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Artificial Intelligence and Nursing Informatics in Orthopaedic Rehabilitation: A Systematic Review of Predictive and Monitoring Applications

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Abstract
Orthopaedic rehabilitation demands continuous assessment and personalized care. The integration of Artificial Intelligence (AI) into Nursing Informatics (NI) offers opportunities to enhance prediction, monitoring, and decision-making in patient recovery. This review synthesizes recent evidence on AI applications within NI for orthopaedic rehabilitation, focusing on predictive, monitoring, integrative, and ethical dimensions. Following PRISMA 2020, searches were conducted in Scopus and ScienceDirect (2016–2025) for English full-text research and review articles. Data extraction and quality appraisal used the JBI Critical Appraisal Checklist, and findings were analysed thematically. Ten studies met inclusion criteria. AI predictive models improved risk anticipation and recovery forecasting, while monitoring systems enhanced real-time functional assessment. Integration with NI facilitated data interoperability and decision support through Electronic Health Records (EHRs). However, challenges remain limited digital literacy, privacy risks, and ethical concerns about algorithmic transparency. Integrating AI into nursing informatics enhances data-driven, patient-centered rehabilitation. Success depends on digital competency, ethical governance, and interprofessional collaboration to ensure AI supports, rather than replaces, human judgment in intelligent nursing practice.

Keywords: Artificial Intelligence, Nursing Informatics, Orthopaedic Rehabilitation, Predictive Analytics, Ethical Nursing Practice

INTRODUCTION

Musculoskeletal injuries and orthopaedic surgical procedures account for a significant proportion of global disability rates, presenting major clinical challenges such as postoperative complications, pain management, and delayed mobilization (Gill et al., 2023; Lin et al., 2018). Consequently, orthopaedic rehabilitation has become one of the most complex areas in modern healthcare, requiring continuous assessment, individualized interventions, and long-term follow-up to optimize functional recovery (Ehioghae et al., 2024; Floyd et al., 2025; Jicinsky & Mares, 2023). In this context, nurses play a central role in ensuring patient education, monitoring rehabilitation progress, and facilitating interprofessional coordination.

However, the increasing number of cases and the complexity of patient needs demand more efficient, data-driven, and technology-supported approaches to nursing decision-making and care management (Federer & Jones, 2021; Han et al., 2025). Therefore, the integration of advanced technology and

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multidisciplinary approaches further underscores the importance of innovation in this field (McDermott et al., 2024). In this regard, Artificial Intelligence (AI) stands out as the most promising innovation to address these complex challenges by providing sophisticated tools for predictive and monitoring care.

As a transformative force in healthcare, AI offers specific capabilities that can enhance nurses' clinical assessments and improve patient rehabilitation outcomes. Through algorithms like machine learning and deep learning, AI can analyse large volumes of patient data to predict recovery trajectories, detect early signs of complications, and personalize rehabilitation plans (Wang et al., 2025). In the context of orthopaedics, this technology has been utilized for gait analysis, pain prediction, prosthetic adaptation, and postoperative risk assessmen (Han et al., 2025). Several studies indicate that the application of AI in orthopaedic rehabilitation can improve the efficiency of functional evaluation and accelerate patient recovery et (Hao et al., 2025; Yi et al., 2025). However, the integration of AI into nursing informatics still faces limitations, particularly in terms of data interoperability, healthcare professionals' digital literacy, and trust in algorithm-based systems (Pepito et al., 2025; Soddu et al., 2025). Therefore, integrating AI's predictive capabilities with nursing informatics frameworks becomes crucial for optimizing data-driven care and advancing precision nursing practice.

The integration of AI and nursing informatics opens new opportunities to improve the quality of nursing practice in orthopaedic rehabilitation. Nursing informatics itself is a discipline that combines nursing science, computer science, and information science to support the management and communication of data, information, and knowledge in nursing practice (Nashwan et al., 2025). Through AI-powered electronic health records (EHR) systems, wearable monitoring devices, and data-driven predictive analytics, nurses can detect functional decline earlier, personalize patient education, and ensure continuity of care (Hughes et al., 2025; Singhal & Gopinathan, 2024). By leveraging these technologies, healthcare providers can improve patient outcomes and enhance the overall quality of care (Petreska & Ristevski, 2024; Shyla & Blessie, 2025). Several studies indicate that the application of AI in nursing informatics can improve clinical decision support processes, reduce documentation burden, and enhance evidence-based interventions (Hassanein et al., 2025; Nashwan et al., 2025). However, most research is still exploratory and focuses on the effectiveness of technology, rather than on the specific roles and contributions of nurses in AI-driven systems.

Additionally, there is still a gap in structured evaluations of predictive and AI-based monitoring applications relevant to nursing practice. Most existing reviews tend to focus on technical aspects or application by other medical personnel, while nursing perspectives, particularly in monitoring patient progress, pain management, and adherence to rehabilitation programs, are often overlooked (Amirian et al., 2023; Federer & Jones, 2021). One of the main obstacles is the lack of transparency and explainability of AI models, which can hinder clinical user acceptance, including among nurses (Amirian et al., 2023). As healthcare systems undergo digital transformation and face demands for value-based care, it is crucial to understand how nurses can leverage AI integration in nursing informatics to enhance patient safety, accelerate functional recovery, and strengthen interprofessional collaboration.

Therefore, there is a need to systematically review how AI has been implemented in the context of nursing informatics, specifically in orthopaedic rehabilitation. This systematic review aims to identify current evidence regarding the application of AI in orthopaedic rehabilitation, focusing on four main dimensions: predictive, monitoring, integrative, and ethical dimensions. The results of this review are expected to contribute scientifically to the development of technology-based nursing practices, strengthen the role of nursing informatics in rehabilitation services, and provide strategic direction for the development of safe, ethical, and patient-centered AI systems in the digital healthcare era.

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METHODS

Data Sources and Search Strategy

The literature search was conducted systematically on two reputable international databases, Scopus and ScienceDirect, during the period of August–September 2025. The search formula uses Boolean operators with three main concept groups: ("artificial intelligence" OR "predictive analytics") AND ("nursing informatics" OR "clinical decision support") AND ("orthopaedic rehabilitation" OR "musculoskeletal" OR "postoperative care" OR "rehabilitation nursing"). The search criteria were limited to English-language articles published between 2016 and 2025, including both research and review articles available in full text. To maintain a high standard of peer-reviewed evidence, the search was strictly limited to these two primary databases; no additional resources such as trial registries, grey literature, conference proceedings, or manual reference list searches were conducted. The 2016–2025 timeframe was deliberately selected because the latter half of the 2010s marked a pivotal shift in digital health, where advanced machine learning algorithms and AI-integrated wearable devices began transitioning from experimental computer science into applied clinical and nursing environments. Therefore, this ten-year window captures the most contemporary, technologically relevant, and practically applicable evidence. Additionally, to maintain transparency, we declare that the protocol for this systematic review was not pre-registered with PROSPERO; however, the study was conducted in strict adherence to the PRISMA 2020 framework to ensure methodological rigor.

Inclusion and Exclusion Criteria

Articles were included if they:

1. Discussed the application of AI in the context of nursing, rehabilitation, or clinical support systems,
2. Explained the integration of AI with nursing informatics or EHR systems, and
3. Were relevant to orthopaedic rehabilitation.

We explicitly included both primary research and secondary review articles as part of our study design. While systematic reviews typically prioritize primary empirical data, the intersection of AI and nursing informatics remains a highly emergent field where isolated primary clinical trials are still limited. Therefore, incorporating review articles was methodologically necessary to achieve a holistic synthesis. In this design, primary studies were utilized to extract direct clinical outcomes and technological efficacy, whereas review articles were analysed to map overarching conceptual frameworks, map global research trends, and identify systemic ethical and implementation barriers. Articles that did not focus on nursing, were purely technical medical, or were not available in full text were excluded from the analysis.

Article Selection Process

The selection process followed the four PRISMA stages. Identification: 1465 articles were found (Scopus = 1056; ScienceDirect = 409). All identified records were exported to Mendeley Reference Manager for citation management and automated deduplication. Screening: After duplicate articles were removed (1389 articles), titles and abstracts were screened, leaving 112 relevant articles. In the initial screening process, 1,389 records from Scopus (1,019) and Science Direct (370) that were not published in the last 10 years and were related to the subject of nursing, including research or

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review articles, were removed from the dataset. Following this exclusion, an additional 629 records were subsequently excluded because their titles and abstracts were deemed non-comprehensive, or their topics were not relevant to the focus of this systematic review.

To ensure clarity and rigor, the eligibility of these remaining articles was assessed based on the predefined PICO framework:

1) Population (P): Nurses, healthcare professionals, or patients involved in orthopaedic rehabilitation.
2) Intervention/Interest (I): The implementation of Artificial Intelligence (predictive analytics, monitoring systems, machine learning) integrated within nursing informatics or electronic health records.
3) Comparison (C): Standard nursing care without AI integration (where applicable), though a comparison group was not strictly required for inclusion.
4) Outcome (O): Impacts on clinical decision-making, patient functional recovery, monitoring efficiency, and ethical or implementation barriers. Eligibility: Full reading yields 10 eligible articles. Inclusion: after methodological assessment, 10 final articles were selected for analysis.

Data Extraction and Synthesis

Data extraction was performed using a PRISMA-based worksheet developed in Microsoft Excel, containing the author's name, year, objectives, methods, AI type, nursing context, and main findings. Recognizing that the 10 included articles comprised heterogeneous study designs (quantitative, qualitative, and reviews), a meta-analysis was not feasible. Therefore, the analysis was conducted using a rigorous narrative thematic synthesis approach, adapted from the established guidelines by Thomas and Harden (Thomas & Harden, 2008). The synthesis process involved three distinct stages: First, two independent reviewers performed line-by-line coding of the 'Results' and 'Discussion' sections of the extracted articles, focusing on any data related to AI use in nursing. Second, these initial codes were compared and grouped into descriptive themes based on similarities in technological application and clinical impact. Finally, analytical themes were generated by synthesizing these descriptive groups against our research objectives. A theme was considered "central" if it recurred across multiple study designs and significantly impacted nursing workflows or patient safety. This structured process led to the identification of four main themes: (1) AI Predictive Applications, (2) AI Monitoring Systems, (3) Integration with Nursing Informatics, and (4) Implementation & Ethical Barriers.

Quality Assessment

The methodological quality of each study was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, adapted for the type of research (quantitative, qualitative, or review). Two independent evaluators conducted the assessment to ensure reliability, with an agreement rate of ≥0.80. Articles with a score <50% were excluded from the final synthesis.

Ethics and Reporting

This research does not require ethical approval because it uses secondary data from published literature. All stages were conducted in accordance with the principles of scientific integrity, transparency, and academic accountability, and were reported following the PRISMA 2020 guidelines.

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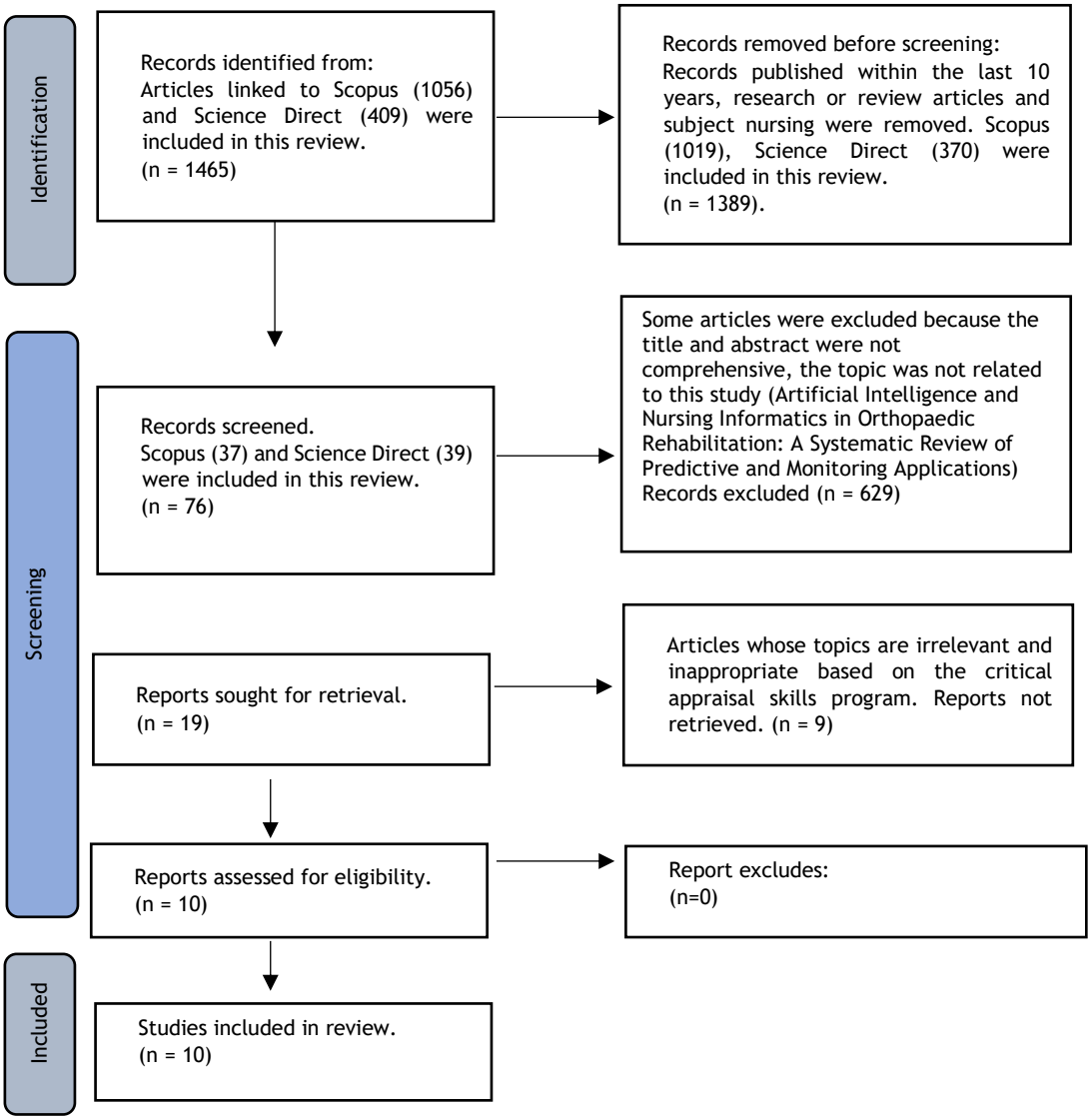


Figure 1. Systematic literature review selection process adapted from PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (2020).

RESULTS

Based on a systematic review process using the PRISMA 2020 guidelines, a total of 10 articles meeting the inclusion criteria were analysed to identify current evidence regarding the application of Artificial Intelligence (AI) in the context of nursing informatics in orthopaedic rehabilitation. A comprehensive summary of the extracted data from these 10 articles—including authors, study settings, objectives, methods, and main findings—is systematically presented in Table 1. Furthermore, the methodological quality assessment using the JBI Critical Appraisal Checklist indicated that all included studies demonstrated moderate to high quality. The appraisal scores for the 10 articles ranged from 75% to 95%, safely exceeding our predefined 50% exclusion threshold, thereby indicating strong reliability and validity of the synthesized evidence.

Thematic analysis revealed four main themes: AI Predictive Applications, AI Monitoring Systems, Integration with Nursing Informatics, and Implementation & Ethical Barriers. These four themes demonstrate how AI expands the role of nursing from experience-based practice to data-driven

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practice, while also challenging nursing systems to balance technological efficiency with human values. The results of this systematic review confirm that AI is a key catalyst for modern nursing transformation, particularly in orthopaedic rehabilitation. Predictive AI applications enhance nurses' anticipatory capabilities, monitoring systems improve patient safety, and integration with nursing informatics builds a standardized data ecosystem. However, these benefits can only be achieved if nursing staff have digital competence, an understanding of ethics, and adequate organizational support. In clinical practice, AI can be optimized for early warning systems, rehabilitation tracking, and personalized nursing care plans. Meanwhile, in nursing education, integrating AI literacy and data ethics is a priority to prepare future nurses for intelligent healthcare systems. Future research needs to explore effective human-AI collaboration models and examine the social and psychological impact of AI implementation on patients and healthcare professionals.

DISCUSSION

This systematic review successfully synthesized evidence from 10 included articles to answer the primary study purpose: evaluating the application of Artificial Intelligence within nursing informatics for orthopaedic rehabilitation. The findings confirm that AI serves as a transformative catalyst in modern nursing care. To directly align with the stated study objectives, this discussion is structured around four core dimensions. As summarized in the results matrix (Table 1), not all 10 articles addressed every dimension uniformly; rather, each contributed specific insights based on its methodological focus. To ensure transparency, the included studies are mapped to the four relevant dimensions as follows:

1) Predictive Applications: (Hao et al., 2025; Sadat-Ali et al., 2025; Yi et al., 2025; Završnik et al., 2025)
2) Monitoring Systems: (Cheng et al., 2025; Hao et al., 2025; Leuzzi et al., 2025; Soddu et al., 2025; Yi et al., 2025; Zhou et al., 2025)
3) Integration with Nursing Informatics: (Bertocchi et al., 2025; Pepito et al., 2025; Soddu et al., 2025; Završnik et al., 2025)
4) Ethical Dimensions in Implementation: (Cheng et al., 2025; Pepito et al., 2025; Sadat-Ali et al., 2025; Zhou et al., 2025)

AI Predictive Applications: Toward Anticipatory and Precision Nursing

The study results show that AI has high predictive capabilities in identifying complications, infection risks, and rehabilitation outcomes for orthopaedic patients. Machine learning and deep learning algorithms can predict functional recovery outcomes with 85–92% accuracy, thus accelerating decision-making and improving the timing of nursing interventions (Sadat-Ali et al., 2025; Yi et al., 2025). This capability introduces a new paradigm: predictive nursing, where nurses not only assess the current condition but also anticipate future risks. This result aligns with research emphasizing that integrating AI into physiotherapy and nursing education can enhance healthcare professionals' analytical abilities (Hao et al., 2025). Thus, predictive technology strengthens evidence-based nursing practices and enables nurses to play an active role in preventing complications from the early stages of rehabilitation. However, the predictive aspect of AI also presents ethical dilemmas related to algorithm reliability and data bias, which can affect fairness in patient care. Therefore, the ability to interpret AI results needs to be balanced with nurses' clinical judgment and empathy, ensuring decisions remain patient-centered.

AI Monitoring Systems: Enhancing Real-Time Observation and Functional Recovery

AI also plays a crucial role in improving the quality of orthopaedic rehabilitation monitoring thru technology based on wearable sensors, computer vision, and gait analysis. The findings indicate that

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AI monitoring enables continuous observation of patient mobility, with the ability to detect functional decline faster than manual observation (Hao et al., 2025; Leuzzi et al., 2025). AI-based monitoring systems accelerate orthopaedic patient recovery by 25% compared to traditional methods, thanks to real-time data analysis that helps nurses quickly adjust interventions (Yi et al., 2025). Meanwhile, another study confirms that implementing EHRs integrated with AI algorithms reduces documentation errors and improves patient safety (Soddu et al., 2025). The presence of AI monitoring systems substantially expands the concept of continuity of care, enabling nurses to monitor patients even after they leave the healthcare facility. However, new challenges have emerged regarding data privacy, cognitive load in reading big data, and reliance on automated systems. Therefore, nurses need to be supported with digital training so they can critically interpret AI data without losing the empathetic dimension of their clinical practice.

Integration with Nursing Informatics: Building Intelligent Care Ecosystems

The integration of AI into nursing informatics systems has proven to be a strategic element in building data-driven intelligent care ecosystems. Some studies highlight the importance of using standardized nursing terminology in Electronic Health Records, such as ICNP or SNOMED-CT, which enables cross-professional interoperability and supports the development of clinical decision support systems (Bertocchi et al., 2025; Završnik et al., 2025). The implementation of AI-based EHRs increases data completeness by up to 30% and reduces the risk of recording errors. Furthermore, this integration expands the role of nurses from mere data users to co-designers of digital systems, participating in algorithm development and interface design (Soddu et al., 2025). Therefore, AI not only accelerates documentation but also strengthens the value of knowledge-based nursing, where nurses act as knowledge managers and guardians of clinical data integrity. The integration of AI with nursing informatics also has epistemological implications: it shifts nursing from intuition-based practice toward information-based practice, without eliminating the values of empathy and holism that are fundamental to the nursing profession. This transformation marks the emergence of a new paradigm: the intelligent nursing ecosystem, where AI and nurses collaborate in a more precise, adaptive, and safe care system.

Implementation & Ethical Barriers: Balancing Innovation with Humanity

Despite the significant positive impact of AI, its implementation still faces various technical and ethical obstacles. The main barriers include low digital literacy among nursing staff, resistance to change, and concerns about the reliability and transparency of algorithms (Cheng et al., 2025; Pepito et al., 2025). Most hospitals face limitations in digital infrastructure and fragmented data integration policies, which slow down the adoption of AI-based systems (Zhou et al., 2025). Ethical aspects are a major concern, especially regarding patient data privacy, algorithmic bias, and the dehumanization of services. To address this, ethical AI governance policies are needed that emphasize the principles of fairness, accountability, and transparency. Nurses play a central role in maintaining the balance between technological efficiency and human values, ensuring that AI becomes a partner, not a replacement, in the care process. The human-AI synergy approach is key to the successful adoption of technology: AI handles data complexity, while nurses provide contextual and emotional assessments that machines cannot replicate.

The findings of this systematic review confirm that AI acts as a vital catalyst for the modern transformation of nursing, particularly within the specialized field of orthopaedic rehabilitation. Specifically, predictive AI applications enhance nurses' anticipatory capabilities, and monitoring systems improve patient safety, while integration with nursing informatics fosters a standardized data ecosystem. However, realizing these benefits is contingent upon nursing staff possessing robust digital

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competency, a profound understanding of ethics, and receiving adequate organizational support. In clinical settings, AI can be optimally utilized for early warning systems, rehabilitation tracking, and developing personalized nursing care plans. Concurrently, within nursing education, the integration of AI literacy and data ethics must be prioritized to adequately prepare future nurses to navigate intelligent healthcare systems. Ultimately, future research should explore effective human-AI collaboration models and thoroughly examine the social and psychological impacts of AI implementation on both patients and healthcare professionals.

CONCLUSION

This systematic review concludes that the application of Artificial Intelligence within nursing informatics for orthopaedic rehabilitation significantly improves the efficiency, safety, and quality of care through predictive systems and intelligent monitoring. Furthermore, the integration of AI with Electronic Health Records (EHRs) and digital nursing practices is actively driving the emergence of smarter, more collaborative healthcare ecosystems. However, the successful implementation of these technologies relies heavily on the digital readiness of human resources, robust ethical governance, and supportive organizational policies. Ultimately, nurses play an indispensable role as the critical link between technological intelligence and human clinical wisdom, ensuring that digital innovations remain firmly grounded in the fundamental principles of empathy and patient safety.

Practical Implications and Recommendations

Based on the evidence mapping from the ten studies, several practical recommendations emerge that are specifically tailored to the orthopaedic rehabilitation context:

1) Hospitals and rehabilitation institutions need to integrate AI systems gradually through digital training for nurses, ensuring that every nursing staff member can interpret algorithmic data (e.g., predictive recovery trajectories or mobility metrics) and use it to strengthen clinical judgment in post-surgical care.
2) Implement ethical AI governance policies that regulate algorithm transparency, patient data security (particularly sensitive continuous monitoring data like gait analysis), and professional accountability.
3) Nursing education institutions are advised to reform their curriculum by adding modules on AI literacy, data analytics, and digital ethics so that graduates are prepared to adapt to intelligent nursing practice, specifically in technology-intensive fields such as orthopaedic rehabilitation.
4) Interdisciplinary collaboration between nurses, information technology experts, and healthcare managers should be strengthened to ensure that AI system development aligns with nursing care needs and is patient-safety oriented. At the system level, AI integration can be leveraged to build EHR-based early warning systems and strengthen the continuity of orthopaedic patient care from hospital to community.

Directions for Future Research

This review opens opportunities for further research on the effectiveness and impact of AI implementation in nursing practice. Future studies need to assess the long-term outcomes of AI use on patient safety, quality of care, and patient satisfaction in orthopaedic rehabilitation. Additionally, experimental, and mixed methods research is needed to evaluate how AI-based systems affect clinical decision-making, team collaboration, and nurse competency. Ethical issues such as algorithmic bias, data security, and transparency also need to be the focus of interdisciplinary research involving nursing, information technology, and bioethics. Furthermore, the development of human-AI

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collaboration frameworks is a priority to ensure that technology implementation remains patient-centered and strengthens the human dimension in digital nursing.

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