive data acquisition, higher accuracy of health data, ease of storage and access to health data, and broader opportunities for healthcare professionals to analyze digital health data without the need for manual calculations on paper (Ebenso *et al.*, 2021).

The application of HIT in the prevention and management of pressure ulcers is becoming a trend in the healthcare field (Sahay *et al.*, 2017). Along with the advancement of HIT, prevention of pressure ulcers is not only done by electronically calculating the risk assessment but also through the development of more advanced methods. Knowledge of the development of HIT in the prevention of pressure ulcers for healthcare professionals, such as nurses, provides insight into future trends and the role of nurses in providing quality nursing care for patients (McBride & TIetze, 2016). Unfortunately, mapping the development of HIT in the prevention of pressure ulcers is still rare. A review of this issue is needed to provide valuable information for the advancement of nursing science. The aim of this study is to review the development of HIT in pressure ulcer prevention among patients based on previously published research.

Materials And Methods

This study conducted a literature review by searching reputable health research databases such as Pubmed, Sage Journals, Google Scholar, JMIR and IEEE journals. We used PICO approach to formulate a research question that is most relevant to the study's context. The research question identified was, "How is the digital health implementation on decubitus preventions among patients?"

To conduct the article search in targeted journal databases, relevant keywords were selected, including combinations such as "Decubitus OR pressure ulcer", "e-health OR digital health OR telemedicine OR telemonitoring OR teleconsultation OR mHealth OR personal health records" and "prevention." The selection of articles was based on predefined inclusion and exclusion criteria. The criteria focused on articles that addressed any kind of ICT implementation in decubitus or pressure ulcer prevention, involved adult as the population of interest, were published in English between 2019 and 2023. Pilot studies, feasibility studies, and literature review studies were excluded. We also excluded articles that has Mixed Method Appraisal Tool (MMAT) score lower standard. A cutoff point of 80 was considered as the threshold score to determine whether an article passed the critical appraisal or not over MMAT (Hong, Fàbregues, *et al.*, 2018; Hong, Pluye, *et al.*, 2018).

The screening and article identification process followed the PRISMA framework, which ensured a structured and systematic approach (Page *et al.*, 2021). Eligible articles were thoroughly read, and their findings were identified and recorded in a table. The results were then narrated and visualized to facilitate understanding of the synthesis results, following the typology of literature review research (Grant & Booth, 2009).

Results & Discussion

Following the search on the targeted databases, a comprehensive total of 2,081 articles were identified, which initially met the inclusion criteria. To ensure the quality and relevance of the articles, a screening process was conducted, involving the removal of duplicates, as well as the evaluation of titles, abstracts, and content. This rigorous screening resulted in the selection of only eligible articles

for further analysis. Figure 1 depicts the article selection and screening process, adhering to the PRISMA flow diagram as determined by the researchers.

Upon completion of the screening process, it was determined that a total of 12 articles fulfilled the criteria established by the research team. These selected articles underwent a thorough critical appraisal using MMAT, and the resulting information obtained from this assessment is presented in Table 1. as shown below.

Table 1 Screening Process

| Authors	Year of Published	Study Design	MMAT Score	ICT type	Target population
McKeown et al	2022	Mixed-Method	100	mHealth	Community
Nurmambetova et al	2023	Qualitative	100	Artificial Intelligence	Healthcare providers
Amann et al	2020	Mixed-Method	100	mHealth	1. Community 2. Healthcare providers
Liu et al	2022	Quantitative	80	Tomography	Healthcare providers
Lau et al	2022	Quantitative	80	mHealth and artificial intelligence	Healthcare providers
Miller et al	2020	Quantitative	100	HER	Healthcare providers
Rangarajan et al	2023	Qualitative	100	IoT	Patients
Monroy et al	2020	Quantitative	80	Big Data	Patients
Siramungklanon et al	2022	Qualitative	100	surveillance system	Caregivers
Cicceri et al	2020	Qualitative	80	Artificial Intelligence	Healthcare providers
Khac et al	2021	Quantitative	80	mHealth	Healthcare providers
Cramer et al	2019	Quantitative	100	Artificial Intelligence	Healthcare providers
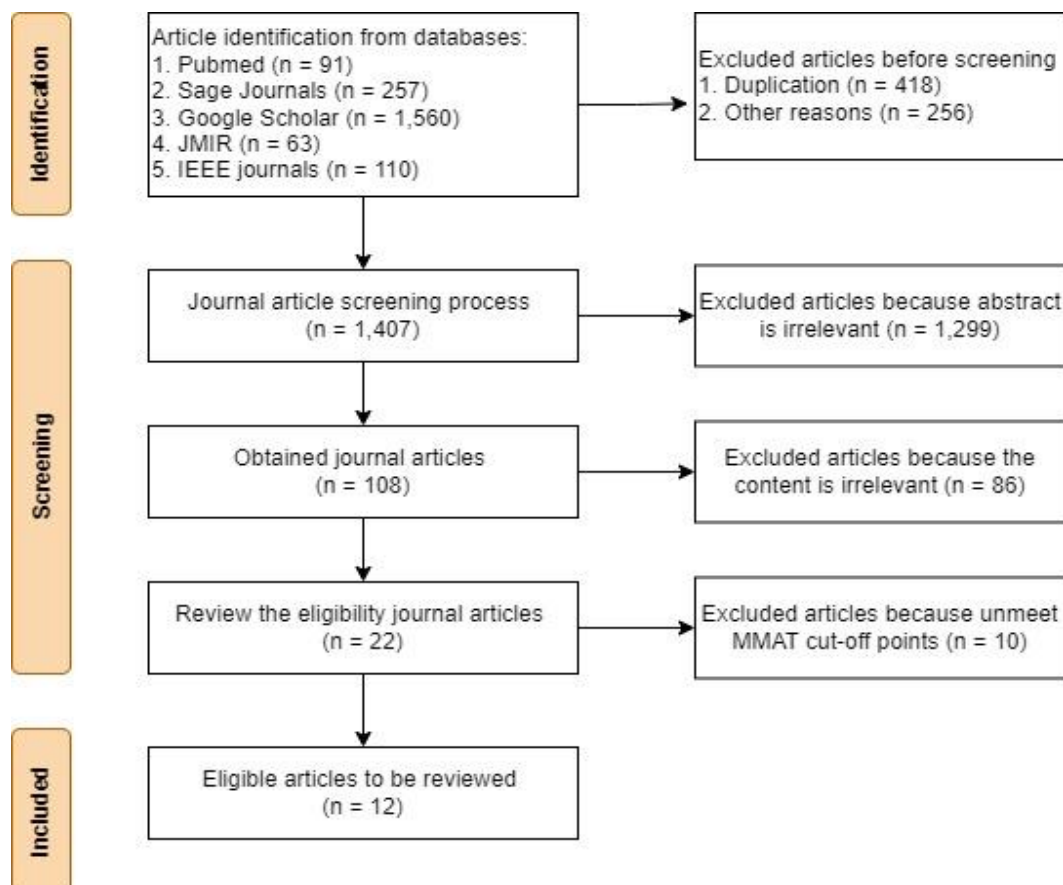
Figure 1 Article selection and screening process PRISMA flow diagram

Big Data analysis

According to the research conducted by Rangarajan *et al.* (2023), sensors can be embedded in patient garments to capture data related to patient activities that can potentially cause pressure ulcers. E-textiles adopt sensors that can capture changes in patient body posture during treatment, which can potentially lead to pressure ulcers. The data obtained is abundant as it is continuously collected at regular intervals throughout the treatment. This indicates that big data from sensors is then combined with fuzzy approaches to identify pressure ulcer risks so that they can be prevented earlier. The key difference is that this e-textile technique is not only used in clothing but also in other items such as socks. The resulting knowledge-based information is processed and classified as low, moderate, or high risk (Monroy *et al.*, 2020).

Artificial Intelligence

The use of artificial intelligence (AI) with natural language processing improves the detection of pressure ulcer incidents in hospitalized patients by combining multiple data sources that are processed using pre-designed algorithms. The results from these algorithms indicate the prediction of pressure ulcer incidents related to hospital care (Nurmambetova *et al.*, 2023). Data is identified from the assessment notes inputted by healthcare professionals, including nurses, into the system. The use of machine learning does not solely replace the role of healthcare professionals but rather serves as decision support to enhance precision in determining patient issues. Increased accuracy is needed to provide higher-quality nursing care (Gehrmann *et al.*, 2018).

The combination of mobile health (mHealth) applications with AI is a step towards facilitating the detection and management of pressure ulcers in patients. YOLOv4 is one such application that implements AI as a tool to identify pressure ulcer incidents through photos taken via smartphones. The results from this tool show a relatively high accuracy ranging from 80% to 90%. This demonstrates that even when AI is integrated into mHealth, it still provides good performance in pressure ulcer assessment. One implication in nursing is its use as an auxiliary tool for early detection of pressure ulcer risks in patients. Assessment is not solely based on observations and verbal assessments but also considers the images generated by AI in mHealth. This approach can improve the accuracy of pressure ulcer detection by nurses (Lau *et al.*, 2022).

Similar to previous research, a sensor is attached to the patient's body to capture changes in their position. This digital data is then transmitted to an information system and processed to indicate the possibility of pressure ulcer incidents using deep learning adoption. These results can be utilized by healthcare professionals for diagnostic or early detection purposes (Cicceri *et al.*, 2020).

The integration of AI into Electronic Health Records (EHR) will help in the detection of pressure ulcer incidents. EHR, as a documentation medium, records abundant healthcare data. The injection of automated classification features using machine learning based on the Braden Scale is one effort to enhance the speed of detection and prevention of pressure ulcer cases. In this study, the precision strength was shown to be 0.09. The automated classification of pressure ulcer risks in ICU patients requires healthcare professionals, such as nurses, to determine when prophylactic therapy should be initiated from the beginning of patient admission (Cramer *et al.*, 2019). This demonstrates the flexibility of AI, which can be implemented not only in standalone applications but also in commonly used hospital applications such as EHR (Jones *et al.*, 2021).

Electronically stored data is valuable and more flexible for analysis of a specific disease (Ferrão *et al.*, 2021). Patient data inputted into EHR is analyzed, revealing patterns of pressure ulcer incidents in adult in-patients who undergo a minimum of 3 days of treatment. The analysis results indicate that inpatients have a 2-3 times higher likelihood of experiencing pressure ulcers due to treatment, especially in patients with malnutrition or undergoing care or surgical procedures. These findings align with standard instruments like the Braden Scale, where poor nutritional status, lack of mobility, and

skin friction increase the risk of pressure ulcers. EHR, as one form of information and communication technology utilized by nurses for documentation, offers greater opportunities (Miller *et al.*, 2020).

Mobile Health (mHealth)

Mobile Health or mHealth is widely used in the healthcare sector nowadays (Heuvel *et al.*, 2020; Mandracchia *et al.*, 2020; Willcox *et al.*, 2019). McKeown *et al.* (2022) developed the iCare system. Regarding information systems, the development of the iCare information system for the prevention and treatment of pressure ulcers is quite good. There are several aspects, such as the use of concise video and direct information, which help users to easily navigate the application. In the development of mHealth, there is a need for customizable menus or topics that users find important or prefer, which would facilitate their accessibility (Inal *et al.*, 2020). The availability of connections that connect patients or system users with healthcare professionals is also crucial in mHealth to create a pleasant user experience, leading to increased frequency of mHealth usage and ultimately achieving the desired impact. The development of mHealth should follow a user-centered design approach, where selecting small font sizes should be avoided to prevent user difficulties and potential abandonment, especially considering that the target users of mHealth for pressure ulcer prevention are likely to be adults or baby boomers (Calonaci, 2021).

mHealth demonstrates a significant positive impact on enhancing the basic knowledge of users acting as caregivers for patients at risk of or suffering from pressure ulcers. mHealth can be utilized as a more flexible and easily accessible educational medium, eliminating the need for direct interaction with healthcare professionals. Caregivers can detect signs and symptoms of pressure ulcers at an earlier stage, thereby fostering heightened awareness (McKeown *et al.*, 2022).

The mobile application for detecting pressure ulcers in spinal injury patients is an innovative breakthrough that can be implemented in the healthcare field, including nursing. The co-designed application provides a menu for early detection using a smart camera to capture images of pressure ulcers. These images are crucial for healthcare professionals during consultations. Clear images are a fundamental requirement for online consultations, as they aid in the interpretation by healthcare professionals. Another unique feature, such as a wound diary, offers a distinct experience for both users and healthcare professionals, enabling them to monitor the progression of pressure ulcers over time. Early detection can occur when signs and symptoms are identified through the diary. The reminder feature to change positions represents a digital nursing application that introduces a new breakthrough in nursing practice. Digital education on the prevention and management of pressure ulcers in patients can also be conducted. Patients can actively read, while healthcare providers can add the latest information on pressure ulcer management (Amann *et al.*, 2020).

The mHealth application was evaluated under ecological conditions by experienced nurses and doctors in assessing chronic wounds (with experience using acetate tracing as a reference). They quickly adapted to the application without prior training, aside from the provided guidelines, using different mobile devices (iOS or Android-based smartphones or tablets). Considering how rapidly someone can become accustomed to the application, the time saved during wound assessment, and the results of this initial validation study, the use of mHealth applications can be implemented in clinical practice, considering the limitations of reproducibility during inter-rater evaluations and for wounds on curved skin surfaces (Khac *et al.*, 2021).

In clinical practice, the use of the mHealth application offers advantages by overcoming difficulties associated with acetate tracing (such as material availability, data storage issues, and time required for area calculations) and ease of access since doctors regularly use their smartphones for such applications (Almathami *et al.*, 2020).

Internet of Things (IoT)

The Internet of Things (IoT) is a rapidly developing digital information technology, especially when technology is related to personal health (Roehrs *et al.*, 2017). The previous challenges in detecting and preventing pressure ulcers in patients relied on periodic manual examinations, limited

observations, less comprehensive findings and conclusions, and the use of manual instruments that had subjective tendencies. IoT, embedded in patches attached to patient clothing, provides a solution for collecting periodic and routine data related to pressure ulcer risks. Data captured through IoT includes changes in pressure ulcer appearance or skin condition, changes in the patient's body angle during observation, and routine patient repositioning. The concept of IoT allows for direct recording, storage, analysis, and automated display of captured digital data, aiding healthcare professionals, including nurses, in monitoring patient conditions. Data analysis is processed through machine learning algorithms embedded in the application (Abdelmoghith *et al.*, 2020). The obtained results can serve as a tool to determine whether a patient is at risk of developing pressure ulcers or not. Comprehensive pressure ulcer prevention can be achieved by periodically monitoring the data and information captured by IoT-enabled patient clothing (Rangarajan *et al.*, 2022).

Tomography

Although EIT development is still in the experimental stage, the technique of imaging pressure ulcer risks in patients using the detection of characteristic electrical current changes in the patient's skin holds promise. In patients at risk of pressure ulcers, the skin exhibits different physiological and pathological signals, providing valuable information for detecting pressure ulcer incidents. This information is captured through specialized sensors and, with the aid of an application, simulates potential pressure ulcer images that may occur in various areas of the patient's body, including location, depth, and size. EIT techniques are considered safe as they are non-invasive, portable, cost-effective, and provide real-time imaging, thereby offering flexibility and accuracy in pressure ulcer detection and prevention, assisting healthcare professionals in decision-making (Liu *et al.*, 2022).

Surveillance systems

Surveillance of pressure ulcer incidents is not widely implemented in various healthcare facilities or other surveillance information systems. To identify such possibilities, surveillance information systems must adhere to guidelines for detecting pressure ulcers, including body pressure, skin moisture, and pH level of skin. The resulting data can be stored and visualized through a website application (Siramungklanon *et al.*, 2022). This information system requires a dashboard as an interface between healthcare professionals. Nurses, in their role of clinical practice, would access the system through the dashboard. The dashboard serves as a communication medium and provides information regarding the health information system (Begum *et al.*, 2020).

Conclusion

In conclusion, the implementation of Big Data, Artificial Intelligence (AI), mHealth, IoT, and surveillance systems holds great potential in the detection, prevention, and management of pressure ulcers in healthcare settings. The utilization of Big Data from sensors embedded in patient garments provides continuous and abundant data that can be combined with fuzzy approaches to identify pressure ulcer risks. AI, particularly machine learning and natural language processing, enhances the detection of pressure ulcers by analyzing multiple data sources and aiding healthcare professionals in making more precise decisions. AI integrated into mHealth applications, such as YOLOv4, demonstrates high accuracy in assessing pressure ulcers, serving as an auxiliary tool for early detection.

IoT enables the collection and analysis of data related to pressure ulcer risks, offering a comprehensive approach to monitoring patient conditions and aiding healthcare professionals in making informed decisions. Tomography techniques, specifically using Electrical Impedance Tomography (EIT), hold promise in imaging pressure ulcer risks, providing real-time and non-invasive information about potential ulcers in various body areas. Surveillance systems play a crucial role in identifying pressure ulcer incidents by adhering to detection guidelines and visualizing the collected data through website applications. The use of dashboards facilitates communication and information exchange among healthcare professionals, improving the overall surveillance of pressure ulcers. Overall, these technologies and systems contribute to enhanced detection, prevention, and

management of pressure ulcers, providing valuable insights and supporting healthcare professionals in delivering high-quality care to patients at risk of developing pressure ulcers.

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Conflict of Interest:

The authors declare no conflict of interest.

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