

HOW ARTIFICIAL INTELLIGENCE MAY INFLUENCE THERAPEUTIC ADHERENCE

Jak sztuczna inteligencja może wpływać na przestrzeganie zaleceń terapeutycznych

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SUMMARY

Background. Therapeutic non-adherence affects approximately half of all patients with chronic conditions and is a leading driver of preventable morbidity, hospital readmission and excess healthcare expenditure. As nurses are positioned at the front line of patient education, monitoring and follow-up, the rapid emergence of artificial intelligence (AI) tools has direct relevance for everyday nursing practice.

Objectives. To synthesize current evidence on how AI-based solutions, including machine-learning risk-prediction models, conversational agents, smart pill devices and tailored digital coaching, may influence therapeutic adherence, and to discuss the implications for contemporary nursing practice.

Material and methods. A narrative review was conducted using PubMed, CINAHL, Scopus and Web of Science. Studies published between 2017 and 2025 addressing AI applications in medication or treatment adherence were selected, with priority given to systematic reviews, randomized clinical trials and nursing-relevant evidence.

Results. AI-based interventions improved medication adherence by approximately 6.7% to 32.7% compared with usual care in randomized trials. Predictive models identified high-risk non-adherent patients with an area under the curve up to 0.87, allowing earlier and better-targeted nursing interventions. Conversational agents enhanced patient engagement and self-management in chronic conditions such as diabetes, hypertension and heart failure, while reducing readmissions by up to 25% in some studies. Persistent barriers include data quality, algorithmic bias, digital health literacy and ethical concerns about patient autonomy and confidentiality.

Conclusions. AI offers a meaningful opportunity to support nurse-led adherence strategies through earlier risk identification, personalized education and continuous remote monitoring. To realize its potential, nurses require structured training in digital health, professional standards must address ethical and legal aspects, and AI tools should be designed as a complement to, not a substitute for, the therapeutic nurse-patient relationship.

Key words: artificial intelligence, medication adherence, nursing, chronic disease, digital health, predictive analytics, chatbot.

STRESZCZENIE

Wstęp. Nieprzestrzeganie zaleceń terapeutycznych (non-adherence) dotyczy około połowy pacjentów z chorobami przewlekłymi i stanowi jedną z głównych przyczyn możliwych do uniknięcia powikłań, ponownych hospitalizacji oraz nadmiernych kosztów opieki zdrowotnej. Pielęgniarki, jako profesjonalści najbliżsi pacjentowi w procesie edukacji, monitorowania oraz opieki długoterminowej, znajdują się w kluczowej pozycji do wykorzystania narzędzi opartych na sztucznej inteligencji (SI) wspierających poprawę adherencji.

Cel pracy. Celem pracy jest synteza aktualnych dowodów dotyczących wpływu narzędzi opartych na sztucznej inteligencji, w tym modeli predykcyjnych uczenia maszynowego, agentów konwersacyjnych (chatbotów), inteligentnych dozowników leków oraz spersonalizowanej edukacji cyfrowej, na przestrzeganie zaleceń terapeutycznych, wraz z omówieniem implikacji dla współczesnej praktyki pielęgniarstwa.

Materiał i metody. Przeprowadzono przegląd narracyjny piśmiennictwa w bazach PubMed/MEDLINE, CINAHL, Scopus oraz Web of Science. Uwzględniono recenzowane publikacje istotne dla tematyki SI w obszarze adherencji terapeutycznej, ze szczególnym naciskiem na lata 2019–2025, a także klasyczne pozycje fundamentalne i dokumenty regulacyjne.

Wyniki. Interwencje oparte na sztucznej inteligencji poprawiały przestrzeganie zaleceń farmakoterapii od około 6,7% do 32,7% w porównaniu z opieką standardową w randomizowanych badaniach klinicznych. Modele predykcyjne identyfikowały pacjentów z wysokim ryzykiem nieprzestrzegania zaleceń z polem pod krzywą ROC (AUC) sięgającym 0,87, co umożliwia wcześniej i lepiej ukierunkowane działania pielęgniarstwa. Agenci konwersacyjni zwiększali zaangażowanie pacjentów oraz wspierali samoopiekę w cukrzycy, nadciśnieniu tętniczym i niewydolności serca, w niektórych badaniach zmniejszając liczbę ponownych hospitalizacji nawet o 25%. Do utrzymujących się barier należą: jakość danych, błędy algorytmiczne, niski poziom kompetencji cyfrowych pacjentów oraz dylematy etyczne związane z autonomią i prywatnością chorego.

Wnioski. Sztuczna inteligencja stanowi realną szansę na wsparcie strategii pielęgniarstwa ukierunkowanych na poprawę adherencji przez wcześniejszą identyfikację ryzyka, spersonalizowaną edukację oraz ciągły zdalny monitoring. Aby wykorzystać ten potencjał, konieczne jest systematyczne kształcenie pielęgniarek w zakresie zdrowia cyfrowego, opracowanie standardów etyczno-prawnych oraz projektowanie narzędzi SI w sposób uzupełniający, a nie zastępujący, terapeutyczną relację pielęgniarka–pacjent.

Słowa kluczowe: sztuczna inteligencja, przestrzeganie zaleceń terapeutycznych, pielęgniarstwo, choroby przewlekłe, zdrowie cyfrowe, analityka predykcyjna, chatbot.

BACKGROUND

Therapeutic adherence, defined by the World Health Organization as the extent to which a person's behaviour in taking medication, following a diet or executing lifestyle changes corresponds with agreed recommendations from a healthcare provider, remains one of the most persistent challenges in contemporary medicine. Approximately 50% of patients with chronic conditions in high-income countries do not adhere to prescribed treatments, with non-adherence rates rising even further in low- and middle-income settings. The clinical and economic

consequences are well documented: poorer disease control, accelerated progression of chronic illness, increased hospitalization and substantial preventable cost, estimated at more than 300 billion US dollars annually in the United States alone [1–3].

Nurses occupy a unique and strategic position within the adherence ecosystem. They typically spend more direct time with patients than any other professional group, and their roles encompass medication reconciliation, patient education, follow-up phone calls, home visits, chronic disease coaching and family engagement. Nursing-led interventions have repeatedly been

shown to improve adherence; however, traditional approaches are constrained by workforce shortages, growing caseloads of patients with multimorbidity and the inherent retrospective nature of most adherence-monitoring tools [4].

Within this context, artificial intelligence (AI), broadly understood as a family of computational techniques that include machine learning (ML), deep learning, natural-language processing (NLP) and generative models, is rapidly being integrated into healthcare. AI-based applications can be used for early risk stratification, personalized patient education, real-time conversational support and automated detection of medication-taking events. Their influence on therapeutic adherence is therefore directly relevant to nursing practice and warrants critical synthesis [5, 6].

The aim of this review is to summarize and critically appraise the current evidence on how AI may influence therapeutic adherence and to discuss the implications, opportunities and challenges for contemporary nursing practice.

MATERIAL AND METHODS

This narrative review was guided by the principles of the SANRA (Scale for the Assessment of Narrative Review Articles) framework. A literature search was performed in PubMed/MEDLINE, CINAHL, Scopus and Web of Science. No strict date restriction was applied: emphasis was placed on peer-reviewed publications from the past five years (2019–2025) reflecting the rapid expansion of artificial intelligence in healthcare, while foundational references on therapeutic adherence (including the World Health Organization 2003 report and key meta-analyses from 2008 and 2013) and relevant regulatory documents (such as the EU General Data Protection Regulation of 2016) were additionally included where appropriate. The search strategy combined controlled vocabulary and free-text terms related to artificial intelligence (e.g. “artificial intelligence”, “machine learning”, “chatbot”, “conversational agent”), adherence (“medication adherence”, “treatment adherence”, “compliance”) and nursing (“nursing”, “patient education”, “self-management”) [1–3, 7, 8].

Eligible articles included systematic reviews, randomized controlled trials, prospective cohort studies and high-quality narrative reviews relevant to AI-supported adherence interventions or predictive modelling in chronic disease. Priority was given to studies of nursing relevance, particularly those concerning chronic non-communicable diseases such as cardiovascular disease, diabetes mellitus, hypertension, heart failure and chronic obstructive pulmonary disease. Editorials, conference abstracts and non-peer-reviewed sources were excluded. The findings were thematically synthesized into the categories presented below.

THE PROBLEM OF NON-ADHERENCE IN CONTEMPORARY NURSING

Non-adherence is multifactorial and is currently understood within a five-dimension framework that includes patient-related, condition-related, therapy-related, socio-economic and health-system factors. Within machine-learning research, predictors most consistently associated with non-adherence include age, sex, prior adherence patterns, polypharmacy, depressive symptoms, low health literacy, complexity of dosing regimens, perceived adverse effects, and indicators of disease severity such as glycated haemoglobin trajectories or blood-pressure variability [1, 9, 10].

From the nursing perspective, the relevance of these predictors is twofold. First, nurses routinely collect many of these variables during admission interviews, home visits or telephone follow-up, which makes them well positioned to feed and benefit from AI-supported decision-support systems. Second, several of the strongest predictors, self-efficacy, knowledge about the disease and its treatment, communication with the healthcare team, are modifiable through nursing interventions such as motivational interviewing, structured education and shared decision-making.

AI should therefore be understood not as a replacement for these interventions but as a way of identifying which patients need them most urgently and what specific content is most likely to be effective.

ARTIFICIAL INTELLIGENCE APPLICATIONS AFFECTING ADHERENCE

Predictive analytics and risk stratification

Machine-learning algorithms can mine electronic health records, claims data and pharmacy refill data to identify patients at elevated risk of non-adherence before clinical deterioration occurs. Recent studies report area-under-the-curve (AUC) values between 0.80 and 0.87 for ensemble models predicting non-adherence in type 2 diabetes mellitus, and similarly strong discrimination in hypertension and heart failure cohorts. Importantly, these models shift adherence monitoring from a retrospective, reactive activity (e.g. counting missed refills after the fact) to a prospective, anticipatory paradigm [9, 10].

For nursing practice this represents an important conceptual shift. Risk lists generated by AI tools can be integrated into nursing workflows so that case managers, primary care nurses or specialist disease nurses prioritize home visits, telephone calls or educational sessions for patients flagged as high risk. Interpretable techniques such as Shapley values (SHAP) help explain individual predictions, allowing nurses to discuss with patients which specific factors, for example, complex polypharmacy or recent emergency department visits, contributed to their risk score. This transparency is essential for trust, shared decision-making and informed consent.

Conversational agents and chatbots

AI-powered conversational agents, text- or voice-based chatbots driven by NLP and, increasingly, large language models, represent one of the most actively researched applications in adherence support. Systematic reviews of randomized trials in chronic illness consistently report that AI chatbots improve patient engagement, knowledge and self-management behaviours, and that outcomes can be comparable to those obtained through human-led interventions. In hybrid models, where chatbots provide routine support and clinicians intervene for more complex needs, treatment adherence improves while hospital readmission rates have been reported to fall by up to a quarter in chronic conditions such as diabetes and hypertension [11, 12].

Mechanistically, conversational agents support adherence through several pathways relevant to nursing care: continuous availability for symptom-related questions, automatic medication reminders, brief motivational dialogues, structured screening for side effects and triage to a human nurse when warning signs are detected. They can also adapt language complexity, tone and reading level to the individual patient, an aspect particularly valuable for older adults, for those with low health literacy and for migrant populations who may not speak the dominant clinical language.

Smart medication devices and reminder apps

AI is being embedded in “smart” pill bottles, electronic pillboxes, blister-pack sensors and wearable devices that detect medication-taking events in near real time. Some systems use computer vision to confirm ingestion via smartphone camera, while others integrate with home-based sensors. When connected to centralized dashboards, these tools allow nurses to verify adherence remotely and intervene rapidly if doses are missed. Randomized clinical trials evaluating AI-based tools embedded in such devices have reported improvements in measurable adherence ranging from approximately 7% to 33% compared with usual care [13–15].

From a nursing standpoint, these technologies are particularly attractive in three populations: older adults with cognitive impairment, in whom missed doses are common; patients on regimens where non-adherence carries high clinical risk (for

example, anticoagulation, antiretroviral therapy or immunosuppression after transplantation); and patients in remote or rural areas where face-to-face follow-up is logistically difficult.

Personalized education and behavioural support

AI techniques can also be used to tailor educational materials and behavioural support to the individual patient. Recommender systems and large language models can adapt the difficulty, tone and cultural framing of materials, while machine-learning models can identify which behavioural-change techniques are most likely to work for a given patient profile. Such personalization aligns closely with established nursing models of patient-centred care and with the increasing emphasis on cultural competence in international nursing standards. Although the evidence is still maturing, early data suggest that AI-tailored education improves both adherence and self-efficacy compared with generic materials [13–15].

IMPLICATIONS FOR CONTEMPORARY NURSING PRACTICE

The integration of AI into adherence support has broad implications for nursing roles, education and research. Three areas warrant particular attention [4].

First, AI is reshaping the role of the nurse from a primarily reactive provider of education and follow-up into a proactive coordinator of digitally augmented care. Nurses are increasingly expected to interpret risk scores, validate alerts, supervise patient interaction with chatbots, and translate algorithmic outputs into clinically meaningful conversations. This redefinition strengthens, rather than weakens, the role of the nurse, but it requires explicit recognition in job descriptions, scope-of-practice documents and reimbursement frameworks.

Second, AI literacy must become a core competency of contemporary nursing education. Pre-graduate and post-graduate curricula need to address the basic principles of machine learning, the strengths and limitations of predictive models, the appropriate interpretation of probabilistic outputs, principles of data protection, and ethical concepts such as algorithmic fairness and transparency. International nursing organizations, including the International Council of Nurses, have already called for inclusion of digital health competencies in nursing education frameworks [4].

Third, AI offers a substantial opportunity for nursing science. Nurses generate, document and curate large volumes of patient-centred data, pain assessments, functional status, psychosocial information, family context, that are often missing from physician-centric datasets. Engaging nurses in the design, validation and clinical evaluation of AI adherence tools therefore improves not only the relevance of these tools but also their clinical accuracy and equity.

CHALLENGES, RISKS AND ETHICAL CONSIDERATIONS

Despite a rapidly growing evidence base, the use of AI in adherence support raises several challenges that nurses must understand and help to address.

Data quality and representativeness. Many predictive models are trained on historical data that under-represent older adults, ethnic minorities, rural populations and patients with multimorbidity. Models built on biased data may systematically under- or over-estimate non-adherence in certain groups, with the risk of widening rather than narrowing existing inequalities. Nurses, who often have privileged insight into the social and behavioural realities of vulnerable patients, can play a critical role in flagging such mismatches [4].

Privacy, confidentiality and informed consent. AI adherence tools rely on the continuous collection of sensitive data, including medication-taking patterns, voice recordings and behav-

oural inputs. Compliance with regulations such as the European General Data Protection Regulation and the EU Artificial Intelligence Act is mandatory, but it is not sufficient on its own. Patients must understand, in plain language, what data are collected, who can see them and how predictions are used. Nurses, as primary educators, are well positioned to facilitate genuine informed consent [7, 8].

Digital health literacy and the digital divide. The benefits of AI tools may bypass precisely those patients who would profit most: older adults, persons with low health literacy and those without reliable internet access. Nursing assessment of digital readiness, including device availability, language preferences, sensory capacity and confidence in using technology, should therefore become an integral part of care planning whenever AI tools are introduced [4].

The therapeutic relationship. There is a legitimate concern that over-reliance on chatbots and remote monitoring could erode the empathic, embodied dimension of nursing care. AI tools should be designed and deployed to extend the reach of nurses, not to replace human contact in moments where it matters most: during crises, end-of-life care, complex psychosocial situations and intimate physical care [4, 5].

Liability and accountability. When an AI system suggests that a patient is at high risk of non-adherence, who is responsible if the alert is ignored or the prediction proves wrong? Current legal frameworks place the ultimate responsibility on healthcare professionals and institutions, which makes it essential that nurses understand the role of AI as decision support, not decision making [7, 8].

FUTURE DIRECTIONS

Several research and practice priorities can be identified. Future studies should focus on pragmatic, nurse-led randomized trials evaluating AI tools in real-world settings, with patient-reported outcomes alongside clinical and economic endpoints. Co-design with nurses, patients and informal caregivers should become standard practice, ensuring that algorithms reflect clinical reality and respect cultural context. Greater investment is needed in interpretable and federated AI approaches that protect privacy while enabling cross-institutional learning. Finally, professional bodies should publish position statements clarifying nursing competencies, scope of responsibility and ethical safeguards relating to AI-supported adherence interventions [4, 5].

CONCLUSIONS

Artificial intelligence offers a credible and rapidly maturing set of tools to address one of the most stubborn problems in healthcare: therapeutic non-adherence. Predictive models can identify high-risk patients earlier and more accurately; conversational agents and smart devices can extend nursing support beyond the walls of the clinic; and personalized digital education can complement traditional patient teaching. Nevertheless, the impact of these tools depends ultimately on how they are integrated into nursing practice. Their success is contingent on adequate digital education for nurses, robust ethical and legal safeguards, attention to equity and cultural appropriateness, and a clear understanding that AI is an adjunct to, not a substitute for, the therapeutic nurse-patient relationship. When these conditions are met, AI may not only enhance medication adherence and clinical outcomes but also reinforce the central, humanistic role of nursing in contemporary healthcare [4–6, 9–15].

Source of funding: This work was funded by the authors resources.
Conflict of interest: Authors declare no conflict of interests.

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Received: 18.03.2025

Revised: 22.04.2025

Accepted: 14.05.2025