LITERATURE REVIEW

Patient safety and technology: a narrative review of key innovations from the last decade

Segurança do paciente e tecnologia: uma revisão narrativa das principais inovações na última década

Seguridad del paciente y tecnología: una revisión narrativa de las principales innovaciones de la última década

Edna Marta Mendes da Silva[1], Clóvis Coutinho da Motta Neto[2], Ediran Ericles Pontes dos Anjos[3], João Pedro Sartor de Azevedo Conceição[4], Luiz Eduardo Fonseca de Britto[5], Marina Irma Pinheiro de Souza[6], Yasmin Yngrid Mendes de Brito[7], Ricardo Ney Cobucci[8]

ABSTRACT

Objectives: To review technologies aimed at patient safety over the last decade, identifying their impact on error reduction and care quality. **Methods**: Narrative review with searches in PubMed and Google Scholar, including studies in Portuguese, English, and Spanish, using descriptors such as "Patient Safety" and "Technology". Twenty-five studies were analyzed, categorized into mobile applications, wearable devices, artificial intelligence (AI), and other innovations. **Results**: Mobile applications reduced medication errors (up to 70%) and promoted self-care. Wearable devices enabled early detection of clinical deterioration, enhancing safety. AI optimized prescriptions, and sensors improved traceability and monitoring. Challenges include privacy and usability. **Conclusion**: Technologies enhance patient safety, reducing errors and promoting patient-centered care. Future studies should explore large-scale AI applications and accessibility in low-income settings.
Descriptors: Patient Safety; Technology; Health; Artificial Intelligence; Review

_____
[1] PhD candidate in Biotechnology in Health, Nurse. Master's degree in Health Education. Preceptor of the multidisciplinary residency in neonatal intensive care. Executive member of the Healthcare-Associated Infection Control Committee. Potiguar University (UNP), Natal, Rio Grande do Norte, Brazil. https://orcid.org/0000-0003-4519-645X

[2] Physician. Resident in Family and Community Medicine. HUOL/EBSERH/UFRN. Federal University of Rio Grande do Norte - UFRN. Natal/Brazil. https://orcid.org/0000-0002-0592-6131

[3] Pharmacist. Potiguar University (UNP), Natal/RN, Brazil. https://orcid.org/0000-0002-9034-8021

[4] Resident Physician in Internal Medicine. Institute of Medical Assistance to Public Servants of the State of São Paulo (IAMSPE). São Paulo, SP. Brazil. https://orcid.org/0009-0008-0363-4531

[5] Undergraduate in medicine. Pernambuco School of Health, FPS, Recife, Pernambuco, Brazil. Pernambuco School of Health, FPS, Recife, PE, Brazil. https://orcid.org/0009-0004-0608-6375

[6] Resident Physician in Internal Medicine. ABC School of Medicine (FMABC). Santo André, SP. Brazil. ABC School of Medicine - FMABC. Santo André/SP, Brazil. https://orcid.org/0009-0007-6549-3212

[7] Undergraduate in medicine. Potiguar University – UNP, Natal, RN. Brazil. Potiguar University (UNP), Natal/RN, Brazil. https://orcid.org/0009-0001-5003-8184

[8] Professor at the School of Medicine and Postgraduate Program in Biotechnology at Potiguar University, Anima, Natal, Rio Grande do Norte, Brazil. Head of the research and technological innovation sector at MEJC/EBSERH/UFRN, professor of the Master's program in Sciences Applied to Women's Health, and deputy coordinator of COREME at MEJC/UFRN, Natal, Brazil. PhD in health sciences and specialist in health preceptorship from UFRN. Potiguar University, Anima, Natal, Rio Grande do Norte, Brazil. https://orcid.org/0000-0002-0184-2061

RESUMO

Objetivos: Revisar tecnologias voltadas para a segurança do paciente na última década, identificando seu impacto na redução de erros e qualidade do cuidado. **Métodos**: Revisão narrativa com busca em PubMed e Google Scholar, incluindo estudos em português, inglês e espanhol, utilizando descritores como "Patient safety" e "Technology". Foram analisados 25 estudos, categorizados em aplicativos móveis, dispositivos vestíveis, inteligência artificial (IA) e outras inovações. **Resultados**: Aplicativos reduziram erros de medicação (até 70%) e promoveram autocuidado. Dispositivos vestíveis detectaram deterioração clínica precocemente, aumentando a segurança. IA otimizou prescrições, e sensores melhoraram rastreabilidade e monitoramento. Desafios incluem privacidade e usabilidade. **Conclusão**: As tecnologias melhoram a segurança do paciente, reduzindo erros e promovendo cuidados centrados. Estudos futuros devem explorar IA em larga escala e acessibilidade em contextos de baixa renda.

Descritores: Segurança do Paciente; Tecnologia; Saúde; Inteligência Artificial; Revisão

RESUMEN

Objetivos: Revisar las tecnologías orientadas a la seguridad del paciente en la última década, identificando su impacto en la reducción de errores y la calidad del cuidado. **Métodos:** Revisión narrativa con búsqueda en PubMed y Google Scholar, incluyendo estudios en portugués, inglés y español, utilizando descriptores como "Patient Safety" y "Technology". Se analizaron 25 estudios, categorizados en aplicaciones móviles, dispositivos vestibles, inteligencia artificial (IA) y otras innovaciones. **Resultados:** Las aplicaciones móviles redujeron errores de medicación (hasta un 70%) y promovieron el autocuidado. Los dispositivos vestibles detectaron deterioro clínico de forma temprana, aumentando la seguridad. La IA optimizó prescripciones, y los sensores mejoraron la trazabilidad y el monitoreo. Los desafíos incluyen la privacidad y la usabilidad. **Conclusión:** Las tecnologías mejoran la seguridad del paciente, reduciendo errores y promoviendo cuidados centrados en el paciente. Estudios futuros deben explorar aplicaciones de IA a gran escala y la accesibilidad en contextos de bajos ingresos.

Descriptores: Seguridad del Paciente; Tecnología; Salud; Inteligencia Artificial; Revisión

INTRODUCTION

Patient safety, defined as the reduction of preventable harm during the delivery of healthcare to a minimum acceptable level, is an essential pillar of quality care.[1] Since the publication of the To Err is Human report[2], which revealed the occurrence of 44,000 to 98,000 deaths annually due to medical errors in the United States, the issue has gained global prominence, highlighting the need for innovative strategies to mitigate care failures. In this context, the integration of emerging technologies has proven to be a promising approach to improving safety, reducing errors, and optimizing care management.[3]

Technological innovations such as mobile apps, wearable devices, and artificial intelligence offer solutions that transcend traditional equipment, incorporating knowledge and intelligent systems that promote self-management, clinician-patient communication, and

treatment adherence.[4,5] These tools have the potential to prevent medication errors, monitor vital signs in real time, and support clinical decisions, promoting safer, patient-centered care. Furthermore, initiatives such as the World Health Organization's Patients for Patient Safety[6] program reinforce the importance of patient and family engagement, which can be enhanced by technologies that promote education and self-care.

Despite advances, gaps remain in our understanding of how these technologies are implemented and their true impact on patient safety. Issues such as usability, accessibility, data privacy, and integration with care flows still require investigation. This narrative review seeks to address these gaps by analyzing the main technological innovations developed between 2015 and 2024, focusing on their applicability and effectiveness in reducing errors and promoting safe care.

Thus, the objective was to review the scientific literature on technologies aimed at patient safety, identifying and characterizing solutions such as mobile applications, wearable devices, artificial intelligence, and other innovations, to understand their impact on the quality and safety of healthcare.

METHODS

This narrative review was conducted to answer the research question: "What available technologies contribute to patient safety?" The search for studies was conducted between July and December 2024 in the PubMed and Google Scholar databases, using the following Health Sciences Descriptors (DeCS): Patient safety, Technology, Mobile applications, Wearable electronic devices, Apps, Serious games, Technology development, Innovation, and Medical devices. These terms were combined with the Boolean operators AND and OR to broaden the retrieval of relevant articles.

Studies published between January 2015 and December 2024, available in full, free of charge, in Portuguese, English, or Spanish, were included. Research protocols, editorials, experience reports, duplicate studies, or studies irrelevant to the research question were excluded after analyzing the title and abstract. The selection process involved three stages: (1) initial screening to identify duplicates and apply the inclusion/exclusion criteria; (2) reading of titles and abstracts to verify relevance; and (3) reading the articles in full to determine final eligibility.

Six researchers independently performed the screening, ensuring rigorous selection. Disagreements were resolved by

consensus. The selection process flowchart, detailing the number of studies retrieved, excluded, and included at each stage, is presented in Figure 1. The selected studies were organized by technological categories (mobile apps and games, wearable devices, artificial intelligence, and other innovations) and qualitatively analyzed to identify contributions to patient safety.
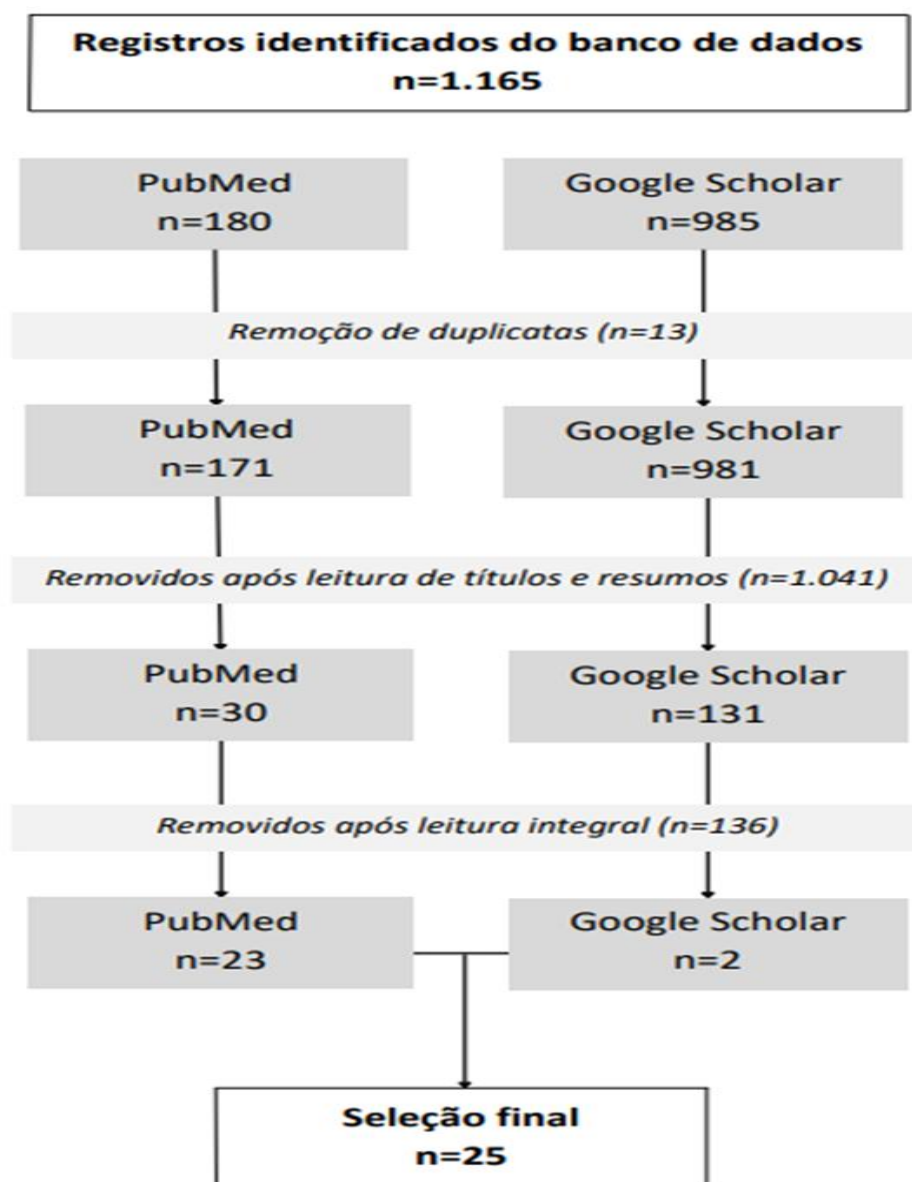

Figure 1. Flowchart of the study selection process.
Source: Prepared by the authors (2025).

RESULTS

The 25 studies covered four technological categories: mobile apps and games (19 articles), wearable electronic devices (3 articles), artificial intelligence (1 article), and other innovations (2 articles). Below, the main results are presented by subtopic according to these categories.

Mobile Apps and Games

The 19 studies on mobile apps and games demonstrated broad applicability in patient safety, focusing on education, error reduction, and patient empowerment. Apps like Minha Cirurgia[7] and MySurgery[8] offered perioperative guidance, reducing anxiety and promoting self-care, with high usability among patients, including vulnerable groups. Tools like SPOT[9] and MyPrescribe[10] reduced opioid and medication prescribing errors, respectively, with accuracy of up to 96.3% and critical reflection among professionals. The eOncosalud[11] monitored adverse events in cancer patients, optimizing hospital resources.

In critical care settings, PedAMINES[12] and Order-Assist[13] reduced medication errors in pediatrics (up to 68%) and anesthesia (70%), respectively. Brain Buddy[14] encouraged dialogue about medication risks between older adults and physicians, while UROSTENTZ[15] prevented complications from ureteral stents. Serious games, such as PlayDecide[16] and Air Medic Sky-1[17], increased educational engagement and safety awareness among professionals and students.

Table 1. Mobile apps and games for patient safety

Author/Year	Population	Main Results	Conclusions
Silva, Lima, Silva, Poveda. (2024)[7]	8 nurses and 8 IT professionals	My Surgery achieved a usability rating of 90.85	Promotes education and surgical safety
Russ et al. (2020)[8]	42 surgical patients	MySurgery reduced anxiety and increased empowerment	Promising for vulnerable groups; needs accessibility
Flint et al. (2019)[9]	Prescribers in palliative care	SPOT achieved 96.3% accuracy in opioid conversion	Secure tool; requires large-scale validation

Keyworth, Hart, Thoong, Ferguson, Tully. (2017)[10]	15 junior doctors	MyPrescribe promoted reflection and reduced prescribing errors	Promising tool; integration with behavioral theories recommended
Villanueva-Bueno et al. (2022)[11]	186 cancer patients	eOncosalud detected 1,368 adverse events	Optimizes resources and improves security
Ehrler, Siebert. (2020)[12]	128 nurses and 152 paramedics	PedAMINES reduced errors in pediatric emergencies by 68%	Effective in critical contexts; supports WHO target
Shim, Kim, Kim, Choi, Lee. (2023)[13]	202 pediatric patients	Order-Assist reduced anesthesia errors by 70%	Reliable tool for efficiency
Holden et al. (2020)[14]	23 elderly people	Brain Buddy promoted dialogue on drug risks	Viable for seniors; improves communication with doctors
Hameed, Shah, Naik, Reddy, Somani. (2021)[15]	33 patients with ureteral stents	UROSTENTZ prevented complications and improved communication	Reduces costs and unnecessary visits
Ward et al. (2019)[16]	Resident doctors	PlayDecide increased incident reporting	Promotes proactive culture; requires institutional support
Dankbaar et al. (2017)[17]	103 students	Serious game more engaging than e-module; longer learning time	Serious games have educational potential, but practical effectiveness needs more research
Lee et al. (2015)[26]	23 hospital apps in Korea	87% focused on timeliness, 78% on safety, 65% on efficiency	Apps meet multiple quality objectives, but real impact requires further study
Jeon et al. (2019)[27]	62 pediatric patients	99.99% accuracy in patient identification	Improves security, but privacy is a challenge
Pierce et al. (2019)[28]	Patients and professionals in Europe	WEB-RADR app facilitates reporting of adverse reactions	Potential in pharmacovigilance; requires greater adherence
Cho, Lee. (2021)[29]	94 hospitalized patients	App increased self-efficacy and safe behaviors	Digital self-education is effective for safety

Aldughayfiq, Sampalli. (2021)[30]	21 participants	NFC app reduced dispensing errors (90% vs. 38%)	Safe and practical; expansion recommended
Lee, Ahn, Lee. (2021)[31]	60 patients	APPSE app improved knowledge and participation	Digital education motivates safe behaviors
Lin, Ho, Chen, Chang, Chien. (2022)[32]	Hemodialysis patients	MEWS app reduced adverse events	Increases safety and efficiency in hemodialysis
Oh, Kim. (2023)[33]	44 nursing students	App increased competence	Effective for safety education

Source: Prepared by the authors (2025).

Wearable Electronic Devices

The three studies on wearable devices highlighted their potential for continuous monitoring and rapid response to clinical events. Devices such as ViSi Mobile[18] and HealthPatch[18] identified clinical deterioration early, with high acceptance (usability ≥ 77.9) and increased feelings of security. HAIL-CAT19 reduced alarm response time by up to 148% in simulations, alleviating the cognitive burden on nurses. The Sensium20 sensor was considered comfortable by 85.4% of patients, with 69.2% feeling greater security, although privacy and usability remain challenges.

Table 2. Wearable electronic devices for patient safety

Author/Year	Population	Main Results	Conclusions
Weenk, Bredie, Koeneman, Hesselink, van Gor, van de Belt. (2020)[18]	90 hospitalized patients	ViSi Mobile and HealthPatch detected early deterioration	Increase security; barriers include false alarms
McFarlane, Doig, Agutter, Brewer, Syroid, Mittu. (2018)[19]	16 nurses in simulation	HAIL-CAT reduced alarm response time by 148%	Improves alarm triage; requires real-world testing

| Joshi et al. (2021)[20] | Hospitalized patients | Sensium was comfortable (85.4%); 69.2% felt safe | Promising for monitoring; needs privacy improvements |

Source: Prepared by the authors (2025).

Artificial intelligence

The study evaluated an AI system for detecting prescription errors at Sheba Medical Center.[21] Using machine learning, the system generated 315 alerts across 282 prescriptions, with 48% of orders modified quickly (median of 1 hour). High sensitivity and specificity reduced undetected adverse events, optimizing operational efficiency and clinical decision-making.

Other Technologies

Two technologies were highlighted: radiofrequency identification (RFID) and a leak detection device in hemodialysis. The application of RFID in surgical gauzes, instruments, smart dressings, and patient monitoring has improved traceability and error prevention.[22] In hemodialysis, tests were conducted on devices with optical and ultrasonic sensors, detecting 67 of 73 blood leaks (98.9% accuracy), reducing anxiety and improving the quality of care.[23]

DISCUSSION

The results highlight the effectiveness of technologies such as mobile apps, wearable devices, artificial intelligence, and innovations like RFID and sensors in reducing errors and promoting patient safety. The studies have in common that these tools improve early detection of adverse events, reduce medication errors (with reductions of up to 70% in critical settings such as pediatrics and anesthesia), and promote patient empowerment through education and self-care.

Apps like PedAMINES and Order-Assist have demonstrated significant impact in minimizing errors in highly complex settings, while wearable devices like ViSi Mobile and Sensium have enabled continuous monitoring, increasing the sense of security for most patients. These advances imply more proactive clinical practice, with the potential to reduce morbidity and mortality associated with care errors and optimize hospital resources, especially in high-demand settings.

Technologies such as AI systems and mobile apps require training to integrate

real-time data into clinical decisions, which can alleviate cognitive overload, as observed with HAIL-CAT.[19] However, adopting these tools requires adjustments to workflows and ongoing training to ensure usability and acceptance. For patients, the impact is equally significant, as apps such as MySurgery and eOncosalud promote greater engagement and treatment adherence, while wearable devices offer greater safety and autonomy. In line with a recent study, the review demonstrates a convergence in the emphasis on continuous monitoring and early detection, especially with artificial intelligence (AI) wearable devices.[24,25] However, while the authors focus on provider-oriented applications[24], this review highlights the role of patient empowerment, evidenced by serious apps and games, suggesting a more holistic approach.

This study reinforces the importance of healthcare information technology for reducing errors, but warns of persistent challenges, such as data privacy and integration with existing systems. While some authors emphasize IT infrastructure, this review covers a broader range of technologies, including RFID and sensors, which offer practical solutions for real-time traceability and monitoring. Advances in AI-enabled wearable devices, such as computer vision systems in surgeries, are noteworthy. These advances complement the findings of this review on AI for prescribing. However, the scarcity of AI studies in this review contrasts with the emphasis on predictive algorithms, suggesting a gap that needs to be addressed.

The review's strengths include a comprehensive analysis of 25 recent studies covering diverse technological categories and clinical contexts, with methodological rigor ensured by the independent screening of six researchers and a rich, contextualized synthesis aligned with the objectives of identifying impactful innovations. However, limitations include the predominance of studies on mobile applications and the exclusion of paid articles, which may have restricted access to high-quality studies. The lack of quantitative analysis, inherent to the narrative format, also limits the ability to generalize the findings.

CONCLUSIONS

Patient safety technologies, including mobile apps, wearable devices, artificial intelligence, and innovations such as RFID and sensors, have demonstrated significant impact on reducing medication errors, detecting clinical deterioration early, and promoting self-care, contributing to safer, more patient-centered care. The integration of these technologies optimizes

care quality, aligning with global patient safety goals.

We suggest exploring the impact of AI technologies on a larger scale, especially in low-income settings, where accessibility is a challenge in future studies. Research into the integration of wearable devices with electronic health records and the long-term evaluation of serious games in professional training are recommended. Furthermore, research addressing ethical issues, such as data privacy, and usability in vulnerable populations can strengthen the implementation of these innovations, ensuring equitable and sustainable benefits for patient safety.

REFERENCES
1. Ministério da Saúde (Brasil). Documento de referência para o Programa Nacional de Segurança do Paciente [Internet]. Brasília, DF: Ministério da Saúde, Fiocruz, Anvisa; 2014 [citado em 11 jul 2025]. Disponível em: https://bvsms.saude.gov.br/bvs/publicacoes/documento_referencia_programa_nacional_seguranca.pdf
2. Institute of Medicine (US) Committee on Quality of Health Care in America. Kohn LT, Corrigan J, Donaldson MS. To err is human: building a safer health system [Internet]. Washington, DC: National Academy Press; 2000 [citado em 11 jul 2025]. Disponível em: https://nap.nationalacademies.org/login.php?record_id=9728
3. Reis CT, Martins M, Laguardia J. A segurança do paciente como dimensão da qualidade do cuidado de saúde: um olhar sobre a literatura. Ciênc Saúde Colet. [Internet]. 2013 [citado em 11 jul 2025]; 18(7):2029-36. Disponível em: https://www.scielo.br/j/csc/a/vHsXdrrnkn6qTnkLkGsFJbr/?format=pdf&lang=pt
4. Feuerwerker LCM, Bertussi DC, Merhy EE, organizadores. Avaliação compartilhada do cuidado em saúde: surpreendendo o instituído nas redes [Internet]. Rio de Janeiro: Hexis; 2016 [citado em 11 jul 2025]. 440 p. (Políticas e cuidados em saúde; n. 2). Disponível em: https://editora.redeunida.org.br/wp-content/uploads/2021/05/Livro-Politicas-e-Cuidados-em-Saude-Livro-2-%E2%80%93-Avaliacao-Compartilhada-do-Cuidado-em-Saude-Surpreendendo-o-Instituido-nas-Redes.pdf
5. Doupis J, Festas G, Tsilivigos C, Efthymiou V, Kokkinos A. smartphone-based technology in diabetes management. Diabetes Ther. [Internet]. 2020 [citado em 11 jul 2025]; 11(6):607-19. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC7048878/pdf/13300_2020_Article_768.pdf
6. World Health Organization. Enhance patient and family engagement for the provision of safer health care. Meeting Report [Internet]. Lisbon, PT: WHO; 2019 [citado em 11 jul 2025]. Disponível em: https://cdn.who.int/media/docs/default-source/patient-safety/pfps/2019_pfps-meeting-report_final.pdf
7. Silva LLT, Lima RC, Silva RI, Poveda VB. Safe care mobile application for surgical patients: development, content validation, and usability validation. Rev Gaúcha Enferm. [Internet]. 2024 [citado em 11 jul 2025]; 45:e2 0230152. Disponível em: https://www.scielo.br/j/rgenf/a/zwxyVXWHdNh6tLP9NWYh9Wk/?format=pdf&lang=en
8. Russ S, Latif Z, Hazell AL, Ogunmuyiwa H, Tapper J, Wachuku-King S, et al. A smartphone app designed to empower patients to contribute toward safer surgical care: community-based evaluation using a participatory approach. JMIR Mhealth Uhealth [Internet]. 2020 [citado em 11 jul 2025]; 8(1):e12859. Disponível em:

https://mhealth.jmir.org/2020/1/e12859/PDF

9. Flint R, Buchanan D, Jamieson S, Cuschieri A, Botros S, Forbes J, et al. The safer prescription of opioids tool (SPOT): a novel clinical decision support digital health platform for opioid conversion in palliative and end of life care - A single-centre pilot study. Int J Environ Res Public Health [Internet]. 2019 [citado em 11 jul 2025]; 16(11):1926. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC6612362/pdf/ijerph-16-01926.pdf

10. Keyworth C, Hart J, Thoong H, Ferguson J, Tully M. A technological innovation to reduce prescribing errors based on implementation intentions: the acceptability and feasibility of MyPrescribe. JMIR Human Factors [Internet]. 2017 [citado em 11 jul 2025]; 4(3):e7153. Disponível em: https://humanfactors.jmir.org/2017/3/e17/PDF

11. Villanueva-Bueno C, Collado-Borrell R, Escudero-Vilaplana V, Revuelta-Herrero JL, Marzal-Alfaro MB, González-Haba E, et al. A smartphone app to improve the safety of patients undergoing treatment with oral antineoplastic agents: 4 years of experience in a university hospital. Front Public Health [Internet]. 2022 [citado em 11 jul 2025]; 10:978783. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC9672512/pdf/fpubh-10-978783.pdf

12. Ehrler F, Siebert J N. PedAMINES: A disruptive mHealth app to tackle paediatric medication errors. Swiss Med Wkly. [Internet]. 2020 [citado em 11 jul 2025]; 150:w20335. Disponível em: https://smw.ch/index.php/smw/article/view/2863/4673

13. Shim JW, Kim CJ, Kim JY, Choi JY, Lee H. The effects of an order-assist mobile application on pediatric anesthesia safety: An observational study. Children (Basel) [Internet]. 2023 [citado em 11 jul 2025]; 10(12):1860. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC10741693/pdf/children-10-01860.pdf

14. Holden RJ, Campbell NL, Abebe E, Clark DO, Ferguson D, Bodke K, et al. Usability and feasibility of consumer-facing technology to reduce unsafe medication use by older adults. Res Social Admin Pharm. [Internet]. 2020 [citado em 11 jul 2025]; 16(1):54-61. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC6710164/pdf/nihms-1023863.pdf

15. Hameed BZ, Shah M, Naik N, Reddy SJ, Somani BK. Use of ureteric stent related mobile phone application (UROSTENTZ App) in COVID-19 for improving patient communication and safety: a prospective pilot study from a university hospital. Cent European J Urol. [Internet]. 2021 [citado em 11 jul 2025]; 74(1):51-6. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC8097645/pdf/CEJU-74-0328.pdf

16. Ward M, Ní SÉ, De Brún A, Korpos C, Hamza M, Burke E, et al. The co-design, implementation and evaluation of a serious board game 'PlayDecide patient safety' to educate junior doctors about patient safety and the importance of reporting safety concerns. BMC Med Educ. [Internet]. 2019 [citado em 11 jul 2025]; 19(1):232. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC6593521/pdf/12909_2019_Article_1655.pdf

17. Dankbaar ME, Richters O, Kalkman CJ, Prins G, Ten Cate OT, van Merrienboer JJ, Schuit SC. Comparative effectiveness of a serious game and an e-module to support patient safety knowledge and awareness. BMC Med Educ. [Internet]. 2017 [citado em 11 jul 2025]; 17(1):30. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC5289006/pdf/12909_2016_Article_836.pdf

18. Weenk M, Bredie SJ, Koeneman M, Hesselink G, van Goor H, van de Belt TH. Continuous monitoring of vital signs in the general ward using wearable devices: randomized controlled trial. J Med Internet Res. [Internet]. 2020 [citado em 11 jul 2025]; 22(6):e15471. Disponível em: https://www.jmir.org/2020/6/e15471/PDF

19. McFarlane DC, Doig AK, Agutter JA, Brewer LM, Syroid ND, Mittu R. Faster clinical response to the onset of adverse events: a wearable metacognitive attention aid for nurse triage of clinical alarms. PLoS One [Internet]. 2018 [citado em 11 jul 2025]; 13(5):e0197157. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC5955574/pdf/pone.0197157.pdf

20. Joshi M, Archer S, Morbi A, Arora S, Kwasnicki R, Ashrafian H, et al. Short-term wearable sensors for in-hospital medical and surgical patients: Mixed methods analysis of patient perspectives. JMIR Perioper Med. [Internet]. 2021 [citado em 11 jul 2025]; 4(1):e18836. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC8103292/pdf/periop_v4i1e18836.pdf

21. Segal G, Segev A, Brom A, Lifshitz Y, Wasserstrum Y, Zimlichman E. Reducing drug prescription errors and adverse drug events by application of a probabilistic, machine-learning based clinical decision support system in an inpatient setting. J Am Med Inform Assoc. [Internet]. 2019 [citado em 11 jul 2025]; 26(12):1560-5. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC7647149/pdf/ocz135.pdf

22. Profetto L, Gherardelli M, Iadanza E. Radio Frequency Identification (RFID) in health care: where are we? A scoping review. Health Technol (Berl) [Internet]. 2022 [citado em 11 jul 2025]; 12(5):879-91. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC9398041/pdf/12553_2022_Article_696.pdf

23. Ou YK, Wu MJ, Ciou WS, Du YC. A clinical trial of the effect of a blood leakage detection device for patients during hemodialysis. Int J Environ Res Public Health [Internet]. 2019 [citado em 11 jul 2025]; 16(13):2388. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC6651021/pdf/ijerph-16-02388.pdf

24. Mahajan A, Heydari K, Powell D. Wearable AI to enhance patient safety and clinical decision-making. NPJ Digit Med. [Internet]. 2025 [citado em 11 jul 2025]; 8:176. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC11929813/pdf/41746_2025_Article_1554.pdf

25. Alotaibi YK, Federico F. The impact of health information technology on patient safety. Saudi Med J. [Internet]. 2017 [citado em 11 jul 2025]; 38(12):1173-80. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC5787626/pdf/SaudiMedJ-38-1173.pdf

26. Lee Y, Latif Z, Hazell AL, Ogunmuyiwa H, Tapper J, Wachuku-King S, Sevdalis N, Ocloo. Evaluation of mobile health applications developed by a tertiary hospital as a tool for quality improvement breakthrough. JMIR Mhealth Uhealth [Internet]. 2015 [citado em 11 jul 2025]; 21(4):299-306. Disponível em: https://mhealth.jmir.org/2020/1/e12859/PDF

27. Jeon B, Jeong B, Jee S, Huang Y, Kim Y, Park GH, et al. A facial recognition mobile app for patient safety and biometric identification: Design, development, and validation. JMIR Mhealth Uhealth [Internet]. 2019 [citado em 11 jul 2025]; 7(4):e11472. Disponível em: https://mhealth.jmir.org/2019/4/e11472/PDF

28. Pierce CE, Vries ST, Bodin-Parssinen S, Härmark L, Tregunno P, Lewis DJ, et al. Recommendations on the use of mobile applications for the collection and communication of pharmaceutical product safety information: lessons from IMI WEB-RADR. Drug Saf. [Internet]. 2019 [citado em 11 jul 2025]; 42(4):477-89. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/pmid/30911975/

29. Cho S, Lee E. Effects of self-education on patient safety via smartphone application for self-efficacy and safety behaviors of inpatients in Korea. Healthc Inform Res. [Internet]. 2021 [citado em 11 jul 2025]; 27(1):48-56. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC7921575/pdf/hir-27-1-48.pdf

30. Aldughayfiq B, Sampalli S. A framework to lower the risk of medication prescribing and dispensing errors: a usability study of an NFC-based mobile application. Int J Med Inform. [Internet]. 2021 [citado em 11 jul 2025]; 153:104509. Disponível em: https://www.sciencedirect.com/science/article/pii/S1386505621001350?via%3Dihub

31. Lee NJ, Ahn S, Lee M. The effects of a mobile application for patient participation to improve patient safety. Health Expect. [Internet]. 2021 [citado em 11 jul 2025]; 25(4):1601-18. Disponível em: https://onlinelibrary.wiley.com/doi/epdf/10.1111/hex.13503

32. Lin CH, Ho TF, Chen HF, Chang HY, Chien JH. Applying healthcare failure mode and effect analysis and the development of a real-time mobile application for modified early warning score notification to improve patient safety during hemodialysis. J Patient Saf. [Internet]. 2022 [citado em 11 jul 2025]; 18(5):475-85. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC9329046/pdf/jps-18-475.pdf

33. Oh JW, Kim JE. Effectiveness of a virtual reality application-based education programme on patient safety management for nursing students: a pre-test-post-test study. Nurs Open [Internet]. 2023 [citado em 11 jul 2025]; 10(12):7622-30. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC10643842/pdf/NOP2-10-7622.pdf