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Artificial Intelligence in Healthcare: Enhancing Efficiency, Ensuring Equity, and Restoring Empathy

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Abstract

Artificial Intelligence (AI) is emerging as a transformative force across many sectors, with healthcare representing both one of the most promising and most challenging areas of application. This review summarizes current and future applications of AI in healthcare, focusing on its potential to improve diagnosis, therapy, chronic disease management, and overall patient care, while also alleviating physicians' workload. Recent literature demonstrates that AI systems can reduce diagnostic errors/delays by mitigating cognitive biases, support imaging and pathology through improved accuracy and speed, and prevent prescribing errors by integrating pharmacogenomic and clinical data into decision -support systems. In chronic disease management, AI-powered wearable devices enable continuous monitoring and early detection of conditions such as atrial fibrillation, thereby reducing the risk of stroke and long-term disability, particularly in elderly people. Therapeutic applications include AI-driven drug discovery, personalized oncology, and tailored medicine that integrates multi-omics and lifestyle data. Beyond direct medical intervention, AI contributes by automating routine tasks, optimizing workflows, and facilitating greater patient –clinician interaction. Despite these benefits, significant challenges remain, including issues of data quality, privacy, security, equity, and the need for transparency and trust in "black box" systems. Looking ahead, the integration of multimodal data, digital twins, and robotics is expected to advance more comprehensive, equitable, and human-centered care. We conclude that, when applied ethically and responsibly, AI should not replace clinicians but rather serve as a powerful partner that enhances medicine by restoring empathy and humanity.

Introduction

Artificial Intelligence (AI) has rapidly emerged as one of the most transformative forces in the 21st century. Often described as a driving engine of the fourth industrial revolution[1], AI is reshaping nearly every domain of human activities including finance, agriculture, education, cybersecurity, and, increasingly and importantly, healthcare[2]. Its capacity to emulate most aspects of human cognition enables novel levels of efficiency, precision, equity, innovation, achievements, and humanity that were unimaginable only a decade ago[2].

Healthcare systems worldwide are confronting unprecedented challenges although the specific issues differ across countries. Aging populations, increasing prevalence of chronic diseases, and rising health care/medical care costs are straining resources while shortages of medical professionals, particularly in rural and underserved areas, limit access to receiving timely and appropriate care[1,3]. Physicians and nurses spend a substantial proportion of their working time on administrative, explanatory, and documentation tasks diverting attention from direct patient care[1,4]. These conditions sometimes lead medical workers to emotional fatigue and burnout, resulting in a decline in the humanistic values that have traditionally anchored medical practice[4,5].

When implemented thoughtfully, AI has a great potential to help reverse this trend. By analyzing vast and complex datasets, AI can facilitate earlier diagnosis, tailor treatments, reduce any kinds of human errors, and support a more patient-centered approach. Rather than dehumanizing medicine, well-integrated AI can free clinicians from repetitive non-specialized tasks, allowing more time for observation, innovation, and meaningful patient interaction[1,4,6]. Nonetheless, ethical challenges, such as privacy, transparency, accountability, bias, and data security, must be addressed to ensure safe and equitable adoption[7,8].

This article provides a concise overview of how AI is transforming healthcare, the current landscape, and its potential to restore humanity to healthcare and medical care.

AI in Diagnosis and Human Errors

Diagnosis is both one of the most critical and one of the most error-prone elements of medical care. Traditional diagnostic processes rely heavily on the experience and judgment of individual clinicians, which, while invaluable, are also subject to fatigue, cognitive bias, and variability in training. The magnitude of this issue is significant; a recent study in the United States estimated that nearly 800,000 Americans annually suffer death or permanent disability from diagnostic errors—specifically, 371,000 deaths and 424,000 permanent disabilities[9].

Obtaining symptoms accurately and carefully, considering candidate diseases thoughtfully, and making differential diagnosis is essential for reaching a correct diagnosis[3,4]. However, in high-pressure settings such as emergency departments[10], physicians are often forced to make rapid judgments, relying on intuitive Type 1 thinking rather than the deliberate, analytical Type 2 thinking described by Kahneman in *Thinking, Fast and Slow*[11]. While Type 1 thinking enables timely decisions, it increases vulnerability to cognitive biases and heuristic shortcuts such as overreliance on initial impressions or stereotyped expectations which can result in missed or delayed diagnoses, particularly in atypical presentations (e.g., young patients with myocardial infarction)[1,3-5,12]. AI-assisted decision support systems could help reduce these misdiagnosis risks by systematically flagging all candidate diseases in the list, including atypical cases in risk algorithms, and promoting adherence to diagnostic protocols regardless of patient demographics.

Another critical but often underrecognized contributor to medical care-related patient harm is medication errors, which include simple mistakes in prescription, inappropriate drug combination, mis-dosing, or wrong administration method (by medical professionals or by patients) and is estimated to be approximately 6.5 per 100 admissions in acute hospitals. These errors often go unnoticed due to the complexity of medication regimens, overlapping contraindications, and fragmented communication among multiple doctors/prescribers. Consequences include adverse drug reactions, therapeutic failure, and the masking or misattribution of symptoms, which may further delay accurate diagnosis. Artificial intelligence–driven clinical decision support systems, such as AI-enabled drug interaction system, integrate patient-specific clinical, biochemical, and pharmacogenomic data to systematically identify and prevent such errors. By embedding these tools into clinical workflows can improve medication appropriateness, minimize drug-related confounders, and improve patient safety[13].

The rapid acceleration of medical knowledge compounds these challenges. Since the "knowledge-doubling time" was estimated to be approximately 50 years in 1950 and became about 73 days in 2020[14], far exceeding human capability to memorize, process and apply latest information. Consequently, there is a growing need for AI support to reduce clinicians' cognitive burden. General-purpose large language models (LLMs) such as ChatGPT and Gemini can provide information for the possible disease candidate list from free-text input with notable accuracy in simulated cases, but they are mostly positioned as tools that "offer suggestions"[15,16]. In contrast, specialized tools such as Glass Health's "Glass AI" generate structured *assessment & plan* documents, incorporating evidence-based differential diagnostic steps and treatment options, positioning them for more direct integration into clinical workflows—subject to professional oversight[17].

AI in Imaging and Pathology

AI is significantly redefining diagnostic imaging by accelerating the interpretation of X-rays, MRIs, and CT scans, thereby shortening time-to-diagnosis—an essential advantage, particularly important in emergency department. It also enhances diagnostic accuracy by learning from vast datasets and identifying subtle patterns and anomalies that human eyes might overlook, thereby reducing misdiagnoses and ensuring timely, correct treatment[18]. For example, AI algorithms can function as a second reader for mammograms, analyzing images with high accuracy to identify subtle signs of breast cancer that might be missed by the human eye, thereby enhancing diagnostic precision[19-21].

Beyond image interpretation, AI also streamlines imaging workflows, lowers costs, and supports personalized diagnostic strategies through risk stratification and predictive analytics. Furthermore, AI's predictive capabilities leverage historical data for early disease detection and risk stratification, while its role in personalized medicine allows for tailored diagnostic approaches and treatment plans based on patient-specific data, moving away from a one-size-fits-all model.

In pathology, AI automates labor-intensive processes such as object recognition, detection, and segmentation, allowing specialists to focus on complex interpretive tasks. Algorithms can screen large volumes of histopathology images with high accuracy, flag urgent cases, and triage normal cases to reduce unnecessary reviews. Beyond detection, AI can assess tumor aggressiveness from 3D imaging and might even predict molecular and genomic profiles from tissue samples, enabling more personalized treatment strategies. Integration with electronic health records enhances consistency, standardization, and inter-reader reliability, while reducing the risk of fatigue-related errors. In addition, it is becoming unrealistic to expect one or two pathologists in a single hospital to provide comprehensive diagnostic coverage across all organ systems. It is anticipated that in the near future, diagnostic services with the integration of AI will become increasingly centralized, with subspecialized pathologists convened at dedicated centers. Through the transmission of digital images, such a system would enable more accurate and reliable diagnoses. A major advantage of digitalization with AI lies in its capacity to facilitate this centralization. Once histopathological specimens are scanned and converted into digital images, they can be transmitted to specialized centers equipped with highly advanced expertise for diagnostic evaluation. This development represents a crucial step toward reducing regional disparities in access to high-quality pathology services[22].

Recent evidence also highlights the potential of AI in under-represented fields such as pediatrics and mental health. In pediatric imaging, deep learning systems have demonstrated high accuracy in classifying childhood pneumonia from chest radiographs, helping to compensate for the shortage of pediatric radiologists in many regions[23]. Beyond imaging, machine learning models have been applied to the early screening of autism spectrum disorder (ASD), using behavioral features such as atypical or inconsistent eye contact, difficulties in forming peer relationships, and challenges in appropriate play, as assessed through standardized behavioral questionnaires, to support earlier diagnosis and intervention[24]. In mental health, randomized controlled trials of AI-powered digital platforms, including conversational agents, have reported reductions in depression and anxiety symptoms, suggesting their promise as scalable adjuncts to conventional therapy[25]. At the same time, these approaches face important limitations, including the need for robust validation across diverse populations, safeguarding patient privacy, and ensuring that digital tools augment rather than replace the therapeutic relationship.

AI in Chronic Disease and Remote Monitoring

AI is also advancing early detection and management of chronic and progressive diseases. Neurodegenerative disorders such as Alzheimer's disease are another key area where AI has shown some promise[8]. Deep learning models applied to neuroimaging can identify early brain changes long before conventional methods, offering opportunities for earlier intervention. Similarly, in chronic conditions like diabetes, AI can integrate lifestyle metrics, laboratory data, and treatment history to predict complications such as nephropathy, neuropathy, or retinopathy, thereby enabling preventive action[8].

Wearable devices connected with AI extend early diagnostic capabilities beyond clinical settings. These devices can continuously monitor physiological parameters including heart rate, oxygen saturation, pulse regularity, and sleep patterns to detect conditions like atrial arrythmia or sleep apnea in real time[1,3,8]. Certain smartwatches have achieved high accuracy in atrial fibrillation detection using photoplethysmography combined with machine learning[26], facilitating earlier intervention and potentially reducing stroke risk. However, the LOOP Study found that AF screening in older adults did not significantly reduce stroke or systemic embolism compared with usual care[27]. Although the data are still controversial, cerebral infarction attributable to atrial fibrillation represents a major determinant of long-term disability and subsequent dependence on nursing care[28]. Hence the clarification of them is extremely important in public health. Beyond its direct clinical consequences, cerebral infarction increases healthcare and long-term care expenditures and imposes considerable physical, psychological, and financial burdens on patients' families[28]. Accordingly, the prevention of atrial fibrillation–related cerebral infarction constitutes a critical public health priority, particularly in the context of rapidly aging societies[1].

AI in Treatment

Treatment paradigms are rapidly shifting toward a more personalized model with AI at the center of this transformation. In drug discovery, AI also transforms the traditionally slow and expensive process with identifying promising molecular targets, predicting drug–drug interactions, and even repurposing existing medications for new indications. This reduces development timelines and costs, improving accessibility to innovative therapies.

Precision medicine is another area where AI has demonstrated transformative potential. By combining omics information and microbiome data as well as lifestyle and environmental data, AI can help determine the most-effective treatment plan for individual patients rather than relying solely on generalized guidelines[3,4,8]. For instance, AI can assist oncologists in selecting targeted therapies that are most likely to be effective based on a tumor's specific genetic mutations[1].

Beyond pharmacological approaches, AI enables more effective management of chronic diseases. Wearable sensors connected to AI provide continuous feedback on patient health, offering personalized lifestyle recommendations and adjusting treatment plans in real time[8]. This proactive, data-driven approach empowers patients to take an active role in their care, while enabling clinicians to intervene before complications occur or progress.

AI is also reshaping mental healthcare. By analyzing patterns in speech, writing, or social media activity, AI systems can detect early signs of depression, anxiety, or other mental health problems although it is notable that AI-based CBT chatbots are recommended only for mild depression, not for moderate to severe cases. Predictive models can identify individuals at risk of suicide, enabling targeted outreach[2,4,8]. AI-powered chatbots and virtual assistants offer 24/7 access to evidence-based tools such as cognitive behavioral therapy, offering scalable, stigma-free, and accessible mental health support[29]. However, WHO 2024 guideline is cautious to use these chatbots for a wide range of depression[30].

Reducing Workload and Enhancing Patient Experience

One of AI's most immediate benefits in healthcare is its ability to reduce the workload of medical professionals, including physicians, nurses, and pharmacists. Among these applications, AI-powered speech-to-text systems can transcribe consultations in real time, automatically generating structured clinical notes and nursing records[1,4,8]. This is particularly valuable given that nurses spend an estimated 20–30% of their working hours on documentation, such as recording vital signs and procedures, which could otherwise be spent directly with patients[31,32]. In addition, natural language processing (NLP) tools can further summarize patient histories, extract key information from electronic medical records, and draft discharge summaries, correspondence, or instructions for patients and healthcare providers in other facilities.

Operational efficiencies extend beyond documentation. AI-driven scheduling systems can optimize patient flow and staff allocation, while in pharmacy management, algorithms can track inventory, forecast demand, and detect prescribing errors before they reach the patient. For patients, these systems shorten waiting times and reduce administrative barriers, enabling more personalized interactions[1,8,29]. Beyond the hospital settings, AI-powered remote monitoring allows patients with chronic illnesses to remain at home under close supervision, minimizing the need for frequent visits[3,4,8]. Mobile health applications integrated with AI platforms can deliver real-time test results, medication reminders, and secure access to medical records, enhancing transparency and patient engagement[1,3,4,12].

Most importantly, by alleviating repetitive administrative burdens, AI allows clinicians to focus on the human aspects of care—listening, explaining, and building trust—all of which are central to patient satisfaction and improved outcomes.

Current Applications Around the World

The implementation of AI in the healthcare is accelerating globally, though approaches vary by each country and healthcare system[2,7,8]. In Japan, for example, the "Innovative AI Hospital System" was launched to promote hospital digitalization, improve diagnostic accuracy, and reduce workload of medical workers[1]. Initiatives include constructing large-scale health/medical databases, developing predictive algorithms for disease risk, and implementing AI-assisted guiding and diagnostic tools of endoscopy and colonoscopy as well as liquid biopsy for cancer screening.

Other countries are pursuing similar strategies, incorporating AI into national health infrastructures. Some prioritize telemedicine platforms with AI-based triage tools to extend access in remote areas. Others emphasize patient-facing innovations, such as AI avatars for standardized informed consent discussions, or mobile applications that notify patients of appointment delays and streamline payments (Nishimura Y. et al., unpublished data). These early applications highlight the versatility of AI, demonstrating its impact not only on clinical diagnosis and treatment but also on organization, communication, and operational workflows that shape the patient journey.

Emerging evidence from low- and middle-income countries (LMICs) highlights AI's huge potential to improve both equity in and access to maternal and neonatal care. A systematic review shows AI implementation in LMICs have enhanced clinical capabilities such as diagnostic accuracy and covering specialist shortages[33], and AI tools have improved imaging interpretation and decision-making infrastructure in these regions[34]. Specifically, it was reported that AI-enabled point-of-care ultrasound analysis could improve gestational age estimation, provider confidence, and care-seeking behavior in LMIC antenatal settings, reflecting anticipated benefits[35]. Additionally, AI-augmented fetal monitoring in Malawi has been shown in observational work to significantly reduce intrapartum stillbirths and neonatal mortality[36]. These examples demonstrate how context-appropriate AI interventions can improve outcomes in resource-constrained maternal and neonatal care settings.

Challenges and Limitations

Despite its promise, AI integration into healthcare faces significant challenges. First, data quality and availability remain critical barriers. High-quality, annotated datasets are essential for effective training, yet such datasets are often scarce, particularly for rare diseases[8]. Fragmented electronic health record systems and inconsistent data formats further complicate large-scale integration[1,4,8]. Second, privacy and data security are persistent concerns. The sensitive nature of clinical data necessitates robust safeguards, including encryption, anonymization, and strict access controls[7,8,29]. Patients must be clearly informed about data usage and associated risks. Third, bias and equity issues arise when AI systems are trained on datasets that are not representative of all the populations they serve. This can lead to disparities in diagnosis, treatment, and outcomes, exacerbating existing healthcare inequalities[7,8]. Several possible strategies have been proposed to minimize/avoid bias and enhance explainability in AI healthcare systems. Algorithmic auditing frameworks can systematically evaluate models for hidden biases across demographic groups, while applying diverse and representative datasets is crucial to prevent the reinforcement of existing inequities[37,38]. Federated learning provides a promising solution by establishing models that can be trained on decentralized data without direct sharing, thereby reflecting diversity while preserving privacy[39]. In addition, the adoption of quantitative fairness metrics—such as demographic parity, equalized odds, and subgroup adjustment—offers measurable benchmarks for ensuring equity in performance[38]. However, research on explainability highlights that many current methods still remain inadequate for clinical decision-making, underscoring the need for models that are both transparent and interpretable[40]. Taken together, these strategies may represent practical pathways to ensure that AI systems not only deliver technical accuracy but also uphold fairness and transparency in clinical practice.

Fourth, transparency and trust are critically essential. Many AI systems operate as “black boxes,” producing outputs without clear explanations how those results were reached out. This lack of interpretability can undermine confidence among both clinicians and patients[2,7,8]. Fifth, limitations of empathy in clinical management must be acknowledged. While AI can process vast amounts of data, it cannot fully replicate the nuanced non-verbal cues such as tone, facial expressions, and body language, which are vital for building trust and fostering understanding in clinical relationships[1,4]. Addressing these challenges will require interdisciplinary collaboration, bringing together technologists, clinicians, ethicists, policymakers, and patient advocates.

Global governance frameworks have been attempted to shape the responsible integration of AI in healthcare although they are still not sufficient enough. The World Health Organization (WHO) has issued ethics and governance guidance emphasizing transparency, accountability, inclusiveness, and safeguarding human rights in AI deployment[41]. In Europe, the recently adopted EU AI Act establishes a risk-based regulatory framework that classifies medical AI applications as “high-risk,” requiring stringent standards for safety, transparency, and post-market monitoring[42,43]. Japan has started discussion for its own AI governance initiatives through the Ministry of Economy, Trade and Industry (METI), along with other Japanese governmental bodies. Their approach emphasizes human-centered principles and aims to create a flexible, context-sensitive regulatory environment[44]. At the same time, many experts argue that regulatory frameworks from high-income countries may not be suitable for LMICs due to differences in healthcare infrastructure, resources, and specific equity issues[34]. Together, these frameworks underscore the necessity of balancing innovation with patient safety, ethical integrity, and equity.

The Future of AI in Healthcare

The next phase of AI in healthcare/medical care is likely to emphasize integration, combining multimodal data streams, including multi-omics, imaging, wearable sensors and social determinants of health, into unified platforms that can support more holistic decision-making. Within this context, emerging technologies such as digital twins, which are virtual models of individual patients, could allow clinicians to simulate treatment scenarios and predict outcomes with unprecedented precision[7,8]. Large language models may streamline communication between healthcare providers and patients by generating tailored explanations and educational materials instantly, while AI-enabled robotics could enhance surgical precision and provide advanced rehabilitation support[1-4].

Perhaps and most importantly, AI has the potential to reduce global health disparities[45]. Cloud-based platforms and increasingly affordable devices could extend expert-level diagnostics and monitoring to remote and underserved populations. Paired with equitable access policies, these advances could help standardize care quality worldwide. The ultimate vision is a healthcare system that is efficient, cost-effective, and profoundly human—one in which technology augments clinicians’ capacity to exercise uniquely human judgment, creativity, and compassion.

To concisely summarize the most important insights presented in this review, Table 1 highlights domains where AI and digital tools can significantly enhance efficiency, alongside areas of clinical practice that rely on uniquely human judgment, empathy, and interpersonal engagement.

Table 1. Task Shifting in Healthcare: AI-Suitable vs. Human-Only Domains

Domain	Tasks Suitable for AI / Generative AI / Digital Tools	Tasks Requiring Human Judgment and Empathy
Clinical Support	- Image interpretation (X-ray, CT, MRI, ultrasound, and pathology) - Data analysis of ECG and EEG - Endoscopic guidance and analysis - Radiotherapy protocol support - Drug interaction/mis-prescription checks - Continuous vital sign monitoring with wearable devices and alerting	- Making final diagnosis - Deciding on treatment strategy - Ethical decision-making in patient care plans
Administrative & Operational	- Supporting clinical notes and surgical reports - Nursing/procedure record assistance - Automated billing/claims processing - Supporting discharge summary and other documentations - Appointment optimization and cancellation prediction - Automated labor-shift scheduling	- Approval of medical records - Resolving disputes in billing or claims - Negotiating schedules considering personal/team needs
Research & Education	- Automated literature search and summarization - Translation and abstract generation - Data mining from PHRs/EHRs and/or biobank data - Statistical analysis - Case simulation (surgery) - E-learning content creation	- Designing research questions - Interpretation of ambiguous data - Mentoring and evaluating students'/ residents'/young doctors' reasoning
Patient-Facing Care	- Chatbot-based symptom analysis and triage - Automated structuring of symptom/ lifestyle data - Generating standard explanatory materials for procedures - Personalized medication/lifestyle guidance - Remote monitoring and automated alerts (Recommending doctor visit) - Pre-visit data collection	- Empathetic patient communication - Delivering difficult/sad news - Building trust and therapeutic relationships - Motivating behavioral/life-style change

Legend: *AI = artificial intelligence.* This table distinguishes between tasks that can be safely automated and those that require human judgment and empathy.

Conclusion

Artificial intelligence, when applied thoughtfully and carefully, is not a threat to human health or medicine but rather a vital tool for preserving and enhancing human well-being. By managing repetitive and data-intensive tasks, AI frees medical professionals to focus on direct patient care, critical reasoning, and research. Guided by strong ethical principles and governance, AI can help build a healthcare system that is both technologically advanced and deeply human-centered. The priority must be to design AI systems that emphasize connection over convenience, presence over productivity, and people over process. In doing so, we ensure that AI strengthens, rather than diminishes, the essential human bond at the heart of medicine.

Conflict of Interest

YN is a stockholder and a scientific advisor of Onotherapy Science, Inc.

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