

Navigating the Pulse: The Evolution and Impact of Pulse Diagnosis Technology in Traditional Chinese Medicine and its Integration with Modern Healthcare

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ABSTRACT

This review article explores the evolution and integration of pulse diagnosis technology rooted in Traditional Chinese Medicine (TCM) within modern healthcare systems. Tracing its origins back over two millennia, traditional pulse diagnosis involves expert practitioners palpating the radial artery to assess internal organ health and Qi balance. While historically reliant on practitioner skill, recent technological advances have introduced digital pulse diagnostic devices employing sensors, artificial intelligence, and machine learning to enhance diagnostic precision and personalize treatment. These innovations bridge the gap between ancient TCM practices and contemporary medical paradigms, improving patient outcomes and diagnostic accuracy. The paper highlights the benefits of integrating pulse diagnosis technology, noting its role in managing chronic diseases, enabling preventive strategies, and fostering patient satisfaction through personalized therapeutic approaches. Clinical studies demonstrate significant improvements in treatment effectiveness when pulse diagnosis guides interventions, underscoring its capacity to detect subtle physiological imbalances often missed by conventional methods. It also addresses social determinants influencing the adoption and effectiveness of these technologies, including economic stability, education, community context, and healthcare access, especially in rural and low-income regions.

Challenges such as limited technological infrastructure, regulatory barriers, disparities in health literacy, and ethical concerns around data privacy and security are examined. The need for standardized diagnostic procedures, robust data protection measures, and supportive policy frameworks is emphasized to facilitate broader implementation.

Keywords: Pulse Diagnosis; Traditional Chinese Medicine; Diagnosis Technology

Introduction

Pulse diagnostic technology, rooted in ancient medical practices, has generated renewed interest in the contemporary health landscape as a prominent tool for disease detection and personalized treatment. Its importance is particularly relevant in the context of personalized medicine, where the integration of traditional diagnostic techniques with advanced technology can enhance patient care and tailor treatment strategies to individual needs (Sultana, et al. [1]). The paper explores the evolution and integration of pulse diagnosis technology, rooted in Traditional Chinese Medicine (TCM), with modern healthcare systems. It traces the historical development of pulse diagnosis, from tactile methods that require expert practitioners to advanced digital technologies that employ sensors and artificial intelligence for

enhanced diagnostic accuracy and personalized treatment. The paper highlights benefits such as improved patient outcomes, greater diagnostic precision, and the bridging of traditional and contemporary medical paradigms. Additionally, it examines social determinants such as economic stability, education, community context, and healthcare access that influence the adoption and effectiveness of these technologies. The paper also highlights the challenges in integrating pulse diagnosis technology into modern healthcare systems and concludes with directions for future research.

Evolution of Pulse Diagnosis Technology

The diagnosis of impulses, an integral component of TCM has a rich historical context that dates back to two millennia (Wang, et al. 2011). Traditionally, this diagnostic method involves the qualified

practitioner who palpates the radial artery in various points on the wrist to discern the patient's health conditions by interpreting the qualities of the wrist, which are believed to reflect the internal state of the organs and the balance of the Qi (vital energy), blood and body liquids (Zhang, et al. [2]). The fundamental texts of TCM, such as the Huangdi Neijing (the classic of internal medicine of the Yellow Emperor), elaborate on the philosophical bases and techniques of diagnosis of pulses, establishing a framework that professionals continue to follow (Matos, et al. [3]). Historically, the diagnosis of impulses was performed with a nuanced understanding of over 30 distinct impulses, each related to specific pathological and physiological phenomena. The diagnostic process is heavily reliant on the practitioner's sensitivity and experience, as it necessitates a combination of tactile sensitivity and interpretive skills to discern the subtle nuances of impulses, such as depth, speed, and rhythm (Song, et al. [2,4]). Consequently, training in this methodology is intense, often requiring years to master, reflecting the complexity and significance attributed to the practice within TCM (Bilton, et al. [5]).

During the transition to the twentieth century, the diagnosis of pulse faced challenges stemming from the modernization of medical practices and the influence of Western medicine (Hajar, et al. [6,7]). Chudakova [8] evaluated the development and use of an Automated Pulse Diagnostic Complex (ADPC) device designed in the early 1980s to replicate and objectify the traditional Tibetan medicine practice of pulse diagnosis in Buryatia, a region in Southeastern Siberia. He noted that over time, the device could not fully automate or replace the skills of Tibetan medical practitioners (emchi). Over the last two decades, technology has been adapted to incorporate new methodologies, such as the diagnosis of digital pulse, which utilizes sensors and software to analyze the most accurate pulse waveforms (Hemdan, et al. [9-12]). This modern adaptation has not only preserved traditional knowledge but also bridged the gap between ancient practices and contemporary health paradigms (Albahri, et al. [3,13-15]). These devices utilize advanced sensors that capture physiological signals in real-time, enabling continuous monitoring of several pulse attributes, including heart rate variability, amplitudes, and frequencies (Shrivastava, et al. [16,17]). For example, an intelligent bracelet capable of integrating various biometric data can provide information on patients' cardiovascular conditions, effectively bridging the gap between TCM and Western medical practices (Li, et al. [18]).

Recent advances in technology have led to the emergence of automated systems that utilize algorithms to interpret pulse signals, thereby significantly improving evaluation efficiency. In particular, these automated systems employ automatic learning techniques to analyze large sets of pulse characteristics, identifying correlations that may not be evident to professionals who rely solely on manual evaluations (Duan, et al. [7,19,20]). For example, the work of Zhang, et al. [21] highlighted the effectiveness of an automatic learning algorithm that can classify pulse conditions with remarkable precision, achieving performance metrics comparable to those of experienced

doctors. This convergence of traditional experience with AI technology not only enhances the diagnostic capabilities of TCM professionals but also aligns with the global trend towards data-based medical care. More recently, Duan, et al. [19] highlighted the role of AI in enhancing decision-making processes, providing evidence based on real-time analysis of pulse data. This evolution not only supports professionals in their clinical decision-making but also encourages a deeper understanding of the nuanced relationship between the characteristics of the pulse and holistic health conditions, as described in traditional texts.

Benefits of Using Pulse Diagnosis Technology

In recent years, various implementations of pulse diagnostic technology in different countries have been observed, reflecting a growing recognition of its potential impact on health monitoring. Innovations in digital health applications and portable devices have expanded the accessibility and precision of pulse diagnosis, allowing more timely interventions. Countries like China and India have integrated the diagnosis of pulse in their health systems as part of TCM and Ayurveda, respectively, while Western nations are increasingly exploring these methods, such as complementary approaches for modern diagnostic practices (Gautam, et al. [22-24]). The convergence of traditional knowledge and contemporary technology illustrates a change of paradigm towards the holistic care of the patient, highlighting the diagnosis of pulse not only as a diagnostic tool but also as a fundamental component in the management of chronic diseases and promoting preventive strategies of medical care (Narayan, et al. [25,26]).

The integration of impulse diagnosis technology in modern healthcare practices enhances patient outcomes by fostering a more comprehensive understanding of individual health conditions (Velik [27]). The objective data provided by these devices can facilitate improved treatment decisions and enable the customization of therapeutic interventions based on the specific patient's diagnostic results. Zhang, et al. [2] argued that patients who receive TCM treatments supported by advanced impulse diagnosis technologies report greater satisfaction due to the greater accuracy in diagnosis and a more personalized therapeutic approach. The application of pulse diagnostic technology in clinical environments exemplifies a crucial intersection of traditional practices and modern health solutions. By employing digitized systems and intelligent technologies, professionals are better equipped to diagnose and manage various health conditions, ultimately improving patient results and increasing the integration of TCM into contemporary clinical practice (Lu, et al. [28,29]). The effectiveness of pulse diagnosis in improving patient outcomes is increasingly supported by contemporary research, demonstrating a marked improvement in diagnostic precision, treatment effectiveness, and patient overall satisfaction in the context of TCM (Tang, et al. [30,31]).

For instance, a study by Bilton [32] examined the correlation between the diagnosis of pulse and clinical results in a cohort of patients with chronic pain. They indicated that practitioners who use

the diagnosis of pulse in conjunction with standardized evaluation scales have been able to achieve more personalized treatment patterns. Patients receiving therapies guided by the diagnosis of pulse have shown a significant decrease in pain levels, thus illustrating an improvement in the effectiveness of treatment. This suggests that the diagnosis of impulse not only facilitates a more nuanced understanding of the body's functional state, but also aligns interventions more closely with the individual needs of patients, thereby promoting optimal healing outcomes. Research carried out by Zhang, et al. [33] also supported these claims, where they employed an experimental design in which the effectiveness of pulse diagnosis was evaluated in a double-blind controlled trial. The study focused on individuals diagnosed with gastrointestinal disorders, where pulse diagnosis guided the selection of plant-based treatments. The results indicated that patients whose treatments have been adapted according to the diagnosis of pulse have experienced greater resolution of symptoms and an improvement in digestive function compared to those who receive generic treatment protocols.

The authors noted that this increase in the accuracy of the diagnosis can be attributed to the capacity of pulse diagnosis to detect subtle physiological imbalances that are often overlooked by conventional diagnostic methods. Beyond the field of individualized treatment, the integration of pulse diagnostic technology into the broader context of modern health practices has the potential for synergy. Using tools such as portable biosensors and mobile health applications that can capture real-time impulse data, healthcare providers are positioned to collect extensive data sets that can validate and refine pulse diagnostic methods (Chen, et al. [20,34,35]). The convergence of traditional diagnostic skills with advanced technologies presents a unique opportunity to enhance clinical practice by promoting an interprofessional approach that respects the historical roots of TCM while incorporating modern scientific rigour (Guo, et al., [28,36]).

Social Determinants

Despite the promising advances in pulse diagnostic technology, the effectiveness and accessibility of these diagnostic methods are significantly influenced by a multitude of social determinants of health, encompassing various non-medical factors that substantially impact health outcomes and the effectiveness of healthcare systems worldwide. These determinants are generally classified into several key domains: economic stability, education, social and community context, and access to health in rural areas. Economic stability refers to the financial resources available to people and communities, which can have a profound impact on their ability to access medical care services and utilize innovative medical technologies, such as pulse diagnostic devices. For example, low-income populations may not prioritize spending on advanced diagnostic tools, which can potentially exacerbate health disparities (Craig, et al. [37]). Additionally, it is crucial to address the economic barriers associated with impulse diagnosis technologies. Price models, reimbursement policies and

cost-sharing mechanisms can have a significant impact on access and use. Governments must involve interested parties, including healthcare professionals, technology developers, and patient advocacy groups, to develop sustainable financing strategies.

Innovative reimbursement policies, such as the pay-for-performance models that reward positive health results rather than the simple provision of the service, could encourage the adoption of these technologies in practice (Junaid, et al. [38-40]). Education plays a fundamental role in literacy in health, which is the ability to understand and use health information effectively. Populations with greater educational achievements are generally better equipped to adopt new technologies, such as pulse diagnosis, understand their implications, and advocate for their use in preventive measures and treatment plans (Coughlin, et al. [41]). On the contrary, educational deficits can hinder the understanding of the importance of such technologies and their applications in personalized medicine, ultimately limiting their general effectiveness in the detection and management of diseases (Shashid, et al. [42,43]). The social and community context also shapes attitudes towards health and wellbeing. Communities with strong social networks and support systems may exhibit higher rates of adoption of health innovations, as collective standards and values can promote acceptance and encourage proactive health-seeking behaviours (Kim, et al. [44]).

However, in communities plagued by stigma, distrust, or a lack of cohesion, the adoption of advanced biomedical technologies, including pulse diagnosis, can encounter resistance. Additionally, these social dynamics can influence how communities share health-related knowledge, which directly impacts the perceived relevance and acceptability of the pulse diagnosis (Prentice, et al. [45,46]). Access to medical care remains a crucial determinant, which encompasses the availability and affordability of services, as well as the presence of adequate medical care infrastructure. In countries where there is a shortage of health professionals or technological resources, the deployment of pulse diagnostic technology may be severely restricted (Maita, et al. [47]). For example, rural or underserved areas may lack the necessary technological support to implement advanced diagnostic tools, thereby widening the gap in health equity (Tagne, et al. [48]). Additionally, insurance and reimbursement coverage policies can hinder the integration of such technologies into standard care practices, particularly in regions where economic inequality persists (Coombs, et al. [49,50]).

Challenges Faced and Considerations when Implementing Pulse Diagnosis Technology

Technological Infrastructure

The relationship between technological infrastructure and the effectiveness of pulse diagnostic technology is essential in understanding its implementation and operational capacity in various geographic contexts. Technological infrastructure encompasses not only the

hardware and software necessary for deploying medical technologies, but also human resources, training systems, and regulatory managers that support these innovations. Disparities in these infrastructures can considerably affect the applicability and success of pulse diagnostic technologies, particularly in contrasting high-income and low-income regions [Narayan, et al. [15,25]]. In high-income countries, a robust technological infrastructure supports the development and integration of advanced medical technologies into healthcare practices. For example, nations like the US and Germany have access to high-speed networks, sophisticated medical devices, and well-trained staff, all of which contribute to the increased efficiency of pulse diagnostic technology. Here, the implementation of pulse diagnostic devices is accompanied by a substantial investment in research and development, resulting in innovation and continuous improvement of these technologies [Narayan, et al. [25]]. In such environments, diagnosis of pulse can be effectively deployed not only for the detection of diseases but also for personalized treatment plans, which are dynamically adjusted in accordance with the evaluations of current patients.

The accessibility of complementary technologies, such as data analysis and artificial intelligence, further enhances the effectiveness of pulse diagnostics, enabling precise health monitoring and timely interventions [Rachmad [51]]. Conversely, in low-income countries, technological infrastructure often faces considerable challenges that hinder the effective deployment of pulse diagnostic technologies. Limited access to reliable electricity and the Internet, insufficient funding for health systems, and a shortage of trained medical staff create a landscape where the potential for pulse diagnostics remains largely unfulfilled. For example, in regions with an underdeveloped health infrastructure, such as certain parts of sub-Saharan Africa, the existence of sophisticated diagnostic technologies, including pulse oximeters, may not be enough if the necessary support systems are missing [Olatunji, et al. [15]]. The lack of qualified practitioners, in particular, undermines essential training programs that aim to maximize the effectiveness of these technologies, leading to ineffective use or misinterpretation of diagnostic results.

Regulatory Environment and Promotion of Innovation

Regulatory environments in low-income countries could also hinder the successful implementation of pulse diagnostic technologies. Increased bureaucracy, a lack of government support, and fluctuating health policies contribute to a climate of uncertainty that discourages investment and innovation. These factors collectively hinder access to advanced diagnostic solutions that could significantly improve disease detection and personalized treatment in such regions [Monlezun, et al. [52,53]]. Studies illustrated that the government play a critical role in the successful adoption of pulse diagnosis technologies, where it provides full support for encompassing the complete development of the workforce, the commitment of stakeholders and the reform of policies aimed at promoting access to fair health care [Frost, et al. [15,25,54]]. Policies that prioritize innovation in medical

technologies can stimulate investments and research in the diagnosis of impulses, promoting progress and leading to effective applications. For example, countries that actively support digital health initiatives through subsidies and tax incentives will see a greater proliferation of diagnostic technologies within their health systems [Ahmed, et al. [55,56]].

In contrast, nations without these support policies face barriers, limiting the adoption of technology to urban areas with sophisticated infrastructures, thereby neglecting rural populations. The disparity in accessing diagnosis of impulses therefore reflects wider social inequalities, as individuals in resource-limited contexts are often left without access to cutting-edge diagnostic tools [Wamble, et al. [57]]. In addition, the variations in regulatory environments between nations highlight the consequential nature of governance in modeling access to healthcare. For example, the rapid approval processes seen in countries such as Singapore, which employ a regulatory sandbox approach, significantly contrast with the prolonged timing of regulatory agencies in other regions, such as the US [Wang, et al. 2021]. These delays can exacerbate the inequalities faced by lower socio-economic populations that may not benefit from the latest technological advancements.

Education

The accessibility of educational resources tailor-made for the diagnosis of impulses also varies between nations, further clarifying the link between education, health literacy, and the effective use of these technologies. Countries with strong public health education systems, such as the Netherlands, often provide global health literacy programs that include training on emerging health technologies. This proactive approach ensures that populations are not only aware of these innovations but are also equipped to understand their implications, leading to improved health outcomes [Brug, et al. [58,59]]. Further, in high-income countries such as Germany and the US, where health literacy levels are relatively high, there is a greater understanding and use of technologically advanced health methods, including the diagnosis of impulses. In these nations, public health initiatives and educational programs often promote greater awareness and comfort with these technologies, thus facilitating the early detection of diseases through the diagnostics of impulses [Menne, et al. [60]]. For example, educational awareness programs have successfully integrated the formation of impulse diagnosis within doctors and community health initiatives.

This integration has shown that educating the population on the relevance and functioning of impulse diagnosis not only demystifies technology but also empowers people to participate proactively in their health management [Hahn [61]]. On the contrary, in low-income countries such as India and Nigeria, disparities in health education and literacy significantly influence the use of impulse diagnosis technologies [Chidambaram, et al. [62-64]]. In regions with lower school

performance and limited access to health information, the understanding and use of these technologies present significant challenges. In India, despite the flourishing growth of mobile health technologies, populations in rural areas often lack the knowledge necessary to engage effectively with these innovations [Manapurath, et al. [65]]. As demonstrated in various studies, individuals with inadequate health literacy are more likely to be wary of new health technologies, which can exacerbate existing health inequalities and hinder disease detection efforts [Chidambaram, et al. [62,66,67]].

Ethical Considerations

In addition to the technical and standardization challenges, concerns relating to diagnostic inaccuracies increase the ethical implications that must be addressed before widespread adoption. Imprecise diagnoses derived from impulse technology can stem not only from technical limitations but also from the insufficient training of healthcare professionals in the use of these advanced diagnostic tools. Kumar, et al. [68] highlighted significant security issues surrounding the Healthcare Internet of Things (H-IoT), which further complicate the reliability of diagnostic results. As the pulse diagnosis devices are connected more and more to wider networks, vulnerabilities in data security and integrity become important concerns. Questions such as data violations or unauthorized access to patient health information can seriously undermine the patients' trust and violate ethical standards regarding confidentiality and informed consent [Shojaei, et al. [69,70]]. Patient confidentiality is of paramount importance in any healthcare facility, and the digitization inherent in pulse diagnostic technology amplifies the urgency of addressing this concern. As health data becomes increasingly scanned and stored on cloud-based platforms, the risk of unauthorized access or data breaches becomes a tangible threat [Alamri, et al. [13,71,72]].

In addition, since pulse diagnosis is based on biometric data, which can serve as a unique identifier, ethical imperatives compel healthcare providers to develop robust protocols to mitigate the risks associated with data leaks or improper use. Chengoden, et al. [73] argued that in similar contexts involving emerging technologies, such as metaverses, confidentiality should be a priority to establish the confidence and commitment of patients. This confidence is crucial as the acceptance of new technologies in healthcare is based on patients' perception of the safeguarding of their privacy. Data security extends conversation beyond simple confidentiality to encompass technological frameworks that store and process patient data. The growing sophistication of cyber-menaces not only poses challenges in maintaining the integrity of health information but also in ensuring compliance with regulatory standards such as the Portability and Responsibility Act (HIPAA) in the United States or the General Data Protection Regulations (GDPR) in Europe [Aldosari, et al. [74,75]].

As pulse diagnostic technology develops, it becomes essential for healthcare providers and technology developers to implement strict safety measures, including end-to-end encryption, secure authentication

mechanisms, and regular safety audits. Without addressing these concerns, the continued adoption of pulse diagnostic technology is likely to undermine the fundamental principles of the patient-practitioner relationship [Ngesa, et al. [69,76]]. Despite these obstacles, the incorporation of pulse diagnosis into contemporary medical procedures presents an opportunity to enhance overall care quality, while also validating and operationalizing traditional knowledge. By acknowledging the advantages of both Western and TCM, a more inclusive healthcare setting can be created, allowing patients to benefit from a variety of treatment options and encouraging a more comprehensive approach to health and wellbeing. Adopting an interdisciplinary and integrated approach could greatly influence the benefits of modern health and patient experiences as pulse diagnostic technology advances.

Conclusion

Given the growing prevalence of chronic conditions such as diabetes, hypertension, and autoimmune diseases, the integration of pulse diagnosis into a modern health framework can clarify personalized treatment approaches and improve patient outcomes [Dhawan, et al. [77,78]]. Several key areas warrant further exploration and in-depth development. First, the integration of advanced sensor technology into pulse diagnosis presents a significant opportunity to refine traditional methods. Electronic diagnostic devices with current pulses, although effective, can benefit from the incorporation of artificial intelligence and automatic learning algorithms. These technologies can analyze large data sets, dislocated on pulse waveforms and complete patient stories, to identify models that a practitioner might miss [Lu, et al. [2,28]]. This progress can facilitate more precise diagnostics and treatment plans by correlating specific pulse characteristics with clinical results, which ultimately stimulates an approach based on TCM evidence. Perhaps longitudinal research could be conducted to assess the effectiveness of pulse diagnosis technology in treating various chronic illnesses.

Patients' outcomes should be tracked over time by these studies, especially in situations where conventional Western methods have proven ineffective. Researchers can convincingly demonstrate the effects of pulse diagnosis interventions in randomized controlled trials, measuring their impact in combination with conventional treatment protocols. These data will be essential in promoting and gaining broad acceptance to incorporate pulse diagnosis technology in traditional medical practice, especially in countries and rural areas where such technology is not well-received. The creation of a standardized procedure for pulse diagnosis is another promising approach. Treatment outcomes may vary depending on how practitioners interpret their impulses. The accuracy and efficiency of pulse diagnosis can be increased by reaching a consensus on classification criteria for impulses that are backed by clinical practice guidelines and empirical data. Working together, TCM specialists and clinical researchers can help develop standardized measurement instruments that will support the reliability of pulse diagnosis in a multidisciplinary setting.

Finally, the rise in telemedicine has created a unique platform for applying pulse diagnosis (Bokolo, et al. [79-81]). As remote consultations for medical care become more common, practitioners can utilize digital platforms as tools to monitor patients' vital signs. Devices that can record and transmit physiological data in real-time may enhance the diagnostic process by enabling medical professionals to continuously monitor patients' health and adjust treatment plans as needed. Future studies should examine patients' dedication and support for remote pulse diagnosis, considering the potential benefits of this technology for improved communication and ongoing care [82,83].

References

- Sultana S, Hriday M S H, Haque R, Das M (2025) Health monitoring through wearables: A systematic review of innovations in cardiovascular disease detection and prevention. *Strategic Data Management & Innovation* 2(1): 96-115.
- Zhang S, Wang W, Pi X, He Z, Liu H (2023) Advances in the application of traditional Chinese medicine using artificial intelligence: a review. *The American journal of Chinese medicine* 51(5): 1067-1083.
- Matos L C, Machado J P, Monteiro F J, Greten H J (2021) Understanding Traditional Chinese Medicine Therapeutics: An Overview of the Basics and Clinical Applications. *Healthcare* 9(3): 1-32.
- Song X (2024) Chinese medicine's socio-cultural historical basis and its application in modern society. *International Conference on Engineering Technology and Medicine Research (ICETMR 2024)*.
- Bilton K, Hammer L, Zaslawski L (2013) Contemporary Chinese Pulse Diagnosis: A Modern Interpretation of an Ancient and Traditional Method. *Journal of Acupuncture and Meridian Studies* 6(5): 227-233.
- Hajar R (2018) The Pulse from Ancient to Modern Medicine: Part 3. *Heart Views* 19(3): 117-120.
- Leung Y A, Guan B, Chen S, Chan H, Kong K, et al. (2021) Artificial intelligence meets traditional Chinese medicine: a bridge to opening the magic box of sphygmopalpation for pulse pattern recognition. *Digital Chinese Medicine* 4(1): 1-8.
- Chudakova T (2015) The Pulse in the Machine: Automating Tibetan Diagnostic Palpation in Postsocialist Russia. *Comparative Studies in Society and History* 57(2): 407-434.
- Hemdan M, Ali M A, Doghish A S, Mageed S S A, Elazab I M, et al. (2024) Innovations in Biosensor Technologies for Healthcare Diagnostics and Therapeutic Drug Monitoring: Applications, Recent Progress, and Future Research Challenges. *Sensors* 24(16): 5143.
- Kim K B, Baek H J (2023) Photoplethysmography in wearable devices: a comprehensive review of technological advances, current challenges, and future directions. *Electronics* 12(13): 2923.
- Rasmi Y, Li X, Khan J, Ozer T, Choi J R (2021) Emerging point-of-care biosensors for rapid diagnosis of COVID-19: current progress, challenges, and future prospects. *Analytical and Bioanalytical Chemistry* 413(16): 4137-4159.
- Yogev D, Goldberg T, Arami A, Tejman Yarden S, Winkler T E, et al. (2023) Current state of the art and future directions for implantable sensors in medical technology: Clinical needs and engineering challenges. *APL Bio-engineering* 7(3): 031506.
- Alamri A, Bawazeer A, Almotiri T, Alharbi S, Alshammari D, et al. (2020) Healthcare digitization and patient confidentiality. *International Journal of Health Sciences* 4(S1): 105-113.
- Ming D K, Sangkaew S, Chanh H Q, Nhat P T, Yacoub S, et al. (2020) Continuous physiological monitoring using wearable technology to inform individual management of infectious diseases, public health and outbreak responses. *International Journal of Infectious Diseases* 96: 648-654.
- Olatunji A O, Olaboye J A, Maha C C, Kolawole T O, Abdul S (2024) Revolutionizing infectious disease management in low-resource settings: The impact of rapid diagnostic technologies and portable devices. *International Journal of Applied Research in Social Sciences* 6(7): 1417-1432.
- Shrivastava S, Trung T Q, Lee N E (2020) Recent progress, challenges, and prospects of fully integrated mobile and wearable point-of-care testing systems for self-testing. *Chemical Society Reviews* 49(6): 1812-1866.
- Soh P J, Vandenbosch G A, Mercuri M, Schreurs D M P (2015) Wearable wireless health monitoring: Current developments, challenges, and future trends. *IEEE Microwave Magazine* 16(4): 55-70.
- Li W, Ge X, Liu S, Xu L, Zhai X, et al. (2024) Opportunities and challenges of traditional Chinese medicine doctors in the era of artificial intelligence. *Frontiers in medicine* 10: 1336175.
- Duan Y Y, Liu P R, Huo T T, Liu S X, Ye S, et al. (2021) Application and development of intelligent medicine in traditional Chinese medicine. *Current Medical Science* 41(6): 1116-1122.
- Zhu X, Wang F, Mao J, Huang Y, Zhou P, et al. (2023) A Protocol for Digitalized Collection of Traditional Chinese Medicine (TCM) Pulse Information Using Bionic Pulse Diagnosis Equipment. *Phenomics* 3(5): 519-534.
- Zhang H, Ni W, Li J, Zhang J (2020) Artificial intelligence-based traditional Chinese medicine assistive diagnostic system: validation study. *JMIR Medical Informatics* 8(6): e17608.
- Gautam N, Salas C, Stafford R, Lu Y, Kim G, et al. (2022) Integrating Evidence-Based Traditional Asian Medicine and Western Medicine: Highlights from the Evidence-Based Traditional Asian Medicine Conference at the Stanford Center for Asian Health Research and Education. *Journal of Asian Health* 2(1): 1-7.
- Patwardhan B, Warude D, Pushpangadan P, Bhatt N (2005) Ayurveda and traditional Chinese medicine: a comparative overview. *Evidence-based Complementary and Alternative Medicine* 2(4): 465-473.
- Rizvi S A A, Einstein G P, Tulp O L, Sainvil F, Branly R (2022) Introduction to Traditional Medicine and Their Role in Prevention and Treatment of Emerging and Re-Emerging Diseases. *Biomolecules* 12(10): 1442.
- Narayan S M, Chung M K, Adedinsewo D, Brant L C C, Davis L L, et al. (2025) Access to digital health technologies: personalized framework and global perspectives. *Nature Reviews Cardiology*.
- Restrepo T M, Araque O, Sanchez Echeverri L A (2024) Technological advances in the diagnosis of cardiovascular disease: a public health strategy. *International Journal of Environmental Research and Public Health* 21(8): 1083.
- Velik R (2015) An objective review of the technological developments for radial pulse diagnosis in Traditional Chinese Medicine. *European Journal of Integrative Medicine* 7(4): 321-331.
- Lu L, Lu T, Tian C, Zhang X (2024) AI: Bridging Ancient Wisdom and Modern Innovation in Traditional Chinese Medicine. *JMIR Medical Informatics* 12: e58491.
- Tang A C, Chung J W, Wong T K (2012b) Validation of a novel traditional Chinese medicine pulse diagnostic model using an artificial neural network. *Evidence-based Complementary and Alternative Medicine* 2012: 685094.
- Tang A C, Chung J W, Wong T K (2012a) Digitalizing traditional Chinese medicine pulse diagnosis with artificial neural network. *Telemedicine Journal and e-health* 18(6): 446-453.

31. Wang H, Cheng Y (2005) A quantitative system for pulse diagnosis in Traditional Chinese Medicine. *IEEE Engineering in Medicine and Biology Society Annual Conference 2005*: 5676-5679.
32. Bilton K, Zaslawski C (2016) Reliability of manual pulse diagnosis methods in traditional East Asian medicine: a systematic narrative literature review. *The Journal of Alternative and Complementary Medicine* 22(8): 599-609.
33. Zhang Q, Bai C, Yang L T, Chen Z, Li P, et al. (2019) A unified smart Chinese medicine framework for healthcare and medical services. *IEEE/ACM Transactions on Computational Biology and Bioinformatics* 18(3): 882-890.
34. Chen H, Lim C E D (2025) Advancing global healthcare: Methodological innovations for integrating Chinese medicine. *Journal of Traditional Chinese Medical Sciences* 12(2): 201-209.
35. Vo D K, Trinh K T L (2024) Advances in Wearable Biosensors for Healthcare: Current Trends, Applications, and Future Perspectives. *Biosensors* 14(11): 560.
36. Guo R, Wang Y, Yan H, Yan J, Yuan F, et al. (2015) Analysis and Recognition of Traditional Chinese Medicine Pulse Based on the Hilbert-Huang Transform and Random Forest in Patients with Coronary Heart Disease. *Evidence-based Complementary and Alternative Medicine* 2015: 895749.
37. Craig K J T, Fusco N, Gunnarsdottir T, Chamberland L, Snowdon J L, et al. (2021) Leveraging data and digital health technologies to assess and impact social determinants of health (SDoH): a state-of-the-art literature review. *Online Journal of Public Health Informatics* 13(3): E14.
38. Junaid S B, Imam A A, Balogun A O, De Silva L C, Surakat Y A, et al. (2022) Recent Advancements in Emerging Technologies for Healthcare Management Systems: A Survey. *Healthcare* 10(10): 1940.
39. Khanna N N, Maindarkar M A, Viswanathan V, Fernandes J F E, Paul S, et al. (2022) Economics of Artificial Intelligence in Healthcare: Diagnosis vs. Treatment. *Healthcare* 10(12): 2493.
40. Rodriguez Manzano J, Subramaniam S, Uchea C, Szostak Lipowicz K M, Freeman J, et al. (2024) Innovative diagnostic technologies: Navigating regulatory frameworks through advances, challenges, and future prospects. *The Lancet Digital Health* 6(12): e934-e943.
41. Coughlin S S, Vernon M, Hatzigeorgiou C, George V (2020) Health Literacy, Social Determinants of Health, and Disease Prevention and Control. *Journal of Environment and Health Sciences* 6(1): 3061.
42. Shahid R, Shoker M, Chu L M, Frehlick R, Ward H, et al. (2022) Impact of low health literacy on patients' health outcomes: a multicenter cohort study. *BMC Health Services Research* 22(1): 1-9.
43. (2010) US. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. *National Action Plan to Improve Health Literacy*. Washington.
44. Kim H, Kim J Y, Park Y J, Park Y B (2013) Development of pulse diagnostic devices in Korea. *Integrative Medicine Research* 2(1): 7-17.
45. Prentice K R, Beitelshes M, Hill A, Jones C H (2024) Defining health equity: A modern U.S. perspective. *iScience* 27(12): 111326.
46. Short S E, Mollborn S (2015) Social Determinants and Health Behaviors: Conceptual Frames and Empirical Advances. *Current opinion in psychology* 5: 78-84.
47. Maita K C, Maniaci M J, Haider C R, Avila F R, Torres Guzman R A, et al. (2024) The Impact of Digital Health Solutions on Bridging the Health Care Gap in Rural Areas: A Scoping Review. *The Permanente Journal* 28(3): 130-143.
48. Tagne J F, Burns K, O Brein T, Chapman W, Cornell P, et al. (2025) Challenges for remote patient monitoring programs in rural and regional areas: a qualitative study. *BMC Health Services Research* 25(1): 374.
49. Coombs N C, Campbell D G, Carangi J (2022) A qualitative study of rural healthcare providers' views of social, cultural, and programmatic barriers to healthcare access. *BMC Health Services Research* 22(1): 438.
50. Gizaw Z, Astale T, Kassie G M (2022) What improves access to primary healthcare services in rural communities? A systematic review. *BMC Primary Care* 23(1): 313.
51. Rachmad Y E (2021) Future Pulse: Artificial Intelligence-Driven Diagnostics in Digital Health. *Book of Primary Care & Community Health Publishing*.
52. Monlezun D J, Omutoko L, Oduor P, Kokonya D, Rayel J, et al. (2025) Digitalization of health care in low- and middle-income countries. *Bulletin of the World Health Organization* 103(2): 148-154.
53. Nasir N, Molyneux S, Were F, Aderoba A, Fuller S S (2023) Medical device regulation and oversight in African countries: A scoping review of literature and development of a conceptual framework. *BMJ Global Health* 8(8): e012308.
54. Frost D, Mahmud M, Kaiser M S, Musoke D, Henry P, et al. (2021) Innovative approaches to strengthening health systems in low- and middle-income countries: Current models, developments, and challenges. *Health Policy and Technology* 10(4): 100567.
55. Ahmed M M, Okesanya O J, Olaleke N O, Adigun O A, Adebayo U O, et al. (2025) Integrating Digital Health Innovations to Achieve Universal Health Coverage: Promoting Health Outcomes and Quality Through Global Public Health Equity. *Healthcare* 13(9): 1060.
56. Brahmabhatt D H, Ross H J, Moayed Y (2022) Digital technology application for improved responses to health care challenges: lessons learned from COVID-19. *Canadian Journal of Cardiology* 38(2): 279-291.
57. Wamble D E, Ciarametaro M, Dubois R (2019) The Effect of Medical Technology Innovations on Patient Outcomes, 1990-2015: Results of a Physician Survey. *Journal of Managed Care & Specialty Pharmacy* 25(1): 66-71.
58. Brug J, van Dale D, Lanting L, Kremers S, Veenhof C, et al. (2010) Towards evidence-based, quality-controlled health promotion: the Dutch recognition system for health promotion interventions. *Health Education Research* 25(6): 1100-1106.
59. Vanneste Y T M, Lanting C I, Detmar S B (2022) The Preventive Child and Youth Healthcare Service in the Netherlands: The State of the Art and Challenges Ahead. *International journal of environmental research and public health* 19(14): 8736.
60. Menne F, Grimmer T, Schipke C G (2023) Comparison of Diagnostic Routines for Suspected Alzheimer's Disease Patients in U.S.-American and German Primary Care. *Neurodegenerative Disease Management* 13(5): 269-280.
61. Hahn R A, Truman B I (2015) Education Improves Public Health and Promotes Health Equity. *International Journal of Health Services* 45(4): 657-678.
62. Chidambaram S, Jain B, Jain U, Mwavu R, Baru R, et al. (2024) An introduction to digital determinants of health. *PLOS Digital Health* 3(1): e0000346.
63. Egwudo A E, Jegede A O, Oyeniya T A, Ezekwelu N J, Abdu Aguye S N, et al. (2025) Integrating digital health technologies into the healthcare system: Challenges and opportunities in Nigeria. *PLOS Digital Health* 4(7): e0000928.
64. Shekoni O, Iversen S, Diaz G J, Aune A, Ubuane P O, et al. (2024) Health-

- care workers' perceptions about the use of mobile health technologies in public health facilities in Lagos, Nigeria. *SAGE Open Medicine* 12: 20503121231224568.
65. Manapurath R, Veetil D R, Kamath M S (2023) Use of modern technologies for promoting health at the population level in India. *The Lancet Regional Health Southeast Asia* 23: 100338.
 66. Padhan S (2023) The promise of technology: Overcoming challenges in rural and remote health care in india. *Journal of Public Health and Primary Care* 4(3): 127-129.
 67. Rasekaba T M, Pereira P, Rani G V, Johnson R, McKechnie R, et al. (2022) Exploring Telehealth Readiness in a Resource Limited Setting: Digital and Health Literacy among Older People in Rural India (DAHLIA). *Geriatrics* 7(2): 28.
 68. Kumar M, Kumar A, Verma S, Bhattacharya P, Ghimire D, et al. (2023) Healthcare Internet of Things (H-IoT): Current trends, future prospects, applications, challenges, and security issues. *Electronics* 12(9): 2050.
 69. Shojaei P, Vlahu Gjorgievska E, Chow Y W (2024) Security and Privacy of Technologies in Health Information Systems: A Systematic Literature Review. *Computers* 13(2): 41.
 70. Weiner E B, Dankwa Mullan I, Nelson W A, Hassanpour S (2025) Ethical challenges and evolving strategies in the integration of artificial intelligence into clinical practice. *PLOS Digital Health* 4(4): e0000810.
 71. Ibrahim A M, Abdel Aziz H R, Mohamed H A H, Zaghamir D E F, Wahba N M I, et al. (2024) Balancing confidentiality and care coordination: challenges in patient privacy. *BMC Nursing* 23(1): 564.
 72. Murdoch B (2021) Privacy and artificial intelligence: Challenges for protecting health information in a new era. *BMC Medical Ethics* 22(1): 122.
 73. Chengoden R, Victor N, Huynh-The T, Yenduri G, Jhaveri R H, et al. (2023) Metaverse for healthcare: a survey on potential applications, challenges and future directions. *IEEE* 11: 12765-12795.
 74. Aldosari B (2025) Cybersecurity in Healthcare: New Threat to Patient Safety. *Cureus* 17(5): e83614.
 75. Conduah A K, Ofoe S, Siaw Marfo D (2025) Data privacy in healthcare: Global challenges and solutions. *Digital Health* 11: 20552076251343959.
 76. Ngesa J (2023) Tackling security and privacy challenges in the realm of big data analytics. *World Journal of Advanced Research and Reviews* 21(2): 552-576.
 77. Dhawan A P, Heetderks W J, Pavel M, Acharya S, Akay M, et al. (2015) Current and future challenges in point-of-care technologies: a paradigm-shift in affordable global healthcare with personalized and preventive medicine. *IEEE Journal of Translational Engineering in Health and Medicine* 3: 1-10.
 78. Hao Y, Cheng F, Pham M, Rein H, Patel D, et al. (2019) A Noninvasive, Economical, and Instant-Result Method to Diagnose and Monitor Type 2 Diabetes Using Pulse Wave: Case-Control Study. *JMIR MHealth and UHealth* 7(4): e11959.
 79. Bokolo A J (2021) Application of telemedicine and eHealth technology for clinical services in response to COVID 19 pandemic. *Health and Technology* 11(2): 359-366.
 80. Moulai K, Sheikhtaheri A, Fatehi F, Shanbehzadeh M, Bahaadinbeigy K (2023) Patients' perspectives and preferences toward telemedicine versus in-person visits: A mixed-methods study on 1226 patients. *BMC Medical Informatics and Decision Making* 23(1): 261.
 81. Su Z, Li C, Fu H, Wang L, Wu M, et al. (2024) Development and prospect of telemedicine. *Intelligent Medicine* 4(1): 1-9.
 82. Albahri O S, Albahri A S, Mohammed K I, Zaidan A A, Zaidan B B, et al. (2018) Systematic review of real-time remote health monitoring system in triage and priority-based sensor technology: Taxonomy, open challenges, motivation and recommendations. *Journal of Medical Systems* 42(5): 80.
 83. Wang Y Y L, Wang S H, Jan M Y, Wang W K (2012) Past, present, and future of the pulse examination (mài zhěn). *Journal of Traditional and Complementary Medicine* 2(3): 164-177.

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