

WORLD MEDICAL ASSOCIATION JUNIOR DOCTORS NETWORK



Special Edition Bulletin on

ARTIFICIAL INTELLIGENCE & DIGITAL HEALTH

Advancing Medicine.
Empowering Doctors.
Transforming Healthcare.



www.wma.net/junior-doctors/

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2026

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ABOUT WMA JDN

What is the JDN?

The Junior Doctors Network (JDN) serves as an international platform for junior doctors to facilitate an open dialogue of global events and activities that are relevant to their postgraduate training and the World Medical Association (WMA).

It was created at the 61st WMA General Assembly (October 2010) in Vancouver, Canada and the inaugural JDN meeting was held at the 62nd WMA General Assembly (October 2011) in Montevideo, Uruguay. The network, which started from a few motivated junior doctors, now has a total of over 1300 members from more than 118 countries from all regions of the world.

Junior doctors are defined as physicians, within 10 years after their medical graduation.

What is the mission?

The purpose of the JDN is to empower young physicians to work together towards a healthier world through advocacy, education, and international collaboration.

What do we do?

Networking:

During the regular JDN meetings, members get to know each other, discuss global health issues, share challenges, and start collaborations on global health issues. The JDN meets on several occasions during the year, both in-person and via online teleconferences:

- Biannual meetings in conjunction with the Council Meeting and the General Assembly of the WMA (April & October)
- Monthly general membership and management team teleconferences
- Ad-hoc online and webinars organized by the JDN

MEET THE WMA JDN MANAGEMENT TEAM



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CHAIRPERSON



DR SHIV JOSHI
SECRETARY



DR LIBAN HASSAN MOHAMUD
MEDICAL ETHICS OFFICER



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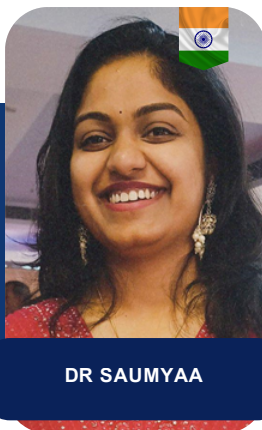
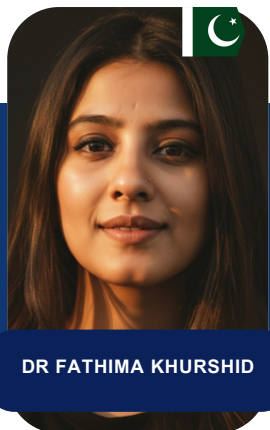


DR BALKISS ABDELMOULA
IMMEDIATE PAST DEPUTY CHAIR



DR SAZI NZAMA
IMMEDIATE PAST MANAGEMENT
TEAM MEMBER

PUBLICATIONS TEAM



SPECIAL FOREWORD BY

Dr. Sathyanarayana TN



Dear All,

We stand at an extraordinary inflection point in the arc of medical history—where artificial intelligence, machine learning, and digital health converge to orchestrate nothing less than the renaissance of personalised medicine. This Special Edition Bulletin of the World Medical Association Junior Doctors Network emerges as both a testament to this paradigm shift and a conscientious navigation of its profound implications.

For our generation of physicians, the era of one-size-fits-all therapeutics is inexorably receding. We are witnessing the dawn of precision health—a meticulously calibrated endeavour wherein algorithms dissect genomic landscapes, decode proteomic signatures, and synthesise multi-omic data to tailor interventions with unprecedented fidelity. The machine learning models we now deploy possess the capacity to predict therapeutic responses, anticipate adverse reactions, and stratify patient populations with a granularity that defies conventional clinical intuition.

Yet this breathtaking potential must be meticulously balanced against the imperatives of equitable health policy. As we harness AI to democratise precision medicine, we confront formidable challenges: ensuring algorithmic transparency, mitigating inherent biases in training datasets, and preventing the exacerbation of disparities that already fracture global healthcare architecture. The policy frameworks we construct today will determine whether these technologies become instruments of liberation or instruments of division.

This compendium represents our collective manifesto—junior doctors across continents, united in our conviction that personalisation must not become privilege. We envision a future where AI-driven insights illuminate pathways for every patient, irrespective of geography or socioeconomic standing. Where health policy evolves symbiotically with technological acceleration, safeguarding human dignity at every algorithmic intersection.

Within these pages resides our generation's audacious blueprint: precision without exclusion, innovation without inequity, and technology perpetually subservient to the sanctity of the healing bond. Let us embark upon this odyssey with intellectual rigour, moral clarity, and indefatigable hope!

Best Regards,

Dr Sathyanarayana TN,
Professor-Public Health Practice,
Lead-Digital Health Systems and Policy,
Indian Institute of Public Health Bengaluru,
PHFI-Institute of Public Health Sciences University, India.

FOREWORD BY **CHAIR**



Dear All,

It is a pleasure to introduce this Special Edition of the WMA JDN Bulletin on Artificial Intelligence and Digital Health. Across health systems, AI is already reshaping how we document, diagnose, communicate, learn, and deliver care. For junior doctors, this is not a distant debate. It is part of our daily practice, our training environments, and the future we are being asked to help build.

This edition brings together the perspectives of junior doctors from across the world: voices that are often among the first to encounter new technologies in frontline care, and that must therefore help shape how they are developed, governed, and used.

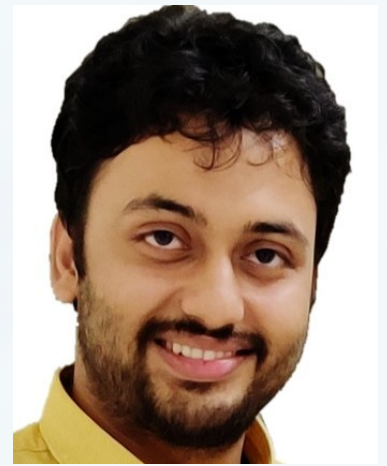
The recently adopted **WMA Statement on Artificial and Augmented Intelligence in Medical Care** provides an essential foundation. It reminds us that these tools must augment, not replace, human judgment; that care must remain patient-centred, physician-led, transparent, safe, and equitable; and that accountability, oversight, and strong data governance are indispensable. It also emphasizes patient rights, meaningful consent, explainability, physician wellbeing, AI literacy, and the need to ensure that innovation reduces rather than deepens global inequities.

As Chair of the WMA Junior Doctors Network, I believe junior doctors have both the opportunity and the responsibility to shape this transition. We must advocate for innovation that serves patients, strengthens trust, supports the health workforce, and remains firmly grounded in ethics, professionalism, and human dignity.

I hope this special edition contributes to that effort with clarity, critical reflection, and a shared commitment to responsible medical leadership.

Regards,
Dr Pablo Estrella-Porter
Chair - Junior Doctors Network
World Medical Association

FOREWORD BY **SECRETARY**



Dear All,

Digital technology and Artificial Intelligence are no longer distant frontiers in medicine. They are active forces transforming how we learn, practice, and deliver care. From clinical decision support to public health, these tools are reshaping the everyday realities of healthcare systems. For junior doctors across the world, this transformation brings not only excitement and opportunity but also a profound responsibility to ensure that innovation remains grounded in human values, equity, and ethical integrity.

This Special Edition of the WMA Junior Doctors Network Bulletin brings together diverse perspectives from across regions and disciplines, reflecting the global nature of both healthcare and technological advancement. The contributions featured in this issue span practical experiences in primary care, innovations in surgical risk assessment, and thoughtful reflections on governance, education, and ethics. Collectively, they capture the curiosity, creativity, and critical thinking that define our generation of young medical professionals as we engage with rapidly evolving digital landscapes.

As we navigate the dynamic relationship between technology and humanity, it is essential that young physicians remain active contributors and not the passive recipients in shaping how artificial intelligence is designed, implemented, and regulated. Our voices are vital in ensuring that these tools strengthen health systems while preserving trust, compassion, and patient-centred care. This special edition on Artificial Intelligence and Digital Health is a step towards this goal.

I congratulate all contributors and the publications team for their insightful work on this timely theme. I hope this edition inspires continued dialogue, collaboration, and responsible innovation within our global community.

Regards,

Dr Shiv Joshi

Secretary - Junior Doctors Network

World Medical Association

FOREWORD BY

PUBLICATIONS

DIRECTOR



Dear Junior Doctors Worldwide,

As we compiled the manuscripts for this special edition, our editorial focus was to ensure a rigorous and globally representative academic discourse. Bridging the gap between advanced public health policy and clinical reality requires meticulous scientific writing, especially when exploring the rapidly evolving frontier of AI & digital health. Our priority was to curate an edition that captures the empirical research, systemic assessments, and daily clinical realities of junior doctors worldwide.

This special edition highlights an exceptionally diverse range of topics from across the globe. Within these pages, you will find comprehensive analyses of AI's role in primary health care and the implementation of AI-based surgical risk prediction, particularly within low- and middle-income countries. Our contributors have thoroughly addressed the ethical and governance challenges in resource-constrained systems, alongside strategies for embedding AI to strengthen immunization systems and surveillance. Furthermore, the edition features critical insights into advancing digital literacy in health professions' education, as well as distinct snapshots of digital health gains and AI ecosystems in regions spanning Kenya, Kazakhstan, Indonesia, and the United Kingdom.

Curating this edition would not have been possible without immense collaborative effort. I want to extend my sincere gratitude to the WMA, the WMA JDN management team, and the dedicated WMA JDN Publications team for their steadfast support and cooperation throughout this project. Their commitment and collaborative excellence have been the driving force behind this publication.

Regards,
Dr Venkatesh Karthikeyan
Publications Director - Junior Doctors Network
World Medical Association

WMA STATEMENT ON ARTIFICIAL AND AUGMENTED INTELLIGENCE IN MEDICAL CARE

WMA STATEMENT ON ARTIFICIAL AND AUGMENTED INTELLIGENCE IN MEDICAL CARE

Adopted by the 76th WMA General Assembly, Porto, Portugal, October 2025

PREAMBLE

1. The World Medical Association (WMA) recognizes that artificial intelligence (AI) is rapidly transforming all sectors, including healthcare. In this statement, the WMA reaffirms its commitment to patient-centered, physician-led care by emphasizing the concept of augmented intelligence – a framing that highlights AI's role in augmenting human judgment – by strengthening rather than supplanting it, while recognizing that in specific, well-defined tasks AI may perform independently but always under human accountability. Through augmentation, AI is supporting rather than replacing human judgment, empathy, and accountability.
2. Building on lessons learned from early deployments, the WMA sets out principles that maximize AI's benefits while mitigating its risks, ensuring that its development, regulation and use remain consistent with medical ethics, international human-rights standards and the public's trust in the profession.

DEFINITIONS AND SCOPE

3. To promote clarity across jurisdictions while embedding the augmented intelligence perspective, the WMA uses the following working definitions in the healthcare ecosystem:
 - Artificial Intelligence (AI): Computer systems designed to perform tasks that normally require human intelligence – such as learning, problem-solving, understanding language, and recognizing patterns.
 - Augmented Intelligence: Use of artificial intelligence designed to support—not replace—human capabilities in healthcare.
 - Physician-in-the-Loop (PITL): an extension of the general “human-in-the-loop” principle whereby a licensed physician—rather than any user—must review and retain final authority over all AI outputs before they shape clinical care. Where clinical care involves multidisciplinary teams, PITL implementation should ensure that all relevant licensed professionals are adequately consulted, while the physician retains ultimate clinical responsibility.
4. Emphasis on “augmented”
 - The term signals a human-centered approach to AI—one that reinforces the physician's role as the final decision-maker. Rather than viewing AI as a replacement, augmented intelligence frames these tools as extensions of clinical expertise, designed to support – not replace – professional judgment, empathy, and responsibility.
 - While “AI” is widely understood as artificial intelligence, emphasizing the augmented perspective helps ensure that systems are designed, validated, regulated, and trusted with the right ethical priorities.

- For the medical profession, this framing also enables more effective advocacy—especially when engaging with policymakers, regulators, and stakeholders who default to the broader term AI. It equips physicians to promote technologies that truly align with the goals of ethical, patient-centered care.

5. Scope and audience

- This statement aims to apply to all uses of AI in medicine, including clinical care and research, where AI primarily augments human decision-making. AI systems in administrative and educational contexts should be applied responsibly and with appropriate human oversight.
- Its principles address physicians, other healthcare professionals, healthcare organizations, developers, regulators, payers, academic institutions, and industry partners, each of whom shares responsibility for ensuring that AI remains a safe, equitable, transparent, and ethically-governed tool in the delivery of healthcare worldwide.

GUIDING PRINCIPLES FOR AI IN HEALTHCARE

6. **Human-centricity:** Human-centricity in AI prioritizes human needs, values, and wellbeing above technological capabilities or performance metrics. This principle includes:
 - Maintaining and respecting patient dignity, autonomy, and rights through meaningful consent for AI use.
 - Preserving patient health and well-being, and the human connection as the paramount considerations.
 - Embedding cultural competence to ensure AI systems respect diverse patient values, clinical needs, languages, and health beliefs.
7. **Physician well-being:** The well-being of physicians and other clinicians must be safeguarded, recognizing that reducing administrative burden and avoiding unnecessary cognitive load are essential not only for supporting healthcare professionals but also for ensuring the quality and safety of patient care.
8. **AI is a Tool:** AI should serve as a means to support healthcare goals rather than an end in itself. Unlike traditional medical tools, AI systems may appear to learn and adapt without continuous human input, making it essential to pair their use with strong human oversight and ethical governance.
9. **Accountability:** AI integration does not diminish physician responsibility for patient welfare and advocacy. Consistent with the PITL principle, physicians must continue exercising professional judgment, and the final responsibility and accountability for diagnosis, indication, and therapy must always lie with the physician. At the same time, the growing prevalence of these tools necessitates clearly distributed accountability. Responsibility should be appropriately allocated among all stakeholders, including but not limited to developers, healthcare organizations, regulators, researchers and clinicians.
10. **Transparency, Explainability, and Trustworthiness:**
 - AI systems must be designed and developed in ways that ensure their outputs and recommendations can be meaningfully understood by their intended end users—whether physicians, other healthcare professionals, or patients—within the relevant clinical context. Transparency extends beyond the “black box” paradigm, while explainability provides insight into the basis for specific outputs, thereby fostering trust and enabling responsible use. Transparency requirements and disclosures must be tailored to the needs of physicians and patients without adding paperwork or extra administrative tasks. Ensuring these qualities is a shared responsibility across all stakeholders, including developers, healthcare organizations, regulators, researchers, and clinicians.

- Mechanisms should exist for meaningful challenges of healthcare AI outputs, enabling patients and clinicians – including physicians – to question, review, or override AI recommendations when appropriate. This capacity is essential for building clinical trust, without which clinicians may reject valuable AI tools or overly rely on opaque systems.
 - Explainability exists on a spectrum, with some complex models functioning as “black boxes” where only input/output relationships can be observed. The level of explainability required should generally be proportional to the clinical risk involved and the degree of autonomy granted to the system. In high-stakes contexts such as life-and-death decision-making, additional safeguards and oversight must be in place whenever full explainability cannot be achieved.
11. **Safe deployment:** Safe deployment of AI in healthcare requires real-world validation demonstrating consistent performance, clinical efficacy, and usability before widespread adoption. Before clinical deployment, AI systems must also undergo rigorous ethical and health equity impact assessments that are context-sensitive and adapted to the specific healthcare setting and population, with particular attention to vulnerable and underrepresented groups. Implementation must include continuous performance monitoring, feedback mechanisms, and iterative improvement protocols to ensure sustained benefit and global accessibility. Risks and harmful consequences, including bias, must be properly understood, anticipated, and mitigated.
 12. **Equitable implementation:** New and beneficial AI healthcare tools must be developed and deployed equitably, with the goal of being accessible worldwide. Equitable implementation should ultimately bridge gaps in healthcare access, treatment, and outcomes, while expanding access to technology across disparate health care facilities.
 13. **Data governance:** All stakeholders must maintain the highest standards of data collection, storage, processing, and sharing to protect patient privacy, and institutional trust. This principle is foundational because healthcare AI depends on data access. Transparency around data provenance – including the origin, diversity, and quality of datasets used to train AI systems – must also be ensured to build trust and verify that data appropriately represents the patients being served.
 14. **Environmental impact:** Effective implementation of AI in healthcare requires careful consideration of its environmental impact and a strong commitment to sustainability. Environmental responsibility must be integrated alongside clinical validation to ensure that new technologies improve care while minimizing harm to the planet.

PHYSICIAN ROLES AND RESPONSIBILITIES

15. **Clinical Judgment and Accountability:** As emphasized in the PITL principle, physician judgment remains essential when using AI in healthcare, serving as both an ethical imperative and a practical necessity. Physicians must maintain professional autonomy and clinical independence to act in the best interests of patients, consistent with the [WMA Declaration of Seoul](#).
16. **Patient Advocacy:** Physicians must safeguard patient health, well-being, and safety, ensuring that AI tools are only used in ways that genuinely benefit patients. Patient safety must remain a fundamental priority, whether or not augmented intelligence is applied.
17. **AI tool development:** Physicians should be involved throughout the development and implementation of AI technologies in healthcare. They must participate in decision-making processes about technology and its use from the outset and be empowered to scrutinize new innovations, including for usability.
18. **Maintenance of competencies:** Physicians must maintain core clinical expertise while also being educated and trained to work responsibly with AI systems. Delegation of tasks to AI must not erode the human

capability required for safe, safety-critical care or for continuity when AI systems are unavailable or unreliable. Healthcare organizations should support this through ongoing education, simulation-based refreshers, periodic skills maintenance, and documented failover procedures that enable clinicians to critically appraise, override, and – when necessary – perform essential tasks independently.

19. **Incident reporting:** Physicians must be empowered to report incidents and question outcomes resulting from the use of AI in healthcare.

PATIENT RIGHTS AND ENGAGEMENT

20. While core patient rights are covered in existing WMA policies, AI introduces new risks – especially due to its reliance on data – that require focused ethical attention.
21. **Informed consent:** Given AI systems' reliance on patient health information, appropriate safeguards for data use are crucial. The principles of informed consent and transparency, building upon the [WMA Declaration of Lisbon's](#) affirmation of patients' rights to information and self-determination, must be rigorously applied in healthcare involving AI. Where possible, patients should be informed about the role AI plays in their care in ways that are understandable and meaningful, while physicians retain responsibility for ensuring safe and appropriate use of AI. In circumstances where full technical comprehension is impractical, informed consent may reasonably extend to a 'consent for governance' model, whereby patients place justified trust in physicians, healthcare institutions, and regulatory oversight to uphold their rights, safety, and welfare.
22. **Data rights:** Patients must be informed about AI systems' limitations and potential for error, as well as how physician oversight helps to ensure their protection. Patients should retain the right to request removal of their data from AI systems where feasible and legally permissible, and the right to understand how their data contributes to their care.
23. **Patient autonomy and explanation rights:** Patient autonomy must be preserved through meaningful consent processes. Patients should retain the right, where feasible, to refuse AI-mediated interventions and request human-only assessment. Where such refusal is not possible due to systemic integration of AI, safeguards must ensure that patients' data remain anonymous and non-traceable. Patients must have access to understandable and non-biased explanations of how AI contributes to their care, tailored to their information needs and preferences. They must also retain the right to dispute AI-generated recommendations they believe to be erroneous and to seek appropriate redress. This must extend to health insurer use of AI to determine patient care, payment, and coverage.
24. **Vulnerable patient population:** Vulnerable patient cohorts, such as those with reduced decision-making capabilities, must not be disadvantaged or harmed through the use of AI in healthcare. Safeguards must include proactive bias mitigation, inclusive dataset development, and tailored consent or governance procedures to protect those unable to fully exercise autonomy. Particular attention must be given to ensuring that informed consent and data rights principles are applied in ways that do not reinforce structural inequities or exclude vulnerable groups from fair access to care.

GOVERNANCE, REGULATION, AND LIABILITY

25. **Up-to-date standards:** Regulation, standards, and guidance must be suitably robust to safeguard patient safety and to ensure that the ethical rules of the medical profession are considered, with regulators empowered to stay up to date with developments and enforce legislation. Health care AI policies should be coordinated and consistent across government entities.
26. **Liability:** Clear lines of legal liability must be established, including the AI developers, as well as physicians, and healthcare organisations. Accountability should be shared and proportional, reflecting each actor's role

in design, deployment, and use, rather than defaulting to a single actor alone.

27. **Continuous audit:** There should be regular reviews and audits of regulatory processes and bodies surrounding AI in healthcare, including bias audits, ethical reviews, and participatory governance with physician input.

CLINICAL INTEGRATION AND IMPLEMENTATION OF HEALTH AI

28. **Tool evaluation and governance support:** AI systems implemented in clinical settings must be validated for clinical relevance, safety, and effectiveness. Regular updates must be implemented to maintain security and ensure systems remain compatible with evolving clinical practices. In complex delivery environments, AI adoption must also be supported by appropriate governance structures that align clinical teams, leadership, and technology teams to ensure safe and responsible implementation.
29. **Workflow integration:** AI tool implementation requires seamless integration within existing workflows to enhance usability and function as supportive additions rather than disruptive elements that impede efficient care delivery. Mechanisms should be established for tracking AI recommendations and their relationship to final clinical decisions.
30. **Post-deployment monitoring:** Robust post-deployment monitoring is critical to ensure AI systems continue performing as intended. AI systems can drift from initial performance parameters when encountering new patient populations not represented in training data, as clinical practices evolve, or even within the same populations over time. Special attention should be directed toward monitoring outcomes in patient groups not adequately represented in training datasets.

DATA GOVERNANCE IMPLEMENTATION

31. **Patient data:** All patient-identifiable information used or generated by AI systems must be collected, stored, and processed in strict accordance with the [WMA Declaration of Taipei on Ethical Considerations Regarding Health Databases and Biobanks](#), as well as all applicable laws and regulations. Security safeguards are mandatory to preserve confidentiality, prevent unauthorised access, and uphold the therapeutic trust that underpins the patient–physician relationship. Additionally, patient data use must follow the same ethical safeguards applied to clinician data, including purpose limitation, transparency and consent, protection against misuse, and, where feasible, anonymisation and minimisation of data collected.
32. **Clinician data:** AI systems are increasingly capturing granular data about clinicians (e.g., keystrokes, voice recordings, workflow metrics, prescribing patterns). Such information can support quality improvement and safety, but it also carries a risk of surveillance, punitive misuse, or erosion of professional autonomy. Therefore:
- *Purpose limitation:* Clinician-identifiable data may be used only for clearly defined clinical, educational, or quality-improvement objectives that have been disclosed to—and agreed by—those clinicians.
 - *Transparency and consent:* Physicians must be informed, in advance and in comprehensible terms, what data are collected, how they will be analyzed, and who will have access. Explicit consent is required for uses beyond direct patient care or clinician-requested feedback.
 - *Protection against misuse:* Data must not be repurposed to penalize clinicians, set unrealistic performance quotas, or otherwise undermine the patient-physician relationship. Any secondary use (e.g. commercial analytics, administrative oversight) requires separate ethical review and consent.
 - *Anonymization and minimization:* Where feasible, clinician data should be de-identified or aggregated, and collection limited to the minimum necessary to achieve the stated purpose.

33. **Governance and oversight:** Healthcare organisations must establish independent oversight mechanisms – such as, and not limited to, data protection officers, ethics committees, and periodic external audits – to verify compliance with safeguards for both patient and clinician data. Breaches or unauthorised uses must trigger transparent disclosure, remediation, and, where appropriate, sanctions. In addition, AI system developers must implement and support robust cybersecurity policies and controls to protect the confidentiality, integrity, and availability of health data throughout the AI system’s lifecycle.

MEDICAL EDUCATION AND CAPACITY BUILDING

34. **AI literacy requirements:** Physicians must maintain appropriate AI literacy in the rapidly evolving AI landscape, including the knowledge and skills to use AI tools properly and the ability to critically understand and assess AI literacy must be systematically integrated into undergraduate medical curricula to ensure all physicians acquire a foundational understanding of these technologies. In addition, AI literacy should be reinforced through mandatory continuing professional development programs, enabling physicians to keep pace with evolving tools and to ensure their safe, ethical, and informed use in practice.
35. **Global equity:** Focused attention must be directed toward bridging AI education gaps between regions, with particular emphasis on enhancing capacity in low- and middle-income countries (LMICs). Equitable distribution of educational resources and opportunities is essential to prevent widening disparities in AI implementation and ensure global benefit from these technological advances.

RESEARCH, INNOVATION AND EVALUATION

36. **Medical research standards:** Any medical research involving AI, whether as the tool or object of study, must abide by accepted international standards of medical research, including, but not limited to, Good Clinical Practice, the [WMA Declaration of Helsinki](#), and the [WMA Declaration of Taipei](#).

GLOBAL CONSIDERATIONS AND COLLABORATION

37. **Cross-jurisdiction applicability:** AI policies and infrastructures should, as far as possible, be aligned to have applicability across jurisdictions.
38. **Diverse healthcare environments:** Appropriate AI solutions must be pursued across diverse healthcare environments, including low-resource settings. This requires supporting locally developed, context-sensitive innovations to ensure AI systems are responsive to local needs, realities, and resource constraints.
39. **Cultural Sensitivity:** AI policies should respect varied cultural approaches while ensuring alignment with fundamental ethical principles, such as respect for human dignity, rights, and wellbeing.

RECOMMENDATIONS

40. **For physicians and medical associations:** Medical professionals and their representative organizations should promote the development of comprehensive AI literacy programs, actively engage in AI governance structures – including contributing to the development of best practices for AI use in medicine – and uphold rigorous ethical standards to ensure quality patient care in an AI-enhanced healthcare environment. They should also consider creating educational materials for patients to support transparency and informed understanding of AI in healthcare.
41. **For healthcare facilities:** Healthcare institutions must establish robust governance frameworks for the safe adoption of AI technologies and implement continuous monitoring processes. Organizations should balance innovation with safety considerations and maintain respect for clinical judgment when deploying AI systems.

Importantly, AI implementation should be pursued when it demonstrably serves patients' interests, without mandating AI use as a condition for licensure, participation, or reimbursement.

42. **For technology developers:** Technology companies and AI developers must prioritize co-design approaches with practicing physicians and provide transparency in system development, deployment and use. Sustained collaboration between clinical and technical experts throughout the entire development lifecycle is essential to create tools that enhance healthcare quality and equity and that effectively support clinical activity.
43. **For regulators and policymakers:** In consultation with medical associations (and other health professions organisations), craft physician-informed regulations and foster international cooperation.
44. **For educational institutions:** Embed AI training in curricula and support global capacity building.
45. **For researchers and innovators:** Pursue ethical, equitable, and evidence-based AI advancements.

Appendix

Narrow AI:

Domain-specific applications confined to clearly defined clinical or administrative objectives.

Generative AI:

Models, often large-language models, that create new clinical content—such as documentation drafts or treatment-plan suggestions—based on training data.

Foundational Models:

Broad, continuously trained models that underpin multiple healthcare applications and therefore require ongoing domain-specific oversight.

Machine learning:

A subset of artificial intelligence in which computer algorithms autonomously improve their performance at a specific task by learning complex relationships or identifying patterns in data, rather than by following explicit, pre-programmed instructions.

Patient-Physician Relationship:

Trust can be enhanced in the patient-physician relationship when:

- Physicians transparently discuss the role of AI in patient care
- AI systems demonstrably improve quality or safety outcomes
- Patients clearly understand how their data is used and protected and how data governance is organized.
- Patients are offered more time with their physician



Artificial Intelligence in Primary Health Care: Promise, Pitfalls, and the Physician's Responsibility

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Primary Health Care (PHC) is the cornerstone of effective, equitable, and sustainable health systems (1). As reaffirmed by the World Medical Association (WMA), strong PHC is essential for achieving Universal Health Coverage (UHC), improving health equity, and responding to the growing global burden of chronic disease (2). In recent years, Artificial Intelligence (AI) has emerged as a powerful force with the potential to transform health care delivery. Nowhere is this potential more consequential, and more ethically complex, than in PHC.

AI in PHC is often discussed in terms of efficiency, innovation, and cost reduction. Yet, from a physician and public health perspective, the central question must be broader and more accountable: Can AI strengthen PHC in a way that is equitable, ethical, person-centered, and aligned with global health priorities?

At its best, PHC is continuous, comprehensive, coordinated, and community-oriented (1). AI technologies, particularly machine learning, clinical decision support systems, and predictive analytics, can meaningfully support these functions(3). In preventive care, AI-enabled risk stratification tools can identify individuals and communities at higher risk of non-communicable diseases (NCDs), enabling earlier interventions and more targeted health promotion (3,4). In PHC settings where physicians face overwhelming patient loads, AI-supported triage systems can help prioritize care, flag critical symptoms, and support timely referrals (1).

For chronic disease management, AI-driven tools can assist in treatment optimization, adherence monitoring, and early detection of complications, particularly for conditions such as diabetes, hypertension, and asthma that dominate PHC caseloads globally (5).

When thoughtfully integrated, these tools can enhance continuity of care rather than fragment it. Importantly, AI has the potential to support PHC delivery, particularly in last-mile, underserved, and remote settings, through telemedicine platforms and automated diagnostics, in line with the WMA's commitment to equitable access to care (2, 5).

Despite its promise, however, AI in PHC carries significant risks if deployed without proper operational guidelines. Algorithms are only as good as the data on which they are trained. Many AI systems rely on datasets drawn predominantly from high-income countries, urban populations, and hospital-based care (6). When applied in low- and middle-income countries (LMICs) or marginalized communities, these systems may underperform, misclassify risk, or reinforce existing health disparities. From a PHC perspective, this raises profound concerns. If AI tools systematically disadvantage certain populations based on geography, ethnicity, gender, or socioeconomic status, they undermine the very equity PHC is meant to promote (5). The WMA emphasizes that technological innovation must not exacerbate health inequities (2, 7). As such, physicians working in PHC must advocate for inclusive datasets, contextual validation, and continuous monitoring of algorithmic bias.

A recurring concern surrounding AI is the fear of physician replacement. As articulated in the WMA Statement on Artificial and Augmented Intelligence in Medical Care, AI should be understood as an augmentative tool that supports clinical reasoning, reduces administrative burden,

and frees physicians to focus on what machines cannot replicate: empathy, ethical judgment, contextual understanding, and trust-building (7). The physician–patient relationship remains central to effective PHC. Over-reliance on algorithmic outputs risks reducing care to transactional decision-making, eroding patient autonomy and shared decision-making. The WMA emphasizes that AI must remain subordinate to human clinical judgment, with physicians retaining ultimate responsibility for patient care (7). This is particularly important in PHC, where diagnostic uncertainty is common, clinical presentations are often undifferentiated, and social determinants of health play a decisive role.

AI in PHC further raises critical ethical questions around data privacy, consent, transparency, and accountability (5,6). PHC settings often serve as the first point of contact with the health system, making them repositories of sensitive, longitudinal patient data. Robust governance frameworks are essential to ensure that patient data are protected, used responsibly, and not exploited for commercial or non-clinical purposes. The WMA emphasizes physician leadership in digital health governance and ethical standard-setting, emphasizing that physicians must be involved in the design, procurement, and oversight of AI systems rather than positioned as passive end-users (7).

For AI to truly strengthen PHC, the health workforce must be adequately prepared. Medical education and continuing professional development should include foundational training in digital health literacy, AI ethics, and the critical appraisal of algorithmic tools. Furthermore, early-career doctors, positioned at the intersection of clinical practice, innovation, and advocacy, can play a pivotal role in shaping AI implementation that is grounded in real-world PHC needs rather than technological novelty.

AI in PHC is, ultimately, a test of our collective values. If implemented thoughtfully, it can strengthen PHC systems, advance UHC, and improve population health outcomes. If implemented poorly, it risks deepening inequities, eroding system trust, and distorting care priorities. For physicians, and especially junior doctors, the task is to engage critically, lead responsibly, and ensure that AI serves PHC in a way that reflects equity, ethics, physician leadership, and patient-centered care.

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Advancing digital and AI literacy in health professions' education: A viewpoint from Regional Youth Champions around the globe

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Introduction

The young generation is widely referred to as “digital natives”, but for young healthcare professionals and students, this digital intuition meets its limits at the increasingly digitalised healthcare system. Readiness for a transformed healthcare is not yet where it needs to be for the digital age, and education is lacking. As young healthcare professionals, students and advocates for health and equity-focused digital transformations, we bring our lived experience and professional activities to the conversation on bridging the digital and AI literacy gap. Representing the Digital Transformations for Health Lab (DTH-Lab) as Regional Youth Champions (RYCs), we work to connect the needs of young people from a regional level to the global level as key stakeholders in the governance of the digital transformation of health.

The rapid integration of digital health and artificial intelligence (AI) into the healthcare ecosystem marks an important shift in the digital transformation of medical practice. However, it also unmasks a problem in how prepared the healthcare workforce is in meeting this transformation (1). This gap is a modern extension of an old challenge; as Selwyn (2004) writes, the “digital divide” is always linked to information inequality, creating political and social problems in all sectors, including healthcare (2). As health systems everywhere face rapid digitalisation, these skills are no longer optional but essential.

According to the DigComp 2.2 framework from the European Commission, digital literacy is about information and data literacy, communication, digital content creation, safety, and problem-solving (3). Digital literacy refers to the skills, knowledge, and attitude that allow people to be equipped for digital environments. It

is a multidimensional competency that includes critical evaluation and the ability to adapt to technological change.

Right now, we are entering a new era: AI systems (in healthcare) represent a disruptive change with implications across specialities and domains. Unlike the digital tools used in health and well-being so far, AI systems can learn and adapt, often in non-transparent ways. AI literacy is defined as an individual’s ability to critically evaluate, use, and communicate with AI. While digital literacy is a requirement for AI literacy, AI literacy requires additional skills, including understanding machine learning principles, algorithmic bias, and model validation (4).

Young health professionals currently lack adequate exposure to digital and AI education

As young health professionals and health professions students, the new digital reality in healthcare is something we face every day. For many early-career clinicians, exposure to digital systems such as electronic health records and telehealth applications occurs informally and opportunistically, rather than through structured education or training. As a result, digital competence is often acquired ad hoc, creating wide variation in confidence, capability, and critical understanding.

This gap is especially relevant because juniors frequently occupy frontline roles: they are early adopters of new technologies in care settings, primary users of digital systems, and key intermediaries between

patients and digital infrastructure. At the same time, they report uncertainty around digital skills during medical school (5).

Also nurses and further allied health professionals are implicated in this development. Nurses are often the primary interface between patients and digital systems, managing electronic health records and monitoring bedside technologies while sustaining continuous patient contact. Despite this central role, most nursing education also provides insufficient digital training, contributing to usability challenges and implementation burden (8).

Over the last few years, DTH-Lab convened over 600 young people in co-creating equitable and inclusive digitally-enabled health systems (9). They found that young people, mostly the future health workforce, see the potential digitalisation brings but emphasise that digital capacity of healthcare workers must be improved to be able to work efficiently in digitally-enabled health systems (9). Across these healthcare professions, these experiences reflect a shared reality across the globe: young healthcare professionals are expected to function within digitally-enabled health systems without being systematically prepared for their ethical, clinical, and organizational implications. The responsibility to teach and train these digital skills is largely put on the individual, instead of the educational institution or healthcare system. Economic disparities further limit access to the devices, connectivity, and educational resources needed for effective digital health training (10).

Digital and AI literacy must be recognised as essential to the future health workforce, not treated as an afterthought

Throughout our work as RYCs, engaging with different aspects of the digital transformation across digital governance, wellbeing and citizenship, we have been able to consider long term consequences of not addressing inequities in digital and AI training that we already see in our own contexts. From our perspective, digital and AI literacy is not optional; it is a core skill not only in our personal lives but in the professional workspace. Using digital and increasingly AI-driven systems without formal training in bias, data governance and accountability may continue to lead to overuse of tools that young professionals do not yet fully understand.

Young professionals should not just adapt to digital systems but help shape how they are designed and governed. Including youth voices in AI policy and curriculum design should not be tokenistic, but a

standard practice. A digital health system built by youth through co-creation, such as DTH-Lab's framework for digitally-enabled health systems (9), encapsulating young people's desired health futures, can address the gaps that already exist; as such, it will more likely make these systems equitable, accountable, and more realistic to actual clinical care happening on the ground.

Conclusion

Young healthcare professionals are entering health systems that are becoming increasingly digitalised or even AI-driven. However, due to structural and institutional shortcomings in educational teaching and training, they are not adequately prepared to use, manage and understand the application of these systems. Improving digital and AI literacy and skills for healthcare professionals is essential in shaping equitable and accountable digitally-enabled health systems.

About DTH-Lab:

Digital Transformations for Health Lab (DTH-Lab) is a global consortium driving inclusive, equitable and rights-based digital transformations for health by generating research, advancing policy innovation, and shaping public and political agendas through multi-sector partnerships and youth co-creation. DTH-Lab focuses on ensuring that digital transformations contribute to healthy societies, with a particular focus on safeguarding the well-being of young people and future generations.

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Impact of Artificial Intelligence and Digital Health on Medical Practice and Public Health in London, United Kingdom

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Artificial intelligence (AI) and digital health technologies are rapidly transforming healthcare delivery, clinical practice, and public health in the UK. Within London's diverse and densely populated healthcare environment, these technologies provide opportunities to enhance diagnostic accuracy, optimise clinical workflows, improve patient access, and strengthen population health surveillance. At the same time, they introduce challenges concerning workforce integration, professional standards, data governance, equity, and patient trust. This viewpoint reflects on the impact of AI and digital health in London, with a focus on clinical practice, public health, and the ethical and practical implications for healthcare professionals.

AI and Clinical Practice

AI has made substantial contributions to diagnostic accuracy and clinical decision-making. Machine learning algorithms are increasingly used in radiology and pathology to detect abnormalities such as tumours and other disease markers, often with sensitivity comparable to or exceeding that of human clinicians(1). Pilot programmes in NHS screening services aim to deploy AI platforms to analyse imaging data efficiently, reducing workload pressures on radiologists and facilitating earlier diagnosis. Surveys by the Royal College of Physicians indicate growing adoption of AI for radiology, automated note-taking, and decision support, although uptake varies across hospital settings (1).

In London, AI-enabled solutions are being trialled in tertiary hospitals such as Great Ormond Street Hospital. Here, ambient AI tools assist with clinical documentation, automatically generating patient notes during consultations. This innovation

reduces administrative burden and allows clinicians to focus more on patient care. These applications illustrate how AI can streamline workflows, improve clinician efficiency, and increase patient-facing time, particularly in high-demand urban hospitals.

Digital Health Platforms and Access to Care

Digital health platforms have significantly expanded access to care beyond traditional clinic visits. Telemedicine, remote monitoring, and mobile health applications allow patients to manage chronic conditions, access GP services, and request prescriptions digitally. In London, these tools are particularly valuable for populations with mobility constraints or busy schedules, enabling continuity of care without requiring in-person visits. Remote monitoring platforms also allow clinicians to track vital signs and symptom trends in real time, facilitating proactive intervention and reducing hospital admissions.

Furthermore, digital health tools have supported large-scale public health initiatives. During the COVID-19 pandemic, mobile applications such as the ZOE Health Study app allowed for near real-time symptom tracking across the UK population. This data helped public health authorities understand the epidemiology of the disease, monitor emerging hotspots, and guide policy decisions. These examples demonstrate how digital platforms can improve both individual patient care and broader public health monitoring.

Public Health and Population Health Management

AI and digital health technologies are increasingly applied to population-level health management. Predictive analytics can identify high-risk individuals, allowing targeted preventative interventions and more efficient resource allocation (2). Projects such as NHS Foresight use de-identified patient data to model trends and anticipate future healthcare demands, supporting strategic planning and improving health outcomes (3). In London, with its ethnically and socioeconomically diverse population, predictive tools can help address inequalities by identifying groups at risk of poor health outcomes and enabling tailored interventions (2).

AI-driven tools can also deliver personalized health information, health coaching, and decision support to patients, improving engagement and adherence to treatment (2). However, successful implementation depends on ensuring digital inclusion, as unequal access to technology could exacerbate existing health disparities, particularly in disadvantaged communities.

Challenges and Professional Implications

Despite the potential benefits, AI and digital health pose challenges for healthcare professionals. Integration into routine practice requires investment in infrastructure, training, and interoperability, and there are concerns regarding algorithm reliability, explainability, and medico-legal liability (1). Clinicians must maintain oversight to avoid deskilling and ensure patient safety, balancing reliance on AI with professional judgment (1).

Regulatory frameworks are evolving to address these issues. The UK Medicines and Healthcare products Regulatory Agency (MHRA) is developing guidance for AI as a medical device, while the government is considering policy initiatives to ensure ethical, safe, and transparent deployment (4). These measures are essential for maintaining patient trust, safeguarding data, and protecting professional standards.

Public trust also plays a critical role in adoption. Surveys indicate that while patients often support AI for administrative tasks, concerns persist regarding clinical decision-making, accuracy, and transparency (5). Addressing these concerns requires involving patients, clinicians, and other stakeholders in system design, evaluation, and continuous monitoring.

Conclusion

AI and digital health are transformative forces in healthcare, offering significant benefits for clinical efficiency, patient access, and public health management, especially in London's complex healthcare system. Realising their full potential requires addressing infrastructural, educational, regulatory, and ethical challenges. By integrating AI responsibly, ensuring professional oversight, and promoting digital inclusion, these technologies can improve patient outcomes, support healthcare professionals, and strengthen the resilience of the NHS. Continuous evaluation and reflective practice will be essential to ensure safe, equitable, and effective deployment in clinical and public health settings.

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Ethical and Governance Challenges of AI and Digital Health in Resource-Constrained Health Systems: A Junior Doctor's Perspective from Indonesia

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The use of artificial intelligence (AI) and digital health technologies is expanding rapidly across healthcare systems worldwide. Clinical decision support tools, electronic health records, telemedicine, and digital health financing platforms are increasingly promoted as solutions to improve efficiency, quality of care, and patient safety (1,2). However, digital innovation does not occur in a vacuum. In resource-constrained health systems such as Indonesia's, the implementation of AI and digital health technologies raises ethical, operational, and governance challenges that are often underrepresented in global discussions (3).

As a junior doctor working at the frontline of clinical care, I interact with digital systems on a daily basis while balancing clinical responsibility, administrative demands, and patient safety. This position offers a practical perspective on how AI and digital health can meaningfully support healthcare delivery, or, conversely, increase clinical burden, depending on system readiness, regulation, and alignment with real-world practice.

The potential of AI and digital health in clinical care

Conceptually, AI and digital health offer significant opportunities to strengthen clinical practice. AI-based decision support systems may assist in risk stratification, diagnostic reasoning, and treatment selection, while digital clinical pathways can promote more standardized and evidence-based care (1,4). Digital medical records and integrated health information systems are also expected to reduce documentation errors and improve continuity of care across services (2).

In geographically diverse countries with uneven distribution of healthcare resources,

digital health innovations such as telemedicine and AI-assisted triage may help expand access to care and optimize limited workforce capacity (2,3). These benefits are particularly relevant in settings facing shortages of specialist physicians, where AI may function as an adjunct to support timely diagnosis and referral rather than as a replacement for clinical judgment.

Implementation challenges in resource-constrained settings

Despite their promise, digital health technologies are often difficult to implement effectively in real-world settings. In many hospitals, digital systems remain fragmented, with limited interoperability between electronic medical records, billing platforms, and national health databases. Rather than reducing workload, this fragmentation frequently increases administrative burden through repeated data entry and parallel documentation processes (2,5).

Junior doctors are commonly expected to operate these systems, often without structured training in digital health or AI literacy. Infrastructure limitations, variable system quality across facilities, and inconsistent technical support further complicate implementation. As a result, technologies intended to support clinical care may unintentionally divert attention away from patients toward administrative and digital tasks (5).

Ethical concerns and patient safety

The integration of AI into healthcare raises substantial ethical considerations.

International guidance highlights the risks of bias, lack of transparency, and potential harm when AI systems are deployed without adequate oversight or contextual adaptation (1). In low- and middle-income settings, these risks may be amplified by differences in population characteristics, healthcare infrastructure, and data quality compared with the environments in which many AI tools are developed.

Accountability is another key concern. When AI-based recommendations influence clinical decisions, responsibility for adverse outcomes may become unclear. Junior doctors, in particular, may feel pressured to follow algorithmic outputs despite conflicting clinical judgment. Maintaining clear professional accountability and reinforcing AI as a decision-support tool, rather than a decision-maker, is essential for safeguarding patient safety.

Governance and regulatory context in Indonesia

Indonesia has established an important policy foundation for digital health transformation. Law No. 17 of 2023 on Health explicitly supports the use of health information technology while emphasizing patient safety, ethical standards, and personal data protection (6). In parallel, the Ministry of Health of the Republic of Indonesia has developed SATUSEHAT as a national health data integration platform aimed at improving interoperability across healthcare facilities (7).

In recent years, national policymakers have also demonstrated strong political commitment to integrating AI into healthcare delivery. Pilot initiatives using AI-supported diagnostics for conditions such as stroke, cancer, and tuberculosis are currently being tested in national referral hospitals, with explicit emphasis on clinical validation and physician oversight (8). In addition, the Ministry has begun fostering a broader health AI innovation ecosystem. In 2025, it launched the Indonesia Healthcare AI Hackathon, bringing together clinicians, engineers, academics, and industry partners to develop AI-based solutions targeting national priority health issues. Importantly, policymakers emphasized that AI is intended to empower healthcare professionals rather than replace clinical expertise (9).

However, evidence from recent national literature suggests that broader adoption of clinical AI in Indonesia remains uneven. A comprehensive review of studies published between 2021 and 2024 identified persistent barriers, including the absence of AI-specific clinical regulations, uneven digital infrastructure, ethical concerns, and limited AI literacy

among healthcare professionals (10). These findings highlight a recurring gap between policy ambition and system readiness.

The role of junior doctors in digital transformation

Junior doctors play a critical yet often underrecognized role in digital health implementation. Beyond being end-users of technology, we act as intermediaries between policy objectives, system design, and daily clinical practice. Our proximity to patient care positions us to identify both the benefits and unintended consequences of digital tools.

Meaningful involvement of junior doctors in digital health planning and governance can help bridge the gap between policy ambition and clinical reality. Such engagement is essential to ensure that innovation remains patient-centered, ethically grounded, and responsive to the realities of frontline care.

Conclusion

AI and digital health technologies offer substantial opportunities for strengthening healthcare delivery in resource-constrained systems. However, innovation without robust governance risks creating new challenges rather than resolving existing ones. The experience of digital health implementation in Indonesia demonstrates that political commitment and pilot projects alone are insufficient without parallel investment in regulation, workforce readiness, and ethical oversight.

From a junior doctor's perspective, the future of AI in healthcare depends not only on technological advancement, but on responsible, context-sensitive implementation. By prioritizing patient safety, ethical principles, and inclusive governance, digital innovation can enhance quality of care and public trust while offering valuable lessons for global digital health efforts.

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Zhancare: A Junior Doctor–Led Artificial Intelligence Ecosystem for Patient Navigation, Clinical Documentation, and Academic Integration in Kazakhstan

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Introduction

Healthcare systems worldwide are increasingly challenged by fragmented care pathways, administrative overload, and inefficiencies in patient routing to appropriate specialists. These issues are particularly relevant in middle-income healthcare settings, where geographic disparities and resource distribution further complicate access to timely and specialized care. In Kazakhstan, patients frequently encounter difficulties identifying suitable specialists, while physicians face substantial documentation burdens and limited opportunities for rapid engagement with international clinical knowledge due to language barriers (1).

Simultaneously, the rapid emergence of digital health solutions has largely been driven by technical teams that may not fully capture the complexities of everyday clinical practice (2). Recognizing this gap, a team of junior doctors initiated Zhancare as a clinician-led digital platform designed to integrate frontline clinical experience with technological innovation (3). Artificial intelligence (AI) is therefore positioned not merely as a technological advancement but as a practical enabler of accessibility, continuity of care, and professional development.

Concept of Zhancare

Zhancare is conceptualized as “medicine in one click,” representing an integrated digital health ecosystem aimed at improving clinical workflow efficiency and patient access to healthcare services (3). Initially launched as a startup initiative, the project has evolved into a hybrid model combining real-world implementation with academic exploration and research potential.

The platform primarily targets physicians and patients, with a particular emphasis on

underserved rural populations where access to specialized care remains limited. Zhancare seeks to consolidate patient navigation, clinical documentation support, and data analytics within a single environment, thereby fostering continuity of care while supporting both clinical and academic workflows.

Functional Architecture

Patient Navigation Module

Zhancare is accessible through both web and mobile interfaces, with the web platform currently serving as the primary operational environment. Patients interact with an AI-driven conversational interface that allows free-text description of symptoms. Based on this input, the system performs preliminary triage and suggests appropriate specialists from an internal physician database.

The platform further enables patients to review available clinicians and directly schedule online consultations by selecting suitable time slots. This functionality streamlines referral processes and enhances access to care, particularly for individuals residing in remote areas.

Clinical Copilot Module

Within the current minimum viable product (MVP), physicians manually document consultation data using structured consultation templates embedded in the platform. Development efforts are ongoing to integrate speech-to-text functionality aimed at automating consultation note generation and reducing administrative workload(4).

Clinicians maintain full editorial control over

documentation, ensuring accuracy and preserving clinical responsibility. The platform incorporates national clinical guidelines from Kazakhstan (5), enabling the AI module to provide protocol-based recommendations upon physician request (6,7). This feature supports diagnostic and treatment decision-making while maintaining the physician as the ultimate decision-maker (8,9).

Academic Analytics Module

Zhancare facilitates structured data collection, including demographic characteristics, diagnoses, anthropometric measurements, and other health-related parameters. These data are intended for secondary analysis and may contribute to the creation of research datasets, supporting academic initiatives and evidence generation.

By integrating clinical data capture with research-oriented analytics, the platform positions itself as a potential infrastructure for both clinical practice and academic development.

Relevance for Junior Doctors

Zhancare primarily supports early-career physicians engaged in independent clinical practice by simplifying consultation workflows and improving efficiency. Structured templates and rapid access to national clinical guidelines help reduce cognitive and administrative burdens while supporting clinical reasoning during patient encounters (5).

Although dedicated resident access is still under development, the platform already enables junior doctors to conduct teleconsultations, streamline patient routing, and standardize documentation practices. These capabilities may also facilitate academic engagement by enabling organized data collection and encouraging research-oriented clinical activity.

Challenges and Ethical Considerations

Patient confidentiality and data privacy are maintained through secure platform design and controlled access to consultation information. AI-generated recommendations are implemented as assistive tools rather than autonomous decision-makers, with physicians retaining full clinical responsibility and oversight (8,9).

Flexible care pathways allow referral to in-person consultations when clinically indicated, ensuring patient safety and continuity of care. From a

regulatory perspective, Zhancare functions as an intermediary digital platform connecting patients with healthcare providers, aligning the project with existing medico-legal frameworks.

Ongoing challenges include refinement of AI accuracy, development of automated documentation features, and continuous monitoring of ethical considerations associated with AI-supported clinical workflows.

Future Perspectives

Future development of Zhancare is oriented toward interoperability and ecosystem expansion. Integration with existing medical information systems is being explored to enable secure data exchange and improve continuity of patient care across healthcare settings.

The platform also aims to expand into medical tourism, facilitating cross-border consultations and improving patient access to specialized expertise. In parallel, an educational module is under development that will provide accredited courses and continuing professional development opportunities for physicians through personalized user accounts.

Within five years, Zhancare aspires to evolve into a comprehensive digital health ecosystem supporting clinical care delivery, physician education, research activity, and international healthcare collaboration.

Conclusion

Zhancare demonstrates that junior doctors can lead the digital transformation of healthcare by developing solutions grounded in real-world clinical needs. Beyond its functional utility as a SaaS (Software-as-a-Service) platform, Zhancare represents a significant research-oriented contribution to the fields of Medical Natural Language Processing (NLP), Clinical Decision Support Systems (CDSS), and Medical Informatics (4,8,9).

The project's technical core — specifically the functional RAG-based (Retrieval-Augmented Generation) prototype for clinical protocols (6,7) and a dedicated Machine Learning pipeline for automated medical document processing (4) — provides a robust framework for AI-assisted healthcare. By digitizing and structuring a comprehensive database of 657 national clinical protocols (5), the platform creates a foundation for evidence-based decision-making. Ultimately, Zhancare illustrates the potential

of clinician-led innovation to bridge the gap between technical AI development and practical clinical excellence, fostering a new era of academic and professional integration in Kazakhstan's healthcare system.

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Beyond Predictive Models: Embedding AI to Strengthen Immunization Systems and Surveillance in LMICs

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Artificial intelligence is rapidly entering global health discourse, yet immunisation systems in low- and middle-income countries (LMICs) continue to struggle with zero-dose inequities, stock-outs, and weak surveillance infrastructure (1,2). Although electronic registries and digital platforms have expanded, translating data into operational action remains inconsistent (1,3). The critical question is therefore not whether AI can predict risk, but whether it can be implemented in ways that measurably strengthen immunisation delivery. Digital transformation has expanded the use of electronic immunisation registries (EIRs) and electronic logistics management systems, but data availability alone has not consistently translated into improved service delivery (1,3). The emerging opportunity lies not in deploying artificial intelligence (AI) as a standalone technological advance, but in embedding it within immunisation systems as an implementation-focused decision-support layer (1,4).

Electronic immunisation registries provide individual-level longitudinal vaccination histories that enable tracking of timeliness, identification of defaulters, and geospatial mapping of underserved populations(1). Evidence from LMIC contexts shows that EIRs can enhance data completeness and programme responsiveness when integrated into routine workflows and supported by sustained governance structures(1,3). However, implementation challenges, including interoperability gaps, connectivity constraints, workforce readiness, and data quality limitations, often undermine the reliability of analytics derived from these systems (3,5). Without strengthening these foundational components, predictive tools risk producing misleading outputs that misdirect scarce outreach resources (4,5).

Machine-learning approaches applied to routine immunization data have

demonstrated capacity to identify infants at increased risk of defaulting before completion of the vaccination schedule (6). Such predictive risk stratification holds promise for enabling targeted follow-up through community health workers and facility-level appointment management (6). Nevertheless, the effectiveness of these tools depends on whether risk signals are embedded within clearly defined workflows that specify who acts, how quickly, and with what accountability (3,5). Implementation science demonstrates that digital innovations influence outcomes through mechanisms of adoption, fidelity, and sustainability, rather than technological performance alone (3,5).

Vaccine availability remains another critical determinant of immunization performance, as stock-outs directly translate into missed opportunities for vaccination(2). Analytical tools can improve forecasting accuracy by incorporating historical consumption patterns and facility-level reporting trends, but predictive accuracy alone does not guarantee supply chain resilience (2,7,8). Studies examining immunization supply chains across multiple countries emphasize that system redesign, stakeholder alignment, and realistic data flows are essential to ensure that analytical insights translate into operational improvements (8). Embedding explainable forecasting algorithms within strengthened logistics management systems offers a pragmatic path toward reducing preventable shortages, provided that interoperability and reporting compliance are addressed (3,8).

Geospatial inequities in essential childhood immunization remain pronounced across LMICs, with clusters of low coverage often

concentrated among socioeconomically disadvantaged populations(4). Integrating registry data with contextual and spatial indicators can support earlier identification of vulnerable regions and micro-planning gaps (4,6). Ethical deployment of AI in such settings requires explicit safeguards to prevent amplification of bias, particularly where marginalized communities are underrepresented in digital datasets (4,5). Transparent model validation, local contextualization of predictors, and routine bias audits are therefore indispensable components of responsible implementation (5,7).

A disciplined pathway for integrating AI into LMIC immunization systems begins with strengthening digital registry quality and standardizing core data elements (1,3). Building interoperable architectures that connect registries, supply chain systems, and surveillance platforms enhances the reliability of downstream analytics (3). Introducing transparent and explainable predictive tools that are directly linked to outreach, supervision, and micro-planning mechanisms ensures that analytical insights translate into concrete service delivery actions (3,6). Evaluation frameworks should prioritize implementation outcomes, such as feasibility, adoption, and sustainability, alongside traditional coverage indicators (3,5).

Public health impact must remain the defining benchmark of AI integration in immunization systems. Reductions in zero-dose prevalence, improved timeliness, decreased stock-out frequency, and narrowing of geographic inequities provide tangible indicators that digital intelligence is translating into service delivery gains (1,2). Technological sophistication alone is insufficient; the central determinant of success is whether AI-generated insights alter frontline practice, supervisory oversight, and policy prioritization (3,5). Embedding predictive tools within accountable workflows, supported by interoperable digital architecture and sustained financing, ensures that analytics move from dashboards to decisions (1,3). Ultimately, the promise of AI in LMIC immunization systems will be realized not through algorithmic novelty, but through disciplined implementation that aligns data science with equity, governance, and delivery reform (1,4). When structured in this way, AI can serve not merely as a predictive instrument, but as a catalyst for resilient, responsive, and inclusive immunization systems (1,2).

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Snapshot of Digital Health Gains in Kenya's Healthcare Landscape

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Kenya ranks among the top 10 African countries in mobile phone usage, with penetration at 113%, alongside broader internet access as 58% of Kenyans are now connected to 4G networks, according to the Communications Authority of Kenya - 2025(1). This penetration has been a significant catalyst for the uptake of digital health interventions coupled with the fact that these tools address persistent systemic challenges such as doctor shortages, weak health infrastructure and the rising burden of chronic disease that continue despite changes in political leadership. Different digital health interventions and strategies have been deployed in different settings with visible impact on health access, quality and coverage.

In 2023, the Kenyan government enacted the Digital Health Act (2) and the Social Health Insurance Act (3), which digitized medical claims submission and reimbursement processes in the public sector to reduce fraud and improve efficiency. Prior to this, these processes were largely paper-based in the public sector, while the private sector had already made significant advances in digitization. Although implementation of these components is at varying stages, the integration of health economics principles into digital health tools has demonstrated clear resource optimization potential for payers, providers and patients.

In recent years, Health Information Exchange (HIE) across the various actors within Kenya's healthcare system has increasingly embraced principles of privacy, confidentiality, and consent management(4). This move has helped build public trust in digital health tools, enabling more Kenyans to adopt them as a quick and convenient means of accessing healthcare services. In turn, this has unlocked the healthcare system's capacity to deliver paperless health services and

facilitate paperless payments from multiple sources and at different points in time. To support this shift, the Ministry of Health has put in place provisions for system integration, interoperability, and analytics through components such as the Unique Patient Identification Framework 2022(5), canonical registries, shared health records and mHealth platforms such as AfyaYangu, as reported by the Digital Health Agency. This embeds a government-led sustainability framework for lasting impact in the health system.

Digital micro m-health insurance innovations, such as M-TIBA by Safaricom, enable low-income Kenyans to intermittently set aside funds for unexpected healthcare expenses, with contributions from as low as a tenth of a dollar. This approach is gradually reshaping the narrative around catastrophic health expenditure once common in Kenya by expanding access to healthcare services ranging from primary care to specialized services. These digital health interventions broaden the possibilities of health financing through mobile wallets. Their success builds on the tremendous headway made by Kenya's iconic M-Pesa which has democratized financial services and created a foundation for Kenya's digital economy.

Artificial intelligence (AI) in healthcare has been increasingly embraced through platforms such as mDaktari, Tibu Health, Byon8, HealthX, Zuri Health, ShamiriAI, Prompts by Jacaranda Health, Nena chatbots by Population Services Kenya, WemAkili by AAR Healthcare, and KlinRisk by Roche. These solutions are widely used for remote patient management, virtual consultations, appointment scheduling and the delivery of tailored care packages that

address physical, psychological, and emotional wellbeing, driving a more holistic understanding of health. Clinical data generated across these care pathways are processed using machine learning (ML) algorithms to uncover insights into disease burden trends and care-seeking behavior, identifying opportunities for timely and targeted medical intervention. As a result, an increasing number of Kenyans are now able to access high-quality, affordable and personalized primary healthcare services, including through basic feature phones (referred to as Katulutulu in Kenya).

Value-based, people-centric, client-facing digital tools such as Fafanuka, Penda Health, Zuri Health, Tibu Health, mDaktari, and m-mama have simplified patient journeys within the healthcare system. These platforms are bridging socioeconomic and informational delays that hinder timely access to care through reducing knowledge asymmetries around healthcare conditions, medicines, diagnostics and interventions. Patient navigation platforms like SasaDoctor, AfyaMoja, AfyaBook and PataDoc have magnified medical plurality and choice which is a defining feature of Kenya's healthcare system. Medicine delivery has been greatly simplified by e-pharmacies such as MyDawa and LiviaHealth and rider delivery systems (referred to as Bodaboda in Kenya) which have removed geographic barriers to accessing medications across the 582,646 km² country. Immersive VR learning and simulation centers such as LIFE by KEMRI and the Mekatilili Innovation Hub are improving the quality of healthcare training especially in surgical training and advancing rehabilitation practices resulting in shorter recovery times and better patient outcomes.

Electronic Medical Records (EMRs) such as Slade360 Advantage, TaifaCare KenyaEMR and AfyaEHMS are transforming patient record management by embedding institutional memory, enabling faster registration and replacing traditional paper-based systems. Mobile adaptations such as the Electronic Community Health Information System (eCHIS) equip Kenya's Community Health Promoters (CHPs) with smartphones to deliver door-to-door primary healthcare services towards advancing Kenya's Universal Health Coverage (UHC) goals. Access to diagnostics has been expanded and made more affordable through initiatives such as Ilara Health and Roche Diagnostics. The government is also rapidly adopting AI-driven solutions exemplified by the rollout of 80 AI-powered digital X-ray units in 2025, which enable faster and more accurate diagnostics.

Kenya has a long history of embracing traditional, complementary, and integrative medicine, dating back to the pre-independence era, including well-known practices such as the Murugu Herbal Clinics and Ayurvedic medicine in Kenya's North Rift and Western regions. 65 years later, the country has issued a new directive to formally recognize and integrate these culturally entrenched healthcare practices into the mainstream health system by 2028(6). Traditional medicine currently serves as the primary source of healthcare for over 70% of Kenyans and as such, healthcare professionals are exploring the use of AI to fast-track the identification and validation of beneficial bioactive compounds within traditional remedies, with the potential to scale and adopt them more widely within evidence-based medical practice.

From a governance and management perspective, digital health tools generate both operational and decision-making gains. Decision-making in the public sector is increasingly guided by evidence-based and decision-support tools that track performance at both national and sub-national levels. Tools such as the Bottom-Up Monitor support progress tracking towards Universal Health Coverage and Digital Public Infrastructure catalyzes evidence-backed health resource planning and outcome-focused allocation. These tools narrow down on key health indicators such as access, efficiency, equity, coverage, cost, and reach for strategic action. Operational efficiencies from EMRs, e-prescriptions and e-claims processing are contributing to a reduction in Kenya's carbon footprint which stands at 0.1% of total world emissions per capita.

Legal and regulatory frameworks in Kenya are rapidly evolving to govern this digital health and AI space with instruments like the Data Protection Act (2019), the National AI Strategy (2025–2030), the National Digital Master Plan (2022–2032) and the Kenya Medical Research Institute Bill for traditional medicine (2025)(5-8). Together, these frameworks are creating an enabling environment for startups and digital health businesses to innovate and scale. This oversight is anchored by the Digital Health Agency within the Ministry of Health which provides institutional leadership and coordination for the sector.

Kenya's digital health journey illustrates how deliberate policy, private-sector innovation, and widespread mobile connectivity can converge to reshape a national health system. What began as isolated technological solutions has evolved into an increasingly integrated ecosystem that supports access, quality, efficiency, and financial protection across the continuum of care, with a future that is increasingly optimistic.

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Artificial Intelligence in Low- and Middle-Income Countries: Opportunities and Ethical Challenges from a Junior Doctor's Perspective

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Introduction

Artificial intelligence (AI) and digital health technologies are increasingly influencing diagnostics, clinical decision-making, medical education, and health system organization (1,2). While much of the global discourse focuses on high-income countries, low- and middle-income countries (LMICs) face distinct challenges, where junior doctors often work in resource-limited settings with high patient loads and limited access to specialist care (3).

In LMICs, AI offers opportunities to support overstretched health systems but also raises ethical, educational, and professional challenges. This viewpoint examines the role of AI and digital health in LMICs, highlighting key opportunities and ethical considerations relevant to junior doctors.

Artificial Intelligence and Digital Health in LMICs: Current Context

Healthcare systems in LMICs often face limited infrastructure, diagnostic capacity, and healthcare workforce shortages (4). Digital health technologies have expanded rapidly due to increased smartphone and internet access, yet AI adoption remains uneven (5). AI tools are frequently introduced through pilots, private initiatives, or NGOs rather than coordinated national strategies, resulting in inconsistent implementation and limited oversight(3).

Junior doctors are often early users but rarely involved in governance or evaluation. Formal AI education is usually absent from medical curricula (6), leaving junior doctors to use these tools without fully understanding their limitations, ethical implications, or underlying data raising concerns for patient safety and care quality.

Opportunities of AI for Healthcare Systems and Junior Doctors in LMICs

When implemented responsibly, AI offers meaningful opportunities to strengthen healthcare delivery in LMICs. AI-assisted diagnostic tools have demonstrated potential in areas such as radiology, electrocardiogram interpretation, dermatology, and ophthalmology, particularly where access to specialists is limited (2,4).

These tools may support junior doctors by improving diagnostic accuracy and facilitating earlier detection of disease. Clinical decision support systems powered by AI can help standardize care, reinforce evidence-based practice, and reduce diagnostic errors in high-pressure environments (2). In healthcare systems with heavy workloads and limited supervision, such tools may assist junior doctors in managing large patient volumes while maintaining safety and consistency. Additionally, AI-enhanced telemedicine platforms can expand access to specialist input, enabling remote consultations and follow-up care for patients in rural or underserved regions (5).

AI also holds promise in medical education and training. Digital platforms incorporating AI can support self-directed learning, clinical simulations, and personalized feedback, which may be particularly valuable for junior doctors with limited access to formal teaching or mentorship (4). Used appropriately, AI can function as an assistive tool that complements clinical judgment rather than replacing it.



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Ethical and Practical Challenges in LMIC Settings

Despite its potential benefits, the use of AI in LMICs raises significant ethical and practical concerns. One major challenge is algorithmic bias, as many AI systems are developed using data from high-income countries that may not reflect local disease patterns, demographics, or healthcare practices (1,5). This can lead to inaccurate predictions and inappropriate clinical recommendations when applied in LMIC contexts.

Data privacy and patient consent are additional concerns, particularly in settings with weak regulatory frameworks and limited digital governance (1,7). The collection, storage, and use of sensitive health data must be carefully managed to protect patient confidentiality and maintain public trust. Furthermore, unclear accountability for AI-assisted clinical decisions raises questions about legal and professional responsibility, especially when errors occur (6).

There is also a risk of over-reliance on AI tools by undertrained healthcare workers, which may undermine clinical reasoning and exacerbate existing inequalities (3). Without adequate training and oversight, AI technologies could reinforce disparities between well-resourced urban centers and underserved rural areas. Without ethical safeguards, AI risks amplifying existing inequities rather than addressing them.

The Role and Responsibility of Junior Doctors

Junior doctors are uniquely positioned at the intersection of emerging technologies and frontline patient care. Despite limited influence on policy decisions, they play a vital role in advocating for safe, ethical, and patient-centered use of AI, supported by basic AI literacy to critically assess its limitations (6).

Through participation in guideline discussions, reporting safety concerns, and transparent communication with patients, junior doctors supported by professional and global networks can help shape responsible AI implementation aligned with local needs and ethical standards (1).

Conclusion

Artificial intelligence has the potential to support healthcare delivery and medical education in low- and middle-income countries, particularly in settings burdened by workforce shortages and limited resources. However, its benefits can only be realized

through responsible implementation, robust ethical oversight, and appropriate training. Junior doctors play a central role in this process, serving as both users and advocates for safe and equitable AI integration. With thoughtful governance and education, AI can become a valuable tool that strengthens, rather than undermines, healthcare systems in LMICs.

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Bridging Algorithms and Clinical Reality: AI-Based Surgical Risk Prediction in Low- and Middle-Income Settings

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Practicing surgery in many low- and middle-income countries (LMICs) involves navigating complex challenges related to healthcare infrastructure, workforce limitations, resource constraints, and gaps in surgical data systems(1,2). In these environments, access to reliable clinical datasets, electronic health records, and predictive analytics remains variable, making implementation of data-driven decision-support tools challenging(1,3). The emergence of artificial intelligence (AI)-based surgical prediction models, including the Predictive Optimal Trees in Emergency Surgery Risk (POTTER) calculator, represents an evolving approach toward individualized perioperative risk estimation and clinical decision support(4). Rather than replacing clinical expertise, these tools aim to complement surgical judgment by integrating patient-level information to improve risk assessment and communication.

Although surgical risk prediction tools have been increasingly developed and evaluated within well-resourced healthcare systems, their transferability, feasibility, and ethical implications in LMIC surgical settings require careful consideration(3,6). Differences in healthcare infrastructure, patient populations, disease patterns, and availability of reliable clinical data may influence model performance when these tools are introduced into new environments(3).

What Are AI Surgical Risk Calculators?

AI surgical risk calculators are predictive models designed to estimate individualized postoperative outcomes by integrating multiple patient and procedural characteristics(7). These variables may include demographics, comorbid conditions, laboratory parameters, operative factors, and perioperative information (7).

Compared with some traditional risk scoring systems based on predefined statistical equations, machine learning approaches can identify complex relationships and interactions among large datasets(3,5).

Several surgical prediction tools illustrate this evolving landscape:

- The Predictive Optimal Trees in Emergency Surgery Risk (POTTER) calculator uses machine learning-based methodology incorporating clinical variables to predict postoperative complications and mortality among emergency general surgery and emergency laparotomy patients(4).
- The ACS NSQIP Surgical Risk Calculator uses large-scale surgical outcomes data to estimate individualized risks and was developed as a decision-support tool for surgeons and patients during preoperative counseling(7).
- Emerging deep learning approaches have explored the use of longitudinal clinical information, physiologic data, imaging, and intraoperative variables to improve perioperative prediction, although many models remain under external validation before widespread clinical adoption(3,8).

In clinical practice, these tools may support informed consent discussions, perioperative risk stratification, and shared decision-making by providing clinicians and patients with individualized estimates of expected outcomes(7).

The LMIC Surgical Context: Barriers and Realities

Implementation of AI surgical risk prediction tools in LMICs requires addressing interconnected challenges

involving infrastructure, data systems, workforce capacity, governance, and sustainability.

- **Data scarcity and heterogeneity:** Many surgical AI models have been developed using datasets from high-income healthcare systems. Differences in patient demographics, disease presentation, healthcare access, perioperative practices, and available resources may influence model calibration and generalizability when these tools are applied in LMIC settings.
- **Infrastructure constraints:** In many resource-constrained healthcare environments, variability in digital maturity may limit sustainable deployment of AI-based clinical tools. Some rural and resource-limited hospitals continue to rely on paper-based documentation systems, which may restrict timely aggregation of surgical outcomes data required for quality improvement and predictive modeling.
- **Workforce adaptation:** Surgical and anesthesia providers in many LMICs face workforce shortages and substantial clinical demands. Introducing new digital technologies requires additional training, workflow adaptation, and institutional support, which may be challenging in already constrained health systems.

These realities demonstrate that AI adoption is not solely a technological challenge; rather, it requires alignment between algorithms, healthcare systems, clinicians, governance structures, and patient needs.

Advantages for LMIC Surgical Practice

1. **Improved patient communication and consent:** Informed consent requires effective communication of expected benefits, risks, and uncertainties associated with surgical procedures. In many healthcare settings, including LMIC contexts, communication of individualized surgical risk may be challenged by differences in health literacy, language barriers, and limited availability of accessible risk information.
2. **Enhanced triage and perioperative planning:** Predictive models may assist surgical teams in identifying patients at increased risk of postoperative complications who may benefit from enhanced surveillance and targeted perioperative planning. In resource-constrained environments where postoperative monitoring capacity may be limited, risk prediction tools could contribute to more informed prioritization of clinical attention.

3. **Local data generation:** The implementation of surgical prediction tools may also create opportunities to strengthen local surgical data systems. Routine collection of structured clinical variables can support quality improvement initiatives, enable local validation studies, and facilitate recalibration of models to reflect regional patient populations.

Ethical and Practical Considerations

The use of AI-based surgical risk calculators raises important ethical considerations related to fairness, transparency, accountability, and equitable deployment (3,10).

Local governance mechanisms, including institutional oversight, ethical review, and continuous monitoring, should be considered when implementing AI-enabled clinical decision-support systems. Responsible deployment requires not only technical validation but also evaluation of whether the technology aligns with local healthcare priorities and patient needs.

The Way Forward: Adaptation, Collaboration, and Capacity Building

To maximize the potential benefits of AI-based surgical risk prediction in LMIC settings, implementation strategies must prioritize local adaptation, validation, and responsible governance. Key strategies include:

- **Local validation studies.** Multicenter collaborations should evaluate AI prediction models using local patient cohorts, assessing discrimination, calibration, and clinical usefulness. When necessary, models should be recalibrated or updated to reflect local epidemiology, healthcare resources, and treatment patterns.
- **Open science frameworks.** Transparent research practices and responsible data-sharing frameworks may strengthen reproducibility and broaden participation in AI development.
- **AI literacy in surgical education.** Incorporating AI literacy, digital health competencies, and ethics into surgical education may prepare future surgeons to appropriately interpret and use AI-enabled decision-support tools.
- **Public-private partnerships.** Collaboration among governments, healthcare institutions, researchers, and technology partners may facilitate development of AI solutions adapted to local infrastructure and healthcare priorities.

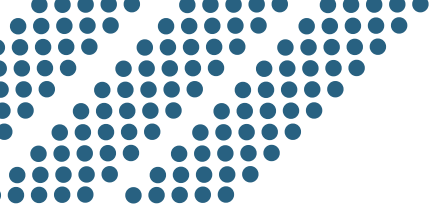
Reflection: AI as a Partner in Surgical Equity

AI-powered risk calculators should not be viewed as solutions to the broader structural challenges affecting global surgery. Persistent disparities in surgical access, workforce availability, infrastructure, and financing require comprehensive health-system strengthening efforts.

The promise of AI in global surgery lies not in replacing clinical judgment but in complementing human expertise with data-driven insights. For surgeons practicing in LMIC environments, the future of AI-enabled care will depend on balancing technological innovation with contextual understanding, ethical responsibility, and commitment to equitable surgical systems.

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WHO CAN BECOME A JDN MEMBER?

To join the JDN you:

- Must be within 10 years of graduation from medical school
- Must be an associate member of the WMA*

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Registration requires validations of the associated documents, there may be a delay of a few weeks from the time of registration to the time you are added to the mailing lists. All registrants who have submitted a completed application will receive an email confirming that they have been added and an invitation to be added to the mailing list; others will be informed how to adequately complete their application.

For more information, please contact membership.jdn@wma.net.