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# Innovative Technologies

## Optimizing Nursing Practice

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Healthcare in the United States is rapidly evolving due to increasingly digitized healthcare settings.[1] Digital health tools—computing platforms, connectivity, software, and sensors—are being developed and procured by health systems to create efficiencies in healthcare processes while lowering the cost of care.[2] Digital health technologies are changing how nurses practice, from robots delivering medications to voice-controlled patient rooms.[3] The increased availability of such tools presents an opportunity to innovate in a way that benefits patient care and supports clinicians at the point of care (POC).

Although the responsibility is shared, nurses are considered the primary health information technology (HIT) users. Nurses are well-qualified to inform developers because their direct interaction with patients allows them to observe inefficiencies, identify potential issues, and prioritize patients' needs.[4] By connecting technological advancements and innovative solutions to healthcare needs, nurses can uncover clinical barriers that limit the full potential of HIT.[5]

Three pervasive HIT advancements that have arisen in the last decade include artificial intelligence (AI), monitoring sensors (hereafter, sensors), and virtual reality (VR). At the POC, these digital companions improve clinical decision-making, increase patient monitoring, and augment nursing interventions. Using real-world examples and forecasting uses of HIT tools, we aim to provide insights and guidance on how the nursing profession can innovate patient-centric digital solutions.

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**KEY POINTS**

- Because of their skills and roles in patient care, nurses are well-positioned to use and envision future capabilities of emerging technologies.
- Nurses currently leverage health information technology tools such as artificial intelligence, monitoring sensors, and virtual reality.
- Nurses' adaptability and central role in digital health initiatives are crucial for enhancing patient outcomes and integrating technological advancements into healthcare practice.

## ARTIFICIAL INTELLIGENCE AND CLINICAL DECISION SUPPORT SYSTEMS

### Artificial Intelligence

With recent technological advancements, AI has become more accessible and capable, expanding the role of HIT in clinical nursing practice. This has sparked significant debate about its use in healthcare and the necessary safeguards.[6] AI supports personalized, evidence-based, and efficient nursing care.[7] Although the rise of generative AI has brought AI into the mainstream, we will take a broad view of AI, explore its applications in clinical decision support, and discuss how generative AI can create efficiencies for nurses.

At its core, AI is the science of developing intelligent computer programs.[8] It enables machines to learn and perform tasks that typically require human decision-making.[9,10] AI can be broadly categorized into traditional AI and generative AI. Traditional AI leverages historical data to make predictions, identify patterns, and automate tasks through predefined algorithms. In contrast, generative AI, such as OpenAI's ChatGPT and DALL-E, creates and summarizes text, voice dialogue, and other forms of content. These two approaches are not mutually exclusive and may be used synergistically to enhance nursing practice. For example, traditional AI can support clinical decision-making by analyzing patient data, whereas generative AI can assist with nursing documentation, patient education materials, and personalized communication. Despite the limited availability of clinical decision support systems (CDSSs) designed specifically for nurses, the integration of both traditional and generative AI holds significant potential to transform nursing practice.[11]

### Clinical Decision Support Systems

In nursing practice, clinical decision-making is cognitive. Nurses assess patients by gathering data and using academic, lived, and learned evidence, also known as intuition, to interpret data effectively and implement nursing interventions.[12] Clinical decision support systems, developed to improve and facilitate nurses' and patients' cognitive function at the POC, are often integrated and accessed by other HIT, such as electronic health records (EHRs), smartphone devices, apps, and clinical dashboards.[13] These systems are either knowledge-based, using rule statements derived from expert medical knowledge, or non–knowledge-based, machine learning algorithms that are iteratively trained to learn and adapt to data in real time.[14] Both traditional and generative AI can be applied to support knowledge-based and non–knowledge-based CDSS. A 2024 study found that more than half of the nurses reported having utilized AI-based CDSS.[15]

A familiar knowledge-based CDSS innovation designed to improve nursing workflow and patient outcomes is a best practice alert (BPA), a programmed hard stop in an EHR that prevents documentation or further navigation until nurses review the alert.[16] An algorithm triggers a BPA and often utilizes patient-specific EHR data in real time.[17] For example, a BPA can highlight the need for a vaccination based on hospital guidelines in combination with patient data such as medical history, diagnosis, and current health status. Ultimately, a CDSS alert ensures that nurses and patients are equipped with the most up-to-date information to make informed clinical decisions.[18]

A non–knowledge-based CDSS utilizes traditional AI approaches through predictive modeling and pattern recognition. The CONCERN (COmmunicating Narrative Concerns Entered by RNs) score, developed and deployed by a nursing team at Columbia University, uses data to decrease patient mortality and hospital readmissions.[19] The notification platform, accessed from the EHR, deploys color-coded early warning scores indicating patients' risk for deterioration and decompensation using data from nursing-specific documentation—vital signs, medications administered, and nursing notes—alerting the patient care teams of potential concerns.[19] This non–knowledge-based CDSS platform is novel, given the use of real-time nursing surveillance documentation patterns to identify patients at risk of adverse outcomes.

### Future Applications of Generative Artificial Intelligence

Integrating generative AI into nursing workflows holds immense promise to revolutionize nursing care by enhancing task management, personalizing care delivery, and facilitating clinical decision-making.[20] For example, recent applications of generative AI have improved the management of EHR inbox messaging.[21] Another recent generative AI application is intelligent programming of answers to questions to reduce nurses' time spent on chart reviews and documentation.[22] For example, AI-generated text summaries facilitate potential near misses and proactive assessment opportunities at the POC. Such generative AI tools can enhance nursing productivity by automating less patient-centric tasks, allowing nurses to spend time with patients and families.[23]

## MONITORING SENSORS

Unlike acute care settings, where monitoring often relies on wired sensors, such as cardiac and respiratory monitors with leads attached to patients' chests and fingers, wireless sensors are increasingly being adopted. Remote patient monitoring via wearable sensors helps minimize delays in urgent care and ultimately improve health outcomes by enabling real-time data transmission to systems monitored by clinicians. Monitoring platforms alert clinicians when patient sensors indicate ranges outside normal limits. This allows clinicians to intervene rapidly without delays often occurring with traditional care.[24]

Sensor technology is becoming more commonly used in the community and home environments.[25] Wireless sensors attach to clothing, such as those used for insulin administration devices, and others, such as watches and rings, are applied directly to the skin. Three common use cases for remote sensors include (1) vital sign monitoring; (2) activity, inactivity, and fall monitoring; and (3) remote fetal monitoring.

#### *Vital Sign Monitoring*

Sensors that monitor vital signs such as heart rate, blood pressure, and oxygen saturation are critical to nursing practice. They provide fundamental data and information to assess and manage diagnoses, conditions, and health statuses. Vital sign monitoring sensors are wired or wireless, allowing continuous monitoring depending on patients' mobility and health status.

A systematic review of 53 studies on wearable use for monitoring blood pressure, heart rate, electrocardiogram, and glucose highlighted the role of wearables in monitoring cardiometabolic health.[26] Wearables can track heart rate as a measure of physical function or health component. For example, incorporating wearables for heart rate variation monitoring into clinical assessments could help in the early detection of physical decline in older adults.[27] Wearables have been used to track user heart rate uploads to build cardiovascular risk phenotyping in patients with hypertension.[28] During the height of the COVID-19 pandemic, wearables detected that patients with central nervous system diseases had a

lower daily average heart rate, went to bed later, and slept longer during lockdowns than prelockdown periods.[29] Nurses can leverage wearable data to assess behavior change, tailor interventions, and develop support strategies to meet patients' and caregivers' clinical needs.

Monitoring electrocardiograms is a valuable tool for nurses in detecting changes indicative of severe cardiac conditions such as ST-elevation myocardial infarction[30] and atrial fibrillation.[31] Physiological parameters, including electrocardiogram results, body temperature, humidity, and activity, obtained from a remote monitoring chest strap were closely correlated with reported health status in patients with chronic heart failure.[32] A t-shirt embedded with a single wireless electrocardiogram monitor and electrodes has been tested and found to be a feasible option for self-monitoring.[33] Studies have also reported high reliability, sensitivity, and specificity for detecting atrial fibrillation.[34] These research findings highlight the potential for wearable monitoring sensors to provide valuable insights into patients' cardiac health, allowing for earlier detection of abnormalities and more proactive management by nurses.

*Pressure Ulcer and Fall Monitoring Sensors*

Nurses use sensor technologies to monitor high-pressure skin areas and assess pressure injury risk. For instance, E-scale is a bed weight monitoring system with load cells placed under the legs of a bed, enabling the detection and classification of specific types of movements, including rolls, turns in place, extremity movements, and assisted turns.[35] Sub-Epidermal Moisture Scanner, a noninvasive, handheld sensor-driven device, assesses the increase in interstitial fluid or subepidermal moisture, indicating early skin tissue damage. One study demonstrated the scanner's ability to detect nonvisible damage, alerting clinicians to implement earlier prevention measures.[36]

Fall prevention systems use data from wearable sensors to monitor different motion characteristics, estimate fall risk, and provide real-time alerts. Wearable sensors are widely used as part of detection systems in the home, as they are inexpensive and can be worn on different body parts embedded in watches, shoes, and belts.[37] Various intelligent home systems, such as Amazon Alexa and Google Assistant, leverage configurable motion sensors to detect patient falls, prompting smartphone automated calls to caregivers and emergency medical services.[38,39]

*Remote Fetal Monitoring*

In maternal health, one increasingly utilized type of remote monitoring is for uterine contractions. The technology to support fetal monitoring, mainly before labor, is used primarily for people at high risk for preterm labor.[40] With sensor improvements, data transfer is optimized through Internet protocols, and monitoring is managed via smartphone apps and shared with caretakers, families, and healthcare providers. These apps, available in major app stores, track self-reported uterine contractions by the pregnant mother.

*Future Applications of Monitoring Sensors*

With each upgrade in sensor technology, data are becoming increasingly accurate, and the transfer rates continue to improve, making monitoring ever more reliable and efficient. Moreover, integrating AI algorithms will avail additional just-in-time predictive analytics to alert clinicians. The increasing trend in wearable devices and mobile health applications will further empower patients and caregivers, allowing them to contribute health-related data for earlier interventions and personalized self-management tools. As these technologies become more pervasive, sensor data have the potential to impact healthcare costs by reducing hospital readmission rates and contributing to value-based care.

## VIRTUAL REALITY

Another technology that is advancing at great speed is VR, an immersive technology defined as "a real or simulated environment in which a perceiver experiences telepresence."[41] Typically, this consists of a headset, haptics, and specific applications designed to mimic a real-world care scenario. Virtual reality tools allow users to interact with a controlled environment at their own pace (Figure 1).

*Patient Care Interventions and Experience*

Virtual reality tools to support patients and caregivers have expanded to novel care delivery methods, education, and emotional assistance. For instance, nurses provide VR tools as a nonpharmacological pain management intervention, guiding patients through immersive environments and distracting them from painful procedures or chronic pain conditions.[42] Additionally, nurses use VR tools to prepare patients for surgery or other medical procedures through a simulated operating room experience, thereby reducing preoperative anxiety and enhancing patient readiness. One example is a VR simulation of the perioperative journey for a total knee replacement, demystifying the procedure and helping manage patients' expectations.

Furthermore, nurses leverage VR tools to educate patients on diagnoses, care procedures, and rehabilitation exercises. This educational approach fosters a collaborative care environment between healthcare professionals

**FIGURE 1.** Nurses using virtual reality. Note: Image generated using the prompt "Nurses using virtual reality" by Gamma AI, version 1.9.1, June 2, 2025.

and patients. Through these innovative practices, nurses are pivotal in harnessing VR technology to enhance patient experience, demonstrating a commitment to holistic and empathetic care.

*Professional Development*

Nurses are also using VR tools in nursing education. By leading and participating in VR simulation training sessions, nurses work alongside their peers to recreate and navigate complex clinical scenarios. For example, nurses might use VR to simulate emergency response procedures for a cardiac arrest. This allows the care team to practice roles, effective communication, and interventions in a controlled yet realistic environment, enhancing clinical skills and improving interdisciplinary teamwork and communication.

Nurses contribute to VR design and development using debriefing sessions postsimulation, where nurses collaborate with other clinicians to reflect on the experience, discuss outcomes, and identify areas for improvement.[43] Moreover, nurses might work with technical experts to customize VR simulations to address specific learning objectives or incorporate new medical devices and clinical challenges, ensuring the content is relevant and aligned with current healthcare standards. By bridging the gap between theoretical knowledge and practical application, VR technology solutions are advancing professional development in nursing.

*Nursing Student Education*

VR has been successfully used to instill and assess clinical knowledge in nursing students, including teaching chemotherapy administration and identifying infectious sites in hospital settings.[42] Virtual reality for anatomy instruction has been effectively implemented in midwifery programs[44] and undergraduate and graduate medical programs.[45] A recent meta-analysis of immersive VR and augmented reality for anatomy education found that both immersive VR and augmented reality were associated with increased knowledge gains compared with traditional teaching methods. Nursing students also perceived the technologies as more beneficial for learning than conventional methods.[45]

Virtual reality has also been used to develop clinical communication skills. An AI-enabled VR simulation has been conducted where nursing students collaborated with an interprofessional team with an AI doctor.[46] Similarly, AI-enabled virtual patients can be used to simulate patient conversations.[47] A VR simulation to assess nursing students' emotional responses and management strategies has also been used in research.[48] The study investigated the dissonance between the emotions students expected to experience and those they experienced while acting as nurses, along with the effectiveness of the emotional regulation strategies used to manage those feelings. Virtual reality is thus a valuable tool for self-reflection before clinical training.

*Future Applications of Virtual Reality*

Further development in VR technology will see even more sophisticated simulations developed to cover an ever-wider range of clinical skills, including complex procedures, patient assessments, and decision-making scenarios. Besides enhancing clinical skills, VR might offer nursing students more individualized learning experiences and self-directed training that could be tailored to their learning needs.

AI integrated into a VR platform has the potential to support adaptive or responsive simulations, thereby improving the learning experience. As VR technologies become more affordable and accessible, their use in continuing education and professional development for nurses will likely expand, offering opportunities for skill enhancement and emotional resilience training without requiring physical presence. This could be particularly useful for nurses working in rural or underserved areas

**Table 1. Summary of Innovative Technologies and Nursing Practice**

| | Current Uses | Future Applications |
|---|---|---|
| AI | CDSSs | EHR inbox messaging, text summaries |
| Monitoring sensors | Vital sign monitoring, fall monitoring, remote fetal monitoring | Personalized care, self-management tools |
| VR | Pain management intervention, surgical simulation, professional development | Self-directed training for nursing students, emotional resilience training |

and those in highly demanding environments, such as intensive care units or emergency departments. Further integration of VR into education and practice could lead to enhanced quality of care, job satisfaction, and reduced burnout among healthcare professionals.

## ARTIFICIAL INTELLIGENCE AND ENHANCED PERSONALIZATION

*Future Applications of Digital Tools*

There is a clear need to understand how nurses can observe, interpret continuously, and act upon patient data, which is crucial in driving changes in patient outcomes. For example, the effectiveness of technologies such as AI, VR, and smart sensors in nursing practice depends not only on the tools themselves but also on the ability of nurses to use them proficiently. Thus, nurses are required to be competent in both the use of technology and the data that these technologies generate. Clinical nurses must be prepared with the data literacy competencies necessary to guarantee the adoption, continued use, and integration of such innovative technologies into practice. Knowledge about these innovative technologies can ease nurses' hesitation or fear of using them at the POC.

Adaptive learning, which uses AI algorithms to create a personalized learning experience, can customize learning based on learner preferences, performance metrics, and identified knowledge gaps.[49] When combined with AI, VR has the potential to facilitate realistic interprofessional clinical care scenarios, better preparing student nurses for the reality of clinical practice. Moreover, it can be used in continuing education, exposing practicing nurses to rare or high-risk situations and allowing them to maintain and enhance their clinical skills.[50]

Used with sensors, AI enables patient-specific recommendations based on patient data, including their health diagnoses and conditions and unique behaviors, characteristics, lifestyle factors, and activities.[51] Intelligent algorithms assist nurses in designing personalized treatment plans based on patients' sensor-derived information to suggest the most optimal care. Table 1 provides a summary of the technological advancements discussed and their future applications for nursing practice.

## CONCLUSION

Integrating technologies such as AI, monitoring sensors and VR in nursing is essential for improving patient outcomes and optimizing clinical workflows and education. As crucial members of interdisciplinary teams, nurses play a pivotal role in ensuring these technologies are effectively used in patient care. Nurses should be a part of codesigning, implementing, and evaluating future innovations to ensure they align with practical clinical needs. The continued role of digital health in improving patient outcomes and ensuring high-quality and safe care depends on nurses' adaptability. Fostering collaboration and placing nurses at the center of these developments provide opportunities for continuous technological improvements and seamless integration into practice, driving improved systems-level outcomes and enhanced patient care.

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