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Review Article

Touchless monitoring in medical-surgical nursing: clinical applications of radar, camera-based and contact-free vital sign technologies: a narrative review

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ABSTRACT

Touchless monitoring technologies have emerged as an innovative approach to continuous physiological surveillance in medical-surgical nursing by enabling the assessment of vital signs without direct physical contact. Conventional contact-based monitoring systems, although reliable, are associated with limitations such as patient discomfort, skin injury, sensor displacement, false alarms and increased risk of infection transmission. Recent advances in radar-based sensing, camera-based monitoring, remote photoplethysmography, thermal infrared imaging, radiofrequency sensing, ballistocardiography and artificial intelligence (AI) have facilitated accurate, real-time monitoring of respiratory rate, heart rate, body temperature, movement patterns, sleep behaviour and tissue perfusion. This narrative review summarizes current evidence regarding the principles, clinical applications, advantages, challenges and future directions of touchless monitoring technologies in medical-surgical nursing. The reviewed literature indicates that these technologies can enhance early recognition of physiological deterioration, improve patient comfort, preserve skin integrity, reduce unnecessary physical contact and strengthen patient safety across postoperative care, intensive care, burn management, rehabilitation, infection prevention and remote patient monitoring. AI-driven predictive analytics further improve clinical decision-making by identifying subtle physiological changes before overt deterioration occurs. Despite these advantages, barriers including measurement accuracy, motion artefacts, interoperability, cybersecurity, implementation costs, ethical concerns and workforce preparedness continue to limit widespread clinical adoption. Touchless monitoring should be considered a complementary clinical decision-support tool that augments rather than replaces comprehensive nursing assessment. Continued technological innovation, rigorous clinical validation, standardized implementation strategies and ongoing nursing education are essential for the safe, effective and ethical integration of these technologies into evidence-based medical-surgical nursing practice.

Keywords: Artificial intelligence, Contact-free monitoring, Digital health, Medical-surgical nursing, Patient safety, Radar-based monitoring

INTRODUCTION

Medical-surgical nursing is a core specialty that focuses on the assessment, treatment and rehabilitation of adults with acute and chronic illnesses. Continuous monitoring of physiological parameters, including respiratory rate, heart rate, blood pressure, oxygen saturation and body temperature, is fundamental for the early detection of clinical deterioration, timely intervention and improved patient outcomes. Evidence suggests that prompt recognition of abnormal vital signs reduces hospital mortality, prevents unplanned intensive care unit admissions and enhances patient safety.[1,2] Conventional physiological monitoring primarily relies on contact-based devices such as electrocardiographic electrodes, pulse oximeters, blood pressure cuffs and temperature probes. Although these technologies provide reliable measurements, prolonged use may result in skin irritation, pressure injuries, adhesive-related skin damage, patient discomfort and signal disruption caused by movement or sensor displacement. These limitations may reduce monitoring efficiency and contribute to false alarms, increasing nursing workload.[3] The COVID-19 pandemic further emphasized the need for contact-free monitoring approaches that could maintain continuous patient surveillance while minimizing direct physical contact and reducing infection transmission.[4,5]

Touchless monitoring technologies have emerged as promising alternatives by enabling continuous physiological assessment without physical attachment to the patient. Technologies including Doppler radar, camera-based remote photoplethysmography, thermal infrared imaging, radiofrequency sensing, ballistocardiography and artificial intelligence (AI) can monitor respiratory rate, heart rate, movement, sleep patterns and tissue perfusion with minimal patient disturbance. AI further enhances these systems by improving signal quality, reducing motion artefacts and enabling predictive analysis for the early identification of clinical deterioration.[4-7]

In medical-surgical nursing, touchless monitoring has demonstrated potential benefits in postoperative care, intensive care, burn management, infection prevention, rehabilitation, fall prevention and remote patient monitoring. These technologies improve patient comfort, preserve skin integrity, reduce unnecessary physical contact and support timely nursing interventions. However, challenges related to measurement accuracy, interoperability, cybersecurity, implementation costs, patient privacy and workforce preparedness continue to influence their widespread clinical adoption.[5,8]

This narrative review aims to critically examine current evidence on radar-based, camera-based and other contact-free vital sign monitoring technologies, with emphasis on their technological principles, clinical applications, advantages, implementation challenges and future directions in medical-surgical nursing practice.

A narrative review methodology was adopted to synthesize contemporary evidence relating to touchless monitoring technologies and their application within medical-surgical nursing. A comprehensive literature search was undertaken using major electronic databases, including PubMed, Scopus, Web of Science, IEEE Xplore, ScienceDirect and Google Scholar. Literature published predominantly between January 2020 and June 2026 was considered, while seminal earlier publications describing foundational technologies were included where necessary to provide historical context.

Search terms included combinations of Medical Subject Headings (MeSH) and free-text keywords such as touchless monitoring, contact-free monitoring, non-contact vital sign monitoring, medical-surgical nursing, radar monitoring, millimetre-wave radar, remote photoplethysmography, thermal imaging, computer vision, artificial intelligence, remote patient monitoring, wireless physiological monitoring and Internet of Medical Things. Boolean operators ("AND" and "OR") were used to optimize retrieval of relevant literature.

Peer-reviewed original research articles, systematic reviews, narrative reviews, clinical validation studies, engineering investigations with direct healthcare applications and international guidance documents published in English were considered eligible for inclusion. Conference abstracts, editorials, duplicate publications, non-clinical engineering reports without healthcare relevance and studies involving animal models were excluded. Retrieved publications were critically appraised and synthesized narratively, with emphasis on technological principles, diagnostic performance, nursing implications, implementation challenges, ethical considerations and future research priorities.

Principles of touchless monitoring technologies

Touchless monitoring technologies are founded on the principle that normal physiological activities generate measurable mechanical, optical, thermal and electromagnetic signals that can be detected without direct physical contact with the patient. Unlike conventional bedside monitoring systems that require electrodes, cuffs, respiratory belts or wearable sensors, contact-free technologies utilize advanced sensing devices positioned at a short distance from the patient to continuously acquire physiological information. These raw biological signals are subsequently processed using digital signal processing, machine learning and AI algorithms to estimate clinically relevant physiological parameters, including respiratory rate, heart rate, body temperature, oxygen saturation, movement patterns and sleep behaviour.[9-11]

Recent advances in biomedical engineering have substantially improved the sensitivity and reliability of these technologies. Modern contact-free monitoring systems are capable of detecting minute physiological changes that were previously measurable only through direct-contact sensors. The integration of high-performance sensors with AI-driven analytics has enabled continuous, real-time physiological surveillance while reducing motion artefacts and environmental noise. Consequently, touchless monitoring has evolved from an experimental engineering concept into a clinically relevant technology with significant implications for medical-surgical nursing practice.[12,13]

From a nursing perspective, continuous contact-free monitoring supports a transition from intermittent assessment to proactive surveillance. Rather than obtaining vital signs at predetermined intervals, nurses can continuously observe physiological trends, identify subtle changes before clinical deterioration becomes apparent and initiate timely interventions. Such an approach aligns with modern patient safety initiatives emphasizing early recognition of deterioration and prevention of adverse clinical events.[14]

Radar-based monitoring

Radar-based monitoring is among the most extensively investigated touchless technologies for continuous physiological assessment. These systems emit low-power electromagnetic waves toward the patient's thorax and analyse the reflected signals generated by microscopic chest wall movements associated with respiration and cardiac contractions. Variations in frequency, phase and amplitude of reflected waves are processed using advanced computational algorithms to estimate respiratory rate, heart rate and cardiopulmonary motion.[15]

Several radar technologies have been evaluated in healthcare, including continuous-wave Doppler radar, frequency-modulated continuous-wave radar, ultra-wideband radar and millimetre-wave radar. Among these, millimetre-wave radar has demonstrated superior spatial resolution and greater sensitivity to subtle physiological movements. Because radar signals penetrate clothing, blankets and lightweight dressings, continuous monitoring can be maintained without disturbing the patient or interfering with routine nursing care. Furthermore, radar systems function independently of ambient lighting conditions, making them particularly suitable for overnight monitoring in medical and surgical wards.[16,17]

The clinical relevance of radar monitoring is especially evident in postoperative care. Patients recovering from surgery frequently receive opioid analgesics that may suppress respiratory drive and predispose them to respiratory depression. Continuous radar monitoring enables early identification of declining respiratory effort before oxygen desaturation becomes clinically evident, allowing nurses to intervene promptly through patient assessment, oxygen supplementation, medication review or escalation of care. Radar systems have also demonstrated utility in high-dependency units, burn centres, isolation rooms and rehabilitation settings where minimizing direct patient contact is advantageous.[18]

Despite these advantages, radar monitoring remains susceptible to interference from excessive body movement, environmental vibration and multiple moving objects within the monitoring field. Continuous refinement of signal-processing algorithms and AI-assisted filtering techniques is expected to improve accuracy and reduce these limitations in future clinical applications.[19]

Camera-based monitoring

Camera-based monitoring has emerged as one of the most promising approaches to contact-free physiological assessment because of remarkable advances in digital imaging, computer vision and artificial intelligence. These systems estimate physiological parameters by analysing subtle optical changes captured through high-resolution cameras positioned near the patient's bedside. Unlike conventional video surveillance, modern camera-based monitoring focuses on extracting physiological information rather than simply observing patient activity.[20]

The most widely investigated technique is remote photoplethysmography (rPPG), which measures imperceptible variations in skin colour produced by pulsatile blood flow during each cardiac cycle. Sophisticated image-processing algorithms isolate these microscopic colour fluctuations from facial images and convert them into estimates of heart rate, respiratory rate, heart rate variability and, under selected conditions, peripheral oxygen saturation. Deep learning algorithms have further enhanced the robustness of rPPG by compensating for variations in lighting, skin tone, facial movement and camera positioning.[21,22]

Camera-based monitoring provides several advantages within medical-surgical nursing. Continuous visual analysis allows simultaneous assessment of physiological parameters and behavioural characteristics such as body movement, posture, facial expressions and activity level. These additional observations may assist nurses in identifying postoperative pain, excessive sedation, agitation, delirium or neurological deterioration. Computer vision systems have also demonstrated considerable value in detecting bed-exit attempts and abnormal movement patterns associated with increased fall risk, enabling timely nursing intervention before injury occurs.[23]

Another important advantage is the ability to monitor patients without disturbing their sleep. Hospitalized individuals frequently experience sleep fragmentation due to repeated nursing observations and routine monitoring procedures. Camera-based systems facilitate continuous surveillance while preserving uninterrupted sleep, thereby supporting wound healing, immune function, cognitive recovery and overall patient well-being.[24]

Although camera-based monitoring demonstrates considerable promise, several limitations remain. Measurement accuracy may be influenced by poor illumination, facial obstruction, excessive patient movement, cosmetic products and camera positioning. Continued improvements in infrared imaging, multispectral cameras and AI-assisted image enhancement are expected to further improve clinical performance across diverse healthcare environments.[25]

Thermal infrared imaging

Thermal imaging represents another important contact-free monitoring technology that measures naturally emitted infrared radiation from the human body. Unlike conventional cameras that rely on visible light, thermal cameras generate temperature maps by detecting infrared energy emitted from skin surfaces. Because all individuals emit infrared radiation regardless of lighting conditions, thermal imaging can provide continuous physiological assessment in both daytime and nighttime environments.[26]

Respiration produces characteristic temperature fluctuations around the nostrils and mouth as warm exhaled air alternates with cooler inspired air. These cyclical thermal changes allow accurate estimation of respiratory rate without direct contact. Thermal imaging also facilitates assessment of body temperature distribution, peripheral perfusion, inflammatory processes, wound healing and localized infection.[27]

Within medical-surgical nursing, thermal imaging has important applications in burn care, postoperative wound surveillance, vascular assessment, infection monitoring and fever screening. Patients with burns, skin grafts, pressure injuries or severe dermatological conditions particularly benefit from contact-free monitoring because repeated application of adhesive sensors may cause pain or tissue damage. Thermal imaging therefore offers an attractive alternative for continuous assessment while preserving skin integrity and patient comfort.[28]

Environmental temperature, humidity, airflow and camera distance may influence thermal measurements, emphasizing the importance of standardized operating procedures and careful interpretation of thermal images within the broader clinical context.[29]

Radiofrequency and wi-fi-based monitoring

Radiofrequency (RF) sensing is an emerging technology that analyses alterations in electromagnetic wave propagation caused by physiological body movements. Breathing and cardiac contractions produce subtle changes in reflected RF and Wi-Fi signals, allowing sophisticated algorithms to estimate respiratory rate, heart rate and body movement without requiring wearable sensors.[30]

A notable advantage of RF-based monitoring is its compatibility with existing wireless infrastructure. Hospitals equipped with modern Wi-Fi networks may eventually integrate physiological monitoring into routine communication systems without extensive additional hardware. This capability has generated considerable interest in smart hospitals and digitally connected healthcare environments. Potential nursing applications include continuous respiratory monitoring, fall detection, sleep assessment, rehabilitation monitoring and home-based postoperative surveillance.[31]

However, signal interference from electronic equipment, structural barriers and simultaneous movement of multiple individuals continues to present technical challenges. Ongoing research aims to improve signal stability and expand the clinical applicability of RF-based monitoring systems.[32]

Ballistocardiography

Ballistocardiography is a contact-free technique that measures minute mechanical forces generated by blood ejection during each cardiac cycle. Modern systems integrate highly sensitive pressure sensors within hospital beds, mattresses or chairs, enabling continuous physiological monitoring without requiring any patient preparation.[33]

Ballistocardiography can estimate heart rate, respiratory rate, body movement, sleep quality and bed occupancy. Because the sensing equipment is concealed beneath the patient, monitoring occurs unobtrusively without restricting mobility or causing discomfort. These characteristics make ballistocardiography particularly useful for older adults, rehabilitation patients, postoperative recovery units and long-term care facilities. However, excessive movement and frequent repositioning may reduce signal quality and limit measurement accuracy.[34]

Artificial intelligence as the foundation of modern touchless monitoring

Artificial intelligence has become the cornerstone of modern touchless monitoring technologies by transforming large volumes of raw physiological data into clinically meaningful information. Machine learning algorithms remove background noise, compensate for motion artefacts, identify physiological patterns and continuously improve diagnostic performance through exposure to diverse clinical datasets. Beyond simple measurement of vital signs, AI enables predictive analytics capable of identifying subtle physiological changes that precede overt clinical deterioration.[35]

For medical-surgical nurses, AI-assisted monitoring provides valuable decision support by generating early alerts based on continuous physiological trends rather than isolated observations. Such predictive capability enhances prioritization of patient care, facilitates timely clinical intervention and strengthens patient safety while preserving the essential role of professional nursing judgment show in Table 1. As digital health technologies continue to evolve, the integration of AI with contact-free monitoring is expected to play an increasingly important role in delivering personalized, efficient and evidence-based nursing care.[36]

CLINICAL APPLICATIONS OF TOUCHLESS MONITORING IN MEDICAL-SURGICAL NURSING

The integration of touchless monitoring technologies into medical-surgical nursing has expanded considerably over the past decade, driven by advances in artificial intelligence, sensor engineering and digital health infrastructure. Continuous contact-free monitoring enables healthcare professionals to observe physiological changes in real time without requiring repeated physical contact with patients. This approach complements traditional nursing assessment by providing uninterrupted physiological surveillance, facilitating early recognition of deterioration, supporting timely clinical decision-making and improving patient safety. Rather than replacing conventional bedside assessment, touchless monitoring functions as an intelligent clinical decision-support system that strengthens evidence-based nursing practice while promoting patient comfort and preserving therapeutic interactions.[37-39]

POSTOPERATIVE MONITORING

Postoperative care represents one of the most important clinical applications of touchless monitoring technologies. Patients recovering from surgical procedures remain vulnerable to respiratory depression, haemodynamic instability, uncontrolled pain, postoperative bleeding, hypothermia, delirium and other complications during the first 24 to 48 hours following surgery. Conventional monitoring often relies on intermittent nursing observations performed at scheduled intervals, creating the possibility that subtle physiological changes occurring between assessments may remain undetected until significant deterioration has already developed.[40]

Radar-based monitoring systems provide continuous assessment of respiratory rate and heart rate without requiring physical attachment of sensors. Respiratory rate is widely recognized as one of the earliest indicators of clinical deterioration and frequently changes several minutes or hours before oxygen saturation declines. Continuous surveillance therefore enables nurses to identify postoperative respiratory depression associated with opioid administration at an earlier stage, facilitating prompt clinical assessment, oxygen therapy, medication review and escalation of care when necessary.[41]

Camera-based monitoring further enhances postoperative assessment by continuously evaluating body movement, facial expressions, activity levels and sleep quality. Artificial intelligence algorithms can identify reduced mobility, excessive sedation, restlessness, pain-related facial expressions and behavioural changes suggestive of postoperative delirium or neurological deterioration. Because monitoring occurs without disturbing resting patients, uninterrupted sleep is preserved while maintaining continuous physiological surveillance, thereby supporting recovery and reducing patient discomfort.[42]

EARLY RECOGNITION OF CLINICAL DETERIORATION

Failure to recognize early physiological deterioration remains one of the principal contributors to preventable adverse events in hospitalized patients. Numerous investigations have demonstrated that abnormalities in respiratory rate, heart rate, movement patterns and behavioural activity frequently precede cardiac arrest, respiratory failure, sepsis and unplanned intensive care unit admission. Continuous monitoring therefore provides an opportunity to recognize deterioration before conventional intermittent assessment detects clinically significant abnormalities.[43]

Artificial intelligence significantly enhances this capability by continuously analysing physiological trends rather than isolated measurements. Instead of relying solely on predefined alarm thresholds, machine-learning algorithms establish individualized baseline patterns and identify subtle deviations that may indicate emerging clinical instability. Automated early warning alerts generated through predictive analytics enable nurses to prioritize high-risk patients, perform focused clinical assessment, initiate appropriate interventions and activate rapid response teams before irreversible physiological deterioration occurs. Such predictive monitoring has the potential to reduce failure-to-rescue events while improving patient outcomes and healthcare efficiency.[44]

INTENSIVE CARE AND HIGH-DEPENDENCY UNITS

Although critically ill patients frequently require invasive haemodynamic monitoring, touchless technologies provide valuable complementary information that enhances comprehensive patient assessment. Continuous observation of respiratory activity, sleep quality, movement patterns and behavioural changes provides additional clinical insights while reducing dependence on adhesive sensors and minimizing unnecessary patient manipulation.[45]

Camera-based monitoring systems facilitate early identification of agitation, confusion, delirium and accidental removal of catheters, intravenous lines or oxygen delivery devices. Radar systems continue functioning beneath blankets and surgical dressings, allowing uninterrupted respiratory monitoring even when conventional sensors become displaced. Integration of artificial intelligence further reduces alarm fatigue by distinguishing clinically meaningful physiological events from movement-related artefacts, thereby improving the specificity of clinical alerts and reducing unnecessary nursing interruptions.[46]

BURN CARE AND PATIENTS WITH FRAGILE SKIN

Burn patients present unique monitoring challenges because repeated application and removal of adhesive sensors frequently causes pain, tissue trauma and disruption of healing wounds. Similar challenges occur among patients with pressure injuries, extensive dermatological disorders, skin grafts and severe adhesive allergies. In these situations, contact-free monitoring provides an important alternative that preserves skin integrity while maintaining continuous physiological assessment.[47]

Thermal infrared imaging is particularly valuable in burn nursing because it simultaneously evaluates respiratory activity, body temperature, tissue perfusion and wound surface characteristics. Localized increases in skin temperature may indicate inflammation or infection, whereas reductions in thermal perfusion may suggest compromised vascular supply or delayed wound healing. Continuous assessment without repeated contact enhances patient comfort and supports evidence-based wound management while minimizing unnecessary manipulation of injured tissue.[48]

ISOLATION CARE AND INFECTION PREVENTION

The COVID-19 pandemic emphasized the importance of minimizing unnecessary patient contact while maintaining continuous physiological surveillance. Touchless monitoring technologies allow nurses to remotely assess respiratory rate, heart rate, movement, body temperature and overall physiological status without frequent entry into isolation rooms. This approach reduces occupational exposure to infectious pathogens, decreases consumption of personal protective equipment and improves workflow efficiency while maintaining patient safety.[49]

Beyond pandemic preparedness, these technologies remain valuable for patients requiring protective isolation because of immunosuppression, organ transplantation or haematological malignancies. Reduced bedside traffic contributes to infection prevention while preserving continuous clinical observation.[44]

FALL PREVENTION AND MOBILITY ASSESSMENT

Falls remain among the most common adverse events occurring in hospitalized adults and are associated with increased morbidity, prolonged hospitalization, reduced functional independence and greater healthcare costs. Conventional bed alarms frequently generate false-positive alerts because they cannot distinguish clinically significant movement from routine repositioning during sleep.[50] Artificial intelligence-assisted camera systems continuously analyse posture, gait, body movement, balance and bed-exit behaviour. Advanced computer vision algorithms identify high-risk movement patterns and notify nursing staff before patients attempt unsupervised ambulation. Compared with conventional bed alarms, AI-assisted systems demonstrate improved specificity and substantially reduce alarm fatigue. Continuous mobility assessment also provides objective information regarding rehabilitation progress, functional recovery and discharge readiness following orthopaedic procedures, neurological disorders and prolonged hospitalization.[1]

SLEEP MONITORING AND RECOVERY ASSESSMENT

Sleep is an essential determinant of postoperative recovery, immune function, wound healing, hormonal regulation and cognitive performance. Unfortunately, hospitalized patients frequently experience fragmented sleep due to pain, environmental noise, routine nursing procedures, alarms and repeated physiological monitoring. Poor sleep quality has been associated with increased delirium, delayed wound healing, prolonged hospitalization and reduced patient satisfaction.

Touchless monitoring technologies objectively evaluate sleep duration, sleep efficiency, nocturnal awakenings, respiratory disturbances, body movement and sleep posture without disturbing resting patients. Nurses can utilize these data to evaluate interventions designed to improve sleep hygiene, optimize analgesia, reduce environmental disturbances and promote recovery. Continuous assessment of sleep patterns may also facilitate early recognition of delirium, respiratory compromise and neurological deterioration.[5]

REMOTE MONITORING FOLLOWING HOSPITAL DISCHARGE

Enhanced recovery after surgery (ERAS) programmes and hospital-at-home initiatives have increased interest in continuous physiological surveillance beyond hospital discharge. Touchless monitoring technologies integrated within patients' homes allow continuous observation of respiratory rate, heart rate, mobility, sleep quality and functional recovery during the postoperative period. Physiological information can be securely transmitted to healthcare professionals for remote review, enabling early detection of complications and timely clinical intervention before emergency readmission becomes necessary.[5]

For nurses, remote monitoring supports continuity of care through telehealth consultations, reinforcement of discharge education, medication review, symptom assessment and coordination of community healthcare services. Such approaches are expected to play an increasingly important role in future models of integrated patient-centred care.[37-39]

Table 1: Comparison of major touchless monitoring technologies used in medical-surgical nursing.[4-6,10-13,21-26,34-38]

Technology	Working principle	Physiological parameters	Major nursing applications	Advantages	Limitations
Radar-based monitoring	Reflection of electromagnetic waves	Heart rate, respiratory rate	Postoperative care, ICU, burn units	Accurate, functions through clothing, unaffected by darkness	Motion artefacts and environmental interference
Camera-based monitoring	Remote photoplethysmography and computer vision	Heart rate, respiratory rate, movement	General wards, fall prevention, delirium monitoring	Completely contact-free and continuous	Dependent on lighting and camera position
Thermal imaging	Detection of infrared radiation	Temperature, respiratory rate, tissue perfusion	Burn care, wound assessment, fever screening	Suitable for fragile skin and infection surveillance	Environmental temperature affects accuracy
Radiofrequency/Wi-Fi sensing	Analysis of reflected wireless signals	Respiratory rate, movement	Smart hospitals, home monitoring	Uses existing wireless infrastructure	Signal interference
Ballistocardiography	Detection of mechanical body vibrations	Heart rate, respiratory rate, sleep quality	Rehabilitation, long-term care, postoperative recovery	Comfortable and unobtrusive	Reduced accuracy during excessive movement

Table 2: Clinical applications of touchless monitoring in medical-surgical nursing.

Clinical setting	Primary application	Potential nursing benefits	Major challenges
Postoperative wards	Continuous respiratory and cardiovascular monitoring	Early recognition of respiratory depression and postoperative complications	Motion artefacts during mobilization
Intensive care and HDU	Continuous physiological surveillance	Delirium detection, improved patient safety	Integration with existing monitoring systems
Burn units	Contact-free wound and temperature monitoring	Preservation of skin integrity and patient comfort	Availability of specialized equipment
Isolation wards	Remote physiological assessment	Reduced infection exposure and PPE utilization	Privacy and cybersecurity concerns
General medical-surgical wards	Early warning surveillance	Timely recognition of clinical deterioration	Staff education and workflow integration
Rehabilitation units	Mobility and gait assessment	Objective evaluation of functional recovery	Limited validation in complex clinical settings
Home monitoring	Post-discharge surveillance	Reduced readmissions and enhanced continuity of care	Connectivity and technical support requirements

ADVANTAGES OF TOUCHLESS MONITORING TECHNOLOGIES

Touchless monitoring technologies provide numerous clinical advantages that extend beyond patient comfort. Continuous physiological surveillance improves early recognition of clinical deterioration while reducing dependence on intermittent manual observations. Elimination of adhesive sensors minimizes skin injury, enhances mobility and improves patient acceptance, particularly among individuals requiring prolonged monitoring. Reduced physical contact supports infection prevention strategies while decreasing unnecessary bedside exposure during outbreaks of communicable diseases. Automated acquisition and documentation of physiological information reduce repetitive nursing tasks, allowing greater emphasis on comprehensive assessment, therapeutic communication, patient education and interdisciplinary collaboration. Artificial intelligence further enhances monitoring by reducing false alarms, improving signal quality and supporting individualized patient assessment through predictive analytics.

Collectively, these benefits contribute to improved patient safety, enhanced workflow efficiency and higher quality nursing care.[5]

Challenges and limitations

Despite considerable technological advancement, several barriers continue to limit widespread implementation of touchless monitoring. Patient movement remains the principal source of measurement error, particularly during repositioning, ambulation, coughing or physiotherapy. Camera-based systems may be affected by poor lighting, facial obstruction or excessive motion, whereas thermal imaging is influenced by ambient temperature and airflow. Radiofrequency sensing remains susceptible to signal interference from surrounding electronic devices and structural obstacles in Table 2.[4-6,10-13,21-26,34-39,42-44] Implementation also requires significant investment in equipment, cybersecurity infrastructure, interoperability with electronic health records and workforce education. The absence of internationally standardized validation protocols limits comparison between available technologies and complicates widespread adoption across healthcare systems. Importantly, touchless monitoring should complement rather than replace comprehensive nursing assessment. Clinical reasoning, therapeutic communication, physical examination and individualized patient-centred care remain indispensable responsibilities of professional nurses.[39]

Future directions

Touchless monitoring technologies are expected to become an integral part of future medical-surgical nursing practice as healthcare systems increasingly adopt digital health, precision medicine and artificial intelligence. Future advancements will focus on improving monitoring accuracy, expanding clinical validation, enhancing interoperability with electronic health records and integrating contact-free technologies into routine nursing workflows.

Artificial intelligence will play a pivotal role by enabling predictive analytics capable of identifying early physiological deterioration, including respiratory failure, sepsis, haemodynamic instability and postoperative complications before conventional monitoring methods detect significant abnormalities. This shift from reactive to proactive patient care has the potential to improve clinical outcomes and enhance patient safety.

Another important direction is the development of multimodal monitoring systems that combine radar sensing, camera-based imaging, thermal infrared technology, radiofrequency sensing and artificial intelligence into a single platform. Such integrated systems are expected to improve diagnostic accuracy, reduce motion artefacts and false alarms and provide comprehensive continuous physiological assessment across diverse clinical settings. Continued technological innovation, multidisciplinary collaboration and rigorous multicentre clinical research will be essential to establish standardized implementation strategies and ensure the safe, ethical and effective adoption of touchless monitoring technologies in modern medical-surgical nursing practice.

CONCLUSION

Touchless monitoring technologies have emerged as a transformative innovation in medical-surgical nursing by enabling continuous, non-invasive and patient-centred physiological surveillance without direct physical contact. Technologies such as radar-based sensors, camera-based monitoring, thermal infrared imaging, radiofrequency sensing, ballistocardiography and AI have significantly enhanced the continuous assessment of respiratory rate, heart rate, body movement, sleep quality and tissue perfusion. These systems improve patient comfort, preserve skin integrity, reduce unnecessary physical contact and facilitate the early detection of physiological deterioration, thereby strengthening patient safety and supporting timely clinical intervention. The integration of AI has further advanced contact-free monitoring through improved signal processing, predictive analytics and individualized physiological assessment. Clinical applications in postoperative care, burn management, infection prevention, fall prevention, intensive care, rehabilitation and remote patient monitoring highlight the potential of these technologies to improve nursing efficiency and healthcare quality. However, challenges related to measurement accuracy, interoperability, cybersecurity, implementation costs, ethical concerns, patient privacy and workforce training remain important barriers to widespread adoption. Touchless monitoring should be viewed as a complementary clinical decision-support tool rather than a replacement for professional nursing assessment. Clinical reasoning, therapeutic communication, physical examination and compassionate patient-centred care remain fundamental responsibilities of nurses. Future integration of AI, multimodal sensing technologies and electronic health record systems, supported by rigorous multicentre research and standardized implementation strategies, will further enhance the safe, ethical and effective use of touchless monitoring. These advancements have the potential to transform patient surveillance, strengthen evidence-based nursing practice, improve clinical outcomes and contribute to safer, more efficient and high-quality medical-surgical nursing care.

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REFERENCES

1. World Health Organization. Global strategy on digital health 2020-2027. World Health Organization. 2025.

2. World Health Organization. Global patient safety action plan 2021-2030: towards eliminating avoidable harm in health care. World Health Organization. 2021.
3. Lindberg C, Brinchmann BS. Nurses and global health responsibility: in light of the COVID-19 pandemic and the war in Ukraine. Int Nurs Rev. 2023;70(2):141-4.
4. Hassanpour A, Yang B. Contactless vital sign monitoring: a review towards multi-modal multi-task approaches. Sensors (Basel). 2025;25(15):4792.
5. Saikevičius L, Raudonis V, Dervinis G, Baranauskas V. Non-contact vision-based techniques of vital sign monitoring: systematic review. Sensors (Basel). 2024;24(12):3963.
6. Molinaro N, Schena E, Silvestri S, Massaroni C. Contactless vital signs monitoring from videos recorded with digital cameras: an overview. Front Physiol. 2022;13:801709.
7. McDuff D. Camera measurement of physiological vital signs. ACM Computing Surveys. 2023;55(9):1-40.
8. Chen W, Yi Z, Lim LJ, Lim RQ, Zhang A, Qian Z, et al. Deep learning and remote photoplethysmography powered advancements in contactless physiological measurement. Front Bioengine Biotechnol. 2024;12:1420100.
9. Debnath U, Kim S. A comprehensive review of heart rate measurement using remote photoplethysmography and deep learning. Bio Medical Engineering. 2025;24(1):73.
10. Verkruysse W, Svaasand LO, Nelson JS. Remote plethysmographic imaging using ambient light. Opt Express. 2008;16(26):21434-45.
11. Sun Y, Thakor NV. Photoplethysmography revisited: from contact to noncontact, from point to imaging. IEEE Trans Biomed Eng. 2016;63(3):463-77.
12. Rouast PV, Adam MTP, Chiong R, Cornforth D, Lux E. Remote heart rate measurement using low-cost RGB face video: a technical literature review. Front Comput Sci. 2018;12(5):858-72.
13. Khanam FTZ, Ahmad M, Shabut AMR, Alomainy A. Remote monitoring of vital signs in diverse non-clinical and clinical scenarios using computer vision systems: a review. Appl Sci. 2019;9(20):4474.
14. Shaik T, Tao X, Higgins N, Li L, Gururajan R, Zhou X, et al. Remote patient monitoring using artificial intelligence: current state, applications, and challenges. wiley interdisciplinary reviews. Data Mining and Knowledge Discovery. 2023;13(2):1485.
15. Bautista MJ, Kowal M, Cave DG, Downey C, Jayne DG. Clinical applications of contactless photoplethysmography for monitoring in adults: A systematic review and meta-analysis. J Clin Translat Sci. 2023;7(1):129.
16. Debnath U, Kim S. A comprehensive review of heart rate measurement using remote photoplethysmography and deep learning. Bio Medical Engineering Online. 2025;24(1):73.
17. Braun B, McDuff D, Holz C. How suboptimal is training rppg models with videos and targets from different body sites. In2024 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshop. 2024: 410-418.
18. Mironenko Y, Kalinin K, Kopeliovich M, Petrushan M. Remote photoplethysmography: rarely considered factors. 2020: 1197-206.
19. Ontiveros RC, Elgendi M, Missale G, Menon C. Evaluating RGB channels in remote photoplethysmography: a comparative study with contact-based PPG. Front Physiol. 2023;14:1296277.
20. Haugg F, Elgendi M, Menon C. GRGB-rPPG: an efficient low-complexity remote photoplethysmography algorithm for heart rate estimation. Bioengineering (Basel). 2023;4:698.
21. Li C, Lubecke VM, Boric-Lubecke O, Lin J. A review on recent advances in Doppler radar sensors for noncontact healthcare monitoring. IEEE Trans Microw Theory Tech. 2013;61(5):2046-60.
22. Ahmad F, Narayanan RM, Schreurs D. Application of radar to remote patient monitoring and eldercare. IET Radar Sonar Navig. 2015;9(7):1-13.
23. Massaroni C, Nicolò A, Schena E, Sacchetti M. Contactless methods for measuring respiratory rate: a review. IEEE Sens J. 2021;21(11):12821-39.
24. Garbey M, Sun N, Merla A, Pavlidis I. Contact-free measurement of cardiac pulse based on the analysis of thermal imagery. IEEE Trans Biomed Eng. 2007;54(8):1418-26.
25. Fei J, Pavlidis I. Thermistor at a distance: unobtrusive measurement of breathing. IEEE Trans Biomed Eng. 2010;57(4):988-98.
26. Raheel MS, Tubbal FE, Raad R, Ogunbona P, Coyte J, Patterson C, et al. Contactless vital sign monitoring systems: a comprehensive survey of remote health sensing for heart rate and respiration in Internet of Things and sleep applications. Sens Diagn. 2024;3:1085-117.
27. Ahmed S, Rahman M, Kim Y. Machine learning for healthcare radars: recent progress in human vital sign measurement and activity recognition. IEEE Access. 2024.
28. Wang Y, Wang Z, Zhang JA, Zhang H, Xu M. Vital sign monitoring in dynamic environments via mmWave radar and camera fusion. 2023;6:653.
29. Zhang B, Jiang B, Zheng R, Zhang X, Li J, Xu Q. Pi-ViMo: Physiology-inspired robust vital sign monitoring using mmWave radars. ACM Transactions Internet Things. 2023;4(2):1-27.
30. Ren W, Cao J, Yi H, Hou K, Hu M, Wang J. Noncontact multipoint vital sign monitoring with mmwave mimo radar. IEEE Transactions on Microwave Theory Techniques. 2024;73(7):4176-90.
31. Liang D, Chen Y, Gao J, Shi T, Yao J. Seamless integration and implementation of distributed contact and contactless vital sign monitoring. 2024.
32. Beltrao G, Schroeder U. Recent developments in contactless monitoring vital signs using radar devices. 2023.

33. Shaya Y. Development of remote radar-based vital sign acquisition for contactless patient monitoring. Front Med Technol. 2026;8:35.
34. Khanam FTZ, Ahmad M, Shabut AMR, Alomainy A. Remote monitoring of vital signs in diverse non-clinical and clinical scenarios using computer vision systems: a review. Appl Sci. 2019;9(20):4474.
35. Ontiveros RC, Elgendi M, Missale G, Menon C. Evaluating RGB channels in remote photoplethysmography: a comparative study with contact-based photoplethysmography. Front Physiol. 2023;5:509.
36. Haugg F, Elgendi M, Menon C. GRGB-rPPG: an efficient low-complexity remote photoplethysmography algorithm for heart rate estimation. Bioengineering (Basel). 2023;4:825.
37. Xiao H, Liu T, Sun Y, Li Y, Zhao S. Remote photoplethysmography for heart rate measurement: a review. Biomed Signal Process Control. 2024;5:67.
38. Chen W, Yi Z, Lim LJR, Lim RQR, Zhang A. Deep learning and remote photoplethysmography-powered advancements in contactless physiological measurement. Front Bioeng Biotechnol. 2024;6:6787.
39. McDuff D. Camera measurement of physiological vital signs. ACM Computing Surveys. 2023;55(9):1-40.
40. Saikevičius L, Raudonis V, Kozlovskaja-Gumbrienė A, Šakalytė G. Advancements in remote photoplethysmography. Electronics. 2025;6:754.
41. Brown A, Van de Vel A, De Sutter P. Remote photoplethysmography for health assessment: a comprehensive review. Front Digit Health. 2025;6:87.
42. Hassanpour A, Yang B. Contactless vital sign monitoring: a review towards multi-modal multi-task approaches. Sensors (Basel). 2025;25(15):4792.
43. Saikevičius L, Raudonis V, Dervinis G, Baranauskas V. Non-contact vision-based techniques of vital sign monitoring: systematic review. Sensors (Basel). 2024;24(12):3963.
44. Raheel MS, Tubbal FE, Raad R, Ogunbona P, Coyte J, Patterson C, et al. Contactless vital sign monitoring systems: a comprehensive survey of remote health sensing for heart rate and respiration in Internet of Things and sleep applications. Sens Diagn. 2024;3:1085-117.
45. McDuff D. Camera measurement of physiological vital signs. ACM Computing Surveys. 2023;55(9):1-40.
46. Shaik T, Tao X, Higgins N, Li L, Gururajan R, Zhou X, Acharya UR. Remote patient monitoring using artificial intelligence: Current state, applications, and challenges. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery. 2023;13(2):1485.
47. Amoran AE. Review of microphone-based contactless vital signs monitoring. Arch Acoust. 2025;7:54.
48. Fujiasih A. Remote vital signs monitoring based on Internet of Things system: literature review. J Nurs Care. 2023;5:239.
49. Hussain Z, Sheng QZ, Zhang WE, Ortiz J, Pouriyeh S. Non-invasive techniques for monitoring different aspects of sleep: A comprehensive review. ACM Transactions on Computing for Healthcare (HEALTH). 2022;3(2):1-26.
50. Abuella H, Ekin S. Non-contact vital signs monitoring through visible light sensing. IEEE Sensors J. 2019;20(7):3859-70.

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