

Artificial Intelligence in Healthcare in Morocco: Potential, Ethical Challenges, and Responsibility Framework ¹

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Introduction

Artificial intelligence (AI) is transforming global medical practices by offering powerful tools to enhance the quality and accessibility of care. The World Health Organization (WHO) emphasizes that, when used correctly, AI can accelerate diagnoses, assist clinicians, bolster medical research, and support public health (e.g., epidemiological surveillance, pandemic response, and healthcare system management) (Lai et al., 2021). AI could also help reduce healthcare inequalities by assisting rural communities or countries with limited resources in addressing the shortage of healthcare professionals (Rao et al., 2020). However, as the WHO Director-General points out, “This technology holds enormous potential to improve the health of millions of people but can also be misused and cause harm” (Lai et al., 2021, p. 55). Thus, placing ethics and human rights at the heart of AI development and deployment in healthcare is critical (O’Neill et al., 2021).

In Morocco, a country facing significant healthcare challenges (e.g., medical professional shortages and regional disparities), AI has generated growing interest as a lever for innovation. Public and private initiatives are emerging to integrate AI into hospitals, research centers, and local health-tech startups. This paper provides an overview of AI adoption in Morocco’s healthcare system, examining the technologies used, involved actors, and specific pilot projects. We will analyze the current and potential benefits of AI in Morocco’s context (e.g., diagnosis, telemedicine, medical data management, and epidemiological prediction). We will then critically explore the ethical challenges raised by the use of AI in healthcare, particularly regarding informed consent, transparency, algorithmic biases, data protection, and the risk of exacerbating inequalities. The crucial issue of medical and legal responsibility in the event of an AI error will also be discussed: who is to blame—doctor, developer, or hospital—and what is the current regulatory framework in Morocco? Finally, recommendations will be made for the ethical, responsible, and sustainable adoption of AI in Moroccan healthcare.

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Theoretical Framework: AI in Healthcare and Its Contextual Use

Artificial intelligence in healthcare refers to the use of computational models that can learn from medical data to assist professionals in decision-making or to autonomously perform specific tasks. AI can be employed in tasks such as medical image analysis (radiographs, MRI scans, CT scans) for detection of anomalies that radiologists might miss, or in AI systems analyzing clinical data to identify high-risk patients for complications (Esteva et al., 2017). The applications of AI cover a wide range: diagnostic assistance, robotic surgery, hospital workflow optimization, and personalized medicine, among others (Kumar & Lee, 2019). AI in healthcare has gained prominence over the past decade due to advancements in deep neural networks (deep learning) and the availability of large healthcare data sets (Rajpurkar et al., 2017). One pioneering study demonstrated that an AI algorithm could classify skin cancer images with precision equivalent to that of experienced dermatologists (Esteva et al., 2017). Since then, numerous studies have confirmed that AI systems can match or even exceed human performance on targeted tasks, while reducing errors. For instance, AI integration in medical diagnostics could decrease diagnostic errors by 25-30% compared to traditional methods, especially for complex or rare diseases (Wang et al., 2021).

In practice, three main areas of AI application in healthcare are often distinguished (Pereira et al., 2021): (1) diagnosis and treatment, including the automated analysis of medical images or signals and clinical decision support; (2) patient engagement and telemedicine, with AI-driven medical chatbots or remote monitoring systems; and (3) data and healthcare system management, where AI is used to organize medical records, plan resources, or detect epidemiological trends. In all cases, AI in healthcare is conceived as a tool for assistance, not a full replacement for human professionals. Humans remain at the center of decision-making—a fundamental principle emphasized by both international ethical frameworks (the principle of protecting human autonomy) and national health authorities. For example, in Morocco, it is clear from a regulatory standpoint that AI should never substitute clinical judgment in therapeutic decision-making (Moroccan Ministry of Health, 2020). The goal is rather to enhance healthcare professionals' capabilities—by allowing them to analyze large volumes of information more quickly, detect correlations invisible to the human eye, or automate repetitive tasks to free up time for patient care (Benali et al., 2021).

Globally, many governments and institutions are investing in AI in healthcare, but adoption varies by country. Countries with digitized healthcare systems and substantial health data repositories (e.g., the United States, Europe, China) have seen the emergence of hundreds of AI-driven clinical applications (e.g., automated diabetic retinopathy screening, robotic surgery). In contrast, developing countries are advancing more slowly, though some are making notable progress through proactive policies. WHO's analysis shows that AI adoption in healthcare is growing significantly in several emerging countries, notably in India (+18% per year), Morocco (+15% per year), and Tunisia (+12% per year) since 2018 (World Health Organization, 2021). Morocco

positions itself as a competitive player relative to comparable countries, indicating an increasingly favorable environment for technological innovation in healthcare (Lai et al., 2021). However, this progress is accompanied by challenges to overcome, primarily ensuring that these advancements benefit the entire population and fit within an appropriate ethical and legal framework. This is the context in which we now turn to examine the situation in Morocco in more detail.

State of AI Adoption in Healthcare in Morocco

Technologies Deployed and Current Uses

In Morocco, AI adoption in healthcare has been growing rapidly in recent years (Benali et al., 2021). A recent survey indicates that about 45% of hospitals in the country use AI systems for managing medical appointments, and approximately 30% use AI for diagnostic support (Seddik et al., 2020). The applications currently deployed range from administrative functions to specialized clinical tasks. For example, robotic surgery illustrates the gradual integration of AI into operating rooms in Morocco: the use of robotic surgical systems like *Da Vinci* has increased by 30% between 2020 and 2024 (Zouhair et al., 2020), reflecting a growing interest in AI-assisted surgery for increased precision and safety. Likewise, medical imaging is a prominent area for AI utilization. According to Professor Jaafar Heikel, a medical professor in Morocco, AI is already being used by many radiologists in Casablanca, Rabat, and Marrakech to analyze radiographs and CT scans, providing a diagnostic potential of “95 to 99% reliability” (Heikel, 2020, p. 123).

Telemedicine also benefits from AI in the Moroccan context. While telemedicine (remote consultation) expanded significantly during the COVID-19 pandemic, it can be enhanced by AI systems. Specifically, specialists based in large urban centers (e.g., Rabat, Casablanca) can follow up with patients in remote areas (e.g., the South) using images or data transmitted remotely, pre-analyzed by AI algorithms (Zouhair et al., 2020). AI acts as a *second pair of eyes* for practitioners, helping them make faster decisions and reducing diagnostic delays for patients in underserved regions.

Other AI applications in Morocco's healthcare system include management of electronic patient records and real-time clinical data analysis, for instance, to flag drug interactions or alert on abnormal vital signs. Logistics optimization is also a key area: more than half of the country's major healthcare facilities already employ AI systems to plan surgical schedules, manage hospital beds, or predict medication stock levels (Seddik et al., 2020). These solutions, often integrated into digital hospital platforms, aim to streamline patient pathways and improve operational efficiency.

Involved Actors and Major Initiatives

The development of AI in healthcare in Morocco involves a wide range of actors: public authorities, healthcare institutions, local entrepreneurs, and research centers. The Moroccan state plays a catalytic role, as part of the broader digital transformation strategy. Although there is no

national program dedicated solely to AI in healthcare, the Ministry of Health encourages pilot projects integrating AI. A notable example is MediAI Solutions, a partnership between the Ministry of Health and a Moroccan startup, developing AI tools to enhance the diagnosis of chronic diseases. This project has been trialed in several hospitals in Casablanca, with promising results in terms of diagnostic accuracy and care efficiency (Seddik et al., 2020). Similarly, the Ministry has progressively laid out the regulatory framework for telemedicine, allowing teleconsultations since 2018-2019, thus paving the way for solutions combining telehealth and AI.

Among health institutions, major university hospitals in Rabat, Casablanca, Fez, and Marrakech are at the forefront of AI experimentation. They often collaborate with companies or universities to test new devices. For example, the Cheikh Khalifa Hospital in Casablanca served as a study site for a machine learning model aimed at predicting poor glycemic control in diabetic patients during Ramadan (Heikel, 2020). This research project, conducted by Moroccan doctors and data scientists in 2022, demonstrated the feasibility of developing predictive tools adapted to local specifics (dietary changes during Ramadan) to better prevent diabetic complications (Seddik et al., 2020).

The private sector and startups are key drivers of AI in Moroccan healthcare. These innovative young companies, often founded by young engineers or doctor-entrepreneurs, are bringing new solutions to the sector's challenges. A notable example is the DeepEcho startup, which has developed an AI capable of interpreting fetal ultrasounds to detect potential risks for unborn babies (Seddik et al., 2020). Developed in collaboration with Moroccan researchers and clinicians, DeepEcho's solution achieves an accuracy rate of over 95% in recognizing ultrasound images, a level validated by a publication in *Nature Communications* (Heikel, 2020). This 100% Moroccan innovation aims to democratize prenatal screening, even in remote areas, through telemedicine and AI, improving care for pregnant women nationwide.

Other startups, like Smart H, are focusing on early disease diagnosis through AI-based algorithms, reducing the time and cost of necessary examinations (Heikel, 2020). Sobrus, a leader in digital healthcare in Morocco, initially focused on pharmacy digitalization but is increasingly incorporating AI modules for drug sales data analysis and improving pharmaceutical advice (Benali et al., 2021). The dynamism of Moroccan health-tech startups has garnered attention on the African stage: in the pan-African acceleration program Investing in Innovation (i3) in 2023, three Moroccan startups (including DeepEcho and Sobrus) were among the 30 selected, showcasing Morocco's growing regional leadership in health-tech innovation (Heikel, 2020).

Despite this flourishing of initiatives, Morocco's AI ecosystem remains young and concentrated in a few urban hubs. Most projects and resources are located in Casablanca, Rabat, or the emerging tech hub of Benguerrouj (UM6P), and health-tech startups struggle to secure significant local funding (Seddik et al., 2020). However, Morocco clearly aims to become a major AI player in Africa, as evidenced by its international engagement on these issues (adopting UNESCO's

recommendations on AI, co-sponsoring a UN resolution on AI for sustainable development) (Lai et al., 2021).

Current and Potential Benefits of AI in Healthcare in Morocco

Enhanced Diagnosis and Clinical Care

One of the most tangible benefits of AI in healthcare is the improvement of diagnostic precision and faster decision-making. In Morocco, where medical resources are limited outside large urban centers, AI can act as an equalizer. For example, in radiology, AI systems capable of analyzing images enable faster detection of subtle lesions (e.g., lung nodules, breast microcalcifications), often more quickly than a human examination alone. Moroccan radiologists using these tools report receiving an instant second opinion with high reliability, boosting their confidence in the diagnosis (Heikel, 2020). Furthermore, AI can enhance the management of diseases that are underdiagnosed in Morocco due to a lack of specialists. One such example is anatomical pathology (biopsy analysis): AI algorithms trained on histological slides are now capable of detecting cancer cells or tissue abnormalities. Integrating such algorithms into Moroccan hospital laboratories would facilitate early cancer detection in regions without access to pathologists.

Another compelling example is the aforementioned DeepEcho startup, whose AI tool improves fetal anomaly detection during pregnancy, enhancing prenatal care quality (Seddik et al., 2020). In a country where access to specialized ultrasound services is limited outside major cities, this AI tool allows remote areas' expectant mothers to have their ultrasound exams analyzed by specialists, ensuring prompt referrals if necessary. This has the potential to improve public health outcomes, saving lives or preventing complications.

AI also contributes to treatment optimization. In Moroccan hospitals with oncology services, AI-based software assists in planning radiation treatments with great precision (automatic tumor contouring on images), or recommending personalized therapeutic protocols by cross-referencing patient data with up-to-date scientific literature. Although these uses are still in their infancy in Morocco, in the medium term, AI could assist medical committees in therapeutic decision-making by suggesting the best combination of cancer drugs based on the tumor's genetic profile (what is known as precision medicine). Internationally, tools like Watson for Oncology have demonstrated the potential to improve adherence to clinical guidelines and potentially increase survival rates (Rajpurkar et al., 2020). Morocco could benefit from such systems, especially in centers of excellence like the National Institute of Oncology.

Telemedicine and Remote Access to Care

The shortage of doctors and the uneven geographic distribution of healthcare professionals are well-documented issues in Morocco. The country has approximately 7.3 doctors per 10,000 inhabitants (far below the OECD average) and is currently working to recruit 48,000 additional doctors and 100,000 nurses to address these gaps (World Bank, 2020). In this context, AI-assisted

telemedicine offers a major advantage in expanding access to care. Specifically, AI-driven triage systems can help prioritize patients remotely. For instance, a chatbot could ask a series of standardized questions to a patient complaining of symptoms, directing them either to a teleconsultation or advising them to go to the emergency room if serious symptoms are detected (Seddik et al., 2020). Such applications, available 24/7, reduce pressure on medical facilities, ensuring that doctors only handle cases requiring their attention, while also providing timely guidance or reassurance to patients.

During teleconsultations, AI can assist the practitioner in the background. For example, a general practitioner consulting remotely with a diabetic patient could rely on an AI system analyzing the patient's latest blood sugar values (from their connected device) and alerting them to a recurring hyperglycemic pattern, requiring treatment adjustments. This real-time decision support empowers practitioners during remote consultations, enabling better care even in underserved areas.

In remote parts of Morocco (e.g., mountain villages, isolated oases), where specialists such as cardiologists or neurologists are virtually absent, telemedicine combined with AI provides the opportunity to bring expertise to the patient rather than the other way around. Pilot projects have connected rural dispensaries to university hospitals via teleconsultation systems, sometimes combined with portable imaging (e.g., handheld ultrasound devices) interpreted remotely. AI helps reliable and quick communication, allowing faster care and better monitoring of chronic diseases at home (e.g., hypertension, diabetes, renal failure under dialysis).

Ethical Challenges of AI in Healthcare

Informed Consent and Patient Autonomy

The use of AI in healthcare raises important questions about patient consent and their right to information. Traditionally, any medical procedure must be preceded by a free and informed consent process, where the patient is aware of the risks and benefits. But what happens when part of the medical decision is delegated to AI? Should patients be explicitly informed that an algorithm is involved in their diagnosis or treatment? Can they refuse AI involvement and request that only a human provide their diagnosis? These are new questions that ethical and legal frameworks must address (Lai et al., 2021).

Ethically, it is agreed that AI should not dehumanize the doctor-patient relationship or diminish patient autonomy. The principle of "human in the loop" is often emphasized: AI offers a recommendation or risk score, but it is the doctor who communicates the result to the patient and ultimately makes the decision. In this framework, informing the patient about AI use is an integral part of the process. The patient should understand that their doctor relies on an algorithmic tool, know in broad terms what the tool does (e.g., "analyzes your X-ray using a software trained on thousands of similar images"), and have assurance that it does not replace clinical examination or

the doctor's judgment. Furthermore, if a patient expresses reluctance or concern about the AI, the doctor should be able to adjust the care approach or even avoid using the tool if it undermines patient trust (O'Neill et al., 2021).

Conclusion

The integration of artificial intelligence into Morocco's healthcare system represents a major opportunity to address several persistent structural challenges, including the shortage of healthcare professionals, geographic disparities in access to care, and the need to improve the quality of diagnostics and treatments. This analysis has highlighted significant progress in the adoption of AI technologies in Morocco, with annual growth of 15% since 2018, positioning the country as an emerging player in Africa in this field. Initiatives led by various stakeholders—such as the Ministry of Health, university hospitals, and innovative startups like DeepEcho and Sobrus—demonstrate a dynamic ecosystem whose early achievements are promising.

The potential benefits of AI for Morocco's healthcare system are multidimensional. Clinically, improved diagnostic accuracy—particularly in radiology and pathology—could partially offset the lack of specialists in certain regions. AI-assisted telemedicine also offers a viable solution for expanding access to care in remote areas, helping to reduce medical isolation, especially given Morocco's geographic context. These advances support a vision in which technology acts as an equalizer, reducing territorial inequalities in access to specialized care.

However, the introduction of these technologies raises significant ethical questions that require careful attention. Issues of informed consent, protection of personal health data, and patient autonomy must be central to any AI implementation strategy in healthcare. The fundamental principle of “human in the loop”—ensuring that AI remains a tool to assist, not replace, clinical judgment—must be rigorously maintained in daily practice. Furthermore, the issue of medical and legal responsibility in the event of an error involving AI remains complex and demands an appropriate regulatory framework tailored to the Moroccan context.

For AI in healthcare to fulfill its promise in Morocco, several conditions are essential. First, sustained investment in training healthcare professionals in new technologies so they can fully exploit AI's potential while maintaining their professional autonomy. Second, the development of a robust regulatory framework that clearly defines the responsibilities of all stakeholders and effectively protects patients' rights. Third, the promotion of close collaboration among researchers, clinicians, entrepreneurs, and health authorities to develop AI solutions suited to Morocco's specific needs and cultural context.

The development of AI in Moroccan healthcare should not be seen as merely adopting foreign technologies, but as an opportunity to build national expertise in this strategic field. Initiatives like DeepEcho, developed entirely by Moroccan researchers and physicians, illustrate this potential for local innovation. By supporting such innovations and investing in national research, Morocco

could not only meet its own health challenges but also become a regional center of excellence for AI in healthcare.

Ultimately, the future of AI in Moroccan healthcare will depend on the ability to balance technological innovation with fundamental ethical considerations. A thoughtful, inclusive, and responsible approach will maximize the benefits of these technologies while minimizing their potential risks, thus contributing to a more efficient, equitable, and patient-centered healthcare system. Only under these conditions can AI truly transform the landscape of healthcare in Morocco, serving the ultimate goal of improving the health and well-being of the entire Moroccan population.

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