

Transforming Health and Life Sciences with AI-powered Metrology: Tackling Precision and Scalability Hurdles

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AI-POWERED METROLOGY IN HEALTH AND LIFE SCIENCES



TACKLING PRECISION AND SCALABILITY HURDLES

STANDARDIZATION AND INTEROPERABILITY

- Standardization ensures uniform data acquisition, measurement accuracy, and reporting across various healthcare applications. ^(23, 24)
- AI-driven metrology solutions must align with universal protocols to facilitate global adoption and regulatory approval.

GLOBAL STANDARDS FOR AI-DRIVEN METROLOGY

- Standardized AI-powered metrology frameworks improve clinical validation and technology adoption in diverse healthcare settings across the globe. ⁽²⁵⁾

INTEROPERABILITY ACROSS MEDICAL DEVICES AND SYSTEMS

- AI-powered metrology should seamlessly integrate with existing healthcare infrastructure, including electronic health records (EHR), imaging systems, and diagnostic platforms. ^(26,27)

REGULATORY COMPLIANCE AND VALIDATION

- AI-based metrology solutions must adhere to global regulatory frameworks (FDA, ISO) to ensure safety, reliability, and clinical trust. ⁽²⁸⁾
- Compliance with Good Automated Manufacturing Practice (GAMP) and Quality Management Systems (QMS) enhances acceptance in medical and pharmaceutical industries. ^(29,30)

DATA INTEGRITY AND CROSS-PLATFORM COMPATIBILITY

- Ensuring data accuracy, reproducibility, and accessibility across multiple platforms strengthens clinical decision-making and patient outcomes. ^(23,31)
- AI-driven metrology should employ robust encryption and validation mechanisms to maintain data integrity across healthcare networks. ^(32,33)

CONCLUSION

- AI-powered metrology is revolutionizing healthcare by enhancing precision, ensuring scalability, and improving interoperability across medical systems.
- Establishing global standards, regulatory compliance, and seamless integration with existing healthcare technologies will drive reliability and clinical acceptance.
- By addressing these challenges, AI-driven metrology can enable accurate diagnostics, optimize manufacturing, and enhance patient care, ultimately transforming healthcare into a more efficient, data-driven, and patient-centric ecosystem.

REFERENCES

- Bhandari A. Revolutionizing Radiology With Artificial Intelligence. Cureus. 2024 Oct 29;16(10).
- Myszczyńska MA, Ojames PN, Lacoste AM, Neil D, Saffari A, Mead R, Hautbergue GM, Holbrook JD, Ferraiuolo L. Applications of machine learning to diagnosis and treatment of neurodegenerative diseases. Nature reviews neurology. 2020 Aug;16(8):440-56.
- Shivani A, Khan M, Sherani AM, Qayyum MU, Hussain HK. REVOLUTIONIZING HEALTHCARE: THE IMPACT OF ARTIFICIAL INTELLIGENCE ON PATIENT CARE, DIAGNOSIS, AND TREATMENT. JURIHUM: Jurnal Inovasi dan Humaniora. 2024 Feb 28;1(5):779-90.
- Rezay S, R Nakan Kalhori S, Saeedi S. Effectiveness of artificial intelligence for personalized medicine in neoplasms: a systematic review. BioMed research international. 2022;2022(1):7842566.
- Bhamidipaty V, Bhamidipaty DL, Guntoory I, Bhamidipaty KD, Iyengar KP, Botchu B, Botchu R. Revolutionizing Healthcare: The Impact of AI-Powered Sensors. Generative Artificial Intelligence for Biomedical and Smart Health Informatics. 2025 Jan 9:355-73.
- Van der Laak J, Litjens G, Ciompi F. Deep learning in histopathology: the path to the clinic. Nature medicine. 2021 May;27(5):775-84.
- Baurasien BK, Alareefi HS, Almutairi DB, Alanazi MM, Alhassan AH, Alshahrani AD, Almansour SA, Alshagag ZA, Alqattan KM, Alotaibi HM. Medical errors and patient safety: Strategies for reducing errors using artificial intelligence. International journal of health sciences. 2023;7(51):3471-87.
- Stranieri A, Venkatraman S, Minicz J, Zarnegar A, Firmin S, Balasubramanian V, Jelinek HF. Emerging point of care devices and artificial intelligence: Prospects and challenges for public health. Smart Health. 2022 Jun 1;24:100279.
- Mottaghi-Dastjerdi N, Soltany-Rezaee-Rad M. Advancements and Applications of Artificial Intelligence in Pharmaceutical Sciences: A Comprehensive Review. Iranian Journal of Pharmaceutical Research: IJPR. 2024 Oct 15;23(1):e150510.
- Singh H, Nim DK, Randhawa AS, Ahluwalia S. Integrating clinical pharmacology and artificial intelligence: potential benefits, challenges, and role of clinical pharmacologists. Expert review of clinical pharmacology. 2024 Apr 2;17(4):381-91.
- Mumtaz H, Sagib M, Jabeen S, Muneeb M, Mughal W, Sohail H, Salfar M, Mehmood Q, Khan MA, Ismail SM. Exploring alternative approaches to precision medicine through genomics and artificial intelligence—a systematic review. Frontiers in medicine. 2023 Oct 2;10:1227168.
- Mann M, Kumar C, Zeng WF, Strauss MT. Artificial intelligence for proteomics and biomarker discovery. Cell systems. 2021 Aug 18;12(8):759-70.
- Verma D, Singh KR, Yadav AK, Nayak V, Singh J, Solanki PR, Singh RP. Internet of things (IoT) in nano-integrated wearable biosensor devices for healthcare applications. Biosensors and Bioelectronics: X. 2022 Sep 1;11:100153.
- Antony A. Flexible and wearable biosensors: revolutionizing health monitoring. In:Biosensors: Developments, Challenges and Perspectives 2024 Jun 1 (pp. 237-258). Singapore: Springer Nature Singapore.
- Neri L, Oberdier MT, van Abeelen KC, Menghini L, Tumarkin E, Tripathi H, Jaipalli S, Orro A, Paolucci N, Gallili I, Dall'Olio M. Electrocardiogram monitoring wearable devices and artificial-intelligence-enabled diagnostic capabilities: a review. Sensors. 2023 May 16;23(10):4805.
- Raika AS, Kumar P, Raika GV, Somnache SN. Advances and challenges in IoT-based smart drug delivery systems: a comprehensive review. Applied System Innovation. 2023 Jun 27;6(4):62.
- Alzajet E, Combert-Labedens M, Javitz H, Yuksele D, Perez-Amparan E, Camacho L, Kiss O, de Zambotti M, Sattari N, Alejandro-Pena A, Zhang J. Menstrual Cycle Variations in Wearable-Detected Finger Temperature and Heart Rate, But Not in Sleep Metrics, in Young and Middle Individuals. Journal of biological rhythms. 2024 Oct;39(5):395-412.
- Vashist S, Luong J. Wearable technologies for personalized mobile healthcare monitoring and management. Wearable Technology in Medicine and Health Care. 2018 Jul 26:235.
- Sadee W, Wang D, Hartmann K, Toland AE. Pharmacogenomics: driving personalized medicine. Pharmacological reviews. 2023 Jul 1;75(4):789-814.
- Dixon D, Sattar H, Moros N, Kesireddy SR, Ahsan H, Lakkimsetti M, Fatima M, Doshi D, Sadhu K, Hassan MJ, Dixon D. Unveiling the influence of AI predictive analytics on patient outcomes: a comprehensive narrative review. Cureus. 2024 May 9:16(5).
- Wen Z, Wang S, Yang DM, Xie Y, Chen M, Bishop J, Xiao G. Deep learning in digital pathology for personalized treatment plans of cancer patients. In:Seminars in diagnostic pathology 2023 Mar 1 (Vol. 40, No. 2, pp. 109-119). WB Saunders.
- Ismail Y, Voleti VK. A Review on Usage of Artificial Intelligence for Early Detection and Management of Alzheimer's Disease. Journal of Pharma Insights and Research. 2024 Oct 4;2(5):007-13.
- Rajpurkar P, Chen E, Banerjee O, Topol EJ. AI in health and medicine. Nature medicine. 2022 Jan;28(1):31-8.
- Hoc Group on Application of AI Technologies. Artificial intelligence in healthcare: Directions of standardization. In:Handbook of Artificial Intelligence in Healthcare: Vol 2: Practicalities and Prospects 2021 Nov 27 (pp. 231-257). Cham: Springer International Publishing.
- Jacob C, Brasier N, Laurenzi E, Heuss S, Mougiakakou SG, Çöltekin A, Peter MK. AI for IMPACTS Framework for Evaluating the Long-Term Real-World Impacts of AI-Powered Clinician Tools: Systematic Review and Narrative Synthesis. Journal of Medical Internet Research. 2025 Feb 5;27:e67485.
- Khang A, editor. Driving Smart Medical Diagnosis Through AI-Powered Technologies and Applications. IGI Global; 2024 Feb 26.
- Rath KC, Khang A, Rath SK, Satapathy N, Satapathy SK, Kar S. Artificial intelligence (AI)-enabled technology in medicine—advancing holistic healthcare monitoring and control systems. In:Computer Vision and AI-Integrated IoT Technologies in the Medical Ecosystem 2024 (pp. 87-108). CRC Press.
- Verma SJ, Baldi A. Evidence-based recommendations for comprehensive regulatory guidelines in medical devices: the imperative for global harmonization. Naunyn-Schmiedeberg's Archives of Pharmacology. 2025 Feb 5:1-5.
- Pedro F, Veiga F, Mascarenhas-Melo F. Impact of GAMP 5, data integrity and QbD on quality assurance in the pharmaceutical industry: How obvious is it?. Drug Discovery Today. 2023 Nov 1;28(11):103759.
- Overgaard SM, Graham MG, Brereton T, Perinca MJ, Halamka JD, Vidal DE, Economou-Zavlanos NJ. Implementing quality management systems to close the AI translation gap and facilitate safe, ethical, and effective health AI solutions. NPJ digital medicine. 2023 Nov 25;6(1):218.
- Vekaterina K. Challenges and opportunities for AI in healthcare. Int J Law Policy. 2024;2:11-5.
- Rai HM, Tsou D, Dairakeo Y. Metahospital: Implementing robust data security measures for an AI-driven medical diagnosis system. Procedia Computer Science. 2024 Jan 1;241:476-81.
- Bala I, Pindoo I, Mijwil MM, Abotaleb M, Yundong W. Ensuring security and privacy in Healthcare Systems: a Review Exploring challenges, solutions, Future trends, and the practical applications of Artificial Intelligence. Jordan Medical Journal. 2024 Jul 15:58(3).