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The medical profession transformed by artificial intelligence: Qualitative study

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Abstract

Background: Healthcaare delivery will change through the increasing use of artificial intelligence (AI). Physicians are likely to be among the professions most affected, though to what extent is not yet clear.

Objective: We analyzed physicians' and AI experts' stances towards AI-induced changes. This concerned (1) physicians' tasks, (2) job replacement risk, and (3) implications for the ways of working, including human–AI interaction, changes in job profiles, and hierarchical and cross-professional collaboration patterns.

Methods: We adopted an exploratory, qualitative research approach, using semi-structured interviews with 24 experts in the fields of AI and medicine, medical informatics, digital medicine, and medical education and training. Thematic analysis of the interview transcripts was performed.

Results: Specialized tasks currently performed by physicians in all areas of medicine would likely be taken over by AI, including bureaucratic tasks, clinical decision support, and research. However, the concern that physicians will be replaced by an AI system is unfounded, according to experts; AI systems today would be designed only for a specific use case and could not replace the human factor in the patient–physician relationship. Nevertheless, the job profile and professional role of physicians would be transformed as a result of new forms of human–AI collaboration and shifts to higher-value activities. AI could spur novel, more interprofessional teams in medical practice and research and, eventually, democratization and de-hierarchization.

Conclusions: The study highlights changes in job profiles of physicians and outlines demands for new categories of medical professionals considering AI-induced changes of work. Physicians should redefine their self-image and assume more responsibility in the age of AI-supported medicine. There is a need for the development of scenarios and concepts for future job profiles in the health professions as well as their education and training.

Keywords

Artificial intelligence, qualitative studies, digital health, eHealth, internet, technology, personalized medicine, health professions

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Introduction and background

Evidence-based medicine is a data-driven field.[1,2] In recent years, the rapid progress in medical research and the digitalization of healthcare have led to an ever-growing amount of data.[3] Artificial intelligence (AI) is being touted as the means to unlock the potential of this treasure trove of data.

AI refers to systems that display intelligent behavior by analyzing their environment and taking actions—with some degree of autonomy—to achieve specific goals.[4] In medicine, specific goals achieved by AI systems are, for instance, the classification of clinically important abnormalities in chest radiographs or detection of melanoma in images of skin lesions at a performance level comparable to practicing physicians.[5,6] Technologies such as image recognition, computer vision, robotics, and natural language processing can support physicians and/or take over medical tasks in the sense of automatization.[7] AI can help to overcome human limitations in collecting, processing, and analyzing data sets (e.g. limited capacity to absorb and process data, fatigability, human bias).[8,9] AI-supported clinical decision support can strengthen efficiency and effectiveness at all levels of healthcare delivery (i.e. screening and prevention, diagnosis, treatment planning, and rehabilitation). However, little research has been performed to analyze the automation capability of different medical tasks with respect to the implications for the physician's job.[10] AI systems always operate at the same level of precision, do not get tired, and have a large memory capacity—characteristics that are in high demand in times of staff shortages, stress, and time pressure in healthcare. Due to the rapid progress in AI research and development, some observers have asked whether AI might replace physicians in the future.[11,12] According to the World Health Organization (WHO), however, AI may not fully replace clinical decision-making, but it could improve decisions made by clinicians.[13] Which medical tasks could be automated by AI systems, and which tasks should be performed by a physician—possibly assisted by AI?

With the aim to improve both efficiency and patient care in a healthcare system threatened by staff shortage and demographic change, AI systems will impact clinical decision-making and diagnostics, transforming the work of physicians in the next decade.[14] According to Topol et al., *"with modern AI, a mix of human and artificial intelligences can be deployed across discipline boundaries to generate a greater collective intelligence"*.[15] Various medical professions might be affected by this to differing extents.[5,11,16–22] Physicians' workflows and activities will be transformed by AI/intelligence mix, but what exactly are the implications for the profession's work practices, team compositions, and collaboration patterns in the future digitized healthcare system[14,23,24]?

With this interview study, we aim to investigate the impact of AI implementations on the future of the medical profession, ways of working in healthcare, and the demand for (new) profession(al)s. We address the following research questions (RQs):

RQ1. Which tasks are affected by AI-centered automation and augmentation?

RQ2. What is the potential of AI to replace medical doctors in the future?

RQ3. What changes to the ways of working can be expected with regard to (3.1) interaction between humans and AI, (3.2) job profiles and role understandings, and (3.3) interprofessional and hierarchical collaboration patterns?

Methods

Study design

We chose an exploratory, qualitative research approach with semi-structured interviews and a thematic analysis.[25] An overview of the methods used is given in Figure 1.

Ethical issues pertaining to human subjects

The ethics committee of the Charité – Universitätsmedizin Berlin, Germany approved this study (EA1/236/19). All participants gave their written informed consent prior to the study. We consulted the Standards for Reporting Qualitative Research to report the methods of this study.[26]

Context

This study was carried out within the context of a research project on learning offerings regarding AI in medicine in Germany.[27]

Sampling strategy

Participants in the study were selected based on their experience at the interface of AI and medicine, with a focus on education. Benchmarks were membership in the "AI Campus Expert Lab Medicine,"[28] pioneering work and research contributions (i.e. scientific publications, policy papers, work experience in major companies) in this field, as well as holding leadership positions in bodies representing the interests of relevant stakeholders (e.g. students, physicians)—for more details, see Appendix 1. Sample size was discussed in the context of the *Information Power in Qualitative Interview Studies Model* by Malterud et al.,[29] considering the relatively broad aim and the cross-case analysis approach as factors for a larger sample size. On the other hand, high sample specificity, high quality of dialogue between researchers and participants, and theoretical saturation in the analysis led us to limit the number of participants to 22 interviews

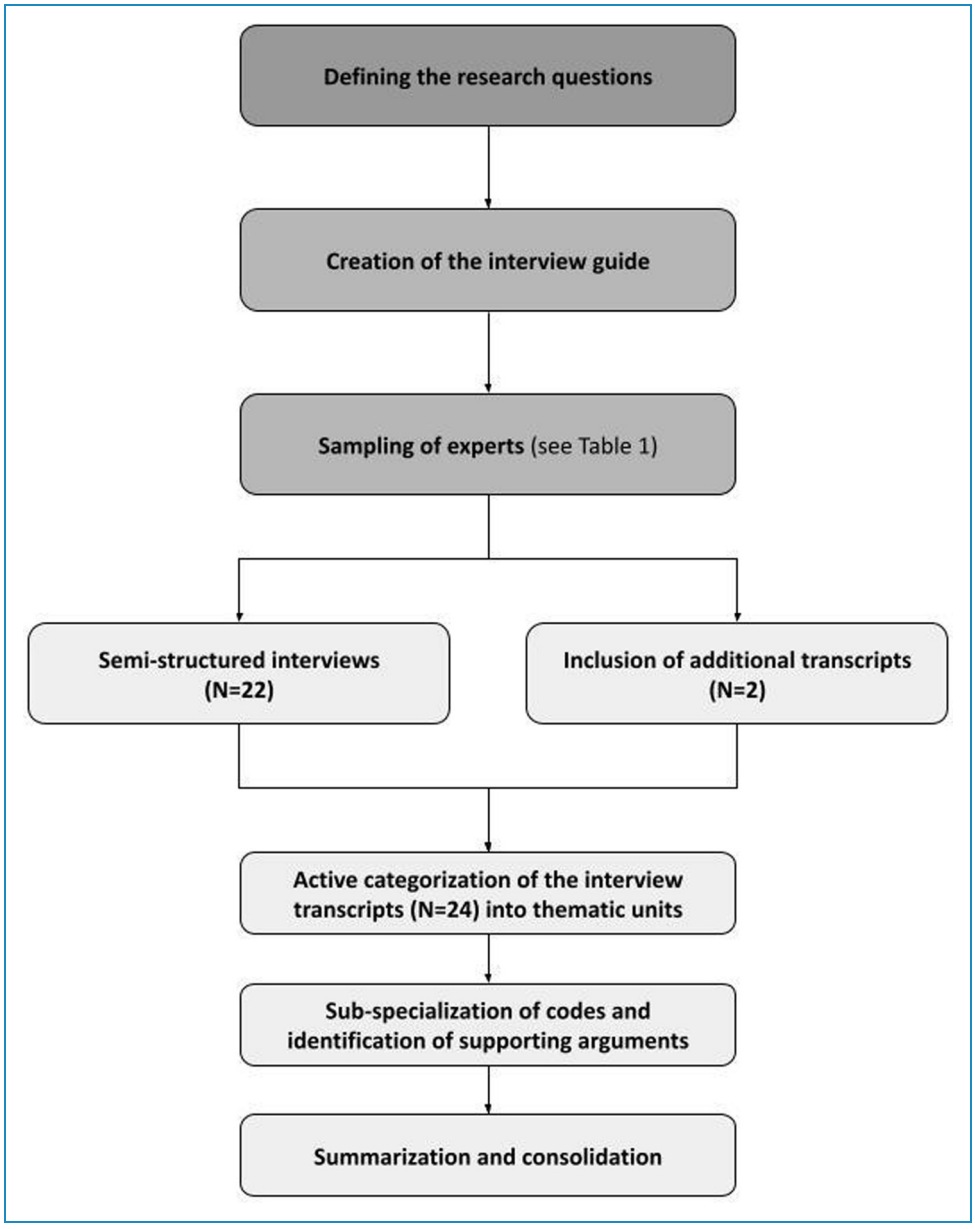

Figure 1. Overview of the methods used.

and the number of included interview transcripts to two (see below, *Data collection*).

Data collection

The interview guide was created based on the research questions, a scoping literature review, and a questionnaire developed for a previous study on teaching in digital medicine.[30] The guiding questions were discussed and selected in several meetings within the research group with the participation of two experienced AI researchers—a computational linguist and a computer scientist—and tested in a pilot interview. The pilot interview, conducted on 22 April 2021, did not result in any changes to the interview guide. The final interview guide consisted of a catalog of 17 items (see Appendix 2). Based on the professional background and position of the interviewee, the research group selected approximately 10 questions for the interview. The selection was always made by the interviewing author and confirmed by the remaining authors. The interviewee was emailed the interview guide tailored to him/her in advance of the interview. Twenty-two interviews were conducted by LM, JB, and JW.

Interviews were conducted with 24 experts in the field of AI in medicine and medical education and training. Their backgrounds were medicine (15/24), computer science/informatics (9/24), medical education (3/24), and other

(8/24; see Appendix 1). Of the 24 experts, 10 had more than one field of expertise (e.g. medicine and computer science) and 17 had more than 10 years of work experience in their respective field. Twenty-one interviews were conducted in German, while interview #7 was conducted in English. Quotes used in this publication were translated and modified for better readability, if necessary. The median length of the interviews was 28 min and 47 s, with a minimum length of 16 min and 17 s and a maximum length of 47 min and 17 s. The interviews were recorded and transcribed verbatim.

Furthermore, two transcripts of expert interviews conducted in German by JB as part of the Higher Education Forum on Digitization were included in the qualitative content analysis. Two members of the "AI Campus Expert Lab Medicine" were interviewed by JB in the context of a theme week held by the Higher Education Forum on Digitization on the topic of AI.[31,32] The content of the questions clearly corresponded to the questionnaire of the mentioned study.

Data analysis

Analysis of the interview transcripts was performed by LM, DF, JB, and JW, whereas coding and categorization were reviewed by all participating researchers. A thematic analysis approach[25] was followed, and the categorization framework developed by Grodal et al.[33] was used for guidance. In a first step, we actively categorized the data into thematic units (*generating initial categories*[33]). Codes emerged for RQs 1–3 (see Figure 2). In a second step, codes were subspecialized, refined, and stabilized by identifying arguments supporting the overarching theory (see Figure 2). In a final step, codes were summarized and consolidated.

Data availability

The data set, in the form of 24 pseudonymized interview transcripts, is available upon request from the corresponding author, in accordance with the EU general data protection regulation. The interviewees' written consent was obtained.

Results

Analysis of the expert interviews revealed three clusters of findings corresponding to the three research questions, representing the impact of AI implementation on the medical profession (see Figure 2):

1. Tasks: specific tasks of physicians will be taken over by AI systems
2. Future prospects of the medical profession: AI will not replace physicians entirely
3. Ways of work: AI will transform how healthcare is delivered

Specific tasks of physicians will be taken over by AI systems

All experts interviewed expect to see a steady increase in the use of AI in medicine. AI could outperform humans in specific tasks in all medical specialties, from prevention to diagnosis, therapy to rehabilitation, and for research purposes.

AI systems are specialists with broad capabilities

Most experts in our study (75%, 18/24) stated that AI systems are specialists—with broad capabilities. Given the rapid increase in complexity in medicine, humans are reaching their limits when it comes to rapidly assessing, consolidating, interpreting, and summarizing large and multidimensional data sets (medical knowledge, scientific findings, patient history data, etc.). AI, however, could do this, enabling precision medicine, where data is processed in a patient-, diagnosis-, and treatment-specific manner.

In addition, AI systems could outperform human interpretation and mathematical abilities in terms of integrable variables and dimensions. AI can contextualize many dimensions of variables in a specific use case and assemble them into a set of rules that is not based as much on simplification as human thinking. It specializes in quickly and completely detecting changes and recognizing patterns in complex data sets.

> *[…] Artificial intelligence is boosting our computing power, boosting our ability to extract patterns from all the signals that we are capturing with all the tools that we have in medicine. (#7, physician and principal research scientist in computational physiology)*

These abilities, along with the consolidation of knowledge and scientific evidence through AI, could support diagnosis and treatment planning, helping to provide a more holistic picture of a patient case.

AI will be used self-evidently in a steadily increasing number of areas in healthcare

All experts (100%, 24/24) agreed that AI would be an essential part of clinical routine in the future and that it would be used self-evidently by physicians and patients.

AI systems could take over documentation and bureaucratic tasks (i.e. time-consuming, repetitive routine activities that do not necessarily have to be completed by physicians), thus facilitating everyday work.

Although interviewees agree that physicians will still be responsible for clinical decision-making, the experts believe that AI-based decision support will change clinical reasoning. Beyond this, AI-based clinical decision support systems in all areas of healthcare (prevention, diagnosis,

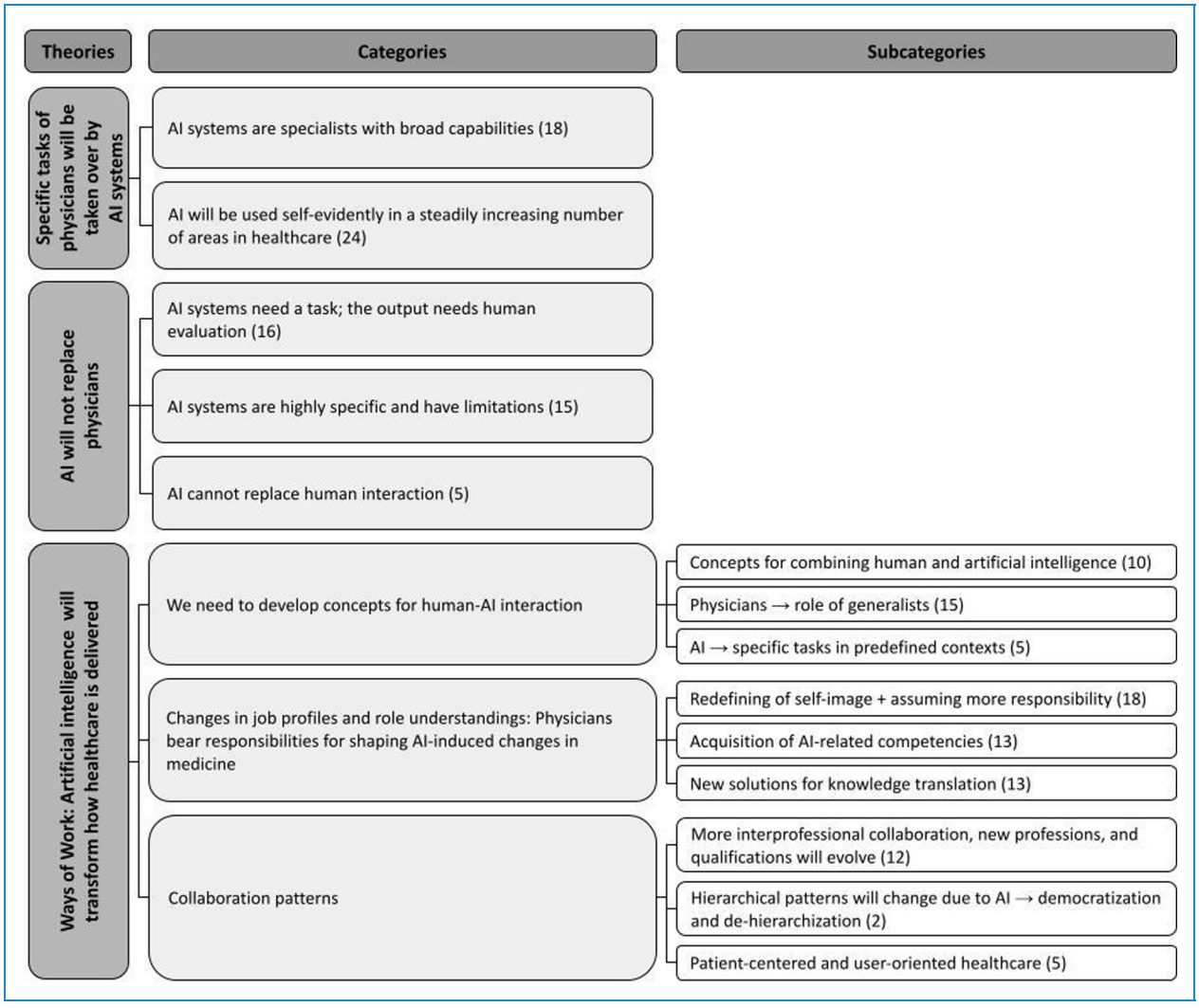

Figure 2. Overview of thematic categorization framework with theories (dark grey), categories (light grey), and sub-categories (white). The numbers in parentheses indicate the number of experts who were assigned one or more statements that aligned with the corresponding topic.

therapy, and rehabilitation) could enable improved efficiency, increased patient safety, and conservation of resources. Some experts suggest making the use of AI decision support mandatory in complex patient cases and medication regimens (pharmacogenetics and drug–drug interactions) and including it in medical guidelines.

> *AI will be able to play a role in all disciplines. In what form, that remains to be seen. But that doesn't just apply to the medical field. It also applies across all sectors and branches of medicine […]. And of course, that also means that the users are different. It's the doctors, patients, health insurers and researchers. All of them will see the opportunities to exploit potential to improve their work. (#21, physician in leading positions in representative bodies of the medical profession and with responsibility for digitization-related topics)*

The interviewed experts see great potential for AI applications for research purposes. In drug development, therapies can be personalized with regard to dosage, selection, timing, and route of administration with the help of AI. New vaccines and precision therapies for cancer could be brought to market through further research into pharmacogenetics. Personalized medicine can also be enabled through research with patient data (e.g. smartphone data, social/demographic data, data from wearables). AI could enable analysis of large amounts of (big) data that was previously inaccessible to researchers.

AI will not replace physicians entirely

Although AI has great potential to completely automate away certain specialized or routine tasks, numerous tasks will continue to require human supervision, problem

definition, or human interaction. The experts interviewed for this study gave three reasons why AI will not replace physicians entirely, which are detailed below.

AI systems need a specific task; the output needs human evaluation. AI models are created by humans to respond to a certain task, which is in turn also defined by humans. According to most experts in this study (72%, 16/24), physicians would be needed to define the questions that AI algorithms should solve. At a higher level, they need to oversee the course of treatment and, in that context, link and classify the outputs of AI systems. AI would act as an additional tool for physicians; according to some experts, there may even be parity between medical and AI assessment. However, the experts agree that the indication for the use of AI should be determined by physicians.

> *With regard to the role model, you have to ask yourself what image a doctor has of himself or herself if he or she believes that the profession is threatened by an AI that […] can do nothing else but volumetrize and measure tumor sizes. […] That is not the image I have of myself as a physician. That would be sad. So I donot feel threatened by these tools at all; on the contrary. I look forward to them. (#1, physician and computer scientist conducting research on AI-based applications for diagnostic support)*

AI systems are highly specific and have limitations. Most experts (63%, 15/24) explained that the role and potential of AI is often still overestimated. AI systems would always be designed for specific use cases. However, the variety of a physician's tasks would be too heterogeneous, complex, and unpredictable for AI systems to handle.

> *For example, a system that has been trained to recognize certain diseases will only look for those diseases and will not be able to recognize other things. […] So there are major limitations for such AI systems because of this specialization. (#20, computer scientist in a leading position in an association for digitalization, responsible for topics in the field of AI)*

AI can only be applied and trained if it has access to large representative data sets. Many important data formats are not yet accessible to AI systems, and there is a lack of representative, freely accessible, and annotated data sets that can be used as a basis for training AI systems. Experts call for the establishment of and adherence to quality standards in data collection and data documentation. Quality standards would also be needed for reporting the results of studies using medical AI systems to ensure transparent disclosure of their benefits and performance. Many medical AI systems have been trained with retrospective data and need to be validated prospectively, though some experts have criticized that this is usually associated with declining performance. Additionally, algorithms trained on publicly available data sets would have limited clinical applicability because real-world data are much more heterogeneous.

> *We collect a lot of data in hospitals, but we often have no data documentation standards to analyze this clinical data in a useful way. […] (#15, physician and founder of an AI-based health start-up)*

Experts emphasized that these limitations of AI systems must be made clear for them to be used beneficially.

AI cannot replace human interaction. AI will not take over the interaction between physician and patient in the coming decades, according to some experts (23%, 5/24). Contrarily, AI would create more time for human attention, anamnesis, and physical examination—the "real" craft of medicine. Thus, the communication skills of physicians will become more important. Thereby, physicians help patients to participate in their own treatment process by enabling them to make informed decisions or take an active part in the decision-making process.

> *[…] AI will not lead to better medicine and more satisfied patients if physicians do not communicate it well. You have to make this clear to physicians: You must also be able to communicate the knowledge. Having it for yourselves is not enough. (#23, physician with a research focus on AI-augmented wearables and mobile health devices)*

In conclusion, the majority of the experts were concerned about AI dividing the medical profession. AI would not replace physicians, but the "AI-naïve" might be replaced by "AI-literate" physicians, according to some experts. Physicians' fear of being replaced by AI would suggest a lack of awareness of the evolution of the physician's professional role. With no general AI yet in existence, physicians' fear of AI today is largely due to a lack of basic knowledge and awareness of AI (in medicine), the experts stated.

Ways of work: artificial intelligence will transform how healthcare is delivered

We need to develop concepts for human–AI interaction. The experts interviewed for this study state that AI could solve major problems in medical research and augment medical practice by complementing the limits of human intelligence. Therefore, according to some experts (41%, 10/24), concepts for combining artificial and human

intelligence in research settings and clinical workflows should be developed. AI should be critically monitored; the danger would be to trust unreflectively in the output of the AI systems (automation bias). Clinical trials and registration studies for AI-based medical devices should be conducted using local databases, and the evidence gathered should be used to inform legislations and guidelines for human–AI interaction in healthcare.

Although AI would perform specific tasks in predefined contexts, physicians would increasingly take on the role of generalists, according to the majority of experts (63%, 15/24); the experts believe the physicians would synthesize and contextualize information from multiple sources, which would lead to a more holistic approach to a disease or patient case. AI systems could be considered as a consultant—a further external opinion the physician should integrate into the decision-making process. Therefore, risk analysis will become more important. A physician would still weigh various possible hypotheses and make the decision in the end, being the "filter behind the AI."

Some experts (21%, 5/24) see AI as an additional tool for physicians for specific tasks in predefined contexts, but in perspective, they suggest that assessment by AI will gain in importance and that AI could even carry equal weight with human doctors in medical decision making.

Changes in job profiles and role understandings: physicians bear responsibilities for shaping AI-induced changes in medicine. The role of physicians is closely linked to the role of AI, as physicians define the areas of application and issues for AI, the experts stated. According to most experts (75%, 18/24), the job profile of physicians might undergo significant changes due to the increasing implementation of AI. However, the core competencies and activities of physicians would remain the same.

Physicians should redefine their self-image and assume more responsibility in the age of AI-supported medicine. AI is perceived differently by physicians than other technological innovations; this is, according to experts, because of certain narratives and the "overblown" AI hype, which make it seem like AI can potentially replace physicians. The medical profession would need to recognize that AI will undoubtedly be integrated into routine clinical practice in the coming years and that it can support clinical practice and improve outcomes. An understanding and vision of both the role of AI and physicians should be developed within the medical profession. The vision for the physician's role and self-image should include critical reflection, consideration, and evaluation of AI decision proposals, the experts suggested.

To fulfill their responsibility and not relinquish it to other stakeholders, physicians should see themselves as an important part of the societal discourse on medical responsibility, medical role conception, and self-image, as well as on ethical, social, and legal issues regarding AI. Experts see medical professional associations as having a responsibility to develop positions and concepts for the introduction of AI in medical practice, education, and research. Physicians should participate in and drive the research and development of medical AI systems. In medical practice, they should take responsibility for advancing personalized medicine and initiate research-based treatment, the experts suggested. Some experts assume that the professional role of physicians *could* change completely—if physicians do not participate in the process and take over responsibilities.

> *Physicians must take the process into their own hands as experts with specific competencies and not leave the field to large corporations. (#15, physician and founder of an AI-based health start-up)*

Additionally, physicians would also need to take responsibility for their own qualification and education in AI. According to the majority of experts (54%, 13/24), physicians should acquire AI-related competencies to be able to handle AI systems, to assess their applicability in a specific case, to detect sources of error, and to evaluate the output of the AI system. According to the experts interviewed, basic AI competencies encompass competencies related to the ethical, legal, and social implications of AI (ELSI competencies), a general understanding of technical functionalities, and the ability to practically apply AI systems. ELSI competencies include, but are not limited to, competency in critical reflection and impact assessment of the application of AI systems—related to both individual patient care and societal or ethical issues. A general understanding of the functionality of AI systems would require basic knowledge in, for instance, data science and machine learning models, the interviewed experts agreed. In addition, basic AI definitions would need to be clarified in the public domain, as skepticism and doubt about AI often stem from an unclear public narrative, some experts said.

Digitization and AI would challenge the medical profession and the skills it requires in entirely new ways. More and more knowledge and evidence is being accumulated in less and less time, which requires an adaptation of medical training concepts as well as new solutions for knowledge translation from research to practice and teaching, many experts stated (54%, 13/24). Moving away from the one-size-fits-all paradigm and toward precision medicine, physicians should learn to better deal with uncertainties in medical practice.

> *There is no permanent certainty in healthcare. And as doctors, we don't like that. […] We are very uncomfortable with uncertainty. […] Being able to learn how to learn means you are perfectly aware and acknowledging that there are so many uncertainties in what we know. (#7,*

physician and principal research scientist in computational physiology)

Ultimately, experts expect a shift in competencies, from less memorization of factual knowledge to more critical, problem-oriented clinical thinking that combines information from multiple sources to provide individualized, research-based treatment and diagnosis.

Collaboration patterns. More interprofessional collaboration, new professions, and qualifications will evolve. Interprofessional collaboration would become even more important in the era of AI in medicine, half of the experts stated (50%, 12/24), as a multitude of perspectives would be accumulated and discussed in clinical everyday life. This could lead to better solutions and a more holistic understanding of the underlying problem.

More and more professions would enter the work environment of physicians: data scientists, mathematicians, physicists, biologists, engineers, etc. Furthermore, existing health professions such as psychologists, physiotherapists, and nurses will work together with the physician and the AI system. In medical research, computer scientists and physicians should work closely together; physicians should be involved in programming AI algorithms, some experts stated. In addition, social scientists should be involved in medical research to explore social determinants of health, as socioeconomic data could soon be integrated by AI and used for research. Some experts suggest recruiting computer scientists abroad as well as prioritizing and incentivizing interdisciplinary research to drive innovation in AI in Germany.

It is important to create expertise for AI in the medical community as well as to establish "Digital Medicine Experts" as a new profession with deeper knowledge and skills at the interface of medicine and AI, the experts said.

Hierarchical patterns will change due to AI, and we need concepts for this. AI could lead to democratization and de-hierarchization in medicine, as complex knowledge and insights become accessible to everyone, some experts proclaimed (8%, 2/24). They anticipate that there will be a shift in eminence as the required skills and activities of physicians change and citizens are empowered to participate in their own healthcare.

Some experts interviewed in this study (8%, 2/24) foresee a transformation in medical education. Much of the knowledge taught in medical school today could become worthless in the future, as AI can make knowledge available to everyone in a consolidated and processed form. Physicians and medical students will spend less time acquiring factual knowledge, because AI can make this available much faster, more comprehensively, and in a more evidence-based way.

It is important to open people's eyes because they are definitely going to work with some kind of AI in ten years. It is important to develop competence and be critical: What can AI do, what can AI not do? How can I use AI for my own benefit? […] This is very important in order to keep medicine effective and not to frustrate people. (#12, physician and founder of an AI-based health start-up)

In addition, interprofessional collaboration must be promoted in education and training. In the age of AI, physicians must work better as a team with other professional groups on an equal footing.

Finally, some experts (21%, 5/24) predicted that, as patient-centered and user-oriented healthcare is becoming increasingly important for healthcare providers, physicians should prepare and adjust to more empowered patients with different needs and expectations, especially so as to not leave the market to private companies.

This process also goes hand in hand with the paradigm that is increasingly coming to the fore: patient-centered healthcare and putting the patients back at the center. Unfortunately, this sometimes is neglected in our not yet so digitized medicine. (#21, physician in leading positions in representative bodies of the medical profession and with responsibility for digitization-related topics)

Discussion

This qualitative interview study gives an overview of the potential impact of AI on medical tasks, physicians' job profile, and the ways of working in a future AI-augmented healthcare system. The study builds upon previous research on this topic and re-examines assumptions and theories that have been made about the effects of AI implementation into clinical routine, following the problematization approach, as described by Chatterjee and Davison.[34]

Repetitive administrative tasks and activities involving the analysis of large, multidimensional but homogeneous data sets in a given context can be taken over by AI systems. Ultimately, AI will not replace physicians in the near future, but it has the potential to significantly change activities and the professional role of physicians and other professions in the healthcare sector. The interdisciplinary expert panel outlines a demand for new professionals through AI and highlights the responsibility of the medical profession for shaping the AI-induced transformation of healthcare. Physicians and their professional associations are challenged by a changing range of tasks and a change in their job profile and professional role. Hierarchies both within a professional healthcare team and in the patient–physician relationship could be broken down by ubiquitously available up-to-date knowledge and consolidated scientific evidence. Reforms in medical education are needed to prepare future physicians for the AI-augmented healthcare system. There is a need for the

development of scenarios and concepts of future health professions.

Changing job profiles–the AI-augmented physician

In 2017, Forbes Magazine published an article titled "Prepare Yourselves, Robots Will Soon Replace Doctors In Healthcare."[35] The question of whether AI will replace physicians has been evaluated in numerous publications (mainly position papers or reviews) in the last five years, focused either on specific medical specialties or on medicine in general.[16,17,19,21,36–45] The results of this study support the position that AI will not replace physicians but will significantly transform the job profile of health professionals and bring about a responsibility to prepare for this transformation.[41] Even though AI can be used for diagnosis, it will remain the task of physicians to validate it. Experts argue that clinical decision support systems should be thought of more as clinical reasoning systems, supporting physicians' way of reasoning by including different sources and types of data. Critical interpretation, contextualization, and integration of outputs from such systems would remain part of the physicians' role.[46,47]

With AI performing routine tasks or automating operational and clinical tasks, physicians' workload will be reduced. This also leads to a shift in workforce skills toward social and emotional skills, bonding between humans, and technological and information management skills.[14,43,48] AI systems being available for patients would facilitate access to health information. Although AI might lead to more egalitarian medicine, fostering shared decision processes between patients and physicians, physicians will still need to address patients' questions and expectations. Furthermore, direction toward appropriate tools and sources and guidance in the interpretation of health information will remain a task of physicians.[49,50]

Our finding that "AI cannot imitate the human connection" is also confirmed by several publications. Most AI systems currently do not embrace empathy or emotional contact. A study examining compliance with medical recommendations depending on the use of AI in the context of a hypothetical scenario of skin cancer diagnosis and treatment showed that patients consider AI tools innovative, but would be more likely to follow recommendations when the assessment is performed by a physician or a physician using AI. The concept of social presence can explain this result.[51] Experts believe that technological singularity—a future point in time at which computers will exhibit superhuman intelligence—cannot be achieved without empathy in healthcare, leading to the development of concepts like artificial empathy or empathy-driven digital tools.[47,52,53] Personalized healthcare is only possible if it is responsive to patient needs, with an emphasis on the physician's perception of (past) medical history and physical examination. In this respect, human judgment will still surpass AI, and critical human skills must be increasingly taught and assessed to continue to ensure safety and efficiency in healthcare.[43,54]

Slow adoption of AI in healthcare can be explained by the traditional risk aversion in this domain, the anxiety stemming from uncertainty, and the fear of being replaced at work.[55] To ensure safe and beneficial solutions, all stakeholders of the healthcare system should actively shape the development and integration of AI solutions in this sector.[48] Palumbo et al. argue that *"targeted initiatives are required to make value co-creation possible in a cyber-physical health-care setting."*[56] Further challenges related to the use of AI but not identified in our study include patient autonomy protection matters, lack of transparency in the use of algorithms, or potential misappropriation of AI to replace services currently offered.[57,58]

The future of jobs in healthcare–new occupational profiles arising in the era of AI

The results of the present study indicate the looming of new occupational profiles with the implementation of AI in healthcare. Already now, the "data-driven physician"[59] emerges, meaning that existing task profiles of doctors will be enriched with data-rich tasks such as collecting, managing, analyzing, and interpreting data, and justifying decisions based thereupon.[48,60] We will see the "bionic radiologist,"[61] dermatologist, pathologist, anesthesiologist, gastroenterologist, and so forth. Their tasks will be unbundled and freed from some routine tasks and those where prediction by AI is more cost-effective (also taking into account the ethical and social costs of bad decisions), then re-bundled to take on new tasks related to data visualization, interpretation, problem definition, and monitoring of algorithmic decisions.

Digital clinical scientists will be an addition to that and will be able to carry out AI-related research studies as well as clinical evaluations of AI systems.[62,63] Moreover, existing clinical scientists focusing on the molecular basis of medicine are already enhancing their task profile with numerous digital practices. Although this shift may not replace all of a physician's tasks, it calls for physicians to take responsibility for their own qualification and education in AI.

Not all tasks will be performed by doctors themselves in the future. Other occupational profiles have already entered the physician's turf, as emphasized by the experts in this study. These include data scientists, data engineers, and "analytics translator" roles.[64] The ways of working together in such multi-professional teams are yet to be defined, the structures and positions yet to be established. These include, for example, reimbursement and financing models for incorporating multiprofessionalism into the health care system.

Feng et al. advocate for the creation of "AI-quality improvement (QI) units," in which clinicians, data scientists,

model developers, hospital administrators, and regulatory agencies collaborate to monitor and improve the quality of AI systems deployed in a hospital setting.[65] The numerous ethical, social, and legal challenges require the augmentation of inter- and transdisciplinary teams. These teams will and already include sociologists, lawyers, ethicists, psychologists, human factor engineers, and other roles. Moreover, evaluation also requires economics experts. This calls not only for physicians to take responsibility for their own AI competencies but also for other professions to be taught the medical competencies necessary for meaningful collaboration in interprofessional teams—and with AI.

Learn how to learn—the need to reform medical education

The impact of AI on the medical profession and the healthcare system in general will require reforms to the education system. The focus is on raising awareness among students, physicians in medical training, and specialists who are occupied with the implications of the changes that the healthcare system is experiencing as a result of the digital transformation.[14,15,66] Experts interviewed for this study agree that AI-related competencies should be prioritized in medical education and (national) concepts for upskilling future physicians should be put in place.[67,68]

The need for qualification regarding AI within the medical profession is immense and enormously heterogeneous. Therefore, new master's programs and micro-credentials or micro-degrees can make a meaningful contribution, since rapid technological developments in AI induce special challenges to keep teaching contents in accordance with the state of the art, requiring more adaptive curricula and possibly new formats such as digital learning opportunities. The same applies to continuing medical education and training, where the need for qualification in AI is even greater than in medical studies.[27,69]

The application-oriented teaching approach of AI competencies should be particularly emphasized. The focus is on the indication for the use of AI systems, their evaluation and interpretation, and the outcome in the context of clinical decision-making. In addition, practical application must be mastered, including the ability to communicate the content to patients and colleagues in the clinical setting. This requires innovative new approaches to teaching that move away from the passive accumulation of knowledge and place a greater focus on "flipped classroom" models, hands-on experiences, and skills orientation, and an emphasis on interprofessional collaboration.[27,70–72] The ability to reflect is of particular importance and can also be described as "learning how to learn." This means reflecting on one's medical skills, for instance, but also critically questioning AI outputs, as physicians act as "filters behind the AI."

The "learn how to learn" approach implies new ways of thinking, including embracing medical uncertainties, and provides problem-solving strategies, which are also part of the so-called "Village Mentoring" concept.[73,74] The focus is on promoting collaborative and interdisciplinary scientific work and non-hierarchical communication. Any member of a research group can become both a mentor and a mentee. The "village" has no permanent members, but is based on projects, so teams can regroup according to current needs and research questions. This allows for better transfer from research to teaching and student involvement in current research projects.[73] In addition, enhanced integration of research and teaching facilitates better adaptation to the rapidly changing work environment in the healthcare sector.

Limitations

This study has some limitations that need to be considered. The experts interviewed made their statements based on all their expertise and the available evidence, but all assessments should be considered from the point of view that they relate to future developments and are therefore not yet verifiable. Representativeness of the results is not given due to the qualitative nature of the study. However, the number of experts supporting a specific statement can be seen as a guidance for the perceived importance of the respective subjects. Still, this quantitative information (number of experts per code) is biased as it is influenced by the questions asked to the respective expert. Furthermore, although the researchers tried to recruit as balanced and diverse a pool of experts as possible for this study, personal contacts and thus another subjective component were important for sampling. Despite these limitations, this study can be a starting point for further research and sheds light on gaps in action toward meaningful AI implementation in healthcare.

Conclusions

AI-induced automation and augmentation will likely result in a profound transformation of work in healthcare. It could lead to a reduced workload, a change in workflows, and a shift in physician's activities to higher-value questions. Physicians will not be replaced, but AI will be used in the best possible way according to their qualifications. AI augments human abilities, especially the capacity to evaluate and learn from data. Yet, the opportunities AI brings must be seized and managed by professionals trained in both AI and medicine. In addition, the medical profession should redefine its self-image, acquire new competencies related to AI, and take on more responsibility in the age of AI-enabled medicine. Ultimately, professional education will need to include AI in the core repertoire of skills for physicians. This study highlights the need to develop scenarios for the use of AI in clinical and research practice, as well as new workflow models and concepts for working in a team that not only includes an unprecedented diversity

of professions and disciplines but also combines human and artificial intelligence.

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