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Chapter 12: The road ahead: challenges and opportunities in artificial intelligence's integration into global healthcare systems

12.1 Introduction

In the ongoing narrative of healthcare, AI assumes a pivotal role. As the driving force behind precision medicine, it fulfills a pressing need for enhanced care. The primary hurdle to widespread AI adoption in healthcare is by no means a technological one - it centers upon ensuring seamless integration of such technologies into daily clinical practice. Nonetheless, AI technologies are making remarkable strides across a diverse array of healthcare applications, serving as a vital catalyst for advancements in medical diagnosis, virtual patient care, treatment adherence, and administrative efficiency. Unquestionably, in line with its primary design directive of automation, AI is proving capable of executing certain responsibilities with superhuman accuracy. This is particularly visible in controlled settings with well-defined parameters, such as the classification of pneumonia from chest X-rays. However, this trend is counterpointed against a myriad of reports both documenting mistakes of astonishing negligence as well as findings that can only be charitably described as absurd. Accordingly, it comes as no surprise that several research reviews have concluded AI systems are currently plagued by a host of limitations and lingering doubts. Despite widespread enthusiasm surrounding its applied potential, AI in the present day still grapples with an assortment of challenges of a technological, ethical, and regulatory nature that academic discourse has scrambled to address. The reported solutions to these challenges span a gamut of innovative training methodologies, model designs, and investigatory techniques. Central among the latter have been efforts benchmarking the performance of biomedical AI algorithms against human experts in the realms of specialties as diverse and impactful as dermatology, neuroscience, and oncology. Therefore, within this

overarching milieu, nuanced technical criticisms, police investigations, and a litany of regulations have factored heavily in forecasting the form taken by AI's convergence with global healthcare systems moving forth. The development of such personalized technologies has garnered considerable interest, promising improved health care outcomes. Major diseases, given certain biomarkers and patient genetic information, can be predicted in a series of discrete time intervals. In this era of precision medicine, it is argued that the integration of these technologies into global healthcare systems will foretell healthcare in the upcoming years. The current article will aim to identify and propose possible strategies to mediate these challenges.

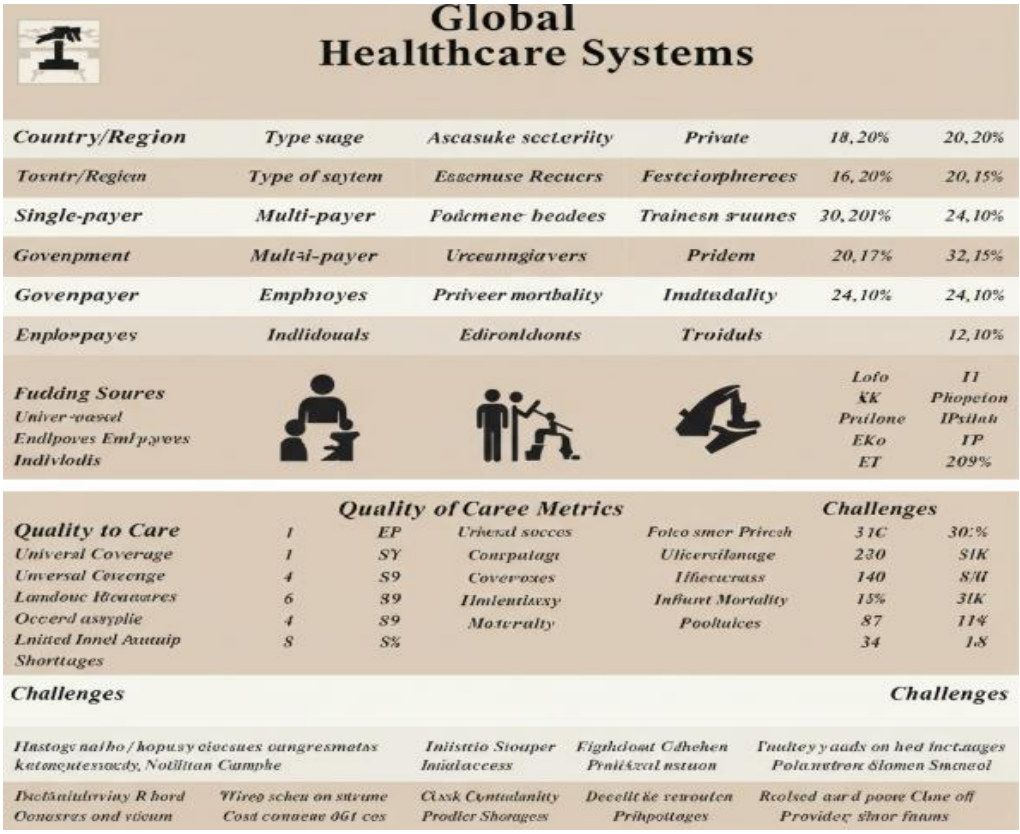

Fig 12.1: Global Healthcare Systems

12.1.1. Background and Significance

As stated, "Artificial intelligence (AI) can be broadly defined as the theory and development of computer systems capable of performing tasks that require human intelligence, such as visual perception, speech recognition, decision-making, and language translation". AI is pushing the boundaries of what machines are capable of. The high-performance computing power that drives AI was borne out of the video

game industry. Now, AI is being used in medical research and delivering life saving drugs. AI neural networks are overtaking human brain function, more closely emulating how the human brain operates. The pervasiveness of AI will continue to grow, simulating human creativity. But with creativity comes fear. So there is, on the one hand, the awe-inspiring side, the powerful side of AI, and on the other side, the almost fear-inducing, menacing side of AI. There is no doubt that the integration of AI into global healthcare systems represents an important step in the evolution of medicine. The impact will be enormous as it eliminates human error in diagnosis which will also eliminate unnecessary medical treatment and unethical testing from clinicians. However, since the AI technologies used for medical purposes are not perfect data-based systems and unreliable or unexpected errors can occur, there is subject room for the recognition and invention of these dangers. It is noted with acceptable reasoning that it would be better to identify and manage difficult cases using human judgment (Chava, 2022; Komaragiri et al., 2022; Chakilam et al., 2024). Moreover, AI is completely rewriting the map of production industries. Most known as "Industry 4.0", it incor porates cyber-physical systems in industry. Engineering prevents industrial processing failure. Complicated systems suggest the lead of preventive planning. There are substantial burdens on the healthcare system. Fatal diseases are best diagnosed early, targeting treatment planning immediately to progress the patient while treating the disease. Systems are predicted to evolve which will incorporate genetic information and biomarkers to point out the health degradation before the appearance of symptoms.

12.2. Overview of AI in Healthcare

This section presents a study on the ways in which artificial intelligence and big data analytics have been utilized and could be additionally implemented in streamlining and enhancing the function of healthcare systems, both in domestic Polish practice and globally. First, the current state of implementation and plans to implement AI in healthcare analysis are presented. Next, the main factors and areas that determine the potential for applying AI analysis in the context of healthcare in both Poland and globally are analyzed. These aspects concern the organization of the health care system, the availability and management of medical data that is their basis, investments made, and the measures taken to ensure their safety.

Health is a fundamental factor influencing the wellbeing of the population and its development—everything else depends on it. However, it is not only determined by a large number of factors but is also a vast field of various activities, concerns, and interests. It involves a wide array of stakeholders such as policy makers, healthcare providers, manufacturers of medical and pharmaceutical products, insurance institutions, and, of course, patients as recipients of healthcare. The policies and actions

that they carry out are interdisciplinary in nature and stratified in structure—in order to function effectively, they need to take place at various levels, from the global, through national, and local, to the individual. Meanwhile, in an era of dynamic development of ICT technologies, artificial intelligence (AI) and big data, the growing amounts and access to extensive healthcare data transform the processes of its acquisition, monitoring, research, and provision. This can be, on the one hand, a huge opportunity for improving health care and health outcomes, and on the other, a considerable challenge in terms of ensuring data protection, preventing its abuse, and guaranteeing equal access to its potential benefits. (Challa, 2022 Komaragiri et al., 2022)

12.2.1. Historical Context

Reflecting on the maturation of health informatics, arguably the earliest medical informatics discipline, provides some important context for the current landscape. The overarching goal of biomedical informatics is to generate data-driven knowledge that ultimately supports efforts to improve healthcare. This aim follows two key objectives, namely (i) the use of data and knowledge for problem-solving and decision-making, and (ii) the design and implementation of informatics-based infrastructures capable of facilitating commercialization. Focused on these objectives, health informatics is equipped with several instruments that allow the producing, collecting, and analyzing of health-related data, with the ultimate goal of enhancing patient care and outcomes. Considerable progress has been made in the informatic disciplines of electronic health records, electronic medical records, and personal health records. These standards have eased data-sharing efforts and facilitated a more effective form of patient care that is centered around ongoing communication among participants. However, the sheer quantity of generated health data continues to burgeon, necessitating further advancements if health informatics is to remain on the cutting-edge of healthcare developments. An attractive development example is the integration of Artificial Intelligence techniques into clinical research, patient care, epidemiological studies, and even population health management strategies that pivot on public health records produced by governmental agencies. In fact, AI technologies can significantly advance the SMART ecosystem. Despite these promising opportunities, vast challenges remain. The individual evaluation and usability assessment of the variety of tools invented by machine learning or deep neural networks in healthcare require substantial regulatory coverage. Moreover, in any EHR system or health information exchange, privacy issues represent a primary concern due to the sensitive nature of personal medical information. To this end, an in-depth regulatory literature review was performed, with associated findings here focused on currently available ethical AI guidelines and the regulatory landscape surrounding AI applications in healthcare. Understanding these

will be increasingly critical as AI is adopted into existing – and novel – global healthcare ecosystems.

12.3. Technological Challenges

In the future, AI tools that provide advice based on personal care data are expected to become part of everyday medical practice. Healthcare providers need to educate and guide patients to make informed decisions supported by a combination of trusted human prediction skills and AI-generated opinions. Patients may increasingly use AI-generated ideas to make clinical decisions about their care. Patient-provider discussions will be vital to ensure that advice on an effective AI basis is constructive and safe, and lose confidence from community members or essentially good care adverse effects. Targeted training programs need to be developed for healthcare providers. It will rebate explain both propositions and restrictions of AI-quadrilateral action plans. Patient safeguarding neuroscience queries patients about reputable sources of AI tools in a feeling implant, healthcare providers usually consult with other brands with multi-faceted knowledge graphs. Healthcare providers that would directly share with patients the information used to support their care recommendations too.

Machine error would be the first cause of liability. Suggestions provided to the healthcare provider that alternative treatments have left out too much in terms of other data, i.e., history, operation periods, and the feature of the data available in connection with these subjects. Another cause doesn't seem to track enough features open to training patients.

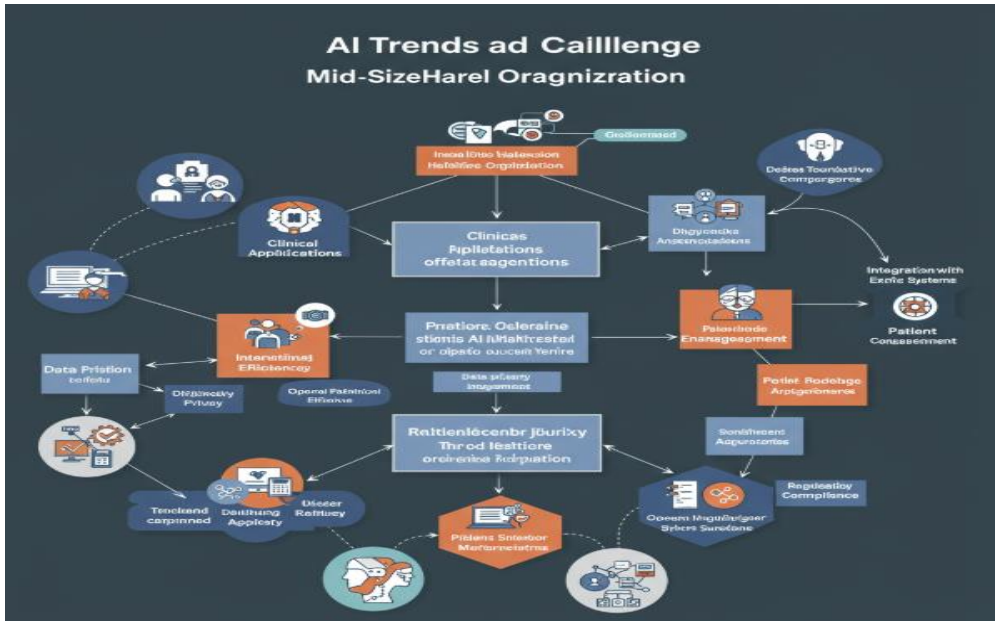

Fig 12.2: AI Trends and Challenges for Mid-Size Healthcare

12.3.1. Data Privacy and Security

Does this technology provide more challenges than opportunities, in terms of data privacy and security? Such questions have dedicated responses. However, a broad perspective is important to frame such answers. Countries with higher human development index generally benefit more from AI in healthcare out of GDP value added. However, this same group of countries has notably lower growth in health value added per capita relative to middle HDI countries. One crucial element for developing and emerging economies to climb the healthcare value ladder is digital health. It is often stated these countries can "leapfrog" the stages of Model I and Model II medical capitalism, and jump straight to a "dematerialized" healthcare system. Recently there have been profound transformations in data collection and storage practices across the globe. By 2025, 463 exabytes worth of health data will be generated on a yearly basis. This amount corresponds to 5,800 MB of data per person, given any population size on Earth. Such an increase is propelled by big data, i.e. both the availability of data and the possibilities of processing it effectively. As of today, the corollary is the constriction of boundaries between different kinds of data.

At one glance, this development has an enormous potential. AI in healthcare can reduce the workload of medical experts, and therefore work scarcity effects could be counterbalanced. Also, it can optimize precision in diagnosing, thus benefiting patient outcomes. However, the issue soon becomes murky, which may question assumptions such as new data having a positive yet asymmetric impact on GDP value added. Who owns and controls the AI technology? In developed economies, despite the (re)distribution of welfare institutions and practices, private entities are taking a lion's share in these new technologies. After all there is no epistemic quality in ownership structures. This must raise privacy questions concerning the implementation of these technologies as well as data security. Strict regulations have mushroomed around the world to protect sensitive data. Any eventual leak can even lead to millions of dollars worth of insurance coverage.

12.4. Ethical Considerations

The integration of Artificial Intelligences (AI) into global healthcare systems brings significant challenges and opportunities to the sector concurrently and both of these demand careful navigational strategies to fully optimize the potential offered by the technology. As such, there are considerable ethical considerations, which are emphasized many times in the literature surrounding AI, which is that the algorithms are only as good as the quality of the data they learn from. Hospitals, clinics, and pharmacies are required to make public data available for input in numerous jurisdictions but in many of the wealthiest countries, especially the USA, health data

is considered so sensitive that only small subsets of it will ever be accessible to scientific analysis. Data linkage developments like cloud-based sharing of imaging files are extremely promising but they apply to a narrow range of applications and the necessary global scale is a way off. On top of data sharing difficulties, some key public health datasets of vital importance for AI analysis – such as morbidity, mortality, and vaccination records – are very low quality and frequently unavailable for the recent years that matter most. This is of highest concern in low- and middle-income countries (LMICs), which typically lack analogous data on the necessary scale in the first place.

Countries now entering the digital age of health records could potentially be operating very different frameworks than the wealthy countries from which algorithm development has so far mostly occurred. It is very likely these frameworks will not (at first) be ready to make data free; however, the early stages of development in AI could cripple healthcare systems that are strictest with data controls. Some heavily HIC-aligned literature brushes over this and calls for data sharing "for the common good of mankind". Popular deployments of AI in underprepared systems may correspond to substantial power imbalances and attendant data misuse possibilities. If ethical mistakes are made in these early days of adoption and implementation of AI in healthcare, the fallout could undermine public trust, which could be devastating for the healthcare industry and also cause patients to look for their healthcare from outside of formal systems where they may encounter significant risks. There are of course numerous other ethical challenges to consider; for example, who should hold liability for mistakes made by medical AI systems?

12.4.1. Bias in AI Algorithms

Over the past decade, artificial intelligence (AI) systems that use deep neural networks have become increasingly popular in medicine. Due to the widespread availability of large-scale labeled data and substantial computing power, AI's diagnostic capabilities have proven to be on par with domain experts in multiple specialties. The diagnostic applications of AI are not limited to traditional medical images. Ones that use multi-modal medical data such as electronic health records and genomic information have been proposed and shown good performance. Despite the remarkable achievements of AI, there are still substantial concerns regarding the fairness and bias of AI models in the field of biomedicine. Bias is ubiquitous in the field of medicine. Bias in healthcare is defined as systematic error due to flaws in the study's design, conduct, or analysis. Since most patients of earlier studies were white males, these medical breakthroughs did not always apply to the other sex or people of color. This led to widespread skepticism and a belief that the published treatment was biased.

It has been four years since the first paper was published and the ethical agenda for AI was one of its hot research issues. The issue of bias and fairness in AI systems has also

been the subject of extensive research. There is a growing understanding of the definition of bias. There is a growing awareness that the unequal behavior of algorithms toward different population sub-groups may be considered a violation of the principles of bioethics. The FDA has published guidelines for the transparency of AI powered technologies in order to attempt to standardize the development of AI models used for diagnostics or prediction of health states. Due to the publication of these guidelines, the attention of the NLP community to this issue in the context of clinical prediction tasks has increased. When evaluating public datasets for mortality prediction and phenotype classification tasks, the benchmark models in NLP failed to maintain fairness. For the in-hospital mortality or phenotype classification task, the models have demonstrated lower performance for the homography of the minority population, while for the physiological decompensation or length of stay task, the models showed significantly worse discrimination between the homography of the majority population. The results underscore the need for attention to the development of interpretable, transparent models guided by guidance to prevent unintentional bias. Based on the research on fairness in healthcare, the findings that AI models can predict unnecessarily protected information are discussed. To alleviate bias and to work properly, the debiasing methods that should be taken are discussed and focusing on the existing debiasing methods from the biomedical NLP or CV is given. Finally, the accessible methods that have been applied in the general domain for bias mitigation and thus could be applied to clinical tasks are also provided. With a better understanding of the Taxonomy of methods and the source of bias, researchers can correctly select the appropriate measure to address bias in various situations.

12.5. Economic Implications

AI has gained particular attention in the current medical industry for its potential applications. However, the potential, success, and benefit of AI in healthcare cannot come without difficulties and challenges. Furthermore, recent advancements and forthcoming opportunities are also presented to illustrate a future strategic path.

12.5.1. Cost-Benefit Analysis

Despite the increasing popularity of Artificial Intelligence (AI) in some arenas, the specific contributions and risks of AI in mental health are not yet fully understood. AI in mental healthcare involves considerable ambiguity. It may relieve some of the burden on the health system, but providing inadequate treatment could have problematic consequences. The search for cyclical connections includes a long-term perspective, drawing attention to the use of AI in mental healthcare before the crisis. However, as debates surrounding AI in mental healthcare have become increasingly entrenched during the crisis, it seems important to reflect not only on historical

developments to gauge what is at stake today. In the discussion about the future of healthcare and mental health, resilience and sustainability have become connected through the concept of deprescription. AI seems to present solutions to these supposedly entangled problems; interpretive analysis can reveal this entanglement.

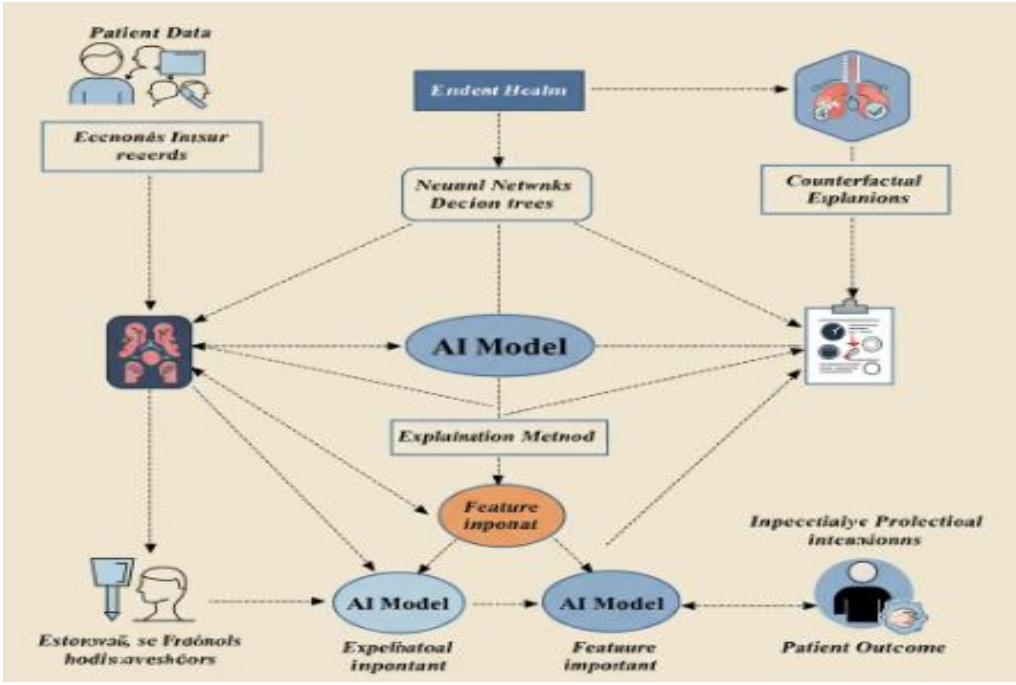

Fig : Explainable Artificial Intelligence in Healthcare

Responsible adoption of healthcare Artificial Intelligence (AI) necessitates that AI systems which benefit patients and populations are financially incentivized at a consistent and sustainable level. AI that does not offer health benefits, subject patients and populations to net harm or risk, negatively affect provider revenues, destabilize local healthcare systems, or do not comply with laws, regulations, and guidelines should not be incentivized. The term 'incentive amount', 'AI financial incentive', 'AI payment', and 'payment amount' will be collectively referred to as the financial incentives AI care. This paper concentrates on patient-specific, assistive, and autonomous AI systems of healthcare. Specifically, a framework is proposed to oversee financial incentives for relevant healthcare AI systems of public and private payors. This framework involves disseminating financial incentives over multiple 'payment amounts' of AI care, depending on various criteria that AI developers, providers, and users are called upon to establish. Additionally, there are recommendations on how to involve affected stakeholders in the administration of the proposed AI financial incentive framework.

12.6. Conclusion

The rapid rise of artificial intelligence (AI) and related technologies, combined with unprecedented growth in digitally collected data, has enabled AI applications to become deeply embedded in multiple aspects of society—including healthcare. In the near future, ongoing advancements in AI and health analytics will play increasingly prominent roles within global healthcare systems, and these advancements will inevitably bring about significant changes in operating patterns, decision-making processes, and patient experiences. Nonetheless, there are still numerous challenges to be tackled if the potential benefits of adopting AI in healthcare systems are to be realized in a timely and effective fashion. Within a hybrid healthcare system like Hong Kong's, there is immense potential for AI and health analytics to improve the ability to deliver high-quality, cost-effective services by making more efficient use of resources in patient management, health promotion and disease prevention. Emerging technologies, such as AI and Internet of Things (IoT), are revolutionizing many business domains, including healthcare. One area where their use promises significant benefits is improving the quality of early detection of diseases. Consequently, much research has been conducted in developing systems and methods that can make use of IoT data to improve the accuracy of disease prediction and early diagnosis on the digital level. By using sophisticated AI algorithms for medical data analysis one can develop models that are able to outperform human doctors in a variety of prediction tasks. New models, algorithms, or systems use IoT data to provide novel ways to detect a variety of medical conditions such as diabetes, cancer, and sepsis, as well as provide early warning of their potential future onset or growth.

12.6.1. Future Trends

There are many types of AI applications and robotic systems, which can be introduced in many aspects of health care. AI's ability to digest and process enormous amounts of data, and derive conclusions that are not obvious to a human, holds the promise of more personalized and predictive care. There have been a number of proof-of-concept and pilot projects that have exhibited promising results for diagnosis, treatment, and health maintenance. There is a rather daunting list of challenges to address, most of which are not purely technical, the key one being demonstrating that the systems are effective and safe enough to warrant the confidence of both the practitioners and their patients. AI technology is currently undergoing a remarkable revival and being applied to many domains. Health applications will both benefit from and contribute to further advances. The more technical challenges of AI, such as privacy, explainability, or fairness, are being worked on in the research community and in the legislative and regulatory world. Education of patients and professionals is key to the societal acceptance of the role that AI and robotics will play. Practitioners must learn enough about how AI models and robotics work to build a working relationship with those tools and build trust in them.

Patients need to understand what AI and robotics can or cannot do and what data is being collected about them. New cost and reimbursement models will need to be developed, especially given that when AI is used to assist professionals, the cost of the system is additive to the human cost of assessing the data. Clinical pathways have to be adapted and new role models for physicians have to be built. The convergence of these approaches will help to build a complete digital patient model generated out of all the data gathered from various sources. AI will be able to support superior, fully personal and predictive medicine, while robotics will automate or support many aspects of treatment and care.

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