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The Role of Nursing in Enhancing Patient Safety during Diagnostic Radiology Procedures

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ABSTRACT

The use of diagnostic radiology is crucial for accurate diagnosis and treatment planning, but also poses a risk of radiation exposure, use of contrast media, sedation, positioning, and procedure complications. Patient identification, pre-procedure assessment, patient preparation, radiation-safety practices, monitoring of contrast media, patient physiological observations, patient education, effective communication and post-procedure care are key roles that nurses can play in patient safety. They offer continuous monitoring and patient interaction, enabling the detection of adverse events and prompt intervention of risk factors. Coordinating between radiologists, radiographers and other healthcare professionals is also facilitated by effective nursing involvement, which helps to minimise communication-related errors and enhance continuity of care. The quality and safety of diagnostic radiology service can further be improved with the implementation of radiology-specific nursing education, standard safety protocols, readiness for emergencies, and collaboration among various health professions.

Keywords: Diagnostic radiology; Nursing care; Patient safety; Radiation safety; Contrast media; Patient monitoring; Radiological procedures.

INTRODUCTION

Diagnostic radiology is a key component of contemporary health care, giving useful information for the detection, diagnosis, planning of treatment and monitoring of many diseases [1]. Conventional radiography, computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography, fluoroscopy and image-guided intervention have significantly enhanced the accuracy and efficiency of clinical decision making [2]. Radiology procedures, though useful for diagnosis, can cause a variety of problems such as radiation exposure, reaction to the contrast media, complications from the medication, falls, positioning injury, or problems related to use of sedation or the invasive procedure in which the patient is involved [3]. A thorough assessment of the risks, communication, and monitoring are essential, as are coordinated, multidisciplinary care practices to ensure patients' safety during these procedures [4].

Nurses are critical to ensuring patient safety both before, during and after a diagnostic radiology procedure [5]. They are not limited to the routine care of patients, but also have a role in identifying patients, verifying clinical data, checking medical history, evaluating allergies and past reactions to contrast dyes, checking drug allergies, and preparing patients for specific procedures [6]. It is especially critical to identify and verify the requested examination and/or verification because an error in patient identity, examination type or anatomical site can lead to inappropriate or unnecessary procedures [7]. Nurses also play a role in informed consent if needed, clarifying the procedure in an understandable manner, answering questions and making sure that the patient follows pre-procedure guidelines (fasting or medication restrictions) [8].

Another area of nursing practice in diagnostic radiology is radiation protection [9]. While the x-ray exam may be conducted by a radiographer, nurses often assist in preparing the patient, positioning the x-ray machine and plate, and monitoring the patient during the exam or providing post-procedure care [10]. An understanding of radiation safety knowledge, which involves justification, optimization and minimization of unnecessary radiation, allows a nurse to assist in the practice of radiation safety. Special attention is needed in the care of vulnerable patients, such as children, pregnant women, elderly, and multiple imaging examinations. The communication of pregnancy status and imaging exposure history should be dealt with properly, and this can be achieved with the help of nurses.

Monitoring of patients during radiological procedures is also crucial. Physiological changes or acute complications can occur in patients who receive contrast studies, sedation, interventional procedures or examinations that involve extended immobility [13]. As a result, it is the responsibility of the nurse to monitor the patient's vital signs, oxygenation, level of consciousness, pain and other clinically relevant parameters per procedure and patient condition [14]. Prompt identification of adverse reactions, especially hypersensitivity reactions to contrast media, enables prompt intervention and escalation of care [15]. Patient safety is further enhanced through effective interprofessional communication, availability of suitable equipment and emergency preparedness between nurses, radiologists, radiographers, anaesthetists and other health care professionals [16].

Patient education and communication are also pertinent aspects of nursing roles in radiology [17]. Patient cooperation and procedural risks can be influenced by anxiety, unknown settings, communication challenges and lack of understanding [18]. These risks can be mitigated by nurses' interactions, which include giving clear explanations, checking for patient understanding, ensuring privacy and dignity and encouraging patients to report symptoms of difficulty in breathing, dizziness, pain or discomfort [19]. Good communication between wards, radiology departments and recovery areas also help to minimise the risk of losing information or giving a wrong medication or ID number [20].

Additionally, nurses play a role in keeping patients safe after the surgery by monitoring their recovery and performing delayed complications checks, treating nausea and pain, and giving patients a discharge checklist. [21] Assessment and intervention documentation, adverse events and patient responses give continuity of care and support for quality improvement. Therefore, nursing participation in diagnostic radiology is an integral part of an effective patient safety system [22]. The ability of nurses to minimize unnecessary risks by incorporating clinical evaluation, radiation safety awareness, careful monitoring, patient teaching, accurate documentation, and interprofessional communication can help to ensure safe and patient-focused diagnostic radiology.

Review

Many medical problems are diagnosed, treated, planned and monitored with diagnostic radiology, which is an invaluable component of modern medicine [23]. In general, radiological procedures are safe but risks associated with ionizing radiation, contrast media, sedation, invasive procedures, positioning injuries, falls, communication errors and risks associated with ionizing radiation are risks [24]. Nurses are at the heart of minimising these risks as they engage with patients in the diagnostic process. Their duties encompass the patient assessment prior to the procedure, identity, preparation, monitoring, communication, emergency response and post-procedure care. In a thorough engagement, it is possible to enhance early detection of risk factors and timely intervention when complications arise.

Table 1. Nursing responsibilities before diagnostic radiology procedures

Nursing responsibility	Key activities	Contribution to patient safety
Patient identification	Verify patient identity using appropriate identifiers	Prevents wrong-patient procedures
Clinical assessment	Review medical history and current health status	Identifies potential procedural risks
Allergy assessment	Determine history of allergies and previous contrast reactions	Reduces risk of adverse reactions
Medication assessment	Review relevant medications	Helps identify medication-related risks
Pregnancy assessment	Determine pregnancy status when relevant to radiation exposure	Supports appropriate radiation protection
Patient preparation	Follow fasting and other procedure-specific instructions	Reduces complications and repeat procedures
Patient education	Explain procedure and provide instructions	Improves cooperation and reduces anxiety
Consent verification	Confirm required consent according to institutional policy	Supports ethical and procedural safety

The pre-procedure nursing assessment is a critical time to assess if patients are at risk for diagnostic imaging procedures [25]. By correctly collecting the information on past contrast use, co-morbids, medications, pregnancy, mobility restrictions and past procedures, the radiology team can formulate a proper safety plan [26]. Patient education is also a key factor as anxious or poorly informed patients may not be able to lie still or follow instructions for optimal imaging and repeat exams.

Clear, simple communication, acknowledging concerns, and checking for understanding will help enhance patient cooperation. These interventions not only have a positive impact on patient-centred care but also help to prevent procedural errors.

Another aspect of nursing participation in diagnostic radiology is radiation protection. All nurses in radiology departments should be aware of some basic principles of radiation safety and should adhere to the radiation safety rules that have been established by the department [27]. While the main responsibility falls with the radiologists and radiographers when giving care for the technical aspects of exposure to radiation, the nurse is also responsible for making sure that patients are identified correctly, conveying needed clinical information, assisting with positioning, and anticipating those patients who may need extra precautions [28]. Special attention should be paid to children and pregnant patients. Appropriate preparation and patient cooperation will also help to minimize repeat imaging, which is another area in which nurses can play a role.

Table 2. Nursing role in radiation and contrast-media safety

Safety area	Nursing intervention	Expected outcome
Radiation protection	Follow departmental radiation-safety procedures	Minimizes unnecessary exposure
Pregnancy screening	Identify and communicate possible pregnancy	Supports appropriate imaging decisions
Patient positioning	Assist with safe and accurate positioning	Reduces movement and repeat imaging
Contrast assessment	Review previous contrast reactions and relevant history	Identifies patients at increased risk
Contrast monitoring	Observe for adverse reactions during and after administration	Enables early recognition of complications
Emergency preparedness	Ensure appropriate emergency resources are available	Facilitates rapid response
Communication	Report patient risk factors to the radiology team	Improves multidisciplinary safety
Documentation	Record relevant reactions and interventions	Supports continuity of care

Special care needs to be attended to with contrast enhanced imaging as it is sometimes combined with a contrast agent that can have adverse reactions. Nurses are also typically directly involved in patient preparation, monitoring and management following contrast administration [29]. Before the procedure, review past reactions and pertinent history helps to recognize potential risks. Nurses should be vigilant while administering and should watch for such effects as skin reactions, difficulty breathing, low and high blood pressure, nausea, or any other unusual symptoms. It is crucial that it is recognised early as it can stop deterioration if it is treated in time. In addition, nurses should know the institutional emergency procedures and monitor the patient after the contrast injection.

In diagnostic radiology, vigilant monitoring is particularly critical when sedation is used, when patients receive invasive image-guided interventions, are examined for a long time, or have contrast media [30]. Monitoring can involve vital signs, oxygen saturation, respiratory status, level of consciousness and pain, as well as general clinical condition, depending on the patient's condition and type of procedure. Nurses form an essential screening barrier as they are able to identify changes in the patient's condition and report this to the responsible clinician in a timely manner. It is also crucial that there is a good flow of communication between the nurse, radiologist and/or radiographer, anesthetic staff and referring doctors to prevent errors. The transfer of information on allergies, medication, mobility, previous reactions and clinical risks ensures continuity of care.

Table 3. Nursing interventions during and immediately after radiology procedures

Patient-safety concern	Nursing intervention	Safety benefit
Physiological deterioration	Monitor vital signs and clinical condition	Facilitates early intervention
Sedation-related complications	Monitor consciousness and respiratory status	Reduces risk of unrecognized deterioration
Contrast reaction	Observe for clinical signs of adverse reactions	Enables prompt treatment
Falls	Assist patients with transfers and ambulation	Prevents fall-related injuries
Positioning complications	Maintain safe positioning and assess discomfort	Reduces injury and pressure-related complications
Pain or distress	Assess symptoms and provide appropriate support	Improves patient comfort and cooperation
Communication errors	Provide structured handover	Reduces loss of critical information
Emergency events	Activate appropriate emergency protocols	Supports rapid multidisciplinary response

The postprocedure nursing care is the latest phase in the safety pathway for diagnostic radiology. Assessment of the patient should be based on the nature of the examination and his/her clinical condition [31]. The patient may need to be monitored beyond sedation and recovery until recovery is achieved, and the patient may need to be assessed for bleeding, pain, infection, or other complications after a procedure that has been performed. Nurses also give instructions on what to do when leaving the hospital and explain what symptoms should be a cause for further medical care. Careful assessment, intervention and adverse event documentation and patient reaction data are required for continuity of care and future risk assessment.

Table 4. Post-procedure nursing care and patient-safety outcomes

Post-procedure activity	Nursing action	Patient-safety outcome
Recovery assessment	Evaluate vital signs and general condition	Confirms clinical stability
Sedation recovery	Assess consciousness and respiratory status	Promotes safe recovery
Pain assessment	Evaluate and manage pain appropriately	Improves comfort and identifies complications
Procedural-site assessment	Check for bleeding or other local complications	Facilitates early detection
Discharge education	Explain precautions and warning signs	Promotes safe self-care
Follow-up communication	Communicate significant findings or concerns	Maintains continuity of care
Documentation	Record assessment and interventions	Supports accountability and future care
Incident reporting	Report adverse events according to policy	Supports quality improvement

In summary, nursing contribution to the field of diagnostic radiology is more than just a part of the patient care process and is a valuable part of a patient-safety system [32]. Nurses play several roles in their contributions to patients, including identifying risks prior to the procedures, providing care in radiation and contrast safety, assisting patients during procedures, managing complications, communicating with patients, and providing post-procedure care [33]. Additional efforts to enhance the quality of nursing education, standardise assessment procedures, emergency preparedness and inter-disciplinary communication may further minimise preventable adverse events, specific to radiology. A structured nursing approach can therefore improve the safety, quality and patient centeredness of the diagnostic radiology services [34].

DISCUSSION

Patient safety is a critical part of diagnostic radiology because patients can be exposed to risks related to radiation, contrast media, sedation, invasive procedures, positioning and communication errors. Nurses are a vital element in minimizing these risks by assessing, preparing, monitoring, educating, and coordinating with the radiology team [35].

The preprocedure nursing assessment is important because it can help determine significant risk factors including allergies, previous reaction to contrast, pregnancy status, comorbidities, medications, and mobility issues [36]. Accurate patient identification and proper examination verification also mitigate against wrong patient, wrong procedure errors. Patient education helps to calm anxiety and enhances cooperation, which aids safe and effective imaging.

The practice of nursing has many areas that are important to consider in relation to the safety of radiation and contrast media [37]. Nurses ensure appropriate radiation-safety and ensure the relevant information of the patient is communicated to the radiologist/ radiographer [38]. Close monitoring will enable adverse reactions and physiological deterioration to be identified early during the administration of contrast media or during sedation. Quick communication and emergency response are crucial when complications occur.

Monitoring following the procedure is also crucial, especially following sedation, contrast enhanced studies or invasive procedures [39]. Nurses evaluate recovery, vital signs, pain and potential problems and give appropriate discharge instructions. Continuity of care provided by accurate records and good handover[40].

In general, the role of nurse is important in ensuring the safety of the patient and the multidisciplinary team of radiology. Enforcing radiology-specific nursing education, standardized safety measures, effective communication, and emergency preparedness can have added benefits in minimizing preventable complications and enhancing the quality and safety of diagnostic radiology services.

CONCLUSION

The importance of nurses improving the safety of patients during diagnostic radiology procedures can be summarized as a complete assessment of the patient, patient identification, patient preparation, radiation safety, monitoring of contrast media, continuous observations, communication and post-procedure care. They are adept at spotting possible issues in their early stages and acting quickly on any complications to prevent adverse events and ensure care is patient-centered. An enhancement of nurses' knowledge, skills, standardized safety procedures, and the communication between the different members of the multi-disciplinary team can further increase the quality and safety of diagnostic radiology services.

REFERENCES

1. European Society of Radiology 2009. The future role of radiology in healthcare. Insights Imaging. 2010 Jan;1(1):2-11. doi: 10.1007/s13244-009-0007-x. Epub 2010 Jan 16. PMID: 22347897; PMCID: PMC3259353.
2. Hussain S, Mubeen I, Ullah N, Shah SSUD, Khan BA, Zahoor M, Ullah R, Khan FA, Sultan MA. Modern Diagnostic Imaging Technique Applications and Risk Factors in the Medical Field: A Review. Biomed Res Int. 2022 Jun 6;2022:5164970. doi: 10.1155/2022/5164970. PMID: 35707373; PMCID: PMC9192206.
3. Ketineni RR, Singh B, Chandralekha AR, M S I, Soni K, Lodha N. Advances in Radiological Imaging Modalities and Their Expanding Role in the Early Diagnosis, Monitoring, and Prognosis of Internal Medicine Disorders: A Comprehensive Review. Cureus. 2025 Dec 18;17(12):e99513. doi: 10.7759/cureus.99513. PMID: 41552161; PMCID: PMC12811736.
4. Nabrawi E, Alanazi AT. Imaging in Healthcare: A Glance at the Present and a Glimpse Into the Future. Cureus. 2023 Mar 14;15(3):e36111. doi: 10.7759/cureus.36111. PMID: 37065355; PMCID: PMC10098436.
5. Thacharodi A, Singh P, Meenatchi R, Tawfeeq Ahmed ZH, Kumar RRS, V N, Kavish S, Maqbool M, Hassan S. Revolutionizing healthcare and medicine: The impact of modern technologies for a healthier future-A comprehensive review. Health Care Sci. 2024 Oct 9;3(5):329-349. doi: 10.1002/hcs2.115. PMID: 39479277; PMCID: PMC11520245.
6. Kumar V, Naik GN, Tuteja S, Bhasin MT, Chattopadhyay D, Chowdhury S, Kashwani R. Evaluation of Radiographic and Clinical Outcomes in the Use of Bone Substitutes in Periapical Surgery and Periodontal Regeneration. J Pharm Bioallied Sci. 2025 Sep;17(Suppl 3):S2218-S2220. doi: 10.4103/jpbs.jpbs_1058_25. Epub 2025 Sep 8. PMID: 41164633; PMCID: PMC12563600.
7. El Taguri A. Essential concepts in modern health services. Libyan J Med. 2008 Sep 1;3(3):148-55. doi: 10.4176/080306. PMID: 21499457; PMCID: PMC3074271.
8. Shapoo N, Shapoo N, Rehman A, Boma N. Smart Healthcare: The Role of Digital Health in Modern Medicine. Health Care Sci. 2025 Jun 1;4(3):179-187. doi: 10.1002/hcs2.70019. PMID: 40568626; PMCID: PMC12185370.
9. Sawhney H, Salam S, Singh S, Kashwani R, Sonawane A, Gupta S, Sankaran NK. Kap assessment for exploring quick response code integration in tele radiography, diagnosis, and digital imaging. Commun. Pract. J. Commun. Pract. Health Visitors' Assoc. 2024;21(4):1450-7.
10. Yogesh MJ, Karthikeyan J. Health Informatics: Engaging Modern Healthcare Units: A Brief Overview. Front Public Health. 2022 Apr 29;10:854688. doi: 10.3389/fpubh.2022.854688. PMID: 35570921; PMCID: PMC9099090.

11. Rani S, Kumar R, Panda BS, Kumar R, Muften NF, Abass MA, Lozanović J. Machine Learning-Powered Smart Healthcare Systems in the Era of Big Data: Applications, Diagnostic Insights, Challenges, and Ethical Implications. Diagnostics (Basel). 2025 Jul 30;15(15):1914. doi: 10.3390/diagnostics15151914. PMID: 40804880; PMCID: PMC12346079.
12. Emami M, Haghdoost AA, Yazdi-Feyzabadi V, Mehrolhassani MH. Identification of Key Components in Health System Using System Thinking Approach: A Scoping Review. Med J Islam Repub Iran. 2023 May 3;37:47. doi: 10.47176/mjiri.37.47. PMID: 37426481; PMCID: PMC10329510.
13. Maleki Varnosfaderani S, Forouzanfar M. The Role of AI in Hospitals and Clinics: Transforming Healthcare in the 21st Century. Bioengineering (Basel). 2024 Mar 29;11(4):337. doi: 10.3390/bioengineering11040337. PMID: 38671759; PMCID: PMC11047988.
14. Saba Raoof S, Durai MAS. A Comprehensive Review on Smart Health Care: Applications, Paradigms, and Challenges with Case Studies. Contrast Media Mol Imaging. 2022 Sep 29;2022:4822235. doi: 10.1155/2022/4822235. PMID: 36247859; PMCID: PMC9536991.
15. Haleem A, Javaid M, Singh RP, Suman R. Telemedicine for healthcare: Capabilities, features, barriers, and applications. Sens Int. 2021;2:100117. doi: 10.1016/j.sintl.2021.100117. Epub 2021 Jul 24. PMID: 34806053; PMCID: PMC8590973.
16. Faiyazuddin M, Rahman SJQ, Anand G, Siddiqui RK, Mehta R, Khatib MN, Gaidhane S, Zahiruddin QS, Hussain A, Sah R. The Impact of Artificial Intelligence on Healthcare: A Comprehensive Review of Advancements in Diagnostics, Treatment, and Operational Efficiency. Health Sci Rep. 2025 Jan 5;8(1):e70312. doi: 10.1002/hsr2.70312. PMID: 39763580; PMCID: PMC11702416.
17. Hu S, Song D, Wan S, Zhang S, Luo C, Li N, Liu G, da Graça Espírito Santo Vasconcelos J, de Carvalho LLC, Neobísi E, da Costa MLB, Etchu Takounjou J, Neves KMD, Dos Ramos da Conceição L, da Costa Encarnação M, Zhao LY. Digital health: current applications, challenges, and future directions for enhancing healthcare quality and safety. Front Public Health. 2025 Sep 26;13:1646802. doi: 10.3389/fpubh.2025.1646802. PMID: 41089861; PMCID: PMC12516163.
18. Batko K, Ślęzak A. The use of Big Data Analytics in healthcare. J Big Data. 2022;9(1):3. doi: 10.1186/s40537-021-00553-4. Epub 2022 Jan 6. PMID: 35013701; PMCID: PMC8733917.
19. Junaid SB, Imam AA, Balogun AO, De Silva LC, Surakat YA, Kumar G, Abdulkarim M, Shuaibu AN, Garba A, Sahalu Y, Mohammed A, Mohammed TY, Abdulkadir BA, Abba AA, Kakumi NAI, Mahamad S. Recent Advancements in Emerging Technologies for Healthcare Management Systems: A Survey. Healthcare (Basel). 2022 Oct 3;10(10):1940. doi: 10.3390/healthcare10101940. PMID: 36292387; PMCID: PMC9601636.
20. Stoumpos AI, Kitsios F, Talias MA. Digital Transformation in Healthcare: Technology Acceptance and Its Applications. Int J Environ Res Public Health. 2023 Feb 15;20(4):3407. doi: 10.3390/ijerph20043407. PMID: 36834105; PMCID: PMC9963556.
21. Sharma R, Chauhan CK, Gupta T, Kumar P, Thakur N. Knowledge, Attitude and Practices of Traditional Medicine in North India: A Cross-Sectional Study. Bull. Health Sphere 2026;1(1):1-10. doi: 10.63150/bhs.2026.01
22. Popescu C, El-Chaarani H, El-Abiad Z, Gigauri I. Implementation of Health Information Systems to Improve Patient Identification. Int J Environ Res Public Health. 2022 Nov 18;19(22):15236. doi: 10.3390/ijerph192215236. PMID: 36429954; PMCID: PMC9691236.
23. Li J, Carayon P. Health Care 4.0: A Vision for Smart and Connected Health Care. IISE Trans Healthc Syst Eng. 2021;11(3):171-180. doi: 10.1080/24725579.2021.1884627. Epub 2021 Feb 15. PMID: 34497970; PMCID: PMC8423174.
24. Aamir A, Iqbal A, Jawed F, Ashfaque F, Hafsa H, Anas Z, Oduoye MO, Basit A, Ahmed S, Abdul Rauf S, Khan M, Mansoor T. Exploring the current and prospective role of artificial intelligence in disease diagnosis. Ann Med Surg (Lond). 2024 Jan 4;86(2):943-949. doi: 10.1097/MS9.0000000000001700. PMID: 38333305; PMCID: PMC10849462.
25. Pinto-Coelho L. How Artificial Intelligence Is Shaping Medical Imaging Technology: A Survey of Innovations and Applications. Bioengineering (Basel). 2023 Dec 18;10(12):1435. doi: 10.3390/bioengineering10121435. PMID: 38136026; PMCID: PMC10740686.
26. Al Kuwaiti A, Nazer K, Al-Reedy A, Al-Shehri S, Al-Muhanna A, Subbarayalu AV, Al Muhanna D, Al-Muhanna FA. A Review of the Role of Artificial Intelligence in Healthcare. J Pers Med. 2023 Jun 5;13(6):951. doi: 10.3390/jpm13060951. PMID: 37373940; PMCID: PMC10301994.
27. Khosravi M, Zare Z, Mojtabaeian SM, Izadi R. Artificial Intelligence and Decision-Making in Healthcare: A Thematic Analysis of a Systematic Review of Reviews. Health Serv Res Manag Epidemiol. 2024 Mar 5;11:23333928241234863. doi: 10.1177/23333928241234863. PMID: 38449840; PMCID: PMC10916499.
28. Lyu G. Data-driven decision making in patient management: a systematic review. BMC Med Inform Decis Mak. 2025 Jul 1;25(1):239. doi: 10.1186/s12911-025-03072-x. PMID: 40598137; PMCID: PMC12219683.
29. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. Future Healthc J. 2019 Jun;6(2):94-98. doi: 10.7861/futurehosp.6-2-94. PMID: 31363513; PMCID: PMC6616181.

30. Khan PA, Badole PJ, Shaikh D. Telemedicine and digital health: The future for pharmaceutical companies and health care. Indian J Pharmacol. 2026 Jan 1;58(1):24-34. doi: 10.4103/ijp.ijp_452_24. Epub 2026 Jan 7. PMID: 41498661; PMCID: PMC12880784.
31. Bhuyan SS, Sateesh V, Mukul N, Galvankar A, Mahmood A, Nauman M, Rai A, Bordoloi K, Basu U, Samuel J. Generative Artificial Intelligence Use in Healthcare: Opportunities for Clinical Excellence and Administrative Efficiency. J Med Syst. 2025 Jan 16;49(1):10. doi: 10.1007/s10916-024-02136-1. PMID: 39820845; PMCID: PMC11739231.
32. Johnson KB, Wei WQ, Weeraratne D, Frisse ME, Misulis K, Rhee K, Zhao J, Snowdon JL. Precision Medicine, AI, and the Future of Personalized Health Care. Clin Transl Sci. 2021 Jan;14(1):86-93. doi: 10.1111/cts.12884. Epub 2020 Oct 12. PMID: 32961010; PMCID: PMC7877825.
33. Motwani A, Shukla PK, Pawar M. Ubiquitous and smart healthcare monitoring frameworks based on machine learning: A comprehensive review. Artif Intell Med. 2022 Dec;134:102431. doi: 10.1016/j.artmed.2022.102431. Epub 2022 Oct 22. PMID: 36462891; PMCID: PMC9595483.
34. Chustecki M. Benefits and Risks of AI in Health Care: Narrative Review. Interact J Med Res. 2024 Nov 18;13:e53616. doi: 10.2196/53616. PMID: 39556817; PMCID: PMC11612599.
35. Ahmed MM, Okesanya OJ, Olaleke NO, Adigun OA, Adebayo UO, Oso TA, Eshun G, Lucero-Prisno DE 3rd. Integrating Digital Health Innovations to Achieve Universal Health Coverage: Promoting Health Outcomes and Quality Through Global Public Health Equity. Healthcare (Basel). 2025 May 5;13(9):1060. doi: 10.3390/healthcare13091060. PMID: 40361838; PMCID: PMC12071628.
36. Jafleh EA, Alnaqbi FA, Almaeeni HA, Faqeeh S, Alzaabi MA, Al Zaman K. The Role of Wearable Devices in Chronic Disease Monitoring and Patient Care: A Comprehensive Review. Cureus. 2024 Sep 8;16(9):e68921. doi: 10.7759/cureus.68921. PMID: 39381470; PMCID: PMC11461032.
37. Sutton RT, Pincock D, Baumgart DC, Sadowski DC, Fedorak RN, Kroeker KI. An overview of clinical decision support systems: benefits, risks, and strategies for success. NPJ Digit Med. 2020 Feb 6;3:17. doi: 10.1038/s41746-020-0221-y. PMID: 32047862; PMCID: PMC7005290.
38. Masoumian Hosseini M, Masoumian Hosseini ST, Qayumi K, Hosseinzadeh S, Sajadi Tabar SS. Smartwatches in healthcare medicine: assistance and monitoring; a scoping review. BMC Med Inform Decis Mak. 2023 Nov 3;23(1):248. doi: 10.1186/s12911-023-02350-w. PMID: 37924029; PMCID: PMC10625201.
39. Mahara G, Tian C, Xu X, Wang W. Revolutionising health care: Exploring the latest advances in medical sciences. J Glob Health. 2023 Aug 4;13:03042. doi: 10.7189/jogh.13.03042. PMID: 37539846; PMCID: PMC10401902.
40. Rana RK, Kapoor N, Kumar D, Verma M, Taneja G. Digital Health Revolution in India: Transforming Health and Medicine. Indian J Community Med. 2024 Dec;49(Suppl 2):S205-S209. doi: 10.4103/ijcm.ijcm_803_24. Epub 2024 Dec 30. PMID: 40124867; PMCID: PMC11927824.