Artificial Intelligence Technologies for Nursing Development: A Review of the Current Literature

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Abstract

Recent years have seen rapid development of artificial intelligence (AI) technology revolutionizing the healthcare industry by a tremendous measure, especially in the field of nursing, highlighting its great potential for application. Aside from assisting nurses to make more accurate decisions in complex clinical environments, AI also provides patients with more convenient remote care services. These trends highlight the indispensable and important value of AI in nursing. The current study comprehensively reviewed the current literature on the application of AI in nursing environments, aiming to deeply analyze the current status of the application of AI technology in nursing practice and to provide a prospective outlook on its future development trends in the nursing field. Through this review, we hope to provide nursing practitioners and healthcare policy makers with valuable information to facilitate the further application of AI technologies in enhancing the quality and efficiency of nursing care.

Key words: nursing care; artificial intelligence; quality of healthcare; technology transfer; review

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Introduction

Since the modernization of the nursing profession, the concept of "nursing" has remained central to nursing philosophy and scholarship, but it is still ridden with complexity and ambiguity, with related study has shown that that nursing is merely a service provided by nurses to patients, and nursing is an act of human caring—a practice embodying six important elements namely the compassion, competence, conscience, assertiveness, commitment, and demeanor (Robinson, 2023). Although the concept of "nursing" has not yet been fully defined, it is of paramount importance to patients and plays an important role in quality of life, health behaviors, mortality, satisfaction and medication adherence (Deschodt et al, 2024). Currently, the nursing profession has become increasingly complex, involving complex nursing practice in diverse care settings covering a wide range of specialties such as surgery, medicine, pediatrics, gynecology, oncology, geriatrics, and rehabilitation medicine (Borghmans et al, 2024). Each of these care environments has its own characteristics and presents different challenges to nursing practice. Patient characteristics such as multimorbidity, sensitivity, and old age combine to determine the complexity of nursing care (Kentischer et al, 2018). In addition, environmental factors significantly impact the complexity of caregiving, including continued

advances in technological treatments, increasing documentation burdens, ongoing practice changes, and higher expectations for caregivers, which are exemplified by the need for grasping adequate professional knowledge as well as knowing patients' health information and their quality-of-care needs (Younger, 2020). These factors add to the complexity of the challenges faced by nurses during care delivery. In response to the complex nursing situation, an increasing number of researchers have begun to apply artificial intelligence (AI) to clinical nursing with promising results. For example, a systematic review and meta-analysis conducted by Lin et al (2024) showed that the use of AI in the perioperative period could facilitate perioperative communication and enable sharing of decisions between patients and clinicians, showcasing the positive value of AI technology for nursing work.

In this study, we conducted a comprehensive review of relevant literature on the application of AI technology (including robotics) in clinical nursing practice published in PubMed (https://pubmed.ncbi.nlm.nih.gov/), Web of Science (https://www.webofscience.com/wos), and Embase (https://www.embase.com/) databases since 2018. We anticipate that the review would bring new insights to more nursing practitioners.

This paper will begin with a brief account of the development of AI in healthcare, and then address the impact of AI technologies, including robotics, on nursing care, and will conclude with current issues and future perspectives based on current research.

Medical AI Development

John McCarthy, a Stanford University computer scientist, coined the term of "artificial intelligence" in 1956 (Wang et al, 2023). The exploration of AI in healthcare has remained uninterrupted since 1976 when AI technology was applied to develop reverse chained expert systems to identify bacteria that cause serious infections and to recommend antibiotic treatments. Currently, AI is widely used in several healthcare scenarios. In precision medicine healthcare, AI technology plays an important role by providing personalized prognosis analysis for patients by analyzing their genetic information, lifestyle habits and environmental factors (Bhinder et al, 2021). For example, Han et al (2024) developed and validated an AI model for predicting 30-day mortality in patients with critical orthopedic trauma, with extreme gradient boosting machine (eXGBM) algorithm recording the highest predictive performance for early mortality in critically ill fracture patients, and external validation of the model achieving 0.913 (95% confidence interval [CI]: 0.878–0.948) area under the curve (AUC) value. This study reveals the significant advantages of AI in the field of clinical prediction model construction. Compared with traditional clinical prediction models with small samples, AI can handle operations of larger datasets, integrate more clinical factors, and obtain better AUC values. However, the practical impact and cost-effectiveness of integrating AI models into routine clinical practice need to be further evaluated. Encouragingly, some ongoing real-world clinical studies are expected to answer these questions. For example, AI has been increasingly used in medical image analysis, such as using deep learning

algorithms to identify and classify abnormalities in X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and other imaging data to improve diagnostic accuracy and efficiency (Gore, 2020). In the context of positron emission tomography (PET)/CT (PET/CT), the main problem for lymph node (LN) staging is the high false positive rate (FPR), which was addressed by Ren et al (2023) with a clinico-bio-radiological (CBR)-based machine-learning columnar graphical model; DeLong test showed that the CBR model containing all-scale features held the highest predictive efficiency and the lowest FPR ($p < 0.05$) in both the CBR model and the lowest FPR among all of the established models. CBR model containing all-scale features held the highest predictive efficiency and the lowest FPR among all of established models ($p < 0.05$) in both the training and test sets (AUCs of 0.90 and 0.89, FPRs of 12.82% and 6.45%, respectively), suggesting that the application of AI technology may greatly improve the diagnostic accuracy of clinically complex conditions.

In addition to its significant value in disease prognosis and diagnosis, AI can also play an important role in disease treatment. First of all, AI technology also shows great potential in new drug discovery and development. Traditional drug discovery and development process entails a rather complex, expensive and lengthy operation, usually costing $2.6 billion and taking an average of 12 years to complete; however, AI technology can predict the effects and side effects of drugs and accelerate the process of drug discovery and development by analyzing a large amount of compound data and biomarkers (Sarkar et al, 2023). With the advent of technologies such as microarrays and high-throughput sequencing, which can generate copious amounts of biomedical data on a daily basis, contemporary drug discovery has ushered in the era of big data. In drug discovery, the first and most important step is to identify appropriate targets (e.g., genes, proteins) related to the pathophysiology of a disease and then search for suitable drugs or drug-like molecules that can intervene on these targets. The AI technology is now available in the research area, enabling rapid access to a wide range of biomedical data repositories to obtain the most up-to-date and appropriate targets, a crucial research process that lays concrete groundwork for the subsequent development of new drugs (Gupta et al, 2021). Meanwhile, AI technology plays an important role in patient monitoring and telemedicine, real-time patient health data collection, and provision of timely medical advice and interventions through wearable devices and remote monitoring systems (Li et al, 2021). Piette et al (2022) conducted a randomized clinical study exploring the use of AI and mobile health tools for patient-centered pain care. In the study, an AI and Interactive Voice Response (IVR)-based Cognitive Behavioral Therapy for Chronic Pain (AI-CBT-CP) was designed, which was demonstrated to be non-inferior to therapist-delivered CBT-CP over the phone and significantly shortened the therapist time entailed. Interventions like AI-CBT-CP can allow more patients to be effectively served through CBT-CP program that use the same number of therapists.

Taken together, with the continuous progress of technology, AI will attain a widening usage trend across all aspects of healthcare. In addition to application in diagnosis and treatment, AI technology is also widely used in surgical assistance,

mental health and behavioral health assessment, patient data management and analysis, etc. (Jayakumar et al, 2021; Sadeh-Sharvit et al, 2023; Nayak et al, 2023). AI can help healthcare organizations to optimize resource allocation as well as improve the efficiency and quality of healthcare services, which has become one of the hottest issues in current research.

Applications of AI in Nursing

Some scholars define AI as software or hardware systems built by humans that are capable of sensing their surroundings through data collection, interpreting the collected structured or unstructured data, and using the knowledge to reason or process the information extracted from such data to determine the best action to be taken to achieve a set goal in the face of a complex objective. In broader definition, AI encompasses a wide range of technologies designed to simulate human cognitive abilities such as learning, reasoning, communication and decision-making (Robert, 2019; von Gerich et al, 2022). AI is broadly used in various fields of medicine such as cardiology, anaesthesiology, pathology, etc. (Itchhaporia, 2022; Hashimoto et al, 2020; Cohen et al, 2021), among which nursing is one of the major branches. The application of AI in the field of nursing can be traced back to the development of expert systems designed to provide clinical decision support in 1985, and since then the challenges facing the adoption of AI in nursing practice have been a focus of industry attention (Robert, 2019; Dhillon et al, 2024; Zhang et al, 2023). AI is now being applied to all aspects of nursing.

Nursing Education

Nursing education plays a crucial role in global healthcare systems and is irreplaceably important in fostering positive patient-professional relationships and promoting continuous nursing professional development (Suikkala et al, 2018). Nursing education not only drives progress in healthcare, but also strengthens the patient-centered care model by integrating technological innovations, an area of education that has a decisive impact on improving the quality-of-care delivery and meeting the growing demand for healthcare (Zhang et al, 2024). Recent advances in AI and machine learning have been remarkable, most notably the Chat Generation Pre-Training Transformer (ChatGPT) developed by Open AI (Sallam, 2023). ChatGPT, a conversational AI platform, has won over the mainstream AI market due to its ability to produce human-like linguistic outputs following deep training on massive amounts of textual data, and to support users in engaging in interactive dialogues, thus winning great attention from mainstream media and academia. The development of this technology not only demonstrates the great potential of AI in language understanding and generation, but also opens up new possibilities for future AI applications. Some academics have therefore used it in nursing education.

ChatGPT's extensive text corpus (including books, articles, websites, and a variety of other textual sources) makes it a strong medical learner. A study applying it to the Registered Nurse Licensing Examination (RNLE) showed that ChatGPT is able to respond quickly within seconds, with ChatGPT's average scores ranging from around 51.6 to 63.75 over four exams, and passing the RNLE in first place in

2022 and second place in 2023, suggesting that ChatGPT may have the potential to assist in nursing education (Huang, 2023). It is recommended that the ChatGPT be integrated into different nursing curricula. Compared to most clinical nurses, ChatGPT may possess a higher level of nursing knowledge. This is evidenced by a cross-sectional study conducted by Wang et al (2024) in which ChatGPT could achieve a knowledge acquisition rate of 64.30%, much higher than clinical nurses' rate of 36.70%, in tracheotomy care, suggesting that the ChatGPT-4.0 outperforms most clinical nurses in answering questions about tracheotomy nursing.

Although these studies confirmed that ChatGPT has significant advantages in nursing knowledge learning, the current study showed that ChatGPT has accuracy and reliability deficiencies in providing explanations and information in the medical field, as demonstrated in Huh's study (2023). Also, Ahn (2023) noted that ChatGPT is prone to retrieve incorrect information from web searches, which may be attributed to the inaccuracy of the data sources it relies on. In addition, ChatGPT runs the risk of being unable to understand questions keyed in, generating misleading or inaccurate explanations, or providing ambiguous responses. It is therefore particularly important to train models of ChatGPT by exposing them to differences between individual nursing education methods.

Application of AI in Nursing Services

According to the latest report of the World Health Organization, the number of nursing workers globally has exceeded 27 million, making nurses the largest occupational group in the health sector (O'Connor et al, 2023). In hospital and community healthcare settings, nurses provide specialized care by assessing patient needs, assisting in diagnosis, planning and implementing healthcare interventions, and evaluating patient prognosis. Related systematic evaluations have shown that nurses are able to provide the same quality of care as primary care physicians in the management of chronic diseases, and may even lead to superior patient outcomes (Laurant et al, 2018). This highlights the central role of nurses and midwives in global health systems and their important contribution to the delivery of high-quality healthcare, which can be further enhanced by AI.

Outpatient Clinics

Outpatient clinic is the first window where nurses confront patients. The main duty of nurses is to receive and assist patients. However, their daily work is replete with a lot of repetitive problems, which can easily lead to work fatigue and decreased efficiency, underlining continuous proposal of outpatient clinic optimization programs (Huang et al, 2018). AI-based outpatient clinic optimization schemes have shown better results, and Li et al (2022) developed an AI-assisted program called Smart-doctor. A randomized controlled trial was conducted at the Shanghai Children's Medical Centre, where participants were randomized into an AI-assisted group and a routine group. Smart-doctor was used as a medical assistant in the AI-assisted group and the results showed that the median queuing time in the AI-assisted group was 8.78 minutes, which was lower than that of the routine group at 21.81 minutes, and the AI-assisted group had an overall satisfaction score that in-

creased by 17.53%. AI technology has also been shown to have a good track record in referral services. Abdel-Hafez et al (2023) created an AI tool to help clinicians categorize many referrals received each year, making more efficient use of clinical specialists' time and improving patient access to care.

Taking these studies together, it can be found that inducting AI into nurses' outpatient work can optimize the patient flow, reduce nurses' workload and enhance patient experience.

Assisted Surgery

Several studies have shown that nurses play an important role in the surgical process and perioperative management of patients; for example, preoperative visiting care carried out by nurses can improve the anxiety state and pain level in patients, and nurse-led nursing care model can effectively promote patients' post-operative recovery (Aydal et al, 2023; Coskun and Duygulu, 2022). In clinical practice, preoperative nurses need to carefully review patient information, as well as organize and prepare the instruments, equipment, medicines and instruments needed for surgery; intraoperative nurses need to work closely with the surgeon to hand over instruments and medicines as needed; and surgical instruments and medicines need to be cleaned up and checked after surgery. Past research results and daily clinical practice have fully demonstrated that nurses play an extremely important role in the whole process of surgery and are indispensable members of the surgical team. However, heavy occupational work and harsh working environment may lead to burnout and thus affect the clinical outcomes of patients (Chen and Meier, 2022). Therefore, some researchers have explored the application of AI to nurses' surgery-related work.

In preoperative care, Yahagi et al (2024) conducted a randomized controlled trial of the effect of routine nurse anaesthesia education versus the ChatGPT intervention on preoperative anxiety, which showed that the ChatGPT intervention significantly reduced preoperative anxiety compared with the routine nurse anaesthesia education; however, State-Trait Anxiety Inventory (STAI) scores were not observed as an overall difference, suggesting the need for improved chatbot algorithms and knowledge bases to enhance performance and satisfaction. In intraoperative care, a research team has developed a system that uses electroencephalogram (EEG) wavelet algorithms to monitor the depth of anaesthesia and automatically adjust drug administration; monitors patient's wavelet index, analgesic index, invasive arterial blood pressure and heart rate; and adjust infusion rate of sedative and analgesic drugs and alert healthcare personnel when the patient is hypotensive, helping anaesthesiologists to maintain anaesthesia effects to ensure the patient's safety (Zhang et al, 2020). In postoperative care, AI technology has been incorporated into electronic health record systems, with supervised machine learning algorithms being applied to process electronic health record data to predict adverse events and unrecorded complications that patients may experience (King et al, 2023). The transfer of patients from the operating theater or anaesthesia recovery room to the general ward could be complicated by residual sedation effects, pain, delirium, fatigue and surgical trauma experienced by the patient (Gutenbrunner et al, 2022).

The use of AI models to identify patient types and predict associated risks not only prevents adverse events, but also assists nurses in making more accurate clinical decisions. This intelligent approach improves the efficiency and safety of nursing care and provides more personalized and accurate care for patients.

Rehabilitation Care

Rehabilitative care plays a crucial role in modern medicine, not only helping patients recover from illness or injury, but also improving their quality of life and ability to care for themselves (Gutenbrunner et al, 2022). The demand for rehabilitation care is rising globally as the population ages and the number of patients with chronic diseases increases (Vaalburg et al, 2023). Nonetheless, the current rehabilitation care system is facing multiple challenges, including a shortage of professional caregivers, especially in rural and remote areas where resources are scarce (Roots et al, 2014). In addition, the uneven distribution of rehabilitation resources has led to unequal access to services, making it difficult for some patients to obtain necessary care services (Al Imam et al, 2022). Meanwhile, more and more hospitals are providing transitional care to home and post-discharge care services, but these care services are generally fragmented, negatively impacting patients' rehabilitation outcomes (Chen et al, 2021). Therefore, this has driven the exploration of AI application in rehabilitation care.

Rodgers et al (2020) conducted an observer-blinded, multicenter, randomized controlled trial to assess the efficacy of robot-assisted training versus an intensive upper limb regimen and usual care for upper limb functional limitation after stroke, using the Massachusetts Institute of Technology-Manus Robotic Fitness System (InMotion Commercial Edition, Interactive Motion Technologies, Inc., Watertown, MA, USA) for robot-assisted training of patients. The results showed that after 3 months of care, patients who received robot-assisted training showed significant improvements in upper limb function, mobility and activities of daily living, but there was no statistically significant difference in cost-effectiveness between robot-assisted and conventional care. Rizzato et al (2023) explored whether a novel digital therapy gaming system was clinically effective for shoulder rehabilitation and analyzed whether this gaming rehabilitation program could attract more patients to participate than the control, non-gaming rehabilitation program, showing that the digital therapy under investigation yielded equivalent efficacy in shoulder rehabilitation as the non-digital therapy. The reported positive relationship between the subject's enjoyment during digital therapy and the intention to train at home suggests promising results in possible patient's exercise engagement at home after receiving rehabilitation at the medical center.

Current Issues and Outlook

In this article, how AI has facilitated the revolution of nursing field is discussed, but certain issues cannot be ignored. Firstly, the accuracy and reliability of AI technology in nursing practice still needs to be improved, as AI may provide less precise medical explanations and information due to inaccurate data sources or algorithmic limitations (Liu et al, 2021). There are two main reasons for this: On

the one hand, medical data are characterized by multi-source and complex format, which challenges the reliability and stability of AI technology. At the algorithmic level, coding bias may cause problems. The imbalanced data quality will also affect the accuracy of the model. In addition, insufficient system identification, lack of health data standardization, barriers to interaction between healthcare providers and the system, as well as high costs may lead to wrong diagnosis, prediction, or decision making, which in turn poses a threat to patient safety. On the other hand, AI technology is also faced with the dilemma of semantic gap and interpretation barrier, and there is currently no general medical reasoning model available yet. Due to the lack of standardized language, complete knowledge base and various standard data sets, the content and form of health data in the information systems and databases vary across different medical units and scientific research institutions, which largely limits the scale of health and medical data sharing. The above problems jointly restrict the application and expansion of AI in the nursing field. At present, most of the research on the application of AI in the field of nursing is still in the initial stage of technology development. Therefore, it is urgent to improve the quality and performance of the AI system to break through the existing bottlenecks and promote its effective application in nursing practice.

While the use of AI in nursing education shows potential, the effective integration of AI technologies to aid teaching and learning remains a challenge. For example, ChatGPT outperformed clinical nurses in terms of nursing knowledge acquisition, but its accuracy and applicability in real-world applications still require further research. Another important issue in this respect is related to the medical ethics aspect. In nursing services, the application of AI can optimize the outpatient process, assist in surgery and rehabilitation care, but this also brings concerns about technology dependence and privacy infringement (Kotter and Pinto Dos Santos, 2024). With the development of AI technology, how to ensure the security and privacy of patient data and how to balance the use of technology with humanistic care are issues that need attention in the future.

Looking ahead, AI is expected to play a greater role in chronic disease management as the population ages and the number of patients with chronic diseases grows. AI technology can provide patients with personalized prognosis analysis by analyzing their genetic information, living habits and environmental factors, thus improving the efficiency and effectiveness of chronic disease management. At the same time, AI technology can help nurses develop more personalized care plans. By analyzing patients' behavioral patterns and physiological data, AI can predict disease progression and remind patients to take their medication on time, thus improving the personalization and precision of care. Several trends also suggest that AI technology is playing an important role in patient monitoring and telemedicine. With wearable devices and remote monitoring systems that collect real-time patient health data and provide timely medical advice and interventions, AI technology is expected to improve access to care in remote areas (Vilela et al, 2024; Tsoi et al, 2021; Geny et al, 2024). Further, as AI technology is deeply applied in nursing practice, ensuring security and privacy of patient data becomes an increasingly critical issue. Strict data protection policies and standards are needed in place to protect

patients' privacy rights. While promoting application of AI technology as an auxiliary tool to nursing practice, the traditional humanistic nursing care for patients and the human-centric professional judgement should not be neglected and replaced by automated means.

Conclusion

In summary, the convergence of AI technology with the nursing field has brought a wave of transformation to nursing practice, despite the technical, ethical and practical challenges. Future research needs to focus on how to improve the accuracy, reliability and safety of AI technologies and how to better integrate AI technologies into nursing practice for more efficient and personalized care. Attention also needs to be paid to the use of AI technology in nursing education and how to improve the quality of nursing services while maintaining the humanistic aspects of nursing. Through these efforts, we can expect AI technology to play a greater role in nursing and provide patients with better quality care services.

> ### Key Points
> - AI is applied in nursing education, outpatient services, surgical assistance, and rehabilitation, improving their efficiency and quality.
> - AI aids nursing education but faces integration challenges, and its accuracy and applicability need further study.
> - AI can improve chronic disease management and telemedicine, but future focus should be on data security, privacy, and balancing technology with human care.

Availability of Data and Materials

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

Author Contributions

YW and ZW designed the study and all authors conducted the study. YW and WL collected and analyzed the data. YW and QL participated in drafting the manuscript, and all authors contributed to critical revision of the manuscript for important intellectual content. All authors gave final approval of the version to be published. All authors participated fully in the work, took public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or completeness of any part of the work were appropriately investigated and resolved.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

References

Abdel-Hafez A, Jones M, Ebrahimabadi M, Ryan C, Graham S, Slee N, et al. Artificial intelligence in medical referrals triage based on Clinical Prioritization Criteria. Frontiers in Digital Health. 2023; 5: 1192975. https://doi.org/10.3389/fdgth.2023.1192975

Ahn C. Exploring ChatGPT for information of cardiopulmonary resuscitation. Resuscitation. 2023; 185: 109729. https://doi.org/10.1016/j.resuscitation.2023.109729

Al Imam MH, Jahan I, Das MC, Muhit M, Akbar D, Badawi N, et al. Situation analysis of rehabilitation services for persons with disabilities in Bangladesh: identifying service gaps and scopes for improvement. Disability and Rehabilitation. 2022; 44: 5571–5584. https://doi.org/10.1080/09638288.2021.1939799

Aydal P, Uslu Y, Ulus B. The Effect of Preoperative Nursing Visit on Anxiety and Pain Level of Patients After Surgery. Journal of Perianesthesia Nursing. 2023; 38: 96–101. https://doi.org/10.1016/j.jopan.2022.05.086

Bhinder B, Gilvary C, Madhukar NS, Elemento O. Artificial Intelligence in Cancer Research and Precision Medicine. Cancer Discovery. 2021; 11: 900–915. https://doi.org/10.1158/2159-8290.CD-21-0090

Borghmans F, Laletas S, Fernandes V, Newnham H. Finding meaning in complex care nursing in a hospital setting. Nursing Inquiry. 2024; 31: e12633. https://doi.org/10.1111/nin.12633

Chen C, Meier ST. Corrigendum to "Burnout and depression in nurses - A systematic review and meta-analysis" [International Journal of Nursing Studies, Volume 124 (2021) 104099]. International Journal of Nursing Studies. 2022; 127: 104180. https://doi.org/10.1016/j.ijnurstu.2022.104180

Chen L, Xiao LD, Chamberlain D, Newman P. Enablers and barriers in hospital-to-home transitional care for stroke survivors and caregivers: A systematic review. Journal of Clinical Nursing. 2021; 30: 2786–2807. https://doi.org/10.1111/jocn.15807

Cohen S, Levenson R, Pantanowitz L. Artificial Intelligence in Pathology. The American Journal of Pathology. 2021; 191: 1670–1672. https://doi.org/10.1016/j.ajpath.2021.07.011

Coskun S, Duygulu S. The effects of Nurse Led Transitional Care Model on elderly patients undergoing open heart surgery: a randomized controlled trial. European Journal of Cardiovascular Nursing. 2022; 21: 46–55. https://doi.org/10.1093/eurjcn/zvab005

Deschodt M, Heeren P, Cerulus M, Duerinckx N, Pape E, van Achterberg T, et al. The effect of consultations performed by specialised nurses or advanced nurse practitioners on patient and organisational outcomes in patients with complex health conditions: An umbrella review. International Journal of Nursing Studies. 2024; 158: 104840. https://doi.org/10.1016/j.ijnurstu.2024.104840

Dhillon G, Zhang Z, Grewal H, Kashyap R. Editorial: Clinical application of artificial intelligence in emergency and critical care medicine, volume IV. Frontiers in Medicine. 2024; 10: 1346070. https://doi.org/10.3389/fmed.2023.1346070

Geny M, Andres E, Talha S, Geny B. Liability of Health Professionals Using Sensors, Telemedicine and Artificial Intelligence for Remote Healthcare. Sensors. 2024; 24: 3491. https://doi.org/10.3390/s24113491

Gore JC. Artificial intelligence in medical imaging. Magnetic Resonance Imaging. 2020; 68: A1–A4. https://doi.org/10.1016/j.mri.2019.12.006

Gupta R, Srivastava D, Sahu M, Tiwari S, Ambasta RK, Kumar P. Artificial intelligence to deep learning: machine intelligence approach for drug discovery. Molecular Diversity. 2021; 25: 1315–1360. https://doi.org/10.1007/s11030-021-10217-3

Gutenbrunner C, Stievano A, Nugraha B, Stewart D, Catton H. Nursing - a core element of rehabilitation. International Nursing Review. 2022; 69: 13–19. https://doi.org/10.1111/inr.12661

Han T, Xiong F, Sun B, Zhong L, Han Z, Lei M. Development and validation of an artificial intelligence mobile application for predicting 30-day mortality in critically ill patients with orthopaedic trauma. International Journal of Medical Informatics. 2024; 184: 105383. https://doi.org/10.1016/j.ijmedinf.2024.105383

Hashimoto DA, Witkowski E, Gao L, Meireles O, Rosman G. Artificial Intelligence in Anesthesiology: Current Techniques, Clinical Applications, and Limitations. Anesthesiology. 2020; 132: 379–394. https://doi.org/10.1097/ALN.0000000000002960

Huang H. Performance of ChatGPT on Registered Nurse License Exam in Taiwan: A Descriptive Study. Healthcare. 2023; 11: 2855. https://doi.org/10.3390/healthcare11212855

Huang YL, Bryce AH, Culbertson T, Connor SL, Looker SA, Altman KM, et al. Alternative Outpatient Chemotherapy Scheduling Method to Improve Patient Service Quality and Nurse Satisfaction. Journal of Oncology Practice. 2018; 14: e82–e91. https://doi.org/10.1200/JOP.2017.025510

Huh S. Are ChatGPT's knowledge and interpretation ability comparable to those of medical students in Korea for taking a parasitology examination?: a descriptive study. Journal of Educational Evaluation for Health Professions. 2023; 20: 1. https://doi.org/10.3352/jeehp.2023.20.1

Itchhaporia D. Artificial intelligence in cardiology. Trends in Cardiovascular Medicine. 2022; 32: 34–41. https://doi.org/10.1016/j.tcm.2020.11.007

Jayakumar P, Moore MG, Furlough KA, Uhler LM, Andrawis JP, Koenig KM, et al. Comparison of an Artificial Intelligence-Enabled Patient Decision Aid vs Educational Material on Decision Quality, Shared Decision-Making, Patient Experience, and Functional Outcomes in Adults With Knee Osteoarthritis: A Randomized Clinical Trial. JAMA Network Open. 2021; 4: e2037107. https://doi.org/10.1001/jamanetworkopen.2020.37107

Kentischer F, Kleinknecht-Dolf M, Spirig R, Frei IA, Huber E. Patient-related complexity of care: a challenge or overwhelming burden for nurses - a qualitative study. Scandinavian Journal of Caring Sciences. 2018; 32: 204–212. https://doi.org/10.1111/scs.12449

King CR, Shambe A, Abraham J. Potential uses of AI for perioperative nursing handoffs: a qualitative study. JAMIA Open. 2023; 6: ooad015. https://doi.org/10.1093/jamiaopen/ooad015

Kotter E, Pinto Dos Santos D. Ethics and artificial intelligence. Radiologie. 2024; 64: 498–502. https://doi.org/10.1007/s00117-024-01286-0 (In German)

Laurant M, van der Biezen M, Wijers N, Watananirun K, Kontopantelis E, van Vught AJ. Nurses as substitutes for doctors in primary care. The Cochrane Database of Systematic Reviews. 2018; 7: CD001271. https://doi.org/10.1002/14651858.CD001271.pub3

Li JPO, Liu H, Ting DSJ, Jeon S, Chan RVP, Kim JE, et al. Digital technology, tele-medicine and artificial intelligence in ophthalmology: A global perspective. Progress in Retinal and Eye Research. 2021; 82: 100900. https://doi.org/10.1016/j.preteyeres.2020.100900

Li X, Tian D, Li W, Hu Y, Dong B, Wang H, et al. Using artificial intelligence to reduce queuing time and improve satisfaction in pediatric outpatient service: A randomized clinical trial. Frontiers in Pediatrics. 2022; 10: 929834. https://doi.org/10.3389/fped.2022.929834

Lin SJ, Sun CY, Chen DN, Kang YN, Lai NM, Chen KH, et al. Perioperative application of chatbots: a systematic review and meta-analysis. BMJ Health & Care Informatics. 2024; 31: e100985. https://doi.org/10.1136/bmjhci-2023-100985

Liu J, Chen Y, Li S, Zhao Z, Wu Z. Machine learning in orthodontics: Challenges and perspectives. Advances in Clinical and Experimental Medicine. 2021; 30: 1065–1074. https://doi.org/10.17219/acem/138702

Nayak A, Vakili S, Nayak K, Nikolov M, Chiu M, Sosseinheimer P, et al. Use of Voice-Based Conversational Artificial Intelligence for Basal Insulin Prescription Management Among Patients With Type 2 Diabetes: A Randomized Clinical Trial. JAMA Network Open. 2023; 6: e2340232. https://doi.org/10.1001/jamanetworkopen.2023.40232

O'Connor S, Yan Y, Thilo FJS, Felzmann H, Dowding D, Lee JJ. Artificial intelligence in nursing and midwifery: A systematic review. Journal of Clinical Nursing. 2023; 32: 2951–2968. https://doi.org/10.1111/jocn.16478

Piette JD, Newman S, Krein SL, Marinec N, Chen J, Williams DA, et al. Patient-Centered Pain Care Using Artificial Intelligence and Mobile Health Tools: A Randomized Comparative Effectiveness Trial. JAMA Internal Medicine. 2022; 182: 975–983. https://doi.org/10.1001/jamainternmed.2022.3178

Ren C, Zhang F, Zhang J, Song S, Sun Y, Cheng J. Clinico-biological-radiomics (CBR) based machine learning for improving the diagnostic accuracy of FDG-PET false-positive lymph nodes in lung cancer. European Journal of Medical Research. 2023; 28: 554. https://doi.org/10.1186/s40001-023-01497-6

Rizzato A, Pizzichemi M, Gobbi E, Gerardi A, Fortin C, Copcia A, et al. Effectiveness and therapeutic compliance of digital therapy in shoulder rehabilitation: a randomized controlled trial. Journal of Neuro-engineering and Rehabilitation. 2023; 20: 87. https://doi.org/10.1186/s12984-023-01188-7

Robert N. How artificial intelligence is changing nursing. Nursing Management. 2019; 50: 30–39. https://doi.org/10.1097/01.NUMA.0000578988.56622.21

Robinson K. Care in nursing as a contested concept? A Bergsonian perspective. Nursing Philosophy. 2023; e12450. https://doi.org/10.1111/nup.12450

Rodgers H, Bosomworth H, Krebs HI, van Wijck F, Howel D, Wilson N, et al. Robot-assisted training compared with an enhanced upper limb therapy programme and with usual care for upper limb functional limitation after stroke: the RATULS three-group RCT. Health Technology Assessment. 2020; 24: 1–232. https://doi.org/10.3310/hta24540

Roots RK, Brown H, Bainbridge L, Li LC. Rural rehabilitation practice: perspectives of occupational therapists and physical therapists in British Columbia, Canada. Rural and Remote Health. 2014; 14: 2506.

Sadeh-Sharvit S, Camp TD, Horton SE, Hefner JD, Berry JM, Grossman E, et al. Effects of an Artificial Intelligence Platform for Behavioral Interventions on Depression and Anxiety Symptoms: Randomized Clinical Trial. Journal of Medical Internet Research. 2023; 25: e46781. https://doi.org/10.2196/46781

Sallam M. ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns. Healthcare. 2023; 11: 887. https://doi.org/10.3390/healthcare11060887

Sarkar C, Das B, Rawat VS, Wahlang JB, Nongpiur A, Tiewsoh I, et al. Artificial Intelligence and Machine Learning Technology Driven Modern Drug Discovery and Development. International Journal of Molecular Sciences. 2023; 24: 2026. https://doi.org/10.3390/ijms24032026

Suikkala A, Koskinen S, Leino-Kilpi H. Patients' involvement in nursing students' clinical education: A scoping review. International Journal of Nursing Studies. 2018; 84: 40–51. https://doi.org/10.1016/j.ijnurstu.2018.04.010

Tsoi K, Yiu K, Lee H, Cheng HM, Wang TD, Tay JC, et al. Applications of artificial intelligence for hypertension management. Journal of Clinical Hypertension. 2021; 23: 568–574. https://doi.org/10.1111/jch.14180

Vaalburg AM, Boersma P, Wattel EM, Ket JCF, Hertogh CMPM, Gobbens RJJ. Supporting older patients in working on rehabilitation goals: A scoping review of nursing interventions. International Journal of Older People Nursing. 2023; 18: e12542. https://doi.org/10.1111/opn.12542

Vilela MAP, Arrigo A, Parodi MB, da Silva Mengue C. Smartphone Eye Examination: Artificial Intelligence and Telemedicine. Telemedicine Journal and E-Health. 2024; 30: 341–353. https://doi.org/10.1089/tmj.2023.0041

von Gerich H, Moen H, Block LJ, Chu CH, DeForest H, Hobensack M, et al. Artificial Intelligence -based technologies in nursing: A scoping literature review of the evidence. International Journal of Nursing Studies. 2022; 127: 104153. https://doi.org/10.1016/j.ijnurstu.2021.104153

Wang H, Fu T, Du Y, Gao W, Huang K, Liu Z, et al. Scientific discovery in the age of artificial intelligence. Nature. 2023; 620: 47–60. https://doi.org/10.1038/s41586-023-06221-2

Wang T, Mu J, Chen J, Lin CC. Comparing ChatGPT and clinical nurses' performances on tracheostomy care: A cross-sectional study. International Journal of Nursing Studies Advances. 2024; 6: 100181. https://doi.org/10.1016/j.ijnsa.2024.100181

Yahagi M, Hiruta R, Miyauchi C, Tanaka S, Taguchi A, Yaguchi Y. Comparison of Conventional Anesthesia Nurse Education and an Artificial Intelligence Chatbot (ChatGPT) Intervention on Preoperative Anxiety: A Randomized Controlled Trial. Journal of Perianesthesia Nursing. 2024; 39: 767–771. https://doi.org/10.1016/j.jopan.2023.12.005

Younger SJ. Leveraging Advanced Practice Nursing in Complex Health Care Systems. Nursing Administration Quarterly. 2020; 44: 127–135. https://doi.org/10.1097/NAQ.0000000000000408

Zhang F, Liu X, Wu W, Zhu S. Evolution of Chatbots in Nursing Education: Narrative Review. JMIR Medical Education. 2024; 10: e54987. https://doi.org/10.2196/54987

Zhang JW, Lv ZG, Kong Y, Han CF, Wang BG. Wavelet and pain rating index for inhalation anesthesia: A randomized controlled trial. World Journal of Clinical Cases. 2020; 8: 5221–5234. https://doi.org/10.12998/wjcc.v8.i21.5221

Zhang Y, Chen X, Lao Y, Qiu X, Liu K, Zhuang Y, et al. Effects of the Implementation of Intelligent Technology for Hand Hygiene in Hospitals: Systematic Review and Meta-analysis. Journal of Medical Internet Research. 2023; 25: e37249. https://doi.org/10.2196/37249