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Ethical AI: A qualitative study exploring ethical challenges and solutions on the use of AI in medical imaging

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ABSTRACT

Background: Artificial Intelligence (AI) is being rapidly deployed in clinical practice in medical imaging settings worldwide. AI applications have the potential to transform this discipline and provide better patient outcomes. However, many ethical challenges exist when implementing AI in clinical practice. This study aims to explore these challenges and suggest ways forward.

Methods: This study was supported by the European Federation of Radiographer Societies (EFRS), together with the European Society of Radiology (ESR) through the EFRS Research Hub at ECR 2024. Ethics approval was in place before data collection. All professionals within the medical imaging AI ecosystem who were registered congress attendees were eligible to participate. This qualitative study employed semi-structured interviews. All interviews were audio recorded after informed written consent by study participants. Transcribed data was analysed using a content analysis approach.

Results: In total, 43 professionals took part in this study. The sample included radiographers, radiologists, medical physicists, health informaticians, and business and IT specialists. Respondents recognised many ethical challenges in the clinical use of AI, such as data protection issues, lack of governance frameworks, potential inequalities in healthcare delivery, lack of diverse data, accountability issues in case of erroneous use, and lack of explainability. They also expressed additional concerns on staff deskilling due to overreliance on technology, AI education gaps and sustainability. Participants proposed that teamwork, continuous monitoring of AI tools, close collaboration with industry, rigorous legislation, and updated academic curricula could help address these ethical challenges.

Conclusions: This study highlights the need to consider different ethical issues before AI implementation and to carefully introduce customised solutions to minimise risks.

Background

Artificial Intelligence (AI) is widely recognised as a potential game-changer in the field of healthcare. AI-based solutions can be used by healthcare professionals to improve patient outcomes, support decision-making of clinicians, and enhance personalised approaches to healthcare [1]. AI proposes solutions across all medical disciplines. In medical imaging, AI can have a profound impact on triage, detection and diagnosis, alongside streamlining operational aspects of patient care [2]. These AI-enabled tools have been deployed to offer optimised workflows, reduce radiation dose received by patients, facilitate patient positioning, achieve advanced image analysis methods, personalise care delivery, and accelerate image acquisition procedures [3–5]. Recent evidence shows an increasing pace of AI clinical deployment in medical imaging settings [6].

However, many challenges exist around deployment of AI tools in clinical settings, and these are related to AI governance issues [7], regulations, accreditation [8], validation and quality assurance of AI

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tools [9,10], acceptance and trust in AI technologies by medical imaging professionals [11–14], AI education/training of professionals [15,16] to name just a few. For these reasons, different professional societies in medical imaging have already issued guidance or position statements on practical considerations for AI implementation [17–19].

Many ethical challenges in the implementation of AI have already been highlighted in the literature [20,21]. In medical imaging challenges include data privacy issues, the need for explainability of AI solutions, potential workforce disruption, and biases arising from poor data diversity [22,23]. Coproduction with patients, practitioners and the public is also seen as a priority for AI adoption, in enhancing safety and trust for professionals and patients [24,25].

This study aims to achieve an in-depth exploration of the ethical challenges faced by medical imaging professionals in clinical AI deployment, and suggest potential solutions to mitigate these challenges to harness the benefits of AI technologies and mitigate the risks in service delivery.

Methods

Study design

This is a qualitative participatory action research (PAR) study. PAR is a research approach that involves community members in the research process to understand and change the world [26,27]. In this case, key stakeholders of the AI ecosystem in medical imaging were involved to understand how we can make AI ethically acceptable in the topics that matter to the native AI community. Semi-structured qualitative interviews were employed for data collection and content analysis for identifying core themes. Reporting of this study conforms with the Consolidated criteria for reporting qualitative research (COREQ) guidelines [28]. A visual summary of the methods followed for this study can be found below (Fig. 1).

Ethics

Participant recruitment, data collection and analysis were performed in compliance with relevant institutional guidelines for research integrity. Approval has been obtained from the Scientific Committee of Corfu General Hospital (ref: 2092/17-10-2023). Participant informed written consent was acquired before the commencement of the interviews.

Setting

This study was supported by the European Federation of Radiographer Societies (EFRS), together with the European Society of Radiology, through the EFRS Research Hub at European Congress of Radiology (ECR) 2024. All interviews were conducted onsite at ECR 2024, from February 28 to March 3, 2024, in Vienna, Austria. This study was conducted in a dedicated space specifically designed to provide privacy and confidentiality for data collection. Participant anonymity was ascertained using a coded system for data presentation.

Participants

All participants of this study were registered attendees of the ECR 2024 and were recruited by the researchers during the congress. All professionals within the medical imaging and/or radiotherapy AI ecosystem (e.g., radiologists, radiographers, medical physicists, engineers, IT experts, academics, industry representatives, computer scientists, etc.) were eligible to participate in this study. Professionals with either hands-on experience of AI solutions and/or theoretical AI knowledge were invited to take part. Participants were selected using purposive sampling. Although alternative recruitment strategies could had been used, with the inclusion of professionals from different regions or settings, it was decided that the ECR would serve as an ideal place for recruitment; ECR is the main European congress for healthcare professionals working in medical imaging. The support delivered by the ESR and the EFRS in providing the space and context was crucial for participant recruitment. Furthermore, people attending ECR are amongst the most up-to-date professionals in topics including many contemporary issues, such as AI, so the research team hoped this approach would give them a native and authentic perspective of the wider ecosystem.

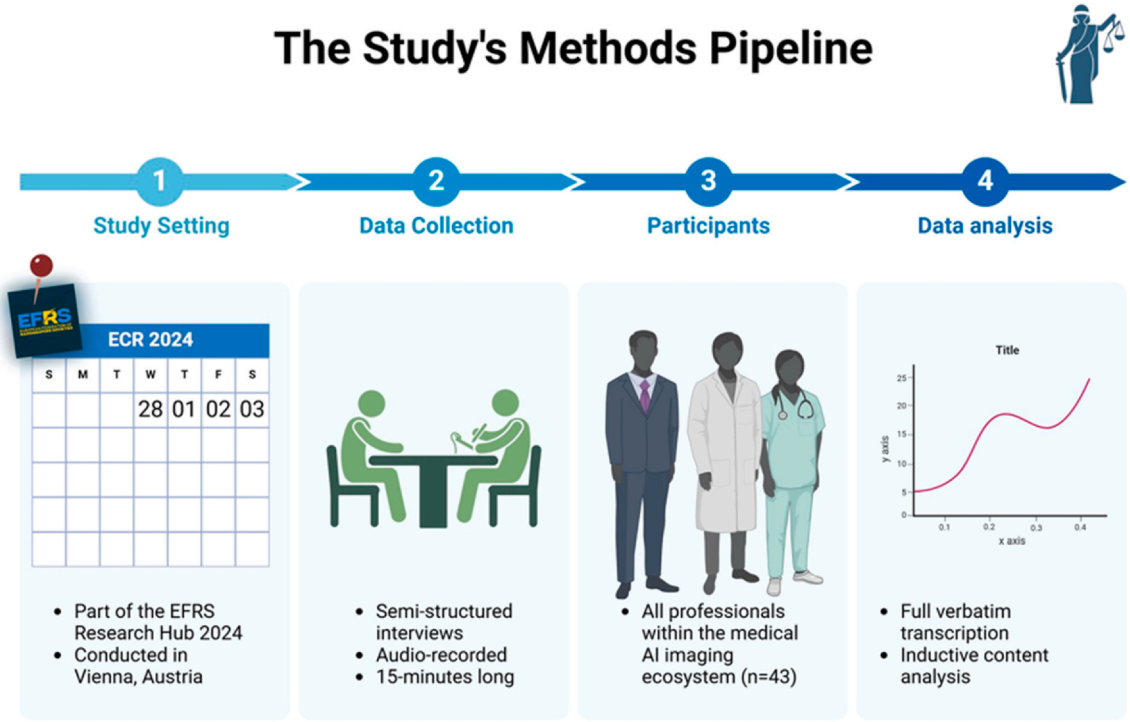

Fig. 1. Visual summary of the study's methods.

Instrument

This study employed semi-structured interviews, an established data collection method of gaining insights of people's' opinions, experiences, and motivations [29]. An interview guide with probes and prompts was constructed by the research team based on prior literature and native expertise, and piloted to help the researchers optimize interview times, keep the focus on the research topic, and maximize participants' contributions [30,31]. In addition, the researchers kept field notes during the interviews, to help with interpretation of the data. The interviewees were asked to describe their professional background and current role, their hands-on experience with AI tools, the ethical challenges associated with AI adoption, and their suggested solutions. The respondents were accordingly prompted to further discuss any issues related to data privacy, consent, AI governance, and algorithmic bias. The interviews were conducted by two researchers (one male and one female) with a radiography background and a Master's Degree in medical imaging. Both were experienced researchers with a steadily growing publication record. Both of them had undergone research methodology training. In addition, rigorous guidance was provided to them from the principal investigator of the study, and interview simulations were also employed for additional training before data collection. No significant differences were noted in the responses, based on the researcher who conducted the interviews. No personal relationships existed between the interviewees and the participants before the commencement of data collection. All participants were well informed about the aim and objectives of this study. The interviews were audio-recorded using a personal computer located between the researchers and the participant. All participants were informed beforehand about the commencement of recording and consented to it. No other individuals were present during the interviews, except the participants and the researchers. Interviews had an average duration of 15 min. Participants were able to withdraw their data at any time before data transcription by contacting the research team.

Data analysis

Audio recordings were transcribed using a full verbatim approach, to ensure that no data was distorted or lost [32]. The transcripts were checked for accuracy by a third researcher. All transcripts were then analysed using an inductive approach, trying to find themes and patterns with shared meaning [33]. Content analysis was employed to transform text into highly organised key results, and it was decided that themes would be the highest level of abstraction [34]. The analysis was performed manually by one researcher, and the colour-coding technique was used to highlight relevant text [35]. The PI has checked the analysis for accuracy and added further comments to ensure consistency and relevance.

Results

In total, 43 respondents were included in this study. Their main demographic data are presented below (Table 1).

Content analysis revealed specific themes, which could be further analysed into relevant categories. These are presented below in a descending order, with frequencies representing the number of times that each category appeared in the data. A visual summary of the main findings is also presented in Figs. 2 and 3.

Ethical challenges

Theme 1: AI data protection (n = 42)

Data protection

The respondents highlighted the ethical challenges associated with data protection, and they expressed further concerns when cloud-based systems are employed for exchange of data.

Table 1
Demographic data of respondents.

Gender	Male (n = 25; 58.1 %)
	Female (n = 18; 41.9 %)
Professional background	Radiographers (n = 35; 81.5 %)
	Radiologists (n = 4; 9.3 %)
	Medical Physicists (n = 2; 4.6 %)
	Health Informaticians (n = 1; 2.3 %)
	Business executives (n = 1; 2.3 %)
Country of practice	United Kingdom (n = 10; 23.4 %)
	Ireland (n = 4; 9.3 %)
	Italy (n = 4; 9.3 %)
	Netherlands (n = 4; 9.3 %)
	Switzerland (n = 4; 9.3 %)
	France (n = 3; 7.0 %)
	Slovenia (n = 3; 7.0 %)
	Denmark (n = 3; 7.0 %)
	Greece (n = 2; 4.6 %)
	Belgium (n = 1; 2.3 %)
	Malta (n = 1; 2.3 %)
	Australia (n = 1; 2.3 %)
	Hong Kong (n = 1; 2.3 %)
	Israel (n = 1; 2.3 %)
	Portugal (n = 1; 2.3 %)
Use of AI tools	Yes (n = 31; 72.1 %)
	No (n = 12; 27.9 %)

> ''…and you need to be perfectly sure that the data that it uses is totally protected.'' (participant 18)

Data privacy

The need to ensure that all personal identifiable information is fully protected was also discussed by the respondents, especially when data with rare pathologies can lead to direct patient identification.

> ''…where we see such rare conditions… these conditions are so rare that a patient probably would be able to identify themselves from that image.'' (participant 6)

Patient information/consent

The ethical challenges around patient consent were also thought to be paramount, and not providing specific information to patients constituted unethical practice.

> ''I guess the patient should agree to their images to be used, not to just use them, but either use totally anonymized, or that the patient should agree about it.'' (participant 21)

Data usage by organisations/individuals

Data sharing among individuals and/or organisations was discussed as an important ethical challenge of using AI in clinical practice, especially when this takes place for purposes of commercial profit.

> ''Individuals are sharing large data sets with industry because they get paid for them.'' (participant 43)

Theme 2: AI and society (n = 31)

Overreliance on technology

The respondents also highlighted the challenge of medical imaging professionals' overreliance on AI, as an important source of ethical dilemmas.

> ''If you're making a diagnosis, you will look at the image first and make your diagnosis, and if you're planning on it, you might then change your mind. If the AI comes up first, they're more likely to be biased by the AI.'' (participant 10)

Accountability

Ethical challenges associated with the accountability aspect of AI, in cases that AI algorithms fail, were also among the respondents' concerns on using AI in clinical practice.

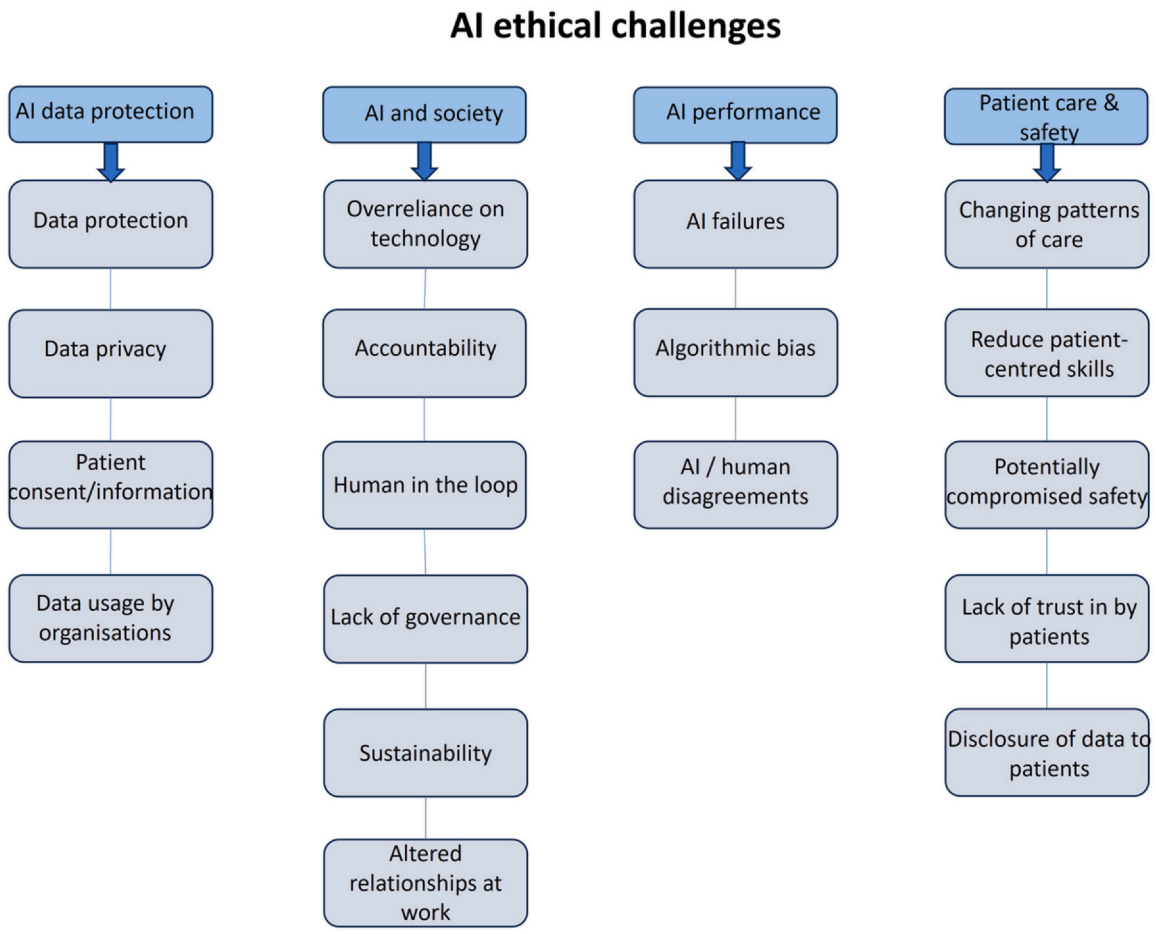

Fig. 2. Visual summary of themes (light blue) and respective categories (grey) regarding ethical challenges of AI, as suggested by participants.

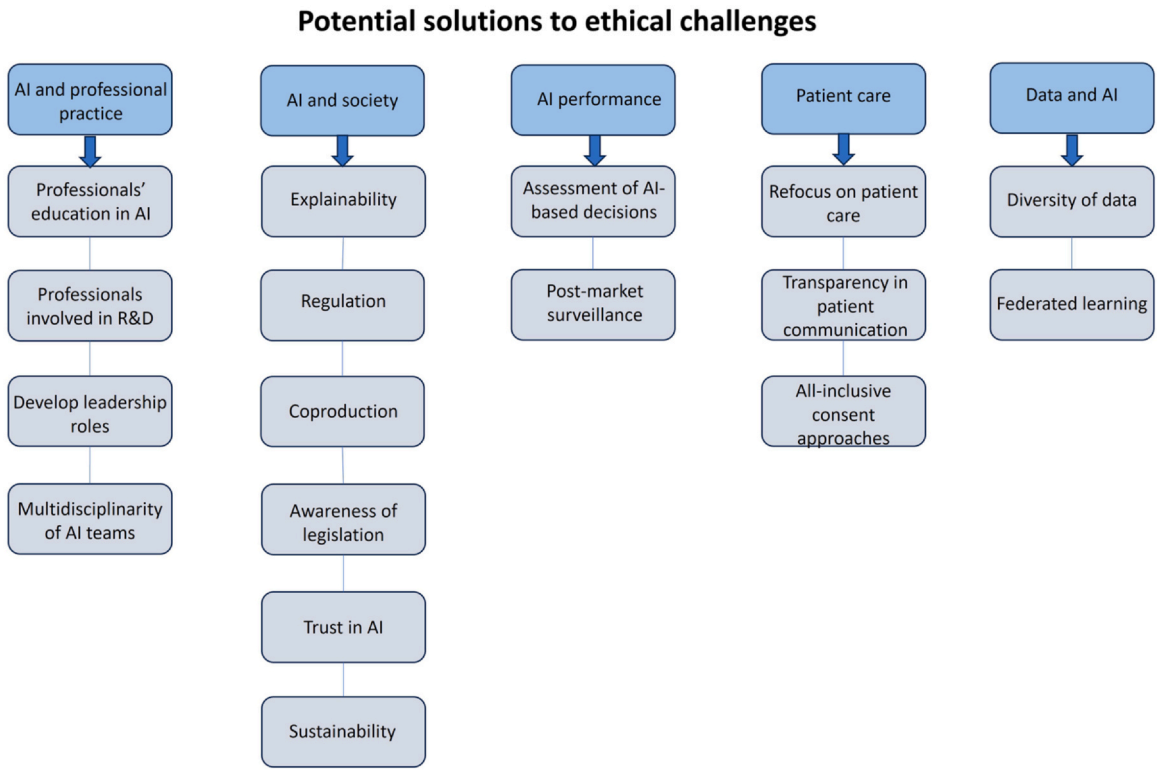

Fig. 3. Visual summary of themes (light blue) and respective categories (grey) with regards to solutions to AI ethical challenges, as suggested by the respondents.

''And so, who then is, if the machine is wrong, who then is, from, who is the responsible? So, that could be a dilemma.'' (participant 27)

Human in the loop

The potential risk of not maintaining a human-in-the-loop approach was highlighted as an ethically questionable aspect of AI.

''Well, in my opinion, the most ethically questionable thing is that if we would let AI decide by its own, that would be the most ethically problematic thing.'' (participant 15)

Lack of AI governance

Lack of specific AI governance frameworks was also identified as an important ethical challenge by the respondents.

''… but we're just lagging behind in legislation and ethical stuff, because also the changes are rapid that we can barely keep up with the changes.'' (participant 26)

Sustainability

The ecological footprint of using AI systems in medical imaging was also thought to be another ethical challenge of the new AI era.

''…yeah, and there's sustainability aspect of work, because you're training more power energy and using it as well, then again, using it in healthcare…'' (participant 14)

Altered relationships at work places

Time-consuming tasks related to AI performed by medical imaging professionals on computers also thought to alter the relationships between colleagues at work places.

''And you spend most of your time on the computer, the time, because you do interact with your colleagues, but it's not the same feeling.'' (participant 33)

Theme 3: AI performance (n = 23)

AI failures

The potential risk of missing AI failures when they occur in clinical practice was also mentioned by the respondents.

''Because we have seen many false positives in AI. And this is an ethical challenge for the radiologists, to decide if they have to trust the AI system or their own knowledge.'' (participant 33)

Algorithmic bias

Algorithmic bias due to biased training of AI algorithms was also discussed, as it poses further ethical challenges to clinical AI.

''And sometimes also, I think that some algorithms, especially in planar radiography, they feed them with the gold standard projection. And sometimes we don't reach a gold standard projection in everyday practice.'' (participant 29)

''First is, it has the ability to increase the disadvantage of AI, experienced by certain groups, because the AI models have been trained on generally people who can afford to get a hospital treatment.'' (participant 42)

Disagreement between AI and humans

Ethical dilemmas of professionals to follow or not the decisions made by AI tools were also identified by the respondents.

''And they'll say the AI is saying, there is this thing here… but you will say there's nothing there in my experience. So, there's a professional ethical boundary there.'' (participant 23)

Theme 4: patient care and safety (n = 14)

Changing patterns of patient care

The potential risk of AI negatively changing the delivery of patient care was thought to be an important ethical challenge.

''… so, ethical problems would be, if AI tries to replace human touch.'' (participant 19)

Reduced patient-centred skills

They also expressed concerns on the risk of future professionals losing important person-centred care skills due to AI automation.

''…no one talks about the business part of AI, and is impacting a lot radiographers' profession, taking out patient-centred care.'' (participant 17)

Potentially compromised patient safety

Another important challenge highlighted by the respondents was the need to ensure that patient safety will not be compromised in future clinical applications.

''I think the main ethical aspect of using it is ensuring that there's something that has first been a no harm, that the patient's safety is not compromised.'' (participant 30)

Lack of trust in AI by patients

The lack of trust in AI by patients was indicated to be a further ethical challenge of AI integration into clinical practice.

''But it is when your patient comes to you and asks, okay, [you]… you're saying, I have breast cancer. Why are you saying that? Can you show me where or what to know? And if you think there is a suspicion around AI from patients?'' (participant 26)

Disclosure of data to patients

The respondents also stressed the ethical challenge of disclosing or not some important information on health outcomes to patients, according to their preferences.

''So, for example, if you could use AI to predict that somebody is going to get dementia or not, somebody would want to know and somebody would not want to know.'' (participant 10)

Suggested solutions

The respondents were also asked to freely discuss their suggested solutions to overcome some of the above ethical challenges of using AI in medical imaging. The derived themes and respective categories are summarized below (Fig. 3).

Theme 1: AI and society (n = 48)

Explainability

The respondents thought that explainable AI would be the solution to many of the ethical challenges for both practitioners and patients.

''They just have to be clear enough to explain what we are doing, why we are doing it, and what can be the benefits of it.'' (participant 40)

AI industry reps also supported explainability initiatives, so that AI procurement will be seamless.

''I think the companies will have a look on this, because this [lack of explainability] could be an argument not to buy it.'' (participant 34)

Regulation

Creating rigorous AI-related regulation and frameworks to guide AI adoption was also mentioned as a suggested future solution.

''So, we have to ensure that we have strict regulation, so we follow with regulation, and that we…all of us… we have enough knowledge to use it properly.'' (participant 25)

Coproduction

They also suggested involving patients in the research and development of AI tools as coproducers.

''I suppose in terms of patient experience, if the patient was involved in the development of AI…maybe again, patients can contribute to ways to develop materials within their courses and face-to-face teaching that involves that more.'' (participant 11)

Awareness/respect of related legislation

A further way to mitigate the above challenges is to gain full awareness of related legislation and follow it throughout, as suggested by the respondents.

''We have to respect the new legislation and regulations developed by the EU right now.'' (participant 5)

Trust in AI

The need to cultivate trust in AI, so that people embrace the new technology was also suggested.

''I think we just need time and people need to see that these things work well and can be relied upon.'' (participant 26)

Sustainability

The respondents also recommended engaging sustainable practices and policies to ensure ethical use of AI.

''We all have to be sustainable.'' (participant 5)

Theme 2: AI performance (n = 22)

Assessment of AI-based decisions

The respondents suggested that professionals will have to gain the ability to expertly monitor AI systems and be drivers in decision-making.

''…radiographers must have the knowledge and ability to monitor the AI tools and say, this is not correct, and have the final decision.'' (participant 17)

Post-market surveillance

Ensuring the effectiveness of AI solutions was also thought to be paramount for the future of AI integration in clinical practice.

''Yeah, I think one of the major things when we deploy it [as] stand alone, is that we monitor that it doesn't do something else.'' (participant 22)

Theme 3: AI and professional practice (n = 22)

Medical imaging and radiotherapy (MIRT) professionals' education in AI

AI education/training was highlighted as a top priority for future medical imaging professionals.

''So, AI training for all of us is a set of priorities, to catch up with AI and get real understanding.'' (participant 38)

MIRT professionals involved in research and development

They also stressed the need to be actively involved in the development and research of AI solutions.

''I think we have to be involved directly in the whole research and development process'' (participant 8)

Develop leadership roles

An important solution for the future of AI in medical imaging was thought to be the development of new leadership roles for MIRT professionals, in the form of Ai champions.

''…radiographers should take some AI leadership roles to manage all these processes and to be deeply involved in every aspect of the process.'' (participant 8)

Multidisciplinarity of AI teams

They also highlighted the need to employ multidisciplinary teams to support the clinical service transformation.

''You need to have multidisciplinarity within medicine, within radiology, and outside of radiology, which is completely different, because that is the balance of ethics.'' (participant 41)

Theme 4: patient care (n = 20)

Refocus on patient care

The respondents also suggested training future professionals to maintain their focus on patient care.

''Yes, so we have to teach them how to care properly.'' (participant 11)

Transparency in patient communication

It was also recommended that patients should always be adequately informed about the use of AI.

''…patients as well have to know if AI is intervening or is supporting decision making.'' (participant 13)

All-inclusive consent approaches

An all-inclusive consent approach was further suggested, as a means of providing effective information on patients and ethical use of AI data.

''…when our patients present to the department, …. we provide them with one general consent form, capturing everything, concerning their care, concerning how diagnosis may be made, and potentially even giving them a choice whether they would like to involve AI in their management.'' (participant 8)

Theme 5: data and AI (n = 5)

Diversity of data

The respondents suggested training AI algorithms using diverse datasets to ensure fairness.

''…To have a representative diverse population to make sure that no group is being disadvantaged by your AI.'' (participant 23)

Federated learning

Federated learning was also recommended as an effective way to mitigate the potential risks of data breaches.

''All data remains in the hospital and the developers come to the hospital, train the algorithm, we start creating the data outside the organization. We believe that this would be a good future direction for us.'' (participant 18)

Discussion

Data use and privacy issues

The findings of this study highlight the great importance of safeguarding patient data throughout the lifecycle of an AI solution. All key

stakeholders involved in the AI ecosystem in medical imaging should uphold data privacy. In addition, any cybersecurity issues arising from the use of AI and the exchange of large amounts of data should be solved by employing some already established safe practices, such as the confidentiality-integrity-availability (CIA) triad framework that has been proposed [36], or by employing differential privacy techniques to train the algorithms [37]. Federated learning strategies have also been suggested to further enhance data protection. Regularly conducted rigorous audits and standardized logging systems will further improve data security [38]. In addition, public awareness campaigns could be to inform the public about the benefits of using anonymised datasets for AI training, explaining the benefits of AI in workflows, diagnosis and prognosis, and therefore gaining the public's support and trust to help create larger databases [39]. Explicit informed consent strategies should be followed to adequately inform patients regarding the use of AI, and these approaches should be always tailored according to the needs and preferences of individuals [40,41]. The new governance frameworks in the UK and EU will help mitigate data privacy risks and standardize processes [10,42–44]. These strategies will help create a culture of trust and safety towards AI [25].

Accountability and professional conduct

Accountability issues have been well-recognised by medical imaging professionals [23]. Many AI applications have been classified as 'high-risk' by the European Union's AI Act, although relevant accreditation has been obtained; a key solution is to use AI applications as diagnostic aids, and not as standalone diagnostic tools, while also creating rigorous regulation to help balance innovation benefits and risks [45]. Looking for ways forward, a human-in-the-loop approach could minimise automation bias [25], by ensuring that humans are involved in all stages of AI training, validation, and integration into clinical practice, employing multidisciplinary AI teams consisting of all professions involved in the AI ecosystem [46,47]. In this new era of multidisciplinarity, it is also essential to consider the collective responsibility of all professionals for AI adoption. Furthermore, the need for continuous post-market surveillance [17] was also stressed as a key step towards ethical AI, since surveillance and audits may enhance the long-term reliability of AI tools, especially as part of the legal responsibilities arising for both organisations and professionals to prevent, recognise, or remedy AI failures.

Impact on patient care and service delivery

The potential of these technologies to change service delivery create new ethical challenges for professionals. There are concerns on AI reducing the person-centred skills of future professionals, and this can be mitigated by engaging in tailored, multidisciplinary educational initiatives [16], aimed at personalised care and optimal people management [25]. This has been integrated in professional bodies' statements, requesting tailored AI training for radiographers with the focus being on patient care and treatment pathways [18]. In this direction, the patients' voices should always be heard, as key stakeholders in the adoption of AI [48]. It must be mentioned that all educational initiatives should be customised to meet the needs of different professionals, since it has been proved that different medical imaging professionals within the AI ecosystem exhibit different needs and priorities regarding AI adoption [23]. Hence, future AI training should opt to allow medical imaging professionals maintain their core diagnostic skills in the new AI era. This will allow them to mitigate the potential risks resulting from overreliance on AI, while also maintaining their profession's core skills and competencies in a truly patient-centred care context. Close collaboration between clinicians, patients, and the industry will offer the advantage of creating patient-centric innovations, enhance trust in AI by patients, and improve person-centred care provided by practitioners [49].

Equality, diversity and reduction of bias

Delivery of healthcare is not equitable; already established healthcare biases, have been created due to prejudice in education, unequal access to care and uneven distribution of resources [50].

AI could facilitate fairer healthcare and reduction of biases through better resource distribution, balanced examples in education, and diversity of used data [51]. However, lack of explainability could prevent clinicians and the public from harnessing the true benefits of AI; the 'black-box' effect has been a well-recognised barrier to successful AI implementation, and there is a strong need for all end-users to understand the reasoning behind AI-led decision making [52]. In addition, when ensuring explainability of AI solutions, transparency is also enhanced, and the 'human-in-the-loop' approach can be maintained [53]. From a medical ethics perspective, explainability is strictly associated with the four core ethical principles, as these were initially introduced by Beauchamp and Childress, and so lack of explainability might have a negative impact on justice, autonomy, beneficence, and non-maleficence [54]. Therefore, future AI tools in medical imaging should foster explainability, since this approach will facilitate evidence-based decision-making and reduce scepticism and uncertainty among professionals and the public [55].

Sustainability

Our findings also highlight sustainability issues as a growing ethical aspect of clinically using AI in medical imaging. The ecological footprint of AI in healthcare is enormous, mainly due to excessive energy requirements and carbon emission throughout the products' lifecycle [56]. On the contrary, AI can minimise carbon emissions by vetting unnecessary medical interventions, and promoting value-based healthcare models [57]. Reducing scan times, minimising use of contrast media, avoiding unnecessary imaging examination repeats will all contribute towards a more sustainable future with AI [58].

Limitations

This study has some limitations. First, since interviews were employed as the collection tool, this study will be inadvertently impacted by the interviewers' reflexivity [59], or social desirability bias of the interviewees [60]. In addition, inclusion of professionals who were all attendees at ECR 2024 only, might have limited the generasibility of the findings, although the sample was diverse in terms of professions, gender, and geographical origins. The small sample size did not allow for further analysis of the themes based on different demographics (gender, professional background). Finally, although radiographers are overrepresented in this study, this is reflective of radiographers' position as the largest workforce in medical imagign in Europe. While this sample is not representative, it certainly keeps the proportions of the different professions within the European landscape.

Conclusion

This study highlights the most important ethical challenges faced by medical imaging professionals in the implementation of AI in clinical practice. There are concerns raised by different professionals regarding the protection of data, confidentiality, cybersecurity, and safe data sharing among organisations. In addition, medical imaging professionals expressed fears of AI negatively impacting patient care, and they warned that all professionals needed to refocus on person-centred care skills. Patient safety was also thought to be paramount to ensure ethical use of AI technologies. A human-in-the-loop approach is needed to ensure seamless interaction between AI and professionals, and ongoing monitoring of AI solutions is necessary to provide efficient and accurate care to patients. Patients and the public must be in the centre of interest, and they must be appropriately informed throughout their interaction with AI technologies across their care pathway.

Ethical approval

Approval has been obtained from the Scientific Committee of Corfu General Hospital (ref: 2092/17-10-2023).

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CRediT authorship contribution statement

Stogiannos Nikolaos: Writing – original draft, Investigation, Formal analysis, Conceptualization. **Georgiadou Eleni:** Writing – review & editing, Project administration, Investigation. **Rarri Nikoleta:** Writing – review & editing, Project administration, Investigation. **Malamateniou Christina:** Writing – review & editing, Supervision, Resources, Project administration, Methodology.

Data availability

The data that has been used is confidential.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ejrai.2025.100006.

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