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"From Intelligent Systems to Intelligent Nursing: Artificial Intelligence in Medical-Surgical Nursing Current Applications, Challenges, and Future Perspectives"

Savita Vishwakarma[1], Shivani Chaudhary[2]
[1]Associate Professor & HOD, Medical Surgical Nursing, Metro College of Nursing, Greater Noida, Uttar Pradesh
[2]Nursing Tutor (MSc Nursing), Metro College of Nursing, Greater Noida, Uttar Pradesh
[1]Corresponding author E-mail: savita.ujjain@gmail.com
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Abstract: Artificial intelligence (AI) is rapidly transforming healthcare by enabling computer systems to analyze complex datasets, recognize patterns, generate predictions, support clinical decisions, and automate selected processes. Medical-surgical nursing, which involves continuous patient assessment, complex clinical decision-making, medication administration, care coordination, monitoring, documentation, and management of acute and chronic conditions, represents an important area for responsible AI integration. Contemporary AI applications include predictive analytics, clinical decision-support systems, automated patient monitoring, risk prediction, natural language processing, intelligent documentation, medication-safety systems, workflow optimization, and personalized care planning. Recent nursing literature indicates that AI can improve decision support, patient monitoring, efficiency, and quality of care, although the evidence base remains heterogeneous and implementation is still developing. At the same time, concerns regarding data privacy, algorithmic bias, explainability, cybersecurity, professional accountability, inadequate infrastructure, digital literacy, and possible erosion of human-centered care require careful consideration. The World Health Organization emphasizes that AI in health should be developed and implemented according to principles of autonomy, safety, transparency, accountability, equity, and sustainability. For medical-surgical nurses, AI should therefore be regarded as an augmentation technology rather than a replacement for professional judgment, therapeutic communication, clinical reasoning, or compassionate care. Future development should emphasize nurse participation in AI design, interdisciplinary governance, standardized evaluation, AI education, explainable systems, equitable access, and continuous monitoring of clinical outcomes. The successful integration of AI into medical-surgical nursing will depend not merely on technological sophistication but on the ability of healthcare organizations to combine computational intelligence with nursing expertise and human values.

Keywords: *Artificial intelligence; Medical-surgical nursing; Machine learning; Clinical decision support; Predictive analytics; Nursing informatics; Patient monitoring; Generative artificial intelligence; Digital health; Clinical decision-making; Patient safety; Nursing practice.*

Introduction

Artificial intelligence has moved from being primarily a research concept to becoming an increasingly visible component of modern healthcare. AI broadly refers to computational methods that enable machines to perform tasks that traditionally require aspects of human intelligence, including pattern recognition, prediction, language processing, classification, and decision support. Machine learning, deep learning, natural language processing, computer vision, and generative AI are among the technologies contributing to this transformation. AI is already being applied in diagnosis, clinical care, drug development, disease surveillance, health-system management, and other areas of healthcare.[7] Its increasing availability creates substantial opportunities for nursing because nurses routinely generate, interpret, and act upon large amounts of clinical information.

Medical-surgical nursing is particularly suited to AI-supported practice because nurses care for patients with diverse medical and surgical conditions and must continuously integrate physiological observations, laboratory results, medication information, clinical histories, patient-reported symptoms, and responses to treatment.

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The complexity of this information can make early recognition of deterioration difficult, especially in environments characterized by high workloads, staffing pressures, interruptions, and large numbers of patients. AI-based systems may assist nurses by identifying patterns that are difficult to recognize through conventional observation alone and by presenting alerts or predictions that support timely assessment and intervention.[1,2]

The emergence of AI does not, however, imply that clinical nursing judgment can be automated. Nursing care involves contextual reasoning, ethical judgment, communication, empathy, advocacy, cultural sensitivity, and understanding of individual patient preferences. AI systems operate on data and algorithms, whereas nursing practice also depends on relationships and professional responsibility. Consequently, the most appropriate model is one in which AI strengthens nurses' cognitive and organizational capabilities while nurses remain responsible for interpreting information, assessing patients, communicating decisions, and providing individualized care.

Evolution and Relevance of Artificial Intelligence in Medical-Surgical Nursing

The use of technology in nursing has evolved from basic electronic documentation and computerized medication systems to sophisticated platforms capable of analyzing real-time clinical information. Earlier digital systems primarily stored and displayed information, whereas AI-enabled systems can process large datasets and generate predictions or recommendations. This transition represents a shift from passive information management toward active decision support.

In medical-surgical settings, AI can potentially integrate information from electronic health records, vital-sign monitors, laboratory systems, medication records, imaging reports, and nursing assessments. Algorithms can then identify combinations of findings associated with adverse outcomes such as clinical deterioration, sepsis, falls, pressure injuries, readmission, or prolonged hospitalization. An umbrella review published in 2025 identified decision-making, patient monitoring, and efficiency as important areas in which AI is influencing nursing practice, while also emphasizing the need to address ethical and implementation challenges.[1] A broader systematic review similarly identified the potential of AI to improve nursing care while emphasizing privacy, autonomy, security, transparency, accountability, and regulatory considerations.[2]

The relevance of AI is particularly evident in environments where nurses must continuously prioritize competing clinical needs. Instead of replacing assessment, an AI system may function as an additional layer of surveillance. For example, a patient whose respiratory rate, oxygen requirement, heart rate, temperature, and laboratory parameters are gradually changing may appear relatively stable when individual measurements are reviewed separately. A predictive algorithm may recognize the combined pattern and identify an increased risk of deterioration. The nurse can then perform a focused assessment and determine whether intervention is warranted.

Current Applications of AI in Medical-Surgical Nursing

AI-Supported Clinical Decision-Making

Clinical decision support is one of the most important applications of AI in medical-surgical nursing. AI-based systems can analyze multiple patient variables and provide risk scores, alerts, recommendations, or prioritized information. Such systems may assist nurses in identifying patients requiring closer observation, recognizing abnormal trends, and supporting escalation of care. Rather than simply displaying isolated measurements, predictive systems can identify relationships among clinical variables and estimate the probability of future events.

For example, AI can support assessment of patients at risk for deterioration by analyzing vital signs, laboratory values, oxygen requirements, medication exposure, and previous clinical events. Such systems may complement established early-warning approaches. Their value is greatest when the resulting information is presented in an understandable form and integrated into existing nursing workflows. An alert that does not explain its significance or that generates excessive false positives can increase workload rather than reduce it. Therefore, AI-supported decision-making should be designed around clinical usability and not technological capability alone.

Early Recognition of Patient Deterioration

Continuous monitoring is a central component of medical-surgical nursing, and AI can enhance this function by analyzing physiological trends. Machine-learning models can be trained to recognize patterns associated with adverse events and may generate alerts before overt clinical deterioration occurs. This approach has potential relevance for sepsis, respiratory failure, cardiac deterioration, postoperative complications, and other acute conditions.

The principal advantage is that AI can examine multiple variables simultaneously and repeatedly. A nurse may need to care for several patients and cannot continuously calculate complex interactions among dozens of variables. An algorithm can perform this computational task continuously. Nevertheless, an AI-generated alert should trigger clinical reassessment rather than

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automatic treatment. The nurse remains responsible for determining whether the prediction corresponds to the patient's actual clinical condition.

Sepsis and Infection Surveillance

Sepsis is a major concern in medical-surgical practice because early recognition and timely treatment are associated with improved outcomes. AI systems can analyze combinations of temperature, heart rate, respiratory rate, blood pressure, oxygenation, laboratory findings, comorbidities, and other variables to identify patients at elevated risk. Such systems can potentially support earlier escalation and more focused surveillance.

However, AI-based sepsis alerts must be interpreted carefully because infection-related symptoms overlap with many other clinical conditions. Excessive sensitivity can produce frequent false alarms, resulting in alert fatigue. Conversely, an algorithm with inadequate sensitivity may fail to identify a deteriorating patient. Therefore, implementation should include prospective evaluation of sensitivity, specificity, positive predictive value, workflow effects, and patient outcomes rather than relying solely on algorithmic performance in retrospective datasets.

Fall and Pressure-Injury Risk Prediction

Falls and pressure injuries are important nursing-sensitive outcomes. Conventional risk assessment relies on structured assessment tools and professional judgment. AI may supplement these approaches by integrating information such as age, mobility, medication exposure, cognitive status, previous falls, continence, activity level, and clinical observations.

Similarly, pressure-injury prediction can incorporate mobility, nutritional status, tissue integrity, moisture, perfusion, and other variables. AI-enabled systems may help nurses prioritize preventive interventions for patients at greater risk. Nevertheless, risk prediction must not become a substitute for physical assessment. A patient classified as low risk may still develop an injury because clinical circumstances can change rapidly.

Medication Safety and Medication Management

Medication administration is a major component of medical-surgical nursing and involves several opportunities for error. AI can contribute to medication safety by identifying potentially inappropriate medication combinations, unusual doses, allergy risks, drug-disease interactions, duplicate therapy, or patterns associated with adverse drug events. When integrated with computerized provider-order entry, electronic medication administration records, barcode systems, and pharmacy information, AI may create an additional safety layer.

The nurse's role remains essential because medication administration involves verification of patient identity, clinical assessment, therapeutic response, patient education, and recognition of adverse effects. AI recommendations should therefore be treated as decision-support information rather than unquestionable instructions. Human verification remains particularly important when algorithms produce recommendations in complex patients with multiple comorbidities.

Intelligent Patient Monitoring

AI can transform conventional monitoring from periodic observation into continuous pattern recognition. Bedside monitors and wearable devices can generate large volumes of physiological information, including heart rate, oxygen saturation, respiratory rate, blood pressure, activity, and sleep-related parameters. AI algorithms can analyze these data and identify clinically meaningful deviations.

For medical-surgical nurses, intelligent monitoring may reduce the cognitive burden associated with reviewing continuous streams of information. Instead of requiring nurses to examine every measurement equally, systems may highlight meaningful trends. Future systems may increasingly combine bedside monitoring with electronic health record data to provide a comprehensive view of patient status.

Natural Language Processing and Nursing Documentation

Documentation consumes a substantial proportion of nursing time. Natural language processing (NLP) enables computers to interpret and process human language and can support extraction of information from clinical notes. AI-assisted documentation systems may help nurses summarize patient information, organize documentation, identify relevant clinical terms, and reduce repetitive administrative tasks.

Generative AI may further assist with drafting summaries, patient education materials, handover information, and documentation templates. However, generated content can contain inaccurate or fabricated information. Therefore, nurses must verify all AI-generated documentation before it becomes part of the legal medical record. Generative AI should assist documentation rather than create unverified clinical records automatically.

Patient Education and Communication

AI-powered conversational systems can provide patients with educational information about medications, procedures, postoperative care, nutrition, chronic disease management, and discharge instructions. Such tools may improve access to information outside routine clinical encounters and can potentially

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provide personalized explanations based on patient characteristics.

For medical-surgical nurses, AI can support preparation of individualized educational materials and reinforce information discussed during direct teaching. However, patient education involves assessment of health literacy, emotional state, language, cultural context, and readiness to learn. Automated systems cannot reliably replace these interpersonal processes. Nurses should remain responsible for ensuring that educational information is accurate, comprehensible, and appropriate.

Workflow and Resource Management

AI can also contribute to operational aspects of medical-surgical nursing. Predictive models may assist with patient-flow management, staffing requirements, bed utilization, discharge planning, workload prediction, and resource allocation. When appropriately implemented, such systems may reduce administrative burden and allow nurses to devote more time to direct patient care.

However, workforce-related algorithms require careful oversight. Staffing decisions based solely on historical data may reproduce existing inequities or fail to account for unexpected clinical complexity. Nurse managers should therefore combine AI-generated forecasts with professional judgment, patient acuity, staffing skill mix, and contextual factors.

Advantages of AI Integration into Medical-Surgical Nursing

The potential advantages of AI extend beyond efficiency. AI may improve early recognition of deterioration, support more consistent assessment, reduce repetitive administrative work, facilitate personalized care, and strengthen clinical decision-making.[1,2] Continuous analysis can also enable nurses to move from reactive to more proactive care. Instead of responding only after a patient's condition has visibly deteriorated, nurses may receive information indicating that closer observation or intervention is warranted.

AI can also improve access to information. Medical-surgical nurses frequently need to integrate multiple sources of information while working under time pressure. Well-designed AI systems can organize relevant data and present clinically meaningful summaries. This may reduce information overload and support prioritization.

Another potential advantage is personalization. AI can analyze individual patterns and potentially support patient-specific recommendations. In chronic disease management, for example, algorithms may identify changes in physiological parameters or treatment adherence patterns that warrant intervention. Such approaches could complement nurse-led self-management education and follow-up.

AI may also contribute to nursing research and quality improvement. Large clinical datasets can be analyzed to identify patterns in adverse events, staffing, patient outcomes, and care processes. Nurse researchers may use AI-supported methods to generate hypotheses, identify populations at risk, and evaluate complex relationships within healthcare data.

Challenges and Limitations

Data Privacy and Security

Healthcare AI depends heavily on patient data. Electronic health records contain highly sensitive information, and inappropriate access, unauthorized sharing, cybersecurity attacks, or insecure use of external AI tools can threaten patient confidentiality. Ethical reviews of AI in nursing repeatedly identify privacy and data protection as major concerns.[3-6]

Nurses should therefore understand institutional policies regarding AI tools and should never enter identifiable patient information into unauthorized platforms. Healthcare organizations must establish secure data governance, access controls, audit systems, encryption, and clear rules concerning data use.

Algorithmic Bias and Inequity

AI systems learn from data, and biased data can produce biased predictions. If training datasets inadequately represent certain populations, the resulting algorithms may perform differently across demographic, socioeconomic, geographic, or clinical groups. WHO identifies inclusiveness and equity as essential principles for AI in health.[7]

For medical-surgical nursing, this means that algorithms should be evaluated across diverse patient populations before widespread implementation. Nurses should be encouraged to question unexpected recommendations and report systematic patterns of inequity.

Lack of Explainability

Some AI systems function as complex models in which the pathway from input to prediction is difficult to understand. This creates problems when nurses are expected to act on recommendations without knowing why the system generated them. Explainability is especially important in clinical care because professionals must be able to justify decisions and communicate appropriately with patients and colleagues.

AI should therefore move toward models that provide understandable reasons, relevant variables, confidence levels, and limitations. A recommendation accompanied by clinically

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meaningful explanation is more useful than an unexplained numerical score.

Accountability and Professional Responsibility

A fundamental question concerns responsibility when an AI-supported decision contributes to harm. Ethical literature emphasizes ambiguity surrounding accountability in AI-supported nursing practice.[3-6] Responsibility cannot simply be transferred to an algorithm.

Healthcare institutions, technology developers, clinicians, administrators, and regulators each have responsibilities. Nurses should remain accountable for their professional actions, but they should not be expected to accept poorly designed or inadequately validated AI systems without appropriate institutional safeguards.

Alert Fatigue and Workflow Disruption

AI is not automatically beneficial. Excessive alerts can increase cognitive workload and contribute to alarm fatigue. If nurses receive frequent alerts that do not require intervention, they may become desensitized and eventually overlook important warnings. Successful implementation should therefore assess alert frequency, clinical relevance, response rates, false-positive rates, and user experience. AI should simplify workflow rather than create an additional technological burden.

Digital Literacy and Workforce Preparedness

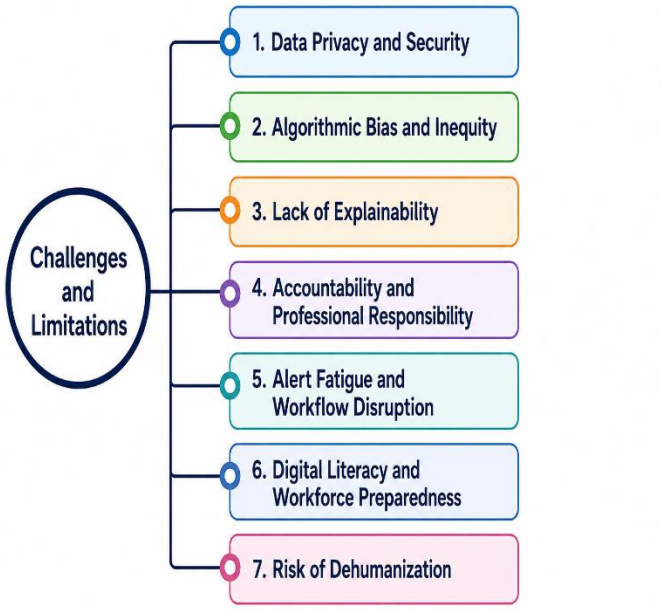
The effectiveness of AI depends on the ability of nurses to understand and critically evaluate it. Recent nursing literature highlights the need for structured AI education and notes that evidence regarding effective integration into nursing education remains limited.[8-10] Nurses need more than technical training. They require knowledge of data quality, algorithmic limitations, privacy, cybersecurity, bias, ethical principles, and responsible use of generative AI.

AI literacy should become part of continuing professional development and nursing curricula. Simulation-based learning can provide opportunities for nurses and students to practice interpreting AI-generated information while maintaining independent clinical reasoning.[8]

Risk of Dehumanization

Nursing is fundamentally a human-centered profession. Excessive dependence on automated systems could reduce direct interaction, weaken therapeutic communication, and encourage task-oriented rather than person-centered care. Ethical discussions emphasize the importance of preserving empathy, compassion, autonomy, and human connection when AI is incorporated into nursing.[3,6]

AI should consequently be designed to give nurses more time for human interaction rather than simply increasing the number of tasks performed electronically.



Ethical and Legal Considerations

The ethical implementation of AI requires respect for autonomy, beneficence, non-maleficence, justice, privacy, and accountability. WHO recommends that AI systems for health place ethics and human rights at the center of their development and use.[7] These principles are particularly relevant to nursing because nurses frequently serve as patient advocates and are closely involved in communicating information and supporting informed decisions.

Patients should know when AI contributes significantly to their care, particularly when algorithmic recommendations influence clinical decisions. Organizations should establish policies concerning disclosure, consent, data management, responsibility, and mechanisms for challenging AI-supported decisions. AI systems should also undergo ongoing evaluation rather than being treated as permanently safe after initial validation.

The NIST AI Risk Management Framework provides a broader model for managing AI-related risks and emphasizes trustworthy and responsible AI across the lifecycle of development and use.[11] Its principles can complement healthcare-specific governance by encouraging organizations to identify, measure, manage, and monitor risks. The generative AI profile published by NIST further recognizes that generative systems create distinctive risks requiring additional safeguards.[12]

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Role of Medical-Surgical Nurses in AI Implementation

Medical-surgical nurses should not be passive recipients of AI technology. Their practical experience makes them important contributors to system design, testing, implementation, and evaluation. Nurses understand workflow realities that may not be visible to software developers or administrators. They can identify whether an alert is clinically meaningful, whether a recommendation is realistic, and whether a new system increases or decreases workload.

Nurses should participate in multidisciplinary AI committees involving clinicians, nurse informaticians, data scientists, information-technology professionals, ethicists, administrators, patients, and legal experts. Such collaboration can improve the clinical relevance and acceptability of AI systems.

Nurses also have an important role in maintaining human oversight. When an AI prediction conflicts with clinical assessment, the nurse should investigate the discrepancy rather than automatically following or rejecting the algorithm. Clinical reasoning remains essential. AI should be viewed as another source of evidence within a broader professional decision-making process.

Future Perspectives

The future of AI in medical-surgical nursing is likely to involve increasingly integrated systems that combine predictive analytics, wearable monitoring, electronic health records, clinical decision support, NLP, robotics, and generative AI. Rather than isolated applications, future platforms may create a continuous clinical intelligence environment in which information is collected, analyzed, summarized, and communicated across the patient's care journey.

Generative AI may increasingly support clinical communication, patient education, handover preparation, literature synthesis, and administrative activities. However, its use should be governed by strong verification requirements because generative systems can produce plausible but incorrect information. Nursing education should therefore emphasize critical appraisal rather than unquestioning acceptance of AI-generated content.[8-10]

Future AI systems should also become more explainable and personalized. Instead of simply stating that a patient has a high risk of deterioration, a clinically useful system might identify the principal contributing factors, show relevant trends, communicate uncertainty, and suggest appropriate assessment priorities. This approach could make AI more compatible with nursing clinical reasoning.

Another important future direction is federated and privacy-preserving learning, in which algorithms can learn from distributed datasets without requiring all patient data to be centrally transferred. Such approaches may facilitate collaboration across institutions while reducing some privacy risks. Nevertheless, technical safeguards alone will not eliminate ethical concerns.

AI development should also include greater nursing representation. Historically, technology development has sometimes focused primarily on physician workflows, diagnostic processes, or administrative needs. Future systems should explicitly address nursing-sensitive outcomes such as falls, pressure injuries, medication safety, workload, missed care, patient education, care coordination, and patient experience.

Recommendations for Responsible Integration

Healthcare institutions should begin AI implementation with clearly defined clinical problems rather than adopting technology simply because it is innovative. Each system should undergo assessment of clinical validity, usability, safety, equity, privacy, cybersecurity, and workflow impact. Nurses should participate from the planning stage through post-implementation monitoring.

Structured AI education should be incorporated into undergraduate and postgraduate nursing programs and continuing professional development. Education should cover fundamental AI concepts, interpretation of predictive outputs, bias, privacy, cybersecurity, ethics, generative AI, documentation standards, and appropriate human oversight.[8-10]

Organizations should also establish governance mechanisms that define who can use AI, what data may be entered, how recommendations should be verified, when patients should be informed, how errors are reported, and how algorithmic performance is monitored. AI systems should be periodically reassessed because clinical populations, workflows, and datasets change over time.

Finally, implementation should be evaluated using outcomes meaningful to nursing and patients. Measures should include patient safety, clinical outcomes, nursing workload, time spent on documentation, alert burden, patient satisfaction, staff acceptance, equity, and cost-effectiveness. Technological performance alone should not determine whether an AI system is successful.

Conclusion

Artificial intelligence represents one of the most significant technological developments influencing contemporary healthcare and has substantial potential to transform medical-surgical nursing. Its current applications include clinical decision support, early deterioration detection, sepsis surveillance, risk prediction,

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medication safety, intelligent monitoring, documentation support, patient education, and workflow management. Evidence from recent nursing literature suggests meaningful potential for improved decision-making, efficiency, monitoring, and care processes, while simultaneously demonstrating that ethical and organizational challenges remain substantial.[1,2]

The future of AI in medical-surgical nursing should not be framed as a competition between human nurses and machines. The more constructive vision is a partnership in which computational systems process complex information while nurses provide contextual interpretation, professional judgment, ethical reasoning, communication, advocacy, and compassionate care. AI can identify patterns, but nurses understand patients as people. AI can generate predictions, but nurses determine their clinical meaning. AI can automate selected tasks, but nurses remain central to the therapeutic relationship.

Responsible adoption will require strong governance, data protection, explainability, algorithmic fairness, professional accountability, AI literacy, interdisciplinary collaboration, and continuous evaluation. WHO's emphasis on ethics, human rights, equity, accountability, and sustainability provides an essential foundation for healthcare AI governance.[7] The NIST AI Risk Management Framework similarly demonstrates the importance of systematic identification and management of AI risks throughout the technology lifecycle.[11,12] Ultimately, the success of AI in medical-surgical nursing will depend not on how much technology can be introduced, but on how effectively technology can be integrated without compromising safety, dignity, autonomy, and the human character of nursing care.

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