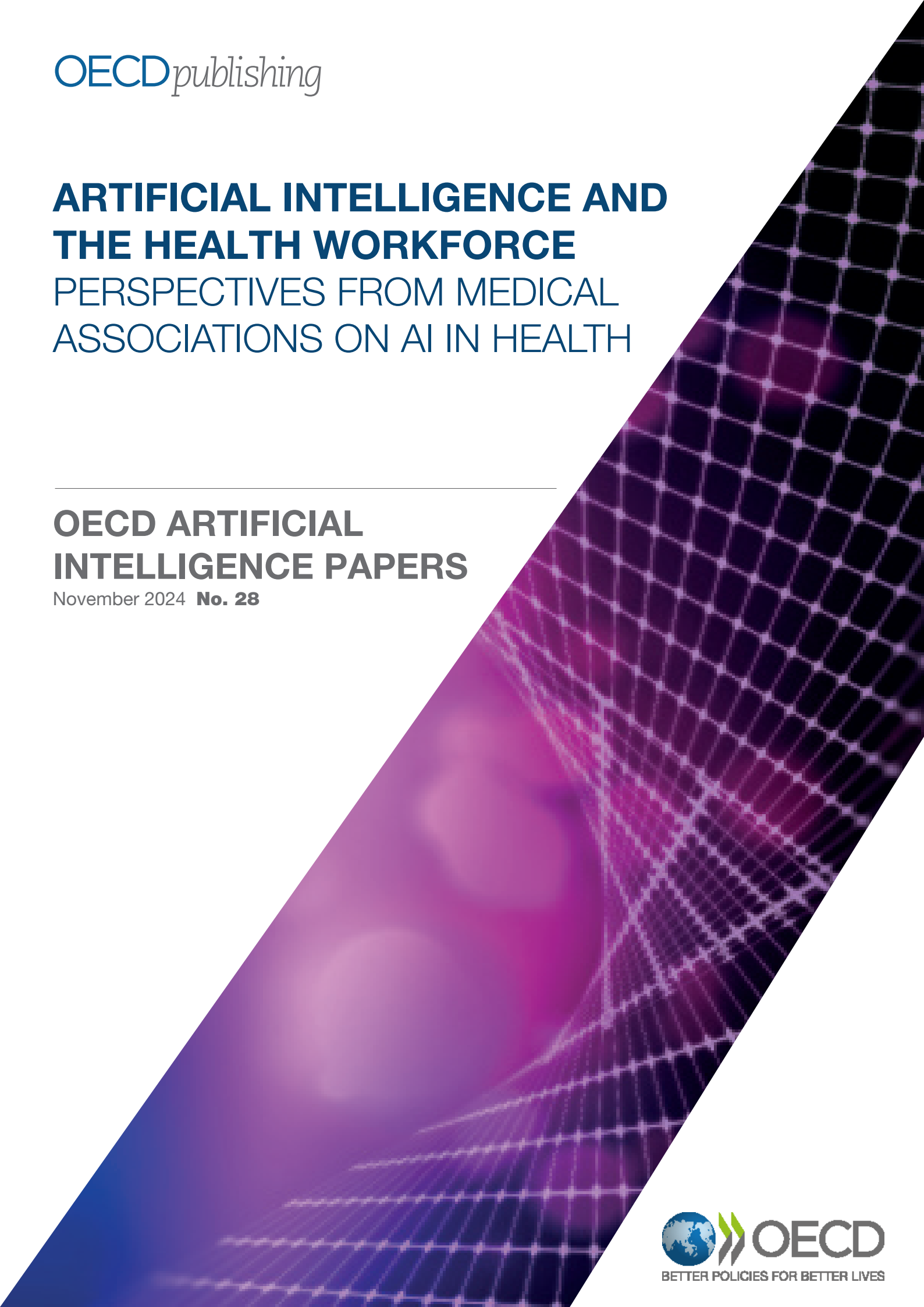
OECD publishing

ARTIFICIAL INTELLIGENCE AND THE HEALTH WORKFORCE

PERSPECTIVES FROM MEDICAL ASSOCIATIONS ON AI IN HEALTH



OECD ARTIFICIAL INTELLIGENCE PAPERS

November 2024 **No. 28**

OECD

BETTER POLICIES FOR BETTER LIVES

OECD Artificial Intelligence Papers

Artificial intelligence and the health workforce: Perspectives from medical associations on AI in health

Margarita Almyranti, Eric Sutherland, Dr Nachman Ash and Samuel Eiszele

Healthcare has progressed through advancements in medicine, leading to improved global life expectancy. Nevertheless, the sector grapples with increasing challenges such as heightened demand, soaring costs, and an overburdened workforce. Factors contributing to health workforce strain include ageing populations, increasing burden from non-communicable and chronic diseases, healthcare providers' burnout, and evolving patient expectations. Artificial Intelligence (AI) could potentially transform healthcare by alleviating some of these pressures. AI in health also poses risks to patients in several ways including privacy and liability concerns or through biased algorithms negatively impacting care. AI in health also poses risks to health providers through potential workforce disruption – with changing roles requiring adapted skills with some functions subject to automation. Striking a balance between innovation and safeguards is imperative. Weak digital and data foundations, inconsistent health data governance, inadequate technology standards, and limited resources can hinder the potential of AI in healthcare. AI in health also poses risks to patients in several ways including through the use of AI algorithms by insurance companies that raise health insurance costs. The OECD conducted a survey into the perspectives of medical associations regarding the integration of AI tools. The survey aimed to contribute to the discussion on AI from the healthcare providers' perspective whose roles are critical to health systems. This investigation was facilitated through a comprehensive questionnaire distributed by the World Medical Association (WMA) on behalf of the OECD. Selected interviews with healthcare professionals and AI experts supplemented the research.

Keywords: Artificial Intelligence, Health, Health Data, Productivity, Innovation, Research, Technology, Doctors, Medical Care, Workforce, Skill Building, Training

JEL Codes: I1, I10, I15, J21, J24, O33.

Résumé

Les soins de santé ont progressé grâce aux progrès de la médecine, conduisant à une amélioration de l'espérance de vie à l'échelle mondiale. Néanmoins, le secteur est aux prizes avec des défis croissants tels qu'une demande accrue, une flambée des coûts et une main-d'œuvre surchargée. Les facteurs contribuant à la pression exercée sur le personnel de santé comprennent le vieillissement de la population, le fardeau croissant des maladies non transmissibles et chroniques, l'épuisement professionnel des prestataires de soins de santé et l'évolution des attentes des patients. L'intelligence artificielle (IA) pourrait potentiellement transformer les soins de santé en atténuant certaines de ces pressions. L'IA pourrait améliorer l'efficacité opérationnelle et libérer un temps précieux permettant aux professionnels de la santé de se concentrer sur les soins aux patients, ce qui conduirait à terme à améliorer les résultats en matière de santé. L'IA peut également contribuer à la recherche en santé ainsi qu'à la découverte et au développement de nouveaux traitements pour une meilleure santé. Ces avantages devraient s'accroître à mesure que les capacités, la confiance et les bases factuelles de l'IA s'améliorent. Des fondements numériques et des données faibles, une gouvernance incohérente des données de santé, des normes technologiques inadéquates et des ressources limitées peuvent entraver le potentiel de l'IA dans le domaine des soins de santé. L'IA dans le domaine de la santé présente également des risques pour les patients de plusieurs manières, notamment préoccupations en matière de confidentialité et de responsabilité ou par le biais d'algorithmes biaisés ayant un impact négatif sur les soins. L'IA dans le domaine de la santé présente également des risques pour les prestataires de santé en raison d'une perturbation potentielle du personnel – l'évolution des rôles nécessitant des compétences adaptées et certaines fonctions étant sujettes à l'automatisation. Il est impératif de trouver un équilibre entre innovation et garanties. L'OCDE a mené une enquête sur les perspectives des associations médicales concernant l'intégration des outils d'IA. L'enquête visait à contribuer au débat sur l'IA du point de vue des prestataires de soins de santé dont les rôles sont essentiels aux systèmes de santé. Cette enquête a été facilitée grâce à un questionnaire complet distribué par l'Association médicale mondiale (AMM) au nom de l'OCDE. Des entretiens sélectionnés avec des professionnels de la santé et des experts en IA ont complété la recherche.

Acknowledgements

The work presented here was undertaken by Dr Nachman Ash and Samuel Eiszele from June to December 2023 with co-operation of the World Medical Association. Margarita Almyranti and Eric Sutherland provided post-research support to incorporate feedback and updates into this paper. Thank you also to Francesca Colombo, Gaetan LaFortune, members of the OECD's Health Committee, and colleagues in the OECD's Science, Technology and Innovation Division for their helpful feedback and comments which have been incorporated.

The views expressed in this document are those of the authors and not necessarily the views of any OECD member country, individual expert, or the European Union.

Table of contents

FIGURES

TABLES

Executive summary

Healthcare has progressed through advancements in medicine, leading to improved global life expectancy. Nevertheless, the sector grapples with increasing challenges such as heightened demand, soaring costs, and an overburdened workforce. Factors contributing to health workforce strain include ageing populations, increasing burden from non-communicable and chronic diseases, healthcare providers' burnout, and evolving patient expectations.

Artificial Intelligence (AI) could potentially transform healthcare by alleviating some of these pressures. AI could improve operational efficiency and liberate valuable time for healthcare professionals to focus on patient care that will ultimately lead to improving health outcomes. AI can contribute significantly to health research and the discovery and development of new treatments for better health outcomes. These benefits are anticipated to expand as the capabilities, trust, and evidence-base for AI improves. However, weak digital and data foundations, inconsistent health data governance, inadequate technology standards, and limited resources can hinder its potential in healthcare. AI in health also poses risks to patients in several ways including through biased algorithms negatively impacting care or the use of AI algorithms by insurance companies that raise health insurance costs. AI in health also poses risks to health providers through potential workforce disruption – with changing roles requiring adapted skills with some functions subject to automation. Striking a balance between innovation and safeguards is imperative.

The OECD conducted a survey into the perspectives of medical associations regarding the integration of AI tools. The survey aimed to contribute to the discussion on AI from the healthcare providers' perspective whose roles are critical to health systems. This investigation was facilitated through a comprehensive questionnaire distributed by the World Medical Association (WMA) on behalf of the OECD. Selected interviews with healthcare professionals and AI experts supplemented the research. A total of 18 medical associations participated in the survey, representing countries from North and South America, Asia/Pacific, Europe, the Middle East, North Africa, and Sub-Saharan Africa.

Key findings from the survey include:

- 72% of the medical associations surveyed believe that the benefits of AI in healthcare outweigh the risks. There was a consistent acknowledgment of the risks, particularly emphasising the lack of understanding, communication, or effective management of AI-related risks in healthcare.
- Medical associations strongly believe that AI will significantly transform the field of medicine, but they also agree (70%) that the role of physicians will remain central. Notably, no respondent believed that AI would replace physicians or their medical practice.
- Ethical concerns and liability are major concerns for AI in healthcare. An overwhelming majority (94%) expressed worries about ethical issues that may arise from AI applications in medical practice, and 71% believe that physicians' liability will increase due to their use of AI solutions. This implies that public and provider trust must be considered for the large-scale deployment of AI in clinical care along with legal guidance for the management of liability.
- Medical associations identified data accessibility and the operational infrastructure (e.g. policies, processes, technical equipment) required for AI applications as significant barriers to AI integration into healthcare (74%). This is worrying insofar as the quality and quantity of available data /

technology / people for the training, testing, and validation of AI solutions significantly impact the ability of those algorithms to be effective and subsequently evolve.

- A lack of trust and/or skills in the use of digital tools among providers, patients, and the public means that when AI innovations are developed, they may not be embraced, used, or scaled sufficiently, thereby limiting their value and benefits.

In short, health providers are not worried about AI replacing their jobs. Instead, providers are worried about AI being designed and implemented without them. There is potential for change in the health workforce, but it is perceived to be more about task shifting between roles and creation of new jobs rather than the elimination of existing jobs due to full automation. Increased productivity from AI may partly address workforce shortages but would not cover the entire spectrum of workforce needs. Rather, AI could usher in new roles within health systems, such as AI data analysts, AI model developers, telemedicine specialists, prompt engineers, and other experts responsible for implementing and updating AI solutions in healthcare systems. At present, the health sector seems to be employing fewer of those specialists relative to other sectors of the economy (OECD, 2019[1]). Special consideration should be given to establishing dedicated internal units and leadership positions to co-ordinate and manage AI applications within health organisations. These units should focus on ethical considerations, ensuring compliance and other critical aspects of AI implementation.

To enable the future of AI in healthcare, policy makers will need to establish regulations, policies, and processes that enable the development of responsible, scalable, equitable, and sustainable AI solutions while ensuring that safeguards for privacy, security, and protection are in place.

In parallel, the health workforce will need to evolve to be able to adapt and adopt this new capability in a way that is best for health workers while providing optimal outcomes for their patients. Based on the survey, there are three actions that emerge:

- **Develop skills for health professionals in the AI age**: Build programmes of continuous learning for experienced professionals – and incorporate AI into schools for future health professional's curricula – so that health workers build skills and know-how to appropriately leverage the capability of AI with trust. In addition, it is critical that the workforce not only evolves, but also keeps pace with international best practices, such as Fast Healthcare Interoperability Resources (FHIR) for data and ISO 42 001 for AI management.
- **Invest in workforce supporting front-line AI solutions in health services**: Work with innovators – and leverage expertise from other industries that have undergone transformation – to understand the opportunities for new workflows and new roles that allow professionals to fully utilise their skills.
- **Safely manage the introduction of AI in healthcare systems:** Embed the voice of the health workforce in the full AI life cycle to ensure that their needs are understood and that new solutions can be effectively integrated into the provision of care. Listen to health workers to understand how to best integrate and scale AI solutions in the provision of care. Engage with health workers to forge a positive AI and data-driven culture that enables the use of data while ensuring its protection.

Taking these actions would support a smooth transition to health systems that are optimising the capabilities of AI that provides positive health outcomes and experience for patients and their providers.

Finally, there may be value in engaging and leveraging further surveys to build on these results for future policy analysis and action.

1 Challenges for the health workforce and use of Artificial Intelligence

Artificial Intelligence (AI) is an emerging powerful force in healthcare, offering vast potential to enhance quality of care, patient satisfaction, and improve operational efficiency. AI is already demonstrating its potential transformative impact by freeing up valuable time for healthcare professionals and yielding better health outcomes, although results are inconsistent. Integrating AI into healthcare is a complex task, requiring a delicate balance between innovation and safeguards due to realise opportunities and address risks (Morley et al., 2022[2]).

AI is currently enhancing healthcare by streamlining tasks such as screening and diagnosis, with future potential for greater contributions. AI's role in improving diagnostic precision, identifying public health threats, combating antimicrobial resistance, providing advanced tools to healthcare professionals, and advancing personalised medicine with better patient monitoring could be a catalyst in routine care as commonly agreed by health professionals (Vandenbroucke et al., 2022[3]) (Jiang et al., 2017[4]).

To successfully integrate AI into healthcare, a responsible and trustworthy approach is essential, prioritising both the public and healthcare providers. Despite recent telemedicine and digital healthcare advancements, healthcare still lags in adopting virtual services and data exchange (Javanmard and Manteghinejad, 2021[5]). Digital transformation necessitates agile methodologies, continuous learning, and international collaboration, mirroring the rapid progress in other sectors (Cascini et al., 2023[6]).

Acknowledging and addressing the challenges to using AI in the health workforce is essential. This paper seeks to understand those challenges and proposes actions to overcome them to improve health outcomes for all.

1.1. Challenges facing the health workforce

The future of the health workforce is at a crossroads. Healthcare systems are challenged by ageing populations of both health providers and their patients, financial constraints of governments, the rapid adoption of digital tools, and preparations for public health emergencies and future pandemics. Each of these challenges have substantial impact on workforce (World Health Organization, 2022[7]).

At the same time, a projected shortage of health professionals is one of the main global health challenges. The World Health Organization (WHO) estimates a deficit of 10 million healthcare workers by 2030, primarily in low- and lower-middle-income nations (World Health Organization, 2020[8]). Across the OECD countries, there is a projected deficit of 3 million health workers in the coming years (OECD, 2023[9]).

Further, healthworkers are reporting alarming levels of burnout, with potentially compounding effects on the projected deficits noted above.

1.1.1. The challenge of burnout: A global concern

Burnout is a significant global challenge regarding the health workforce. It typically results from chronic workplace stress and a feeling of loss of control over the professional role. Burnout can manifest in emotional exhaustion, feeling drained, increased irritability, sleep troubles, severe fatigue, reduced job performance, and a sense of depersonalisation (Youssef et al., 2022[10]). Burnout also has far-reaching consequences for the quality of patient care and healthcare systems, as it can lead to increased absenteeism, higher turnover rates, and subsequently, a decrease in the quality of care provided (Murthy, 2022[11]). This has a cascading effect on healthcare systems that are already struggling to retain skilled professionals and maintain the delivery of high-quality care.

Increase in work-related pressures, especially as evidenced by the COVID-19 pandemic, can significantly elevate the prevalence of burnout among healthcare workers, and can be attributed to several factors, including overwhelming workload, prolonged stress, reduced support systems, and a general lack of control due to the rapidly evolving nature of the pandemic. Comprehensive international studies have revealed that during the pandemic, healthcare workers worldwide faced an alarming rise in burnout and loss of personal life, with emotional exhaustion reportedly escalating from 36% pre-pandemic, to 63% during the pandemic. Further to this, depersonalisation – the loss of connection with one's personal work – reportedly surged from 25% to 44% among the health workforces (The Lancet, 2020[12]), (World Health Organization, 2020[13]). Looking forward, in the post pandemic era, 51.7% of health professionals reported that AI can improve their quality of life at work (Vandenbroucke et al., 2022[3]), establishing a foundation to prevent overwhelming conditions in the coming years and during future health crises.

The use of Health Information Systems (HIS) may be another critical factor influencing burden amongst healthcare workers. HIS play a critical role in modern healthcare, offering numerous benefits such as continuity of care through improved data management, streamlined processes, and enhanced patient care. The implementation and use of these systems can increase the burden on the health workforce by the demands for documentation, coding, and other administrative tasks, potentially contributing to burnout. In a broad sense, HIS have had an impact on the workload of healthcare professionals:

- Electronic Health Records (EHRs) have revolutionised patient data management but often require extensive documentation by healthcare professionals. The pressure to complete electronic documentation can lead to increased workload, time constraints, and reduced face-to-face patient interactions, which are associated with depersonalisation and burnout (Arndt et al., 2017[14]).
- HIS provide access to vast amounts of patient data and medical literature. Healthcare workers are expected to stay updated, and make informed decisions based on this wealth of information. Accordingly, the need to sift through and synthesise this information can contribute to cognitive overload and burnout (Gardner et al., 2018[15]).
- As HIS evolve, healthcare workers must continually update their digital skills and adapt to new systems. When combined with clinical responsibilities, the need for ongoing training can be time-consuming and stressful, if not acknowledged as time to be invested (Koon, 2021[16]).

Addressing burnout is crucial for the well-being of healthcare professionals and the sustainability of healthcare systems. Interventions aimed at alleviating the stressors and workload pressures that contribute to burnout should be prioritised by countries, to help mitigate this global issue, and to ensure a resilient and effective health workforce.

1.1.2. Health workforce shortages

Despite the increasing number of doctors, nurses, and other health workers over the past two decades in most OECD countries, the increase has not been sufficient to meet the growing demand for healthcare

due to population ageing and the pandemic exacerbated pre-existing shortages. This calls for urgent actions to address this workforce shortage.

The WHO has also recognised the gravity of this crisis and has outlined a Global Strategy on Human Resources for Health that underscores the importance of strengthening health workforce capacities to ensure the presence of adequate, skilled, and motivated professionals (World Health Organization, 2020[8]). Several factors, including educational disparities, migration trends, and the uneven distribution of healthcare workers compound the shortage. As a result, healthcare providers are often overwhelmed by heavy workloads, leading to burnout (detailed in section 1.1.1). In addition, the shortage may have an even more negative impact on rural and underserved areas, potentially increasing health inequalities.

Innovative solutions (e.g. in telemedicine, interprofessional collaboration, and policy) are imperative to address the shortage of healthcare workers to prevent negative impacts on patient care. For example, AI has been used by radiologists to interpret chest radiographs more efficiently, allowing these providers to spend more time with patients (Shin et al., 2023[17]). Strategies should encompass investments in healthcare education, cross-border collaborations aimed at sharing expertise, and the development of task-shifting models that empower non-physician healthcare workers to perform essential services.

1.2. Artificial Intelligence: A tool to help improve health outcomes

The exploration of AI in healthcare commenced during the latter half of the previous century (Shortliffe et al., 1973[18]), (Pauker et al., 1976[19]). While initial aspirations to revolutionise healthcare with AI tools remained confined to the realm of research for many years, the application of AI systems in the healthcare industry is now a reality and offers significant opportunities.

The growing potential of AI applications across various clinical domains can be attributed to three primary factors:

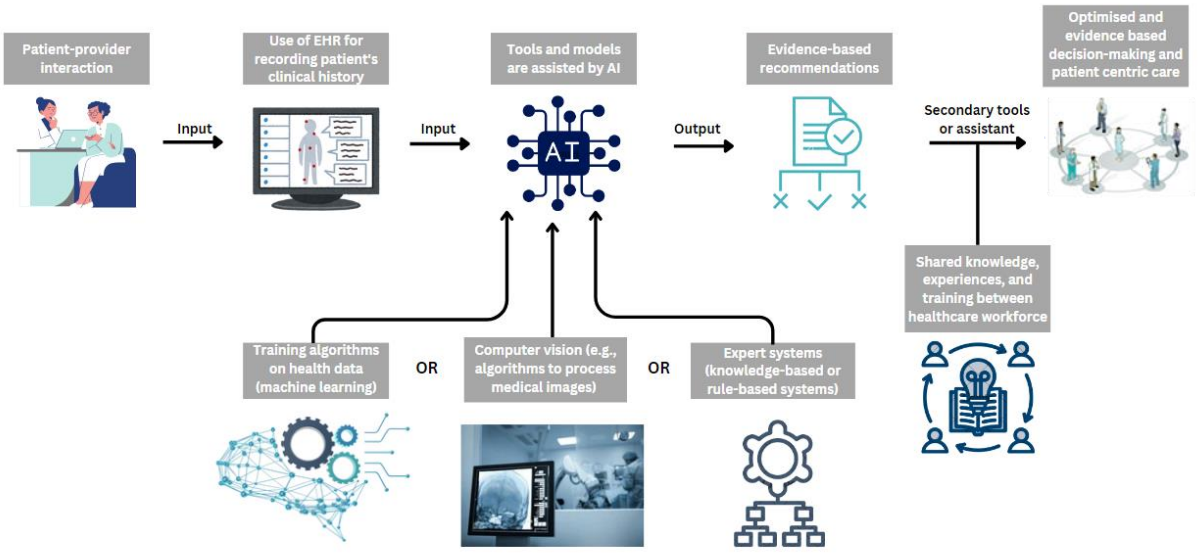
- The exponential growth of electronic health data that powers AI algorithms, and recent significant technological advances in computing and machine learning, have facilitated the development of intricate algorithms and their practical application at the bedside (Yu, Beam and Kohane, 2018[20]), (Bohr and Memarzadeh, 2020[21]).
- Furthermore, the democratisation of AI is marked by the emergence of numerous startup companies alongside established industry leaders. The vast amount of health data, coupled with the challenges noted above have positioned healthcare as one of the most captivating sectors for AI use. The COVID-19 pandemic has further accelerated the adoption of AI applications in healthcare, driven by both urgent requirements and the availability of data (Oliveira Hashiguchi, Slawomirski and Oderkirk, 2021[22]).
- Demands for change are pressing, as the challenges confronting health systems are expanding, and AI presents itself as a potential solution for fostering safer, and more efficient, healthcare systems (Oliveira Hashiguchi, Slawomirski and Oderkirk, 2021[22]), (Ayers et al., 2023[23]).

AI has found its place in various facets of the healthcare industry, encompassing clinical decision-making (Montani and Striani, 2019[24]), public health (Gunasekeran et al., 2021[25]), biomedical research (Athanasopoulou et al., 2022[26]), drug development (Vijayan et al., 2022[27]), health system administration, service redesign (Secinaro et al., 2021[28]), and more. These AI tools cater to a wide spectrum of healthcare professionals, designed for use by both providers and patients. This section explores two such uses – AI in streamlining processes for enhanced decision-making and in the use of generative AI.

1.2.1. Streamlining processes and enhancing decision-making

Algorithms play an increasing role in supporting healthcare providers' decision-making processes, a concept commonly known as clinical decision support (CDS). Most general practitioners believe that the implementation of AI tools can further enhance CDS by reducing errors and increasing the reliability of decision making and thus health outcomes (Vandenbroucke et al., 2022[3]). CDS can leverage EHR data to provide healthcare professionals with timely and relevant information to assist them in clinical decision making (Sutton et al., 2020[29]). AI could significantly enhance CDS by efficiently processing and analysing vast amounts of data, facilitating predictive analytics, aiding in diagnostics, and generating personalised treatment recommendations (see Figure 1.1).

Figure 1.1. AI-Supported clinical decision-making support system



Source: Authors.

Many of these AI-augmented CDS applications are centred around image analysis within various medical imaging domains, including radiology, pathology, ophthalmology, and dermatology. Algorithms are trained to discern intricate patterns, such as cancerous tissues within histological slides of prostate biopsies or the detection of tuberculosis in chest X-rays (Harmon et al., 2019[30]). The mode of interaction between the algorithm and the physician varies based on the specific workflow in which the tool is integrated. It may serve as a secondary tool, alerting healthcare professionals to potential pathologies that may have been overlooked by human experts, or as an assistant, guiding the physician to specific regions of interest (see Box 1.1).

Box 1.1. Case analysis – Implementing AI in a pathology laboratory of Maccabi Healthcare Services

The Maccabi Healthcare Services (MHS) in Israel, in collaboration with IBEX, a startup, embarked on a significant project to harness artificial intelligence (AI) in pathology for diagnosing prostate cancer, breast cancer, and gastric cancer (Sandbank et al., 2022[31]). This innovative tool, developed by pathologists for pathologists, analyses digital pathology images derived from biopsy slides (Pantanowitz et al., 2020[32]).

The AI tool is trained with exhaustive data annotated by pathologists. It evolved to become a system for prostate cancer, where pathologists receive digital slides with AI-generated results highlighting suspicious areas. In the cases of breast and gastric cancers, it currently operates in the background to alert if something is potentially missed.

This tool has been implemented in numerous laboratories worldwide, adapting to different scanning methods, coloring techniques, and slide preparations. While it demonstrates high performance with excellent sensitivity and specificity, it continually undergoes refinement based on feedback (Sandbank et al., 2022[31]), (Badve, 2023[33]). In one laboratory, it even identified historical diagnostic errors made by physicians, adding to its benefits.

The development process is ongoing, with plans to integrate the tool into laboratory management systems to enhance efficiency. Importantly, pathologists are deeply involved in the project, influencing its deployment and user interface.

Concerns about AI displacing the health workforce are not evident here. There is currently a shortage of pathologists, and AI aids in productivity and error reduction without replacing them. Some pathologists prefer traditional microscopes, but AI is generally welcomed as a supportive tool. It is unlikely that AI will entirely replace pathologists, but it may fully automate certain low-risk evaluations.

In summary, the integration of AI into pathology at MHS has demonstrated the potential to improve diagnostic accuracy, reduce errors, enhance productivity, and ultimately benefit both patients and the healthcare organisation. Yet, the process for development and adoption takes years – and its overall impact is dependent on its adoption by more organisations, professionals, and disciplines.

This is a promising example of how AI can augment healthcare professionals' capabilities and efficiency without replacing them entirely.

Source: Interview by Authors with Maccabi Healthcare Services.

Complementary approaches that combine the strengths of clinicians and AI are promising. An example for such a process would be to first use the AI to evaluate the output and refer to a clinician in cases where confidence of the AI algorithm is relatively low. In the evaluation of AI algorithms on breast cancer mammograms and X-ray TB screening, researchers demonstrated the potential for improved accuracy and reduced physician workload, contingent upon the chosen process (Dvijotham et al., 2023[34]).

1.2.2. Challenges and risks with the use of AI in healthcare

While there is clear enthusiasm around the use of AI in healthcare, it is imperative to acknowledge the challenges and risks inherent in its utilisation. Data stands as a central source of both challenges and risks, being governed by both privacy and data protection regulations and health data confidentiality regulations.

Additional organisational and ethical obstacles may impede gaining access to data. Even when these obstacles are surmounted, data quality may prove suboptimal, necessitating extensive data cleaning efforts to remove duplicates, normalise measures, and validating coding methods. As one interviewee noted, enhancing data quality consumed considerably more time and resources than training the AI model.

Data-related pitfalls include using data that is not representative for the target population of the algorithms which may inadvertently perpetuate existing biases (Challen et al., 2019[35]). With mounting awareness of data-related pitfalls, several methods for minimising their potential hazards have been developed (Nazer et al., 2023[36]). It requires policies and binding regulations to guarantee that these methods are incorporated in the process of algorithmic development. The OECD council has adopted several recommendations which aim to guide governments in producing the policies and regulations required to support these data and AI activities, including the AI principles (OECD, 2024[37]), the Privacy Guidelines (OECD, 2002[38]) and the Health Data Governance recommendations (OECD, 2017[39]). Coherent and comprehensive principles are helpful; however, human oversight is necessary to ensure its application and that additional action is taken when appropriate. Further, communication with the users of AI solutions is necessary to support trust and adoption of the solutions.

These challenges, among others, help to understand why many AI projects in healthcare are narrowly focused. Scaling up projects to the level of healthcare systems is challenged by the generalisability of the algorithms trained on limited health data that may not be representative of broader populations. Further, concerns for scaling up relate to algorithmic robustness in real-world scenarios in new geographies or settings, the scarcity of high-quality health data, and limited institutional and human capacity to fully harness the potential of AI (Oliveira Hashiguchi, Slawomirski and Oderkirk, 2021[22]).

1.2.3. Generative Artificial Intelligence (GAI) in health

Artificial Intelligence (AI) is a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their levels of autonomy and adaptiveness after deployment (OECD, 2024[40]).

Generative artificial intelligence (GAI) refers to systems capable of producing content on demand, such as text, images, or sound. The rapid advancements in AI in recent years facilitated the development of models capable of generating content that appears indistinguishable from that produced by a human counterpart. The popular Large Language Models (LLMs) are pre-trained models with immense amounts of data from general-purpose dataset (e.g. books, internet) and use self-supervised learning to predict the next token in a sentence, given the surrounding context. The process is repeated over and over and may use additional modes of learning until the model reaches an acceptable level of accuracy. The introduction of such models as the ChatGPT platform in November 2022, generated significant enthusiasm in the field of AI, sparking a vigorous debate on the potential benefits, limitations, and risks of ChatGPT in healthcare (Ayers et al., 2023[23]). Likewise, GPT-4, introduced in March 2023, quickly gained the attention of researchers and practitioners across various medical specialties, standing out as a multimodal LLM capable of processing not only text but also diverse media types, including images, voice files, and videos.

Potential healthcare applications of LLMs encompass facilitating clinical documentation, creating discharge summaries, generating notes, obtaining insurance pre-authorisation, functioning as chatbots to address patient queries using personalised data, assisting in patient triage, aiding physicians in diagnosis, and suggesting treatments. Patients can achieve greater autonomy by receiving tailored assessments of their data, symptoms, and concerns, receiving specific recommendations, and engaging with personalised health chatbots.

LLM-based models have demonstrated their efficacy by successfully navigating common physician licensing-like tests, progressively improving with each tool generation (Singhal et al., 2023[41]).

Thirunavukarasu and colleagues evaluated ChatGPT 3.5 in primary care using the Membership of the Royal College of General Practitioners Applied Knowledge Test (AKT) and found an average overall performance of 60.17%, a commendable score but falling below the mean human passing mark of the last two years (70.42%) (Thirunavukarasu et al., 2023[42]). While LLMs are approaching human expert-level performance, further development is necessary to match the capabilities of qualified primary care physicians in the AKT (Thirunavukarasu et al., 2023[42]). It remains to be seen whether medical decisions made by LLMs can compare to those by physicians.

Validated high-performance models can serve as assistant tools to aid the health workforce crisis. A particularly promising application of GAI tools is clinical notetaking. Clinical notes are essential in modern healthcare for maintaining continuity of care, supporting research, ensuring quality, and meeting legal requirements. However, as notetaking is often time-consuming and considered as an administrative task, the quality of clinical notes might often be suboptimal. AI-based clinical note-taking tools are already in development (Moor et al., 2023[43]) (See Box 1.2).

Some of the challenges posed using GAI tools in healthcare are like those of other AI-based tools. One of those challenges is data bias, where the use of historic or obsolete data perpetuates biases from prior treatment practices (e.g. different treatments based on ethnicity or gender) or inaccuracies. Another is the lack of algorithmic transparency, which can be mitigated by requiring aspects of the algorithm to be explainable in plain language with respect to OECD Recommendation of the Council on AI (Principles 1.3 and 1.5b) (OECD, 2019[44]). AI paternalism is also a concern, with the risk of altering patient-physician relationships and diminishing patient voice, as doctors may overly rely on AI to the detriment of patients' lived experiences and clinical judgment. Furthermore, an overreliance on AI could potentially lead to a loss of clinical skills and decision-making abilities among health workers.

Notably, unique challenges to LLMs – and GAI models – is the risk of hallucinations. Hallucinations refer to false statements introduced by the model without clear basis, resembling the model "hallucinating". The hallucinations are particularly concerning, as they may be subtle and convincing, making them difficult to distinguish from real facts for physicians.

Consequently, in view of all these potential risks to patients' well-being, safety and quality healthcare outcomes, a satisfactory proof of safety and accuracy of the AI performance is required prior to deployment in real life patient care, accompanied by ongoing monitoring of performance accuracy and safety and a second human review of LLM-based recommendations are essential. Additionally, a path for patients to contest the records or recommendations of the AI should be clearly available.

The use of GAI in healthcare presents more complex issues than other AI-based tools, given their potential widespread adoption across healthcare settings and in various scenarios and domains. Consequently, ethical, and regulatory concerns are elevated. Transparency, continuous training and interdisciplinary collaboration between health professionals, data professional, legal professionals, and experts in the AI field as well as accountability are required to navigate these concerns.

Box 1.2. Case analysis – AI-powered clinical note taking in healthcare

This case study – shared by an interviewee – delves into the transformative use of AI in clinical scribing through a tool for notetaking during the provider – patient interaction.

The clinical scribe is a critical liaison in the patient-provider interaction to reflect what happened during the interaction, results, and next steps. Usually, the provider takes notes during the encounter or needs to recall shortly afterward. Notetaking may reduce the focus on the patient during the encounter.

The interviewee describes an alternative procedure: at the beginning of the interaction, expressed consent is obtained to record the conversation while safeguarding personally identifiable information. The encounter is captured by transforming voice to text. At that point the ChatGPT application compiles a concise 300-word summary of the consultation. This is then reviewed by the treating provider who can update it prior to committing it to the patient record.

Results

The outcomes of this AI-powered clinical scribe are striking. Approximately 20% of the notes require no changes, while the remaining 80% necessitate minor adjustments, often involving the addition of information that was not evident in the conversation. The most significant impact is observed in terms of efficiency, with a 15% increase in the number of patients seen during an emergency department shift.

Further, by completing the notetaking tasks immediately with the patient rather than after-the-fact at a computer workstation – the provider is not required to remember critical details between the health encounter and its documentation. Notetaking at the bedside minimises the risk of forgetting crucial details. Notably, 100% of patients have consented to this AI-driven approach, prioritising the ease and effectiveness of healthcare delivery.

Notably in one consultation, the patient did not natively speak the same language as the health provider. The scribe tool was able to listen to the patient describe their symptoms in their native language and then translate to a language the provider could understand. This was tested with the guidance of a personal translator who confirmed the accuracy of the translation. If this is successful at a larger scale, this could assist with addressing some health inequities where language is a barrier.

While the benefits are evident, some risks persist including privacy protection, cost, and training. The opportunities from the use of such tools are significant in facilitating less administrative burden, improved data quality, and better results for patients and providers.

Source: Interviewee, Moor et al. (2023[43]), "Foundation models for generalist medical artificial intelligence, https://doi.org/10.1038/s41586-023-05881-4.

1.3. Artificial Intelligence and the health workforce

A comprehensive OECD study (OECD, 2023[45]) explored the initial impacts of AI adoption in various industries' labour markets, shedding light on AI's role in the workforce. While not explicitly focused on healthcare, the study raised relevant issues that could apply to the health workforce. Contrary to widespread concerns about job security, the study revealed that AI's impact on job displacement has been limited thus far. Early AI adoption primarily takes place in large enterprises experimenting with these technologies, notably in sectors like manufacturing and banking. Many of these early adopters show hesitancy toward significant staff reductions. Instead, they opt to adapt their workforce dynamics by scaling back recruitment, encouraging voluntary departures, and facilitating retirements. In healthcare, where there is a persistent demand for skilled professionals, the opposite effect is observed, with AI emerging as a potential solution to mitigate the growing shortage of healthcare professionals.

As detailed in section 1.1, the health workforce faces distinct challenges characterised by high burnout rates, extended working hours, and significant pressure on the health workforce. AI could transform healthcare by efficiently managing essential yet repetitive tasks (e.g. notetaking, billing, scheduling), and grant healthcare professionals more time to dedicate to intricate cases requiring their expertise and more time for patient care. Furthermore, emerging evidence demonstrates that AI and generative AI yield productivity gains, leveling the performance among workers in identical roles (OECD, 2023[45]). Productivity gains are critical in healthcare, not to replace jobs, but to address pressing issues such as labour shortages and prolonged waiting times.

To fully grasp AI's impact, it is crucial to comprehend the daily challenges faced by healthcare professionals. These challenges encompass extensive paperwork, data management, and thorough patient record reviews (Beamtree Global Impact Committee, 2023[46]). AI can intervene by automating data entry, categorisation, and analysis, while predictive analytics aid in early disease detection and personalised treatment planning. Reports indicate that across the health workforce, comprising nurses, physicians, dentists, pharmacists, and specialists, up to 30% of all administrative tasks can be automated by 2030 (Spatharou, Hieronimus and Jenkins, 2020[47]). A practical example of this has been noted at John Hopkins University Hospital, where AI has been used to assign patients in need of an emergency room 30% faster, reduce transfer delays from operating rooms by 70%, and dispatch ambulances 63 minutes sooner to pick up patients from other hospitals (John Hopkins Medicine, 2020[48]).

While analysing the potential impacts of AI on the workforce in domains beyond healthcare, the net impact of AI on employment is theoretically ambiguous. AI might displace some human labour (displacement effect) but could also increase labour demand due to heightened productivity (productivity effect). Additionally, AI can create new tasks, leading to the formation of new jobs (reinstatement effect), especially for workers with skills that complement AI (OECD, 2023[45]).

In healthcare, the displacement effect could be minimal and confined to specific domains, if present at all. The productivity effect may partly address workforce shortages but would not cover the entire spectrum of the issue. The reinstatement effect could usher in new roles such as AI data analysts, AI model developers, telemedicine specialists, prompt engineers, and other experts responsible for implementing and updating AI solutions in healthcare systems.

Integrating AI into healthcare is not devoid of challenges. Examples of concerns including work intensification, data privacy, transparency, and potential biases in AI decision-making – topics explored in the questionnaire and presented in the next sections. Addressing challenges demands a meticulous and ethical approach to AI implementation, enabled by sector-specific policies and regulations, which ensure AI tools maintain impartiality, transparency, and accountability to uphold trust in human-driven and AI-augmented healthcare systems (See Box 1.3).

Box 1.3. Case analysis – Navigating AI adoption and governance in healthcare – The AMA's approach

Representatives from the American Medical Association (AMA) addressed the evolving landscape of AI adoption within the medical community. Acknowledging initial apprehensions relating to job security, especially among radiologists, there is a notable shift towards embracing AI for its potential to enhance healthcare services.

A consensus emerged on prioritising low-risk, high-value AI implementations primarily focused on administrative functions; however, discussions underscored the crucial issue of liability. Determining accountability for AI-generated decisions remains a challenge, necessitating careful policy formulation. The AMA's position is that liability with AI cannot be borne solely by health professionals as (a) they are not involved in the development of the AI tools, and (b) are not involved in mandating their use.

The regulatory landscape of AI tools in health presents a dichotomy, with ongoing considerations for AI as a regulated medical device, aligning with the FDA's oversight. Generative AI remains largely unregulated, posing concerns due to limited governance structures. Regarding regulation, policy development is seen as pivotal, with the AMA actively crafting guidance to help facilitate smooth AI integration. Questions about physicians' accountability and transparency standards for clinical AI applications prompt careful deliberation.

Health insurers' utilisation of AI for claims determination raises concerns about potential impacts on coverage limits and access to care. Bias and data privacy emerged during the conversation as crucial considerations, highlighting the need for balance between leveraging health-related data for AI and ensuring patient confidentiality. Transparency, governance, and data privacy emerged as additional focal points, especially when it comes to preventing re-identification of sensitive patient information (a phenomenon that is possible with AI tools) and thereby upholding patient data privacy, confidentiality, and security. Concerns regarding health-related inputs into ChatGPT emphasise the need for clear guidelines, regulation, or policy to prevent data misuse.

Looking ahead, maintaining data privacy, enhancing transparency, and empowering stakeholders (including patients) with more control over their data are seen as crucial endeavors for a successful integration of AI in the healthcare sector. The AMA remains an important player in navigating the complex landscape of AI adoption and governance to ensure better healthcare outcomes.

Note: Based on interviews with representatives of the American Medical Association (18.09.2023).

2 Design of this study on Artificial Intelligence and health workforce

To obtain a comprehensive understanding of the perspectives held by physician organisations in different countries concerning the adoption of AI tools in healthcare, a collaborative initiative was launched in partnership with the World Medical Association (WMA). The primary aim of this study is to explore countries' viewpoints on the advantages, drawbacks, applications, prospects, and degrees of engagement with AI-based tools in healthcare. This exploration is carried out through a survey distributed to medical associations worldwide affiliated with the WMA, supplemented by targeted interviews with experts.

The survey consisted of three segments, each tailored to specific objectives. For a more comprehensive representation of the research model and questionnaire, refer to Table 2.1 and Figure 2.1.

- The first section contains statements and questions aiming at comprehending the perspectives of medical association representatives on the opportunities, risks, and barriers related to AI in healthcare.
- The second part focuses on discerning these associations' current involvement in AI, their strategies to influence policy and regulation pertaining to AI applications in their countries, and their future intentions.
- Lastly, the third segment aims to assess the level of AI preparedness of the associations to adapt to expected changes brought on by the adoption of AI.

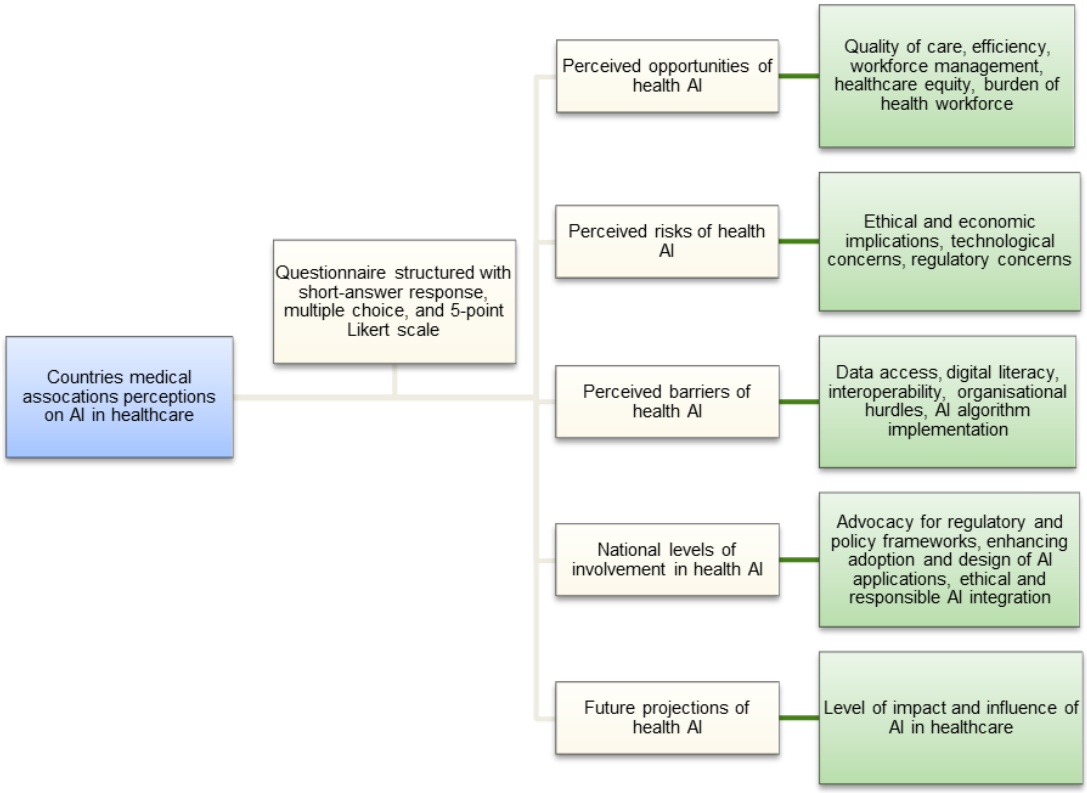
Table 2.1. Structure of the final questionnaire sent to countries' medical associations

Subsection	Number of questions
General Perceptions of Health AI	10 questions, 5-point Likert scale
Future Projections of Health AI	1 question, multiple choice
Opportunities of Health AI	9 questions, 5-point Likert scale
Risks of Health AI	12 questions, 5-point Likert scale
Nations Involvement in Health AI	9 questions, 5-point Likert scale; 1 question, multiple choice
Barriers of Health AI	10 questions, 5-point Likert scale

Source: Authors, WMA Survey.

The survey, including questions, drop-down answer options, and supplementary information, was translated into both French and Spanish to broaden the reach and response rate of the survey. Furthermore, recognising the potential variability in the use of the term "AI" across different countries and cultures, a standardised definition of AI from the OECD was provided at the beginning of the survey (OECD, 2019[44]). Note that this definition was lightly updated with the update to OECD AI principles in 2024 (OECD, 2024[40]).

Figure 2.1. AI in healthcare questionnaire research model



Source: Authors, WMA Survey.

The survey was developed by formulating questions and statements after conducting a comprehensive review of relevant literature, with a specific focus on peer-reviewed papers that addressed opportunities and risks related to AI in healthcare. Majority of the questions were structured as statements, requiring respondents to indicate their degree of agreement or disagreement by employing a Likert scale (see Table 2.2), while some were presented as closed-ended questions. In addition, open-ended questions were included to enable respondents to offer their insights in their own words.

Table 2.2. Summary of the 5-point Likert Scale used in the AI and the Health workforce Survey

Scale	Left-Most	Left of Centre	Centre	Right of Centre	Right-Most
Rating	1	2	3	4	5
General Perceptions of Health AI	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Opportunities of Health AI	Not likely at all	Unlikely	Somewhat likely	Likely	Very likely
Risks of Health AI	Not likely at all	Unlikely	Somewhat likely	Likely	Very likely
Barriers of Health AI	No problem at all	Creates minor difficulties	Creates moderate difficulties	Creates major difficulties	A huge obstacle
Nations Involvement in Health AI	Not in our scope	Consider to be involved	Minorly involved	Moderately involved	Deeply involved

Source: Authors, WMA Survey.

3 Results of survey on Artificial Intelligence and health workforce

The survey respondents' profiles are detailed in Table 3.1. Respondents represented the medical associations indicated their organisation's location by country or region, and the organisation's name. These medical associations typically advocate the professional interests of doctors, promote public health initiatives, and maintain high standards of medical practice. They also seek to shape health and social policy, provide continuing medical education, and ensure ethical standards in the medical field. In total, there were 18 responding medical associations that completed the survey, 17 of them from individual countries and one representing the European region (indicated with an asterisk). The results are presented below in aggregate to respect confidentiality.

Table 3.1. Respondents to the AI in Health workforce Survey

Geographical Region	Country or Region where Organisation is Active	Organisation Name
Asia/Pacific	Malaysia	Malaysian Medical Association
	Republic of Korea	Korean Medical Association
North America	The United States	American Medical Association
	Haiti	Association Médicale Haïtienne
Latin America	Brazil	APM – Associação Paulista de Medicina
	Uruguay	Sindicato Médico del Uruguay
Europe	Denmark	Danish Medical Association
	France	Conseil national de l'Ordre des médecins (CNOM)
	Germany	German Medical Association
	Iceland	The Icelandic Medical Association
	Netherlands	Royal Dutch Medical Association
	Poland	Polish Chamber of Physicians and Dentists
	Israel[1]	Israeli Medical Association
Middle East and North Africa (MENA)	Nigeria	Nigerian Medical Association
Sub-Saharan Africa	Rwanda	Rwanda Medical Association
	Sénégal	Ordre National des Médecins du Sénégal
	Somalia	Somali Medical Association
International	–	World Medical Association

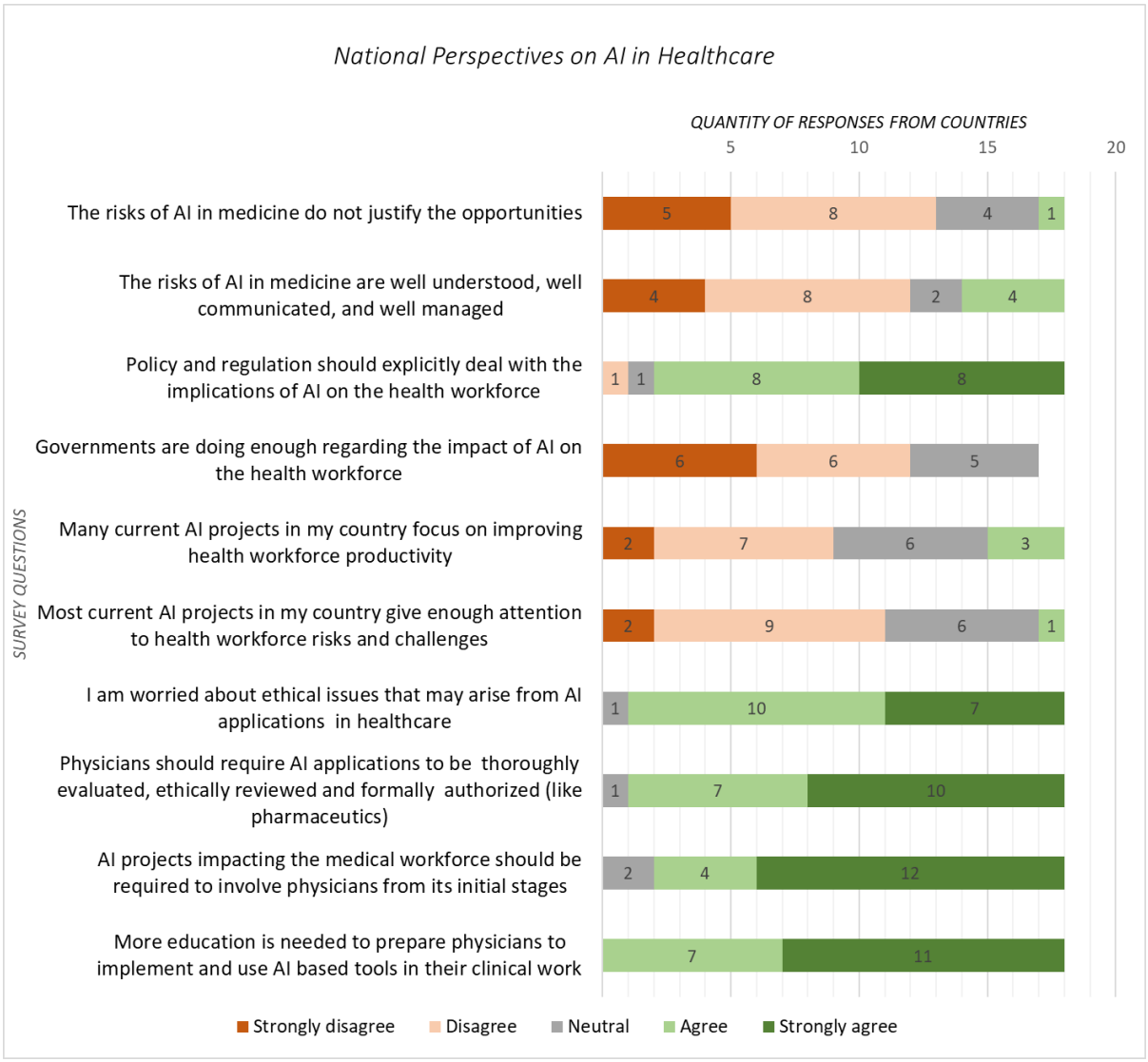
Source: Authors, WMA Survey.

[1] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem, and Israeli settlements in the West Bank under the terms of international law.

3.1. General perspectives on AI in healthcare

Medical associations were asked about their perspectives on AI in healthcare across different statements (See Figure 3.1).

Figure 3.1. General perspectives of country medical associations on AI in healthcare



Source: Authors, WMA Survey, N=18.

Respondents demonstrated agreement regarding the necessity for physicians' involvement in AI projects within the health workforce from the very beginning (n=16). They also agreed on the need for additional education to equip physicians in implementing and utilising AI-based tools in their clinical practice (n=11). Following closely was the consensus that AI applications for healthcare should undergo thorough evaluation, ethical review, and formal authorisation, like the processes for pharmaceuticals or medical devices (n=10). Conversely, the strongest disagreement was observed in relation to the belief that governments are adequately addressing the impact of AI on the health workforce (n=6). This level of

disagreement was closely followed by the view that the risks of AI in medicine do not justify the opportunities (n=5).

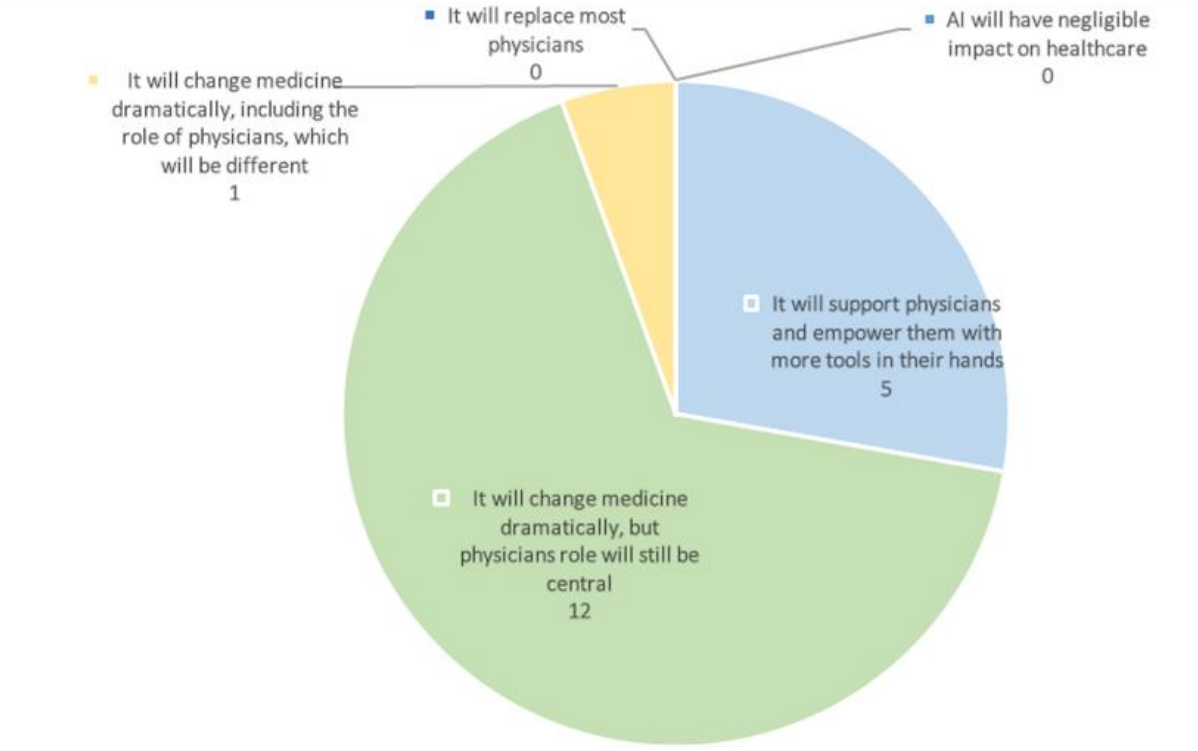
In elaborating their responses, the surveyed medical associations believe that:

- The benefits of AI in healthcare are more significant than its risks.
- The understanding, communication, and management of AI risks in healthcare need improvement.
- AI implementation programmes in their countries often overlook health workforce risks, challenges, and productivity improvements.
- Governments should take further action (e.g. regulation, policy, safeguards, communications) regarding the impact of AI on the health workforce.

3.2. Anticipated trajectory of AI in healthcare

Medical associations were asked their perception regarding the trajectory of AI in healthcare for the next 10 years.

Figure 3.2. Countries medical associations anticipated trajectory of AI in healthcare



Source: Authors, WMA Survey.

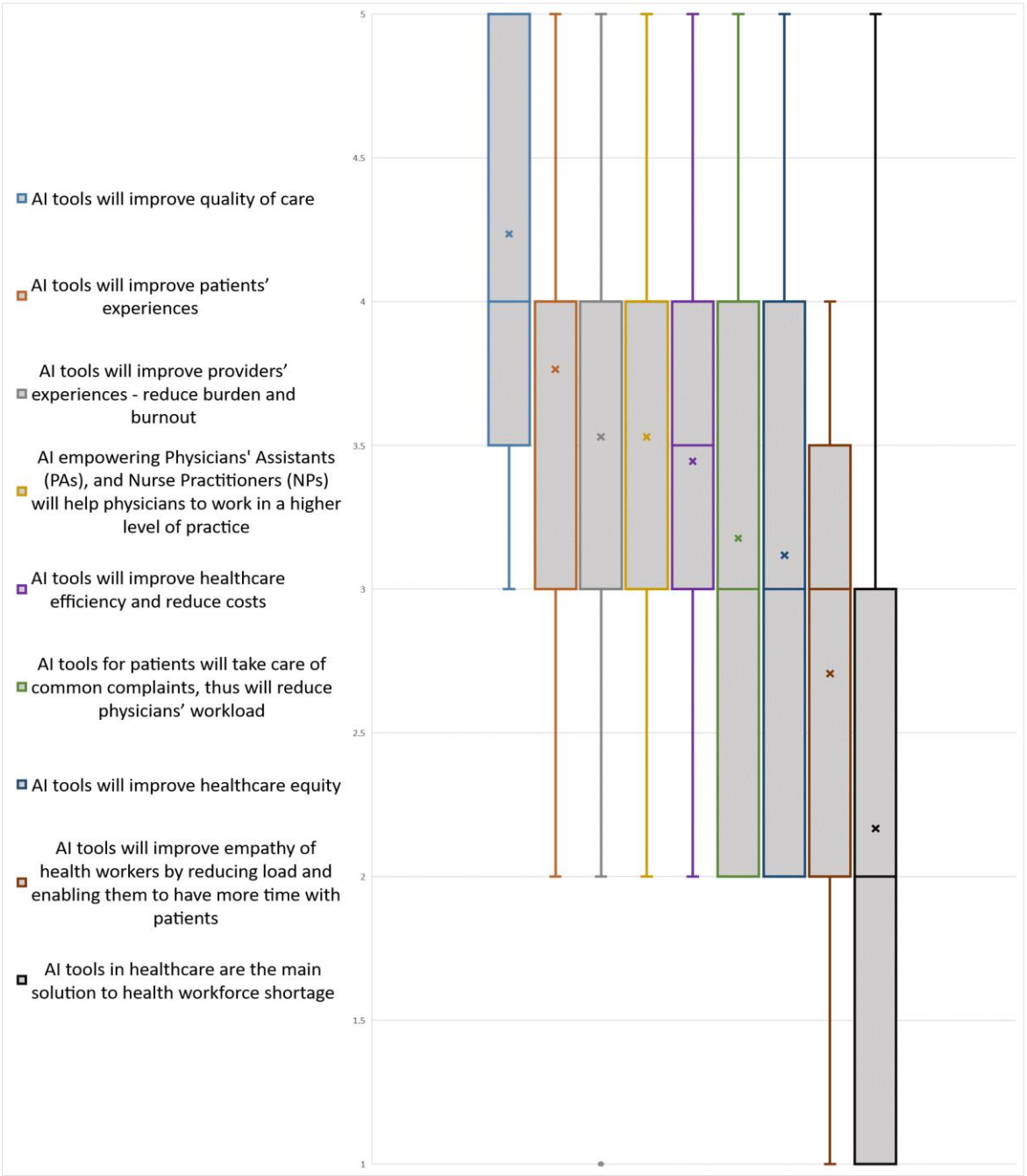
Most of the representatives from national medical associations expressed their anticipation of AI dramatically altering the landscape of healthcare and medicine (Figure 3.2). They emphasised that the role of physicians would remain fundamental in care delivery (n=12, green shading). Furthermore, there is a strong indication that AI will support physicians and equip them with more 'tools' to enhance their capabilities (n=5, blue shading). Additionally, one respondent highlighted the belief that AI would significantly alter medicine, including the role of physicians, leading to a different healthcare landscape

post-adoption and implementation (n=1, yellow shading). Conversely, no respondent believed that AI would have a negligible impact on healthcare (n=0), and no respondent believed that AI would replace most physicians (n=0).

3.3. Perceived opportunities of implementing AI in healthcare

Medical associations were asked for perceptions of how AI would most impact healthcare (Figure 3.3).

Figure 3.3. Medical associations perceived opportunities of Implementing AI in healthcare sector



Source: Authors, WMA Survey.

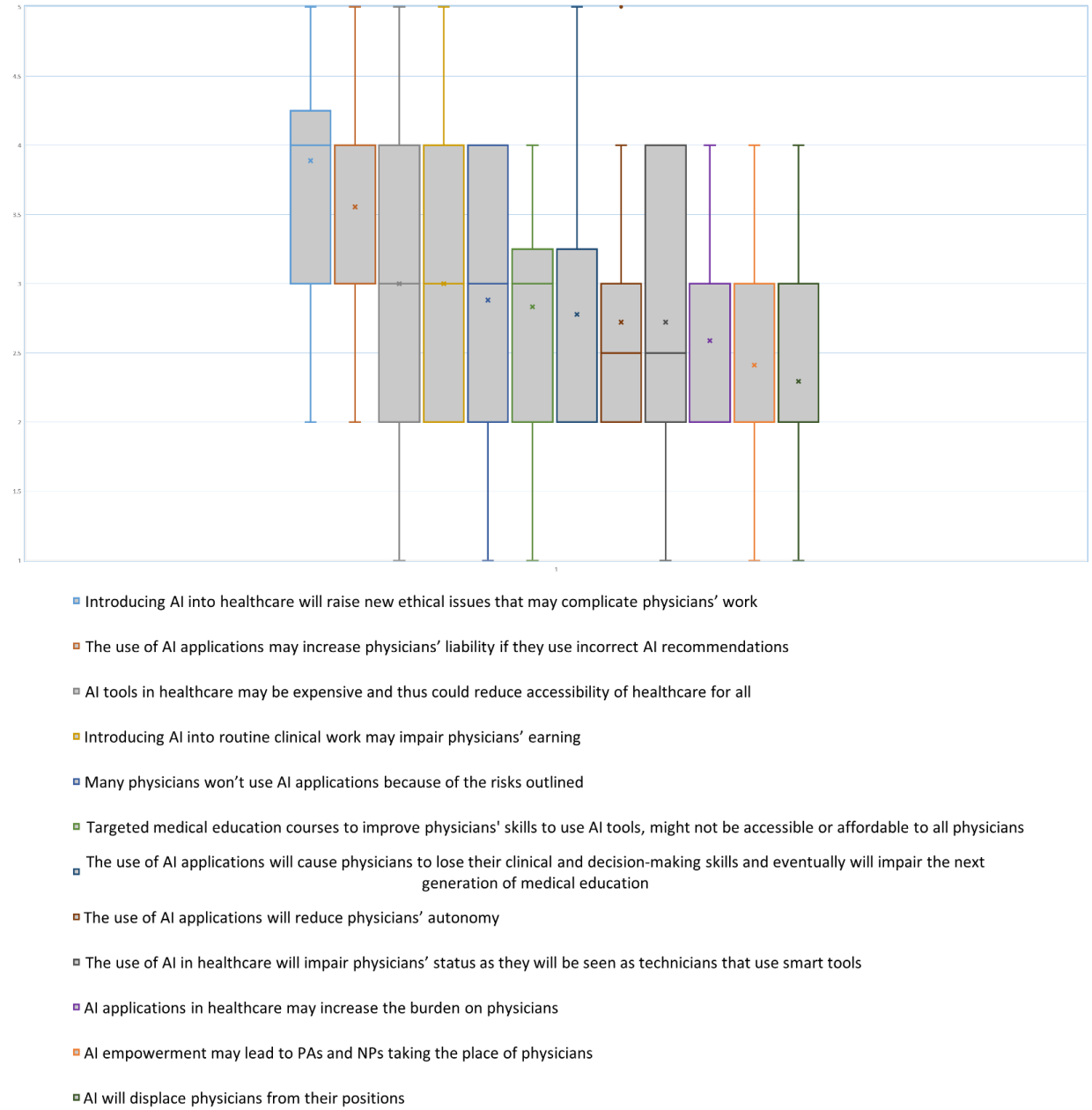
This graph displays the distribution of the answers of the respondents, including the range from the minimum to the maximum values (indicated by the thin lines) and the distribution across the upper and lower quartiles (indicated by the boxes). The mean result is noted by an 'x.' Each statement from the questionnaire is arranged from left to right, with statements on the left indicating the most likely perceived opportunities (determined by their mean), and those on the right representing the least likely perceived opportunities.

The opportunity considered most likely was the improvement of care quality through AI tools, with a mean of 4.26 (on a 5-point Likert scale). Subsequently, respondents agreed that AI tools would improve patient experiences (mean weighting 3.76), improve providers' experiences by reducing the burden and burnout within the health workforce (mean weighting 3.53), empower physician assistants (PAs) and nurse practitioners (NPs) to allow physicians to fully utilise their skills (mean weighting 3.53), and enhance healthcare efficiency while reducing costs associated with the healthcare ecosystem (mean weighting 3.44). There was an outlier concerning burden and burnout, with one respondent indicating this to be 'not likely at all.' The lowest level of agreement pertained to the notion that AI would improve empathy among health workers by reducing their workload, enabling them to have more time with their patients (mean weighting 2.70), and that AI tools are the primary solution to health workforce shortages (mean weighting 2.17).

3.4. Perceived risks of implementing AI in healthcare

In a second stage, medical associations were asked about their perception of risks to the adoption of AI by health professionals. Each scenario from the questionnaire is represented from left to right, with scenarios on the left indicating the most likely perceived risks (determined by their mean), and those on the right representing the least likely perceived risks (Figure 3.4).

Figure 3.4. Medical association perceived risks that prevent the adoption of AI in health



Source: Authors, WMA Survey.

Medical associations expressed varying levels of concern regarding AI-related risks in healthcare. The most significant concerns revolved around ethical issues. Specifically, there was a strong belief that AI integration in healthcare would introduce new ethical challenges that could complicate physicians' work (mean rating 3.89; scale details in Table 3.5).

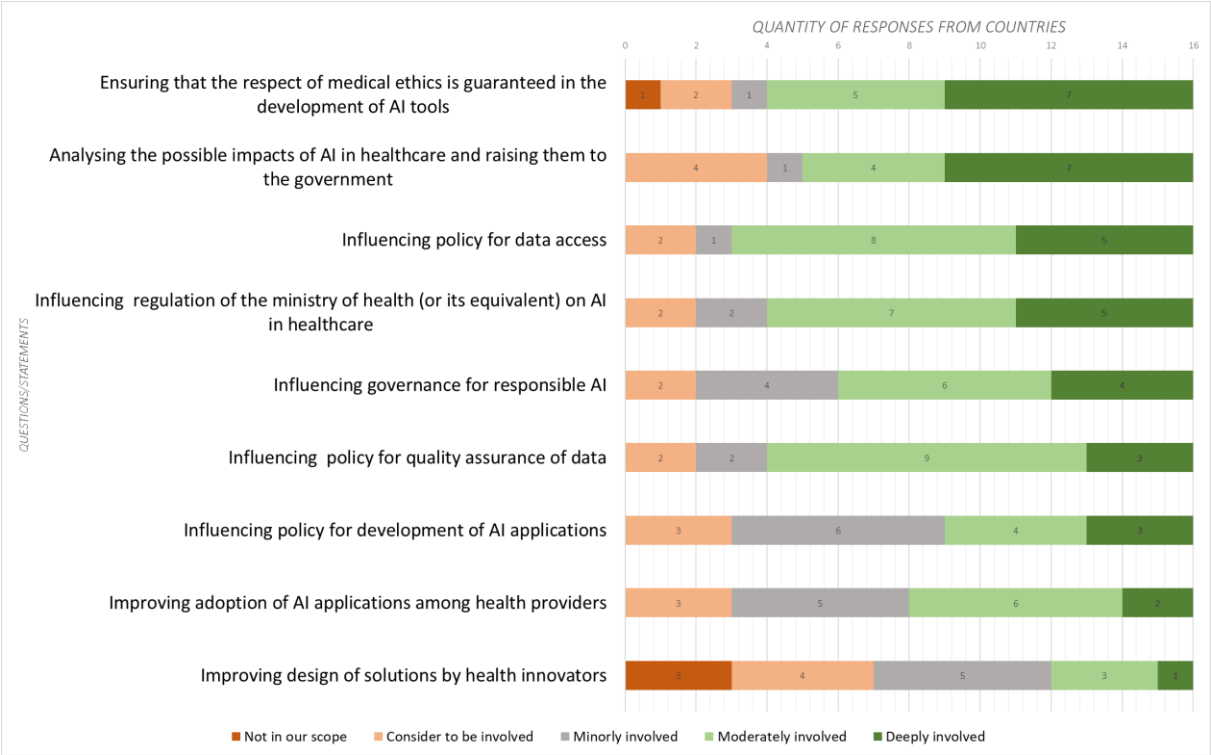
The potential financial implications of integrating AI tools into routine clinical work were also a source of notable agreement. There was a concern that this could have an adverse effect on physicians' earnings (mean rating 3.00). Furthermore, the costs associated with AI tools in healthcare were identified as a potential barrier to accessibility (mean rating 3.00). Respondents considered the risk of AI leading to physician assistants and nurse practitioners replacing clinical physicians as less likely compared to other scenarios (mean rating 2.41). Similarly, the idea of AI displacing physicians from their roles was seen as

a less likely risk compared to other scenarios (mean rating 2.29). Although respondents perceived AI applications as somewhat likely to reduce physician autonomy (mean rating 2.72), there was an outlier with one respondent indicating this as very likely.

3.5. Overall trends in involvement of countries medical associations in health AI

Medical associations were asked about their involvement in AI-related projects within the health sector (Figure 3.5).

Figure 3.5. Medical association self-reported involvement in AI projects



Source: Authors, WMA Survey.

In the graph, the questionnaire statements have been arranged to place statements with the highest level of involvement by medical associations at the top, while statements with lower levels of involvement are situated toward the bottom.

An evident trend is the consistent pattern in which these associations exhibit varying degrees of engagement across the scenarios outlined in the questionnaire, ranging from 'deep involvement' to 'minor involvement'. Among respondents, the most substantial involvement is seen in activities related to analysing the potential impacts of AI in healthcare and conveying these findings to their respective governments, as well as initiatives to ensure compliance with medical ethics in AI tool development (n=7 indicating 'deep involvement' in both cases).

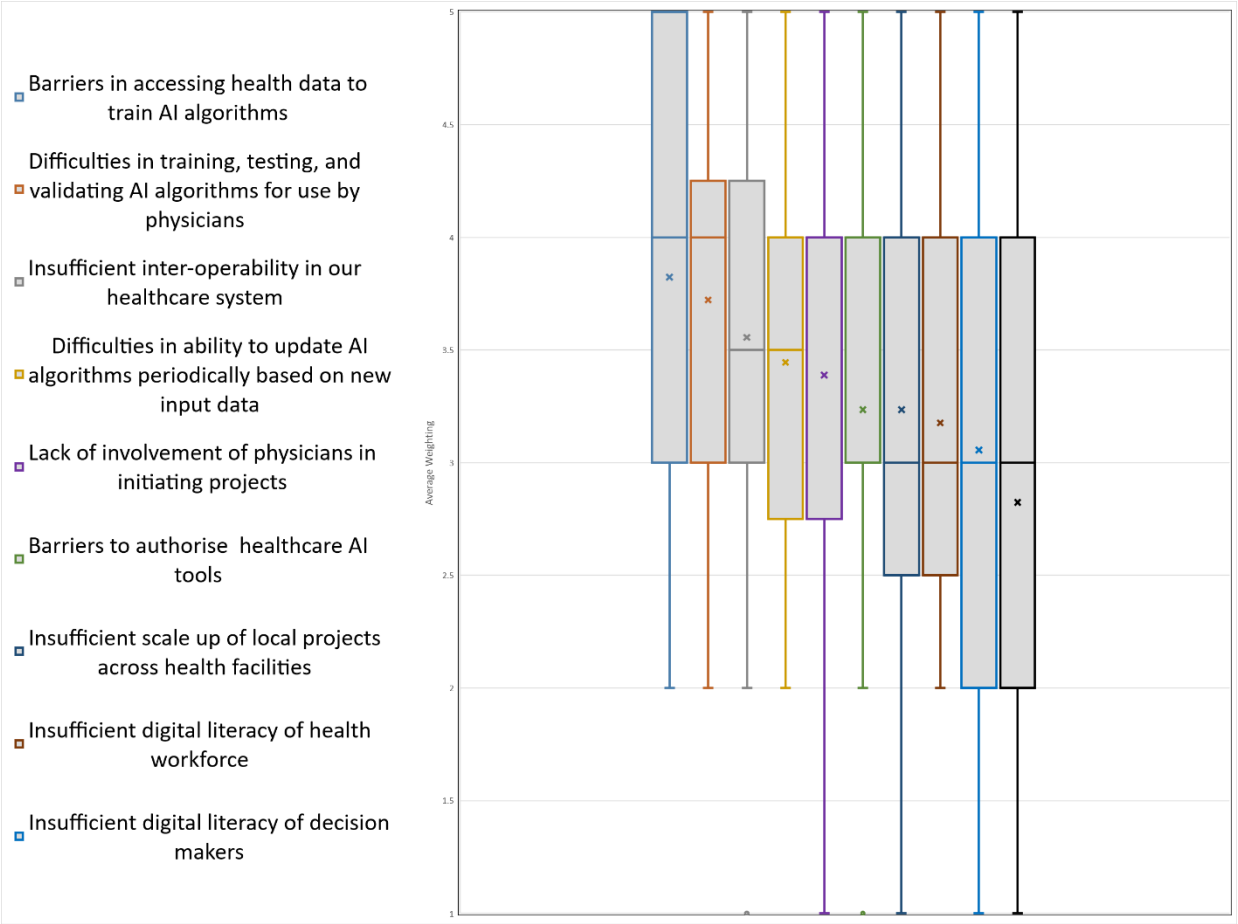
Another significant trend is the active participation of countries' medical associations in influencing policy pertaining to data access (n=15 indicating 'moderate involvement' or 'deep involvement'), influencing policy for data quality assurance (n=14 indicating 'moderate involvement' or 'deep involvement'), and influencing the regulation of the ministry of health (or its equivalent) concerning AI in healthcare (n=13 indicating 'moderate involvement' or 'deep involvement'). On the other hand, medical associations reported little or no involvement in enhancing the design of solutions developed by health innovators (n=14).

While medical associations reported that more than 70% are involved in the development of policy for AI, remarkably few (less than 25%) are involved in the design of solutions they are meant to use.

3.6. Perceived national obstacles to AI implementation in healthcare

Finally, medical associations were asked about their perceptions of AI-related barriers in healthcare (Figure 3.6).

Figure 3.6. Medical associations perceived barriers of implementing AI in healthcare sectors



Source: Authors, WMA Survey.

In general, all respondents viewed the obstacles outlined in the questionnaire as causing at least moderate difficulties. The most prominent barriers related to AI adoption and integration pertain to challenges in accessing health data for training AI algorithms (mean weighting 3.82), and the complexities involved in training, testing, and validating AI algorithms for use by physicians (mean weighting 3.72). There was also a notable level of agreement among medical associations that periodically updating AI algorithms based on new input data and dealing with insufficient interoperability within their healthcare systems pose moderate-to-major challenges (mean weighting 3.56 and 3.45, respectively). Respondents considered health and digital literacy among patients, the public, and decision makers (i.e. stakeholders) as less of a barrier to AI adoption and integration in healthcare compared to the other statements outlined in the questionnaire (mean weighting 2.82). Most topics were perceived to create at least minor difficulties.

4 Charting a path forward for AI in health

The survey highlights key insights for shaping future AI policies in healthcare: build on positive perceptions on the future of AI in healthcare by involving health providers in the design of new AI solutions, plan for evolving physician roles, manage risk through the full AI life cycle, enable training to improve digital health literacy, and establish clear ethical and liability guidelines.

4.1. Positive perceptions of AI in healthcare outweigh the risks

In the survey, a strong majority of respondents (72.2%) did not agree with the statement that "*the risks of AI in medicine do not justify the opportunities*" (See Figure 3.1). Medical associations' acknowledgement of the opportunities and risks of AI in healthcare was prevalent throughout the entire questionnaire, encompassing low-, middle-, and high-income countries. It can be concluded that the potential benefits of AI underscore the imperative of its use to enhance health outcomes for all. Substantiating this viewpoint, all medical associations involved in the questionnaire indicated some level of positive agreement that "*AI-based tools will improve the quality of care*" (See Figure 3.3.).

As with all novel innovations, particularly those involving human health, thorough discussions about the risks of such innovations should precede their adoption and integration. There was relatively strong disagreement with the statement "*the risks of AI in medicine are well understood, well communicated, and well managed*" (See Figure 3.1.). Efforts must intensify to comprehend the potential risks of AI in healthcare, which involves educating countries, medical associations, and healthcare workers; ensure the risks are addressed without impeding the realisation of AI's substantial benefits.

While there are positive perceptions, some scepticism of the value of AI remains. This is not surprising as it is common for innovative medical tools to face significant scepticism upon their initial introduction, yet later prove to be highly successful and beneficial to patients. For example, Magnetic Resonance Imaging (MRI) was initially met with reservation as a means for accurate diagnosis in the late 1990s, and it is now considered one of the most crucial medical instruments, routinely utilised by healthcare workers (AMA Journal of Ethics, 2002[49]). More recently, there was initial scepticism regarding novel mRNA vaccine technology for different variants of the COVID-19 virus. The value of mRNA vaccines has been demonstrated, with approximately 12 billion shots administered and a relatively low frequency of serious side-effects (El-Elimat et al., 2021[50]). Public scrutiny of emerging health technologies parallels concerns surrounding AI applications. Effective communication is crucial for governments and stakeholders to foster trust and promote positive perceptions among the public and healthcare providers.

The response of medical associations to the statement that "*many physicians will not use AI applications because of the risks*" is concerning, with only a third deeming it likely or very likely to use it as a tool (See Figure 3.4.). The contradiction between the acknowledgment of AI's opportunities in healthcare and the concern that many physicians will not use AI due to potential risks is troubling. Governments should address this obstacle by involving and constantly collaborating with health providers in the development,

implementation, and ongoing management of AI solutions and policies; promoting education for providers to effectively use AI tools and understand how to address the associated risks. Respondents strongly agreed on the necessity of (continuing) education programmes to prepare physicians for the implementation and use of AI-enabled tools in their clinical work (See Figure 3.1.), with all respondents indicating either agreement or strong agreement. Moreover, the time for adoption is likely to be a significant factor in determining the extent to which physicians will utilise AI tools. While there may be initial reluctance in the preliminary stages of AI implementation, it is probable that this will diminish as the applications become more integrated into the daily professional lives of physicians.

4.2. AI will change healthcare and the physician's role will stay central

Healthcare professionals, particularly physicians – in the focus of the questionnaire – express a belief that their professions will not be replaced by AI tools. One of the survey questions explored their perceptions of AI in medicine ten years into the future. Two-thirds of the respondents selected the statement, "*AI will change medicine dramatically, but physicians' role will remain central*" (See Figure 3.2.). There was also strong agreement towards the notion that AI applications will empower physicians with more tools at their disposal. Importantly, none of the medical associations believed that "*AI would replace most physicians in the healthcare sector*." Further, none believed *"AI will have negligible impact on healthcare"* (See Figure 3.2.). These beliefs were shared across varying countries and continents, where varying levels of AI awareness, integration, and use for medical-related purposes exist (OECD AI Policy Observatory, 2023[51]).

In line with these findings, one interviewee stated, *"AI is not going to replace physicians, but physicians who use AI will replace those who don't."* This sentiment is further reinforced by another respondent, which emphasised that *"AI will not be able to replace the expertise and professionalism of physicians – compromising the patient-doctor relationship – but can serve to support and streamline work protocols and reduce administrative burden."*

According to OECD research, nearly three-quarters of doctors and nurses reported performing tasks for which they were overqualified, primarily related to administrative duties (OECD, 2016[52]). The British Medical Association indicated that more than 13.5 million hours of doctors' time are lost each year in England due to inadequate technology – the equivalent of almost 8 000 doctors (British Medical Association, 2022[53]). Furthermore, reports indicate that across the health workforce, comprising nurses, physicians, dentists, pharmacists, and specialists, up to 30% of all administrative tasks can be automated by 2030 (Spatharou, Hieronimus and Jenkins, 2020[47]). There is a growing belief that advanced digital tools, like AI-powered systems, will provide more support to the health workforce by acting as 'advisors' or 'assistants,' especially for administrative tasks, rather than hinder their performance or ultimately replace their expertise.

Despite the strong belief that AI tools will support the health workforce, the level and extent to which these novel innovations will be supportive is yet to be defined, due to its relatively early stages of adoption and integration globally (National Academy of Medicine, 2022[54]). Two-thirds of the surveyed medical associations did not agree with the statement that "*AI tools in healthcare are the main solution to health workforce shortages*" (See Figure 3.3.). AI integration is currently occurring at a larger scale in higher-income countries with sufficient digital infrastructure, funding, and regulatory frameworks to support AI use in healthcare compared to lower-income countries. This might further incentivise migration of healthcare professionals. On the other hand, AI adoption will support physicians which could – in lower-income countries – streamline processes, enhance decision-making, and enable task-shifting models that empower all healthcare workers to optimise their performance. As a result, this could help alleviate the pressures caused by a lack of healthcare workers in these regions.

Although AI does not appear to be the primary solution to health workforce shortages, there was relatively strong agreement among respondents that AI-based tools will generally "*enhance the experience of healthcare providers by reducing burden and burnout*" (See Figure 3.3.). Reducing the workload on physicians by automating tasks will not be enough to significantly alleviate the shortage of physicians in many healthcare systems.

48.2% of the responding medical associations disagree with the idea that "*AI empowerment may lead to Physician Assistants (PAs) and Nurse Practitioners (NPs) replacing physicians*" (See Figure 3.4). One could argue that an advantage of AI applications is to expand the scope of work for PAs and NPs, further relieving the burden on physicians; however, responders did not see this as a step toward broadly replacing physicians. With respect to possible changes in the professional and financial status of physicians due to AI integration into healthcare, about half of the responders considered it unlikely that "*the use of AI in healthcare will diminish physicians' status, as they will be viewed as technicians using smart tools*." Regarding "*introducing AI into routine clinical work may impair physicians' earnings*," the responders were evenly split across the range of responses (See Figure 3.4). Despite widespread agreement on avoiding physician job losses, responders expressed concerns about physicians' status and earnings in the AI era.

In support of this overall discussion topic, The Australian Medical Association (AMA) published a position statement emphasising the role of physicians in the AI era: "*A human – usually a medical practitioner – must always be ultimately responsible for decisions and communication and should have meaningful involvement at all stages of the patient's journey"*, and "*The AMA upholds that human-delivered medical care must never be replaced by AI*" (Australian Medical Association, 2023[55]).

4.3. Data accessibility and managing AI applications perceived as significant barriers

This study revealed critical insights into the perceived barriers surrounding the adoption and integration of AI tools in healthcare. Among the numerous challenges identified, data accessibility and the management of AI tools stood out as the most significant barriers.

Data accessibility was a prominent issue highlighted by respondents, with the majority acknowledging that it poses major obstacles to AI integration into healthcare (See Figure 3.6.). Data accessibility is an important consideration for governments and key stakeholders as the ability of AI algorithms to learn and adapt significantly depends on the quality and quantity of data available (European Commission, 2023[56]). Within the realm of data accessibility, and as established by the OECD Council recommendation on Health Data Governance, two pivotal aspects warrant discussion (OECD, 2017[39]).

- *Data privacy and security:* A substantial body of literature has examined the hurdles related to data accessibility. This includes the stringent regulations governing health data privacy and security, which are necessary to safeguard patients' sensitive information. In healthcare, data breaches can have severe consequences, including legal repercussions and damage to patient trust (Sutherland et al., 2023[57]). Any AI integration must navigate complex legal and ethical frameworks to ensure data privacy and security while permitting data access for AI. This entails compliance with established regulations, fashioned on the principles of the OECD Privacy Guidelines (OECD, 2002[38]), and in force in most jurisdictions, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States or the General Data Protection Regulation (GDPR) in the European Union (Price and Cohen, 2019[58]), (McGraw and Mandl, 2021[59]).
- *Data Standardisation and Interoperability*: The survey also underlined concerns regarding interoperability issues within healthcare systems, with most respondents acknowledging it as a major barrier to AI integration (See Figure 3.6.). Healthcare systems often use a multitude of legacy systems and data formats, making the exchange and integration of data challenging

(OECD, 2023[60]). Consequently, the absence of data standardisation (including quality standards) and interoperability represents a significant obstacle to the full realisation of the potential of AI in healthcare, given that these two aspects are fundamental to the generation and utilisation of high-quality data. The medical associations' concerns align with previous research that underscores the importance of standardised data formats and seamless interoperability for AI applications (Lehne et al., 2019[61]), (European Parliament, 2019[62]).

Another model for making health data accessible for AI development and innovation is exemplified in the OECD Council Recommendation on Enhancing Access to and Sharing of Data, which includes the concept of Data Intermediaries (OECD, 2021[63]). A version of this concept has been promoted in the recent legislation by the EU on the creation of a European Health Data Space as an ecosystem for health where governance frameworks and harmonised standards and practices are being established.

The survey also revealed that medical associations perceived significant challenges in the training, testing, and validation of AI algorithms for use by physicians (See Figure 3.6.). Effective management of AI tools is paramount, given their potential to profoundly impact patient outcomes and healthcare operations. In this regard, several critical considerations come to the forefront.

- *Algorithmic Bias and Fairness*: The management of AI tools involves addressing issues such as algorithm bias and fairness. AI algorithms are only as effective as the data on which they are trained, and if these data are biased, the algorithms inherit the biases. Biased algorithms can result in disparities in patient care, especially in underrepresented populations (Tipton K et al., 2023[64]); for example AI algorithms applied to chest radiographs systematically missing diagnoses (Seyyed-Kalantari et al., 2021[65]). Consequently, it is critical to identify and mitigate biases both in datasets for AI tools and in AI algorithms, which is a complex challenge necessitating ongoing research and development.
- *Clinical Validation*: Ensuring that AI algorithms are clinically valid and safe for use is another aspect of managing AI tools, an aspect of AI adoption that respondents strongly agreed with (See Figure 3.1.). Clinical validation involves rigorous testing, validation, and integration into healthcare workflows. Substandard validation processes can result in adverse outcomes, undermining trust in AI systems (Park, Choi and Byeon, 2021[66]). It is paramount to establish stringent clinical validation procedures adapted to the fast pace of digital innovation. Notably, regulatory bodies such as the FDA in the United States have developed frameworks for the clinical validation of AI in healthcare (US Food & Drug Administration, 2021[67]).
- *Continuous Learning*: Another facet of managing AI tools is their ability to adapt and learn from new input data, a significant barrier to its adoption into healthcare as perceived by responding medical associations (See Figure 3.6.). Continuous learning is essential for AI systems to stay up to date and relevant. This process presents its own set of challenges, as updating AI algorithms can introduce new risks or uncertainties, along with additional labour to validate or make use of new features.

4.4. Low levels of health and digital literacy as barriers to responsible AI innovation and adoption in healthcare

Digital literacy encompasses the proficiency in utilising digital tools for communication, collaboration, problem-solving, safety, digital content creation, and understanding and employing information. Digital health literacy further incorporates health literacy, which refers to an individual's capacity to locate, comprehend, and utilise information and services to guide health-related decisions and actions for themselves and others (Centers for Disease Control and Prevention, 2023[68]).

Medical associations showed a common concern about low levels of digital and health literacy being potential barriers to AI adoption in healthcare (See Figure 3.6.). Specifically, 13 out of 18 medical associations (72%) identified "*insufficient digital literacy of health workers*" and "*insufficient digital literacy of decision makers"* as creating moderate to major difficulties for AI adoption and integration. Furthermore, 9 out of 18 medical associations (50%) associated "*insufficient health and digital literacy of patients and the public*" as creating moderate to major difficulties. It is important to note that there was considerable variation among responses concerning health and digital literacy, ranging from causing no difficulties to creating major challenges. These variations could be associated with the differences in the adoption of digital tools in the countries that provided responses.

Trust is pivotal for the effective and responsible integration of AI tools into healthcare. Importantly, improved health literacy has been shown to foster trust among the public concerning digital health-related innovations and technologies (Paige, Krieger and Stellefson, 2016[69]). A lack of trust in the use of digital tools among providers, patients, and the public means that when AI innovations are developed, they may not be embraced, utilised, or scaled sufficiently, thereby nullifying their value. In line with this, a survey conducted in early 2023 indicated that 70% of the public in the United States were not amenable to the use of AI for their diagnosis (Tyson et al., 2023[70]).

Educational programmes can contribute to bridging the knowledge gaps and tackle insufficient digital and health literacy. Such programmes may inform healthcare providers, patients, and the public about the relevance, risks, advantages, and applications of AI tools in healthcare. Supporting this notion, all 18 of the surveyed medical associations (100%) agreed with the statement that *"more education is needed to prepare physicians to implement and use AI based tools in their clinical work*" (See Figure 3.1.). Different countries possess varying levels of digital and health literacy due to (but not limited to) varying income levels, educational systems, and cultural nuances. Therefore, it is imperative for governments, policy makers, and key stakeholders to make concerted efforts to tailor educational content to suit these diverse needs (Norman and Skinner, 2006[71]), (Whitehead et al., 2023[72]).

4.5. Ethical and liability concerns regarding AI in healthcare

Ethics and laws play pivotal roles in shaping the responsible integration of AI in healthcare. Ethical considerations guide the development and deployment of AI-based systems, ensuring that patient safety, fairness, and transparency remain at the forefront of care and decision-making (Zhang and Zhang, 2023[73]). Legal frameworks assign accountability, clarify responsibilities and lay liability in case of AI-related errors or adverse outcomes that rise to the level of civil or criminal liability (NAM, 2023[74]) (NAM, 2023[74]; Naik et al., 2022[75]), (the Precise4Q consortium, 2020[76]). Together, ethics and laws provide the necessary foundation to build trust, ensure compliance with regulations, and enhance the positive impact of AI on healthcare systems.

4.5.1. Ethics

Due to their importance, ethical considerations on AI in healthcare were explored extensively in the questionnaire. Regarding general perceptions of AI in healthcare, 17 out of 18 medical associations (94%) agreed with the statement "*I am worried about ethical issues that may arise from AI applications in healthcare*." Further corroborating this, 94% also believed that "*physicians should require AI applications to be thoroughly evaluated, ethically reviewed, and formally authorised (like pharmaceuticals)*", and that "*introducing AI into healthcare will raise new ethical concerns that may complicate physicians work*" *(*See Figure 3.1. and Figure 3.4. respectively).

Although the specific ethical risks of AI in healthcare were not explored in the questionnaire, common concerns are present in the literature. Firstly, AI solutions can potentially exhibit and propagate biases.

Training AI applications requires extensive patient data sets, but the datasets also need to be representative of the targeted populations to minimise biases and the potential disadvantage to the groups underrepresented in the algorithms (Buolamwini and Gebru, 2018[77]). When conceptualising and deploying AI solutions, diligent efforts should ensure the representativeness of the target population in the training data. Several countries are establishing patient cohorts to support research based on expansive population data (e.g. Rotterdam study in the Netherlands, the Korean Genome and Epidemiology Study, and the Australian Imaging Biomarkers and Lifestyle Study of Ageing). These cohorts enable a demographic comparison between their patient population and the broader population, shedding light on potential differences. At a minimum, AI solutions must transparently disclose the nature of their training data.

> *"Among women with breast cancer, Black women had a lower likelihood of being tested for high-risk germline mutations compared with white women, despite carrying a similar risk of such mutations. Thus, an AI algorithm that depends on genetic test results is more likely to mischaracterise the risk of breast cancer for Black patients than white patients." (Parikh, Teeple and Navathe, 2019[78])*

Secondly, AI solutions raise significant privacy and security concerns. Although the removal of personally identifiable information is essential, especially within healthcare, a potential risk arises from the interconnection of individual-related data, as seen in EHRs, potentially enabling reidentification. If malicious actors gain access to these data, privacy breaches might result in data misuse and harm. Furthermore, the vast data AI uses for training makes it a specific target for cyberattacks, aiming to either breach privacy or render the AI solutions unusable (Sutherland et al., 2023[57]).

To address these privacy and security concerns, several controls can be implemented. These encompass privacy-enhancing technologies (e.g. encryption, de-identification, federated learning, trusted computer environments and more, as detailed in (OECD, 2023[79])) and digital security measures, fostering a culture of privacy and security through training programmes, and providing guidance for data access to ensure appropriate authorisation based on context and granularity (Sutherland et al., 2023[57]).

Another significant ethics-related concern expressed by the medical associations surveyed is that "*AI tools in healthcare may be expensive, potentially reducing accessibility to healthcare for all."* 72% of medical associations perceived this as likely. A primary objective of the healthcare sector is to achieve universal health coverage, ensuring value-based healthcare for all income groups and nations, overcoming financial barriers to necessary medical care (World Bank, 2021[80]). A concern with AI-based healthcare tools is their reliance on components inaccessible to all nations, potentially limiting benefits for some countries.

Resource constraints, technological disparities and limited expertise can challenge low income-countries to effectively adopt AI in their healthcare system. Some of these challenges are detailed below:

- **Digital Infrastructure and Connectivity** (World Health Organization, 2021[81])
  - *Requirement:* Robust digital infrastructure and high-speed internet connectivity.
  - *Challenge:* Limited access to reliable and high-speed internet, inadequate digital infrastructure.
- **Data Quality and Standardisation** (de Hond et al., 2022[82])
  - *Requirement:* Access to comprehensive and diverse healthcare data is essential for training AI algorithms effectively. Ensuring data quality and standardisation to enable interoperability and effective AI algorithm training.
  - *Challenge:* Limited resources to collect and maintain diverse and comprehensive healthcare data sets and to maintain high data quality.
- **Funding and Financial Resources** (National Academy of Medicine, 2022[54])
  - *Requirement:* Adequate funding and financial resources for investing in AI research, development, implementation, and maintenance.

- *Challenge:* Limited financial resources, budget constraints, and competition with other essential healthcare needs for funding.

Although some low- to middle-income countries (LMICs) still face challenges in digitalising healthcare, including data collection, digital literacy and lower rates of AI-related research and development (Wahl et al., 2018[83]), (López et al., 2022[84]), positive examples of AI in healthcare are emerging. For instance, recent ophthalmology studies from the Kingdom of Thailand and the Republic of Rwanda have demonstrated the potential of AI-assisted diabetic retinopathy screening in LMICs (Ruamviboonsuk et al., 2022[85]), (Mathenge et al., 2022[86]). Furthermore, AI-based tools in low-resource settings in the Republic of Rwanda, including automated drone deliveries of medical supplies to rural regions, have proven to be extremely beneficial (Mhlanga et al., 2021[87]). There are opportunities for sharing these innovations more broadly.

4.5.2. Liability

The potential utilisation of AI in healthcare has raised substantial concerns regarding the assignment of liability for medical errors arising from AI-augmented healthcare delivery (Khullar et al., 2021[88]). This concern was shared by 89% of surveyed medical associations in their response to "*The use of AI applications may increase physicians' liability if they use incorrect AI recommendations*" (See Figure 3.4). The current landscape of AI-related liability in healthcare encompasses two primary aspects (Maliha et al., 2021[89]), (Chan, 2021[90]), (Jassar et al., 2022[91]):

- 'Medical Malpractice'
  - *Implications for physicians*: Held liable for failure to critically evaluate AI recommendations.
- 'Products Liability'
  - *Implications for physicians:* When affiliated with the designers of AI-based devices.

One of the interviewees representing the American Medical Association (AMA) offered their perspective on the subject, emphasising the ongoing challenge of establishing accountability in AI-based decisions and highlighting the critical need for meticulous policies. The AMA's stance underscores that placing the entire responsibility on physicians is impractical for several reasons. Firstly, physicians may not be directly involved in the development process of AI tools. Secondly, they may not hold exclusive authority in mandating the tools' usage. The situation becomes notably complex when there is an underlying concept of 'negligence if AI is not utilised'.

Literature has highlighted cases of adverse patient outcomes attributed to inaccuracies in malfunctioning clinical AI-based software (Graber et al., 2019[92]), (Brown and Miller, 2014[93]). Future adverse outcomes linked to AI systems in healthcare are not only possible but potentially inevitable (Saenz et al., 2023[94]). Moving forward, governments and policy makers should concentrate and co-ordinate on devising liability frameworks that establish accountability and clarify responsibilities in cases of AI-related errors or adverse outcomes. These frameworks should aim to:

- Fairly distribute liability throughout the healthcare and AI providers ecosystems.
- Prevent undue imposition of responsibilities on physicians and frontline clinicians.
- Guarantee that patients have redress in warranted cases in a clear and efficient manner.
- Encourage the safe development and integration of AI.

The optimal solution is contingent on one's perspective regarding desirable AI innovation, weighed against considerations for safety and protection and considering liability. Increased liability may deter experimentation during research and development phases (Maliha et al., 2021[89]); however, not addressing liability fails to protect patients and their providers. A one-size-fits-all solution is unlikely, and addressing these challenges will require nuanced and context-specific approaches.

4.6. Limitations of the study

The findings of this study should be interpreted with a consideration of the study's inherent limitations. In this exploratory study, the focus was to gather the perceptions of medical associations across various countries, using the outreach of the WMA. It is essential to recognise that one prominent limitation of this study relates to the modest sample size, encompassing responses from 18 medical associations. This limited representation poses a challenge to the generalisability of findings, as perceptions regarding AI in healthcare can exhibit significant variation across different countries and regions.

Furthermore, the medical associations that opted to participate in this study might not fully represent the diversity of perspectives within each respective country and within the healthcare workforce, as they often represent mainly physicians. Consequently, there is a potential for selection bias, as participating associations may hold unique viewpoints and experiences concerning AI, differing from those of non-participating associations. As discussed throughout the analysis, certain associations may exhibit a greater inclination toward technological progressiveness, while others may lean toward a more conservative stance, which could potentially introduce response bias.

Also, it is essential to acknowledge that this study's cross-sectional design does not capture the long-term stability of these perceptions over time. Given that AI is a rapidly evolving technology, the opinions and practices concerning its integration in healthcare are also rapidly evolving. Consequently, this study may not fully represent the most current perceptions and practices in the field. To address this concern, a major segment of the study aimed to gain insights that extend into the future by understanding the involvement of medical associations in health AI and their intentions going forward.

Finally, as the integration of AI into healthcare engages diverse stakeholder groups, encompassing patients, healthcare providers, and AI developers, amongst others, it is essential to comprehend their perspectives to progress discussions and to advance AI's potential in healthcare. While medical associations play a pivotal role in the successful integration of AI tools into healthcare, providing leadership, guidance, and medical expertise, it is equally crucial to seek input from other essential stakeholders. Future efforts should prioritise gathering the perspectives of these key stakeholders to facilitate more well-informed decisions and recommendations concerning the implementation of AI in healthcare.

5 Future directions for Artificial Intelligence and health workforce

This paper has described perspectives of medical associations regarding the potential integration of AI in health solutions into routine care. Key messages from this paper are that medical associations are not as worried about the impacts of AI on their roles as they are about the implementation of AI in health solutions without medical professionals involved in the design, development, and implementation. Ensuring that AI is used to complement humans, rather than replace them, is vital. Action should demystify AI and engage health professionals (Beamtree Global Impact Committee, 2023[46]).

Going forward there are several tracks of work that could be beneficial; considering **skills development for health professionals**, **impacts on the broader health workforce** that supports the front-line use of AI in health, and **methods to advance assurance, adoption, and adaptation** of AI in health tools. In addition, this review of perceptions of medical associations related to the impact of AI in health could be extended to a more diverse set of countries to understand variations in perception to develop differentiated approaches that are appropriate for specific contexts.

- **Develop skills for health professionals in the AI age**: In the current healthcare landscape, health professionals are expected to engage in continuous education and training, particularly regarding the assimilation of new health discoveries and innovations. The integration of AI can be likened to adopting a novel protocol for immunotherapy in cancer treatment who had to undergo specialised re-training to address the advancements in cancer treatment, including understanding the mechanisms of immunotherapy, patient selection criteria, potential side effects, and the management of these side effects. Similarly with AI, health workers need to comprehend the significance of this innovation, grasp the essential knowledge, and effectively implement the innovation. This work would examine the additional skills helpful among front-line professionals in the use of AI in health solutions.
- **Invest in workforce supporting front-line AI solutions in health services**: There is an opportunity to integrate new positions to complement the integration of AI in health. Healthcare organisations are planning the development and recruitment of these pivotal roles for the successful integration and acceptance of AI, such as data scientists or data engineers focusing on AI (“AI Data Scientist”). The establishment of internal units and leadership positions to co-ordinate and manage AI applications within health organisations, with a particular focus on ethical considerations, ensuring compliance and other critical aspects of AI implementation, will also be important. This work would consider the potential impacts of the broader workforce in health, considering changes in other industries.

Safely manage the introduction of AI in healthcare systems: A central part to optimise the adoption of AI in health systems is the inclusion of health professionals in the full AI life cycle through design, development, implementation, and ongoing maintenance. This includes listening to health professionals for their criteria for assurance of the clinical validity of novel AI in health solutions and their requirements for its use in their workflow. This work would articulate requirements and frameworks that support spread and scale of innovation while ensuring personal privacy and safety and support use of novel solutions by health professionals.

Glossary

Artificial Intelligence (AI) System	An AI system is a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their levels of autonomy and adaptiveness after deployment (OECD, 2024[40]).
Machine Learning	Computer technology with the ability to automatically learn and improve from experience without being explicitly programmed (ISO, 2019[95])
Generative Artificial Intelligence (GAI)	A subset of artificial intelligence that generates new content like text or images. In a healthcare setting, it may be paired with other AI models to perform tasks like history summarisation or inbox responses (CHAI, 2024[96]).
Predictive Artificial Intelligence	Predictive AI is artificial intelligence that collects and analyses data to predict future occurrences. Predictive AI aims to understand patterns in data and make informed predictions (Abdullahi, 2024[97]).
Large Language Model (LLM)	A large language model (LLM) is a type of artificial intelligence model that has been trained through deep learning algorithms to recognise, generate, translate, and/or summarise vast quantities of written human language and textual data (European Commision, 2023[98])
Natural Language Processing (NLP)	Natural language processing (NLP) refers to computer programmes and tools that automate natural language functions by analysing, producing, modifying, or responding to human texts and speech. NLP is a subset of artificial intelligence (AI) that uses language as an input, produces language as an output, or both (OECD, 2023[99]).

References

Abdullahi, A. (2024), *Geekflare*, https://geekflare.com/predictive-ai-vs-generative-ai/. [97]

AMA Journal of Ethics (2002), *Learning to Listen*, AMA Journal of Ethics. [49]

Arndt, B. et al. (2017), "Tethered to the EHR: Primary Care Physician Workload Assessment Using EHR Event Log Data and Time-Motion Observations", *The Annals of Family Medicine*, Vol. 15/5, pp. 419-426, https://doi.org/10.1370/afm.2121. [14]

Athanasopoulou, K. et al. (2022), "Artificial Intelligence: The Milestone in Modern Biomedical Research", *BioMedInformatics*, Vol. 2/4, pp. 727-744, https://doi.org/10.3390/biomedinformatics2040049. [26]

Australian Medical Association (2023), *Artificial Intelligence in Healthcare - Position Statement*. [55]

Ayers, J. et al. (2023), "Comparing Physician and Artificial Intelligence Chatbot Responses to Patient Questions Posted to a Public Social Media Forum", *JAMA Internal Medicine*, Vol. 183/6, p. 589, https://doi.org/10.1001/jamainternmed.2023.1838. [23]

Badve, S. (2023), "Artificial intelligence in breast pathology – dawn of a new era", *npj Breast Cancer*, Vol. 9/1, https://doi.org/10.1038/s41523-023-00507-4. [33]

Beamtree Global Impact Committee (2023), *More Time to Care - Automation, Digitisation and the Workforce*. [46]

Bohr, A. and K. Memarzadeh (2020), "The rise of artificial intelligence in healthcare applications", in *Artificial Intelligence in Healthcare*, Elsevier, https://doi.org/10.1016/b978-0-12-818438-7.00002-2. [21]

British Medical Association (2022), *Getting IT Right: A Prescription for Safe, Modern Healthcare*. [53]

Brown, S. and R. Miller (2014), "Legal and Regulatory Issues Related to the Use of Clinical Software in Health Care Delivery", in *Clinical Decision Support*, Elsevier, https://doi.org/10.1016/b978-0-12-398476-0.00026-9. [93]

Cascini, F. et al. (2023), "Strengthening and promoting digital health practice: results from a Global Digital Health Partnership's survey", *Frontiers in Public Health*, Vol. 11, https://doi.org/10.3389/fpubh.2023.1147210. [6]

Centers for Disease Control and Prevention (2023), *What Is Health Literacy?*, Centers for Disease Control and Prevention, https://www.cdc.gov/healthliteracy/learn/index.html [68]

(accessed on 13 October 2023).

CHAI (2024), *Assurance Standards Guide Coalition for Health AI (CHAI)*, https://chai.org/wp-content/uploads/2024/07/CHAI-Assurance-Standards-Guide-6-26-2024.pdf. [96]

Challen, R. et al. (2019), "Artificial intelligence, bias and clinical safety", *BMJ Quality & Safety*, Vol. 28/3, pp. 231-237, https://doi.org/10.1136/bmjqs-2018-008370. [35]

Chan, B. (2021), "Applying a Common Enterprise Theory of Liability to Clinical AI Systems", *American Journal of Law & Medicine*, Vol. 47/4, pp. 351-385, https://doi.org/10.1017/amj.2022.1. [90]

de Hond, A. et al. (2022), "Guidelines and quality criteria for artificial intelligence-based prediction models in healthcare: a scoping review", *npj Digital Medicine*, Vol. 5/1, https://doi.org/10.1038/s41746-021-00549-7. [82]

Di Gennaro, F. (ed.) (2021), "Acceptance and attitudes toward COVID-19 vaccines: A cross-sectional study from Jordan", *PLOS ONE*, Vol. 16/4, p. e0250555, https://doi.org/10.1371/journal.pone.0250555. [50]

Dvijotham, K. et al. (2023), "Enhancing the reliability and accuracy of AI-enabled diagnosis via complementarity-driven deferral to clinicians", *Nature Medicine*, Vol. 29/7, pp. 1814-1820, https://doi.org/10.1038/s41591-023-02437-x. [34]

European Commision (2023), , https://knowledge-centre-interpretation.education.ec.europa.eu/en/news/what-large-language-model. [98]

European Commission (2023), *Open data and AI: A symbiotic relationship for progress*, https://data.europa.eu/en/publications/datastories/open-data-and-ai-symbiotic-relationship-progress (accessed on 27 October 2023). [56]

European Parliament (2019), *How the general data protection regulation changes the rules for scientific research*. [62]

Friedler, S. and C. Wilson (eds.) (2018), *Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification*, PMLR, https://proceedings.mlr.press/v81/buolamwini18a.html. [77]

Gardner, R. et al. (2018), "Physician stress and burnout: the impact of health information technology", *Journal of the American Medical Informatics Association*, Vol. 26/2, pp. 106-114, https://doi.org/10.1093/jamia/ocy145. [15]

Graber, M. et al. (2019), "Electronic Health Record–Related Events in Medical Malpractice Claims", *Journal of Patient Safety*, Vol. 15/2, pp. 77-85, https://doi.org/10.1097/pts.0000000000000240. [92]

Gunasekeran, D. et al. (2021), "Applications of digital health for public health responses to COVID-19: a systematic scoping review of artificial intelligence, telehealth and related technologies", *npj Digital Medicine*, Vol. 4/1, https://doi.org/10.1038/s41746-021-00412-9. [25]

Harmon, S. et al. (2019), "Artificial intelligence at the intersection of pathology and radiology in prostate cancer", *Diagnostic and Interventional Radiology*, Vol. 25/3, pp. 183-188, https://doi.org/10.5152/dir.2019.19125. [30]

ISO (2019), *Online Browsing Platform (OBP)*, https://www.iso.org/obp/ui/#iso:std:iso:20252:ed-3:v1:en. [95]

Jassar, S. et al. (2022), "The future of artificial intelligence in medicine: Medical-legal considerations for health leaders", *Healthcare Management Forum*, Vol. 35/3, pp. 185-189, https://doi.org/10.1177/08404704221082069. [91]

Javanmard, S. and A. Manteghinejad (2021), "Challenges and opportunities of digital health in a post-COVID19 world", *Journal of Research in Medical Sciences*, Vol. 26/1, p. 11, https://doi.org/10.4103/jrms.jrms_1255_20. [5]

Jiang, F. et al. (2017), "Artificial intelligence in healthcare: past, present and future", *Stroke and Vascular Neurology*, Vol. 2/4, pp. 230-243, https://doi.org/10.1136/svn-2017-000101. [4]

John Hopkins Medicine (2020), *Practical Uses for Artificial Intelligence in Health Care*, John Hopkins Medicine, https://www.hopkinsmedicine.org/news/articles/2020/02/practical-uses-for-artificial-intelligence-in-health-care (accessed on 19 October 2023). [48]

Khullar, D. et al. (2021), "Public vs physician views of liability for artificial intelligence in health care", *Journal of the American Medical Informatics Association*, Vol. 28/7, pp. 1574-1577, https://doi.org/10.1093/jamia/ocab055. [88]

Koon, S. (2021), "Physician Well-being and the Future of Health Information Technology", *Mayo Clinic Proceedings: Innovations, Quality & Outcomes*, Vol. 5/4, pp. 753-761, https://doi.org/10.1016/j.mayocpiqo.2021.06.001. [16]

Lehne, M. et al. (2019), "Why digital medicine depends on interoperability", *npj Digital Medicine*, Vol. 2/1, https://doi.org/10.1038/s41746-019-0158-1. [61]

López, D. et al. (2022), "Challenges and solutions for transforming health ecosystems in low- and middle-income countries through artificial intelligence", *Frontiers in Medicine*, Vol. 9, https://doi.org/10.3389/fmed.2022.958097. [84]

Maliha, G. et al. (2021), "Artificial Intelligence and Liability in Medicine: Balancing Safety and Innovation", *The Milbank Quarterly*, Vol. 99/3, pp. 629-647, https://doi.org/10.1111/1468-0009.12504. [89]

Mathenge, W. et al. (2022), "Impact of Artificial Intelligence Assessment of Diabetic Retinopathy on Referral Service Uptake in a Low-Resource Setting", *Ophthalmology Science*, Vol. 2/4, p. 100168, https://doi.org/10.1016/j.xops.2022.100168. [86]

McGraw, D. and K. Mandl (2021), "Privacy protections to encourage use of health-relevant digital data in a learning health system", *npj Digital Medicine*, Vol. 4/1, https://doi.org/10.1038/s41746-020-00362-8. [59]

Mhlanga, M. et al. (2021), *From A to O-Positive: Blood Delivery Via Drones in Rwanda*, Reach Alliance, http://www.mastercardcenter.org. [87]

Montani, S. and M. Striani (2019), "Artificial Intelligence in Clinical Decision Support: a Focused Literature Survey", *Yearbook of Medical Informatics*, Vol. 28/01, pp. 120-127, https://doi.org/10.1055/s-0039-1677911. [24]

Moor, M. et al. (2023), "Foundation models for generalist medical artificial intelligence", *Nature*, Vol. 616/7956, pp. 259-265, https://doi.org/10.1038/s41586-023-05881-4. [43]

Morley, J. et al. (2022), "Governing Data and Artificial Intelligence for Health Care: Developing an International Understanding", *JMIR Formative Research*, Vol. 6/1, p. e31623, https://doi.org/10.2196/31623. [2]

Murthy, V. (2022), "Confronting Health Worker Burnout and Well-Being", *New England Journal of Medicine*, Vol. 387/7, pp. 577-579, https://doi.org/10.1056/nejmp2207252. [11]

Naik, N. et al. (2022), "Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility?", *Frontiers in Surgery*, Vol. 9, https://doi.org/10.3389/fsurg.2022.862322. [75]

NAM (2023), *Toward a Code of Conduct Framework for Artificial Intelligence in Health, Health Care, and Biomedical Science*, National Academy of Medicine, https://nam.edu/programs/value-science-driven-health-care/health-care-artificial-intelligence-code-of-conduct/. [74]

National Academy of Medicine (2022), "Artificial Intelligence in Health Care", *National Academy of Medicine*, https://nam.edu/wp-content/uploads/2019/12/AI-in-Health-Care-PREPUB-FINAL.pdf (accessed on 13 October 2023). [54]

Nazer, L. et al. (2023), "Bias in artificial intelligence algorithms and recommendations for mitigation.", *PLOS digital health*, Vol. 2, p. 6, https://doi.org/10.1371/journal.pdig.0000278. [36]

Norman, C. and H. Skinner (2006), "eHealth Literacy: Essential Skills for Consumer Health in a Networked World", *Journal of Medical Internet Research*, Vol. 8/2, p. e9, https://doi.org/10.2196/jmir.8.2.e9. [71]

OCDE (2023), *Panorama de la santé 2023 : Les indicateurs de l'OCDE*, Éditions OCDE, Paris, https://doi.org/10.1787/5108d4c7-fr. [100]

OECD (2024), "Explanatory memorandum on the updated OECD definition of an AI system", *OECD Artificial Intelligence Papers*, No. 8, OECD Publishing, Paris, https://doi.org/10.1787/623da898-en. [40]

OECD (2024), *OECD.AI Policy Observatory*, https://oecd.ai/en/ai-principles. [37]

OECD (2023), "AI language models: Technological, socio-economic and policy considerations", *OECD Digital Economy Papers*, No. 352, OECD Publishing, Paris, https://doi.org/10.1787/13d38f92-en. [99]

OECD (2023), "Emerging privacy-enhancing technologies: Current regulatory and policy approaches", *OECD Digital Economy Papers*, No. 351, OECD Publishing, Paris, https://doi.org/10.1787/bf121be4-en. [79]

OECD (2023), *Health at a Glance 2023: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/7a7afb35-en. [60]

OECD (2023), *OECD Employment Outlook 2023: Artificial Intelligence and the Labour Market*, OECD Publishing, Paris, https://doi.org/10.1787/08785bba-en. [45]

OECD (2023), *Ready for the Next Crisis? Investing in Health System Resilience*, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/1e53cf80-en. [9]

OECD (2021), *Recommendation of the Council on Enhancing Access to and Sharing of Data*, [63]

https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0463.

OECD (2019), *Health in the 21st Century : Putting Data to Work for Stronger Health Systems*, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/e3b23f8e-en. [1]

OECD (2019), *Recommendation of the Council on Artificial Intelligence*, https://legalinstruments.oecd.org/en/instruments/oecd-legal-0449. [44]

OECD (2017), *OECD Recommendation on Health Data Governance*, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0433 (accessed on 2024). [39]

OECD (2016), *Health Workforce Policies in OECD Countries: Right Jobs, Right Skills, Right Places*, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264239517-en. [52]

OECD (2002), *OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data*, OECD Publishing, Paris, https://doi.org/10.1787/9789264196391-en. [38]

OECD AI Policy Observatory (2023), *Contributions to public AI projects by country and project impact*, OECD AI Policy Observatory, https://oecd.ai/en/data?selectedArea=ai-software-development&selectedVisualization=contributions-to-ai-projects-by-country-and-project-impact (accessed on 24 October 2023). [51]

Oliveira Hashiguchi, T., L. Slawomirski and J. Oderkirk (2021), "Laying the foundations for artificial intelligence in health", *OECD Health Working Papers*, No. 128, OECD Publishing, Paris, https://doi.org/10.1787/3f62817d-en. [22]

Paige, S., J. Krieger and M. Stellefson (2016), "The Influence of eHealth Literacy on Perceived Trust in Online Health Communication Channels and Sources", *Journal of Health Communication*, Vol. 22/1, pp. 53-65, https://doi.org/10.1080/10810730.2016.1250846. [69]

Pantanowitz, L. et al. (2020), "An artificial intelligence algorithm for prostate cancer diagnosis in whole slide images of core needle biopsies: a blinded clinical validation and deployment study", *The Lancet Digital Health*, Vol. 2/8, pp. e407-e416, https://doi.org/10.1016/s2589-7500(20)30159-x. [32]

Parikh, R., S. Teeple and A. Navathe (2019), "Addressing Bias in Artificial Intelligence in Health Care", *JAMA*, Vol. 322/24, p. 2377, https://doi.org/10.1001/jama.2019.18058. [78]

Park, S., J. Choi and J. Byeon (2021), "Key Principles of Clinical Validation, Device Approval, and Insurance Coverage Decisions of Artificial Intelligence", *Korean Journal of Radiology*, Vol. 22/3, p. 442, https://doi.org/10.3348/kjr.2021.0048. [66]

Pauker, S. et al. (1976), "Towards the simulation of clinical cognition", *The American Journal of Medicine*, Vol. 60/7, pp. 981-996, https://doi.org/10.1016/0002-9343(76)90570-2. [19]

Price, W. and I. Cohen (2019), "Privacy in the age of medical big data", *Nature Medicine*, Vol. 25/1, pp. 37-43, https://doi.org/10.1038/s41591-018-0272-7. [58]

Ruamviboonsuk, P. et al. (2022), "Real-time diabetic retinopathy screening by deep learning in a multisite national screening programme: a prospective interventional cohort study", *The Lancet Digital Health*, Vol. 4/4, pp. e235-e244, https://doi.org/10.1016/s2589-7500(22)00017-6. [85]

Saenz, A. et al. (2023), "Autonomous AI systems in the face of liability, regulations and costs", *npj Digital Medicine*, Vol. 6/1, https://doi.org/10.1038/s41746-023-00929-1. [94]

Sandbank, J. et al. (2022), "Validation and real-world clinical application of an artificial intelligence algorithm for breast cancer detection in biopsies", *npj Breast Cancer*, Vol. 8/1, https://doi.org/10.1038/s41523-022-00496-w. [31]

Secinaro, S. et al. (2021), "The role of artificial intelligence in healthcare: a structured literature review", *BMC Medical Informatics and Decision Making*, Vol. 21/1, https://doi.org/10.1186/s12911-021-01488-9. [28]

Seyyed-Kalantari, L. et al. (2021), "Underdiagnosis bias of artificial intelligence algorithms applied to chest radiographs in under-served patient populations", *Nature Medicine*, Vol. 27/12, pp. 2176-2182, https://doi.org/10.1038/s41591-021-01595-0. [65]

Shin, H. et al. (2023), "The impact of artificial intelligence on the reading times of radiologists for chest radiographs", *npj Digital Medicine*, Vol. 6/1, https://doi.org/10.1038/s41746-023-00829-4. [17]

Shortliffe, E. et al. (1973), "An Artificial Intelligence program to advise physicians regarding antimicrobial therapy", *Computers and Biomedical Research*, Vol. 6/6, pp. 544-560, https://doi.org/10.1016/0010-4809(73)90029-3. [18]

Singhal, K. et al. (2023), "Large language models encode clinical knowledge", *Nature*, Vol. 620/7972, pp. 172-180, https://doi.org/10.1038/s41586-023-06291-2. [41]

Spatharou, A., S. Hieronimus and J. Jenkins (2020), *Transforming healthcare with AI: The impact on the workforce and organizations*, McKinsey & Company. [47]

Sutherland, E. et al. (2023), "Fast-Track on digital security in health", *OECD Health Working Papers*, No. 164, OECD Publishing, Paris, https://doi.org/10.1787/c3357f9f-en. [57]

Sutton, R. et al. (2020), "An overview of clinical decision support systems: benefits, risks, and strategies for success", *npj Digital Medicine*, Vol. 3/1, https://doi.org/10.1038/s41746-020-0221-y. [29]

The Lancet (2020), "COVID-19: protecting health-care workers", *The Lancet*, Vol. 395/10228, p. 922, https://doi.org/10.1016/s0140-6736(20)30644-9. [12]

the Precise4Q consortium (2020), "Explainability for artificial intelligence in healthcare: a multidisciplinary perspective", *BMC Medical Informatics and Decision Making*, Vol. 20/1, https://doi.org/10.1186/s12911-020-01332-6. [76]

Thirunavukarasu, A. et al. (2023), "rialling a Large Language Model (ChatGPT) in General Practice With the Applied Knowledge Test: Observational Study Demonstrating Opportunities and Limitations in Primary Care", *JMIR medical education*, Vol. 9, http://doi.org/10.2196/46599. [42]

Tipton K, L. et al. (2023), "Impact of Healthcare Algorithms on Racial and Ethnic Disparities in Health and Healthcare.", *Agency for Healthcare Research and Quality- AHRQ*, Vol. 24, https://doi.org/10.23970/AHRQEPCCER268. [64]

Tyson, A. et al. (2023), *60% of Americans Would Be Uncomfortable With Provider Relying on AI in Their Own Health Care*, http://www.pewresearch.org. [70]

US Food & Drug Administration (2021), *Artificial Intelligence/Machine Learning (AI/ML)-Based Software as a Medical Device (SaMD) Action Plan*, http://www.fda.gov. [67]

Vandenbroucke, F. et al. (2022), *Barometer- L'adoption de l'Intelligence Artificielle dans les hôpitaux en Belgique*. [3]

Vijayan, R. et al. (2022), "Enhancing preclinical drug discovery with artificial intelligence", *Drug Discovery Today*, Vol. 27/4, pp. 967-984, https://doi.org/10.1016/j.drudis.2021.11.023. [27]

Wahl, B. et al. (2018), "Artificial intelligence (AI) and global health: how can AI contribute to health in resource-poor settings?", *BMJ Global Health*, Vol. 3/4, p. e000798, https://doi.org/10.1136/bmjgh-2018-000798. [83]

Whitehead, L. et al. (2023), "Barriers to and Facilitators of Digital Health Among Culturally and Linguistically Diverse Populations: Qualitative Systematic Review", *Journal of Medical Internet Research*, Vol. 25, p. e42719, https://doi.org/10.2196/42719. [72]

World Bank (2021), "Technology and Universal Health Coverage: Examining the role of digital health", *Journal of Global Health*, Vol. 11, https://doi.org/10.7189/jogh.11.16006. [80]

World Health Organization (2022), "Working for Health 2022-2030 Action Plan". [7]

World Health Organization (2021), *Global strategy on digital health 2020-2025*, http://apps.who.int/bookorders. [81]

World Health Organization (2020), *Global strategy on human resources for health: Workforce 2030*. [8]

World Health Organization (2020), "Mental health and psychosocial considerations during the COVID-19 outbreak". [13]

Youssef, D. et al. (2022), "Prevalence and correlates of burnout among physicians in a developing country facing multi-layered crises: a cross-sectional study", *Scientific Reports*, Vol. 12/1, https://doi.org/10.1038/s41598-022-16095-5. [10]

Yu, K., A. Beam and I. Kohane (2018), "Artificial intelligence in healthcare", *Nature Biomedical Engineering*, Vol. 2/10, pp. 719-731, https://doi.org/10.1038/s41551-018-0305-z. [20]

Zhang, J. and Z. Zhang (2023), "Ethics and governance of trustworthy medical artificial intelligence", *BMC Medical Informatics and Decision Making*, Vol. 23/1, https://doi.org/10.1186/s12911-023-02103-9. [73]

Annex A. Artificial Intelligence and the health workforce survey structure

Contact Person

Please provide the name, affiliation, and email address of the main contact person for this questionnaire. The OECD may follow up with the identified person(s) if clarification is required.

1) Full name*
2) Country*
3) Role*
4) Organisation*
5) Email address*

Definition

Artificial Intelligence (AI) system: An AI system is a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy (OECD, 2019[44]).[2]

Perceptions

6) How much do you agree with the following statements?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The risks of AI don't justify the opportunities	☐	☐	☐	☐	☐
The risks of AI in medicine are well understood, well communicated, and well managed	☐	☐	☐	☐	☐
Policy and regulation should explicitly deal with the implications of AI on the health workforce	☐	☐	☐	☐	☐
Governments are doing enough regarding the impact of AI on the health workforce	☐	☐	☐	☐	☐

[2] The survey was published in 2023, prior to the update of the OECD definition of AI in 2024.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Many current AI projects in my country give enough attention to workforce risks and challenges	☐	☐	☐	☐	☐
I am worried about ethical issues that may arise from AI applications in healthcare	☐	☐	☐	☐	☐
Physicians should require AI applications to be thoroughly evaluated and formally authorised (like pharmaceuticals)	☐	☐	☐	☐	☐
AI projects impacting medical workforce should be required to involve physicians from its initial stages	☐	☐	☐	☐	☐
More education is needed to prepare physicians to implement and use AI based tools in their clinical work	☐	☐	☐	☐	☐

Looking forward 10 years on the future of AI in medicine: (Select the most appropriate answer).

- AI will have negligible impact on care.
- It will support physicians and empower them with more tools in their hands.
- It will change medicine dramatically, but physicians' role will still be central.
- It will change medicine dramatically including the role of physicians, which will be different.
- It will replace most physicians.

7) Grade the **opportunities** of AI applications in healthcare by the likelihood of it to happen:

	Not likely at all	Not likely	Somewhat likely	Likely	Very likely
AI tools will improve quality of care	☐	☐	☐	☐	☐
AI tools will improve patients' experiences	☐	☐	☐	☐	☐
AI tools will improve providers' experiences – reduce burden and burnout	☐	☐	☐	☐	☐
AI tools will for patients will take care of common complaints, thus will reduce physicians' workload	☐	☐	☐	☐	☐
AI empowering Physicians' Assistants (PAs), and Nurse Practitioners (NPs) will help physicians to work in a higher level of practice	☐	☐	☐	☐	☐

	Not likely at all	Not likely	Somewhat likely	Likely	Very likely
AI tools improve empathy of health workers by reducing load and enabling them to have more time with patients	☐	☐	☐	☐	☐
AI tools in healthcare are the main solution to health workforce shortage	☐	☐	☐	☐	☐
AI tools will improve healthcare efficiency and reduce costs	☐	☐	☐	☐	☐
AI tools will improve healthcare equity	☐	☐	☐	☐	☐

8) Grade the **risks** of AI by the likelihood of it to happen.

	Not likely at all	Not likely	Somewhat likely	Likely	Very likely
AI will displace physicians from their positions	☐	☐	☐	☐	☐
AI empowerment may lead to PA's and NP's taking place of physicians	☐	☐	☐	☐	☐
AI applications in healthcare may increase the burden on physicians	☐	☐	☐	☐	☐
The use of AI applications will reduce physicians' autonomy	☐	☐	☐	☐	☐
The use of AI applications will cause physicians to lose their clinical and decision-making skills and eventually will impair the next generation of medical education	☐	☐	☐	☐	☐
The use of AI applications may increase physicians' liability if they use incorrect AI recommendations	☐	☐	☐	☐	☐
Introducing AI into healthcare will raise new ethical issues that may complicate physicians' work	☐	☐	☐	☐	☐
Introducing AI into routine clinical work may impair physicians' earnings	☐	☐	☐	☐	☐

	Not likely at all	Not likely	Somewhat likely	Likely	Very likely
The use of AI in healthcare will impair physicians' status as they will be seen as technicians that use smart tools	☐	☐	☐	☐	☐
AI tools in healthcare may be expensive and thus could reduce accessibility of healthcare for all	☐	☐	☐	☐	☐
Targeted medical education courses to improve physicians' skills to use AI tools, might not be accessible or affordable for all physicians'	☐	☐	☐	☐	☐
Many physicians won't use AI applications because of the risks above	☐	☐	☐	☐	☐

9) If you have any more additional risks that you may see in implementing AI in healthcare or you would like to comment on one or more of the risks, please write it here:

What do you think should be the **most important goal** of AI applications at the national level? (Select the most appropriate answer).

- Improve quality of healthcare.
- Improve patients' experience.
- Develop solutions to mitigate health workforce shortage.
- Develop solutions to reduce burden on providers and reduce burnout.
- Develop solutions that will reform healthcare services.
- 'Other'

Involvement

Is your organisation involved in adoption of AI in health? (Select the most appropriate answer).

- Yes, we are involved.
- No, but we are planning to be involved soon.
- No, but we are planning to be involved in the future.
- No, we don't have plans to deal with AI in health for now.

10) How is your organisation (the medical association) involved in adoption of AI in health?

	Not in our scope	Consider to be involved	Minorly involved	Moderately involved	Deeply involved
Analysing the possible impacts of AI in healthcare and raising them to the government	☐	☐	☐	☐	☐
Influencing policy for data access	☐	☐	☐	☐	☐
Influencing policy for quality assurance of data	☐	☐	☐	☐	☐
Influencing policy for development of AI applications	☐	☐	☐	☐	☐
Influencing regulation of the ministry of health (or its equivalent) on AI in healthcare	☐	☐	☐	☐	☐
Influencing governance for responsible AI	☐	☐	☐	☐	☐
Improving adoption of AI applications among health providers	☐	☐	☐	☐	☐
Improving design of solutions by health innovators	☐	☐	☐	☐	☐
Ensuring that the respect of medical ethics is guaranteed in the development of AI tools	☐	☐	☐	☐	☐

Readiness

11) From your perspective, the current status of implementation of AI projects in your country is: (Select the most appropriate answer, in a case that no option is suitable, please select other and elaborate).
    - There are currently no meaningful AI projects in use.
    - There are some pilot projects in health organisations.
    - There is one or more than one regional (cross organisations) pilot implementations.
    - There are regional or organisational comprehensive implementations.
    - There is a national implementation.
    - There are some national comprehensive implementations.
    - 'Other'
12) Does the design of AI solutions in your country consider stakeholder (health workforce) perspectives?
    - Yes.

- Partially.
- No.
- Don’t know.

13) What are the main barriers to systematic and efficient use of AI for health?

	No problem at all	Creates minor difficulties	Creates moderate difficulties	Creates major difficulties	A huge obstacle
Lack of involvement of physicians in initiating projects	☐	☐	☐	☐	☐
Barriers in accessing health data to train AI algorithms	☐	☐	☐	☐	☐
Difficulties in training, testing, and validating AI algorithms for use by physicians	☐	☐	☐	☐	☐
Difficulties in ability to update AI algorithms periodically based on new input data	☐	☐	☐	☐	☐
Insufficient inter-operability in our healthcare system	☐	☐	☐	☐	☐
Barriers to authorise healthcare AI tools	☐	☐	☐	☐	☐
Insufficient digital literacy of decision makers	☐	☐	☐	☐	☐
Insufficient digital literacy of health workforce	☐	☐	☐	☐	☐
Insufficient health and digital literacy of patients and the public	☐	☐	☐	☐	☐

Would you like to add any other barriers to use AI for health? (Enter your answer below).

Would you like to add anything else regarding the impact of AI on the health workforce? (Enter your answer below).

The end

We would like to thank you for the time that you invested in answering this questionnaire.

Annex B. Level of involvement in adoption of AI in health by countries medical associations

Table A B.1. Level of involvement in adoption of AI in health by countries medical associations

Country	Level of involvement	Number designation
Brazil	*No, but we are planning to be involved in the future*	2
Denmark	*Yes, we are involved*	4
World	*No, but we are planning to be involved in the future*	2
France	*Yes, we are involved*	4
Germany	*Yes, we are involved*	4
Haiti	*No, but we are planning to be involved in the future*	2
Iceland	*No, but we are planning to be involved soon*	3
Israel	*No, but we are planning to be involved soon*	3
Malaysia	*No, but we are planning to be involved soon*	3
Netherlands	*Yes, we are involved*	4
Nigeria	*No, but we are planning to be involved in the future*	2
Poland	*Yes, we are involved*	4
Republic of Korea	*No, but we are planning to be involved soon*	3
Rwanda	*No, but we are planning to be involved soon*	3
Senegal	*No, but we are planning to be involved soon*	3
Somalia	*No, we don't have plans to deal with AI in health for now*	1
United States	*Yes, we are involved*	4
Uruguay	*No, but we are planning to be involved soon*	3