Perspectives of medical imaging professionals about the impact of AI on Swiss radiographers

Abstract

Introduction: Artificial Intelligence (AI) is increasingly implemented in medical imaging practice, however, its impact on radiographers practice is not well studied. The aim of this study was to explore the perceived impact of AI on radiographers' activities and profession in Switzerland.

Methods: A survey conducted in the UK, translated into French and German, was disseminated through professional bodies and social media. The participants were Swiss radiographers (clinical/educators/ researchers/students) and physicians working within the medical imaging profession (radiology/nuclear medicine/radiation-oncology). The survey covered five sections: demographics, AI-knowledge, skills, confidence, perceptions about the AI impact. Descriptive, association statistics and qualitative thematic analysis were conducted.

Results: A total of 242 responses were collected (89% radiographers; 11% physicians). AI is being used by 43% of participants in clinical practice, but 64% of them did not feel confident with AI-terminology. Participants viewed AI as an opportunity (57%), while 19% considered it as a threat. The opportunities were associated with streamlining repetitive tasks, minimizing errors, increasing time towards patient-centered care, research, and patient safety. The significant threats identified were reduction on work positions (23%), decrease of the radiographers' expertise level due to automation bias (16%). Participants (68%) did not feel well trained/prepared to implement AI in their practice, highlighting the non-availability of specific training (88%). 93% of the participants mentioned that AI education should be included at undergraduate education program.

Conclusion: Although most participants perceive AI as an opportunity, this study identified areas for improvement including lack of knowledge, educational supports/training, and confidence in radiographers. Customised training needs to be implemented to improve clinical practice and understanding of how AI can benefit radiographers.

Introduction

Artificial intelligence (AI) has undergone rapid developments to transform business, society and healthcare practices (1,2). Medical imaging (MI) is one of the healthcare areas that is being the most impacted by AI, with recent research showing that AI can perform as well as or better than humans in detecting, classifying and monitoring diseases (1,3,4). The advancements in AI have enabled the swift and simultaneous extraction and correlation of multiple imaging parameters, surpassing the limitations of human perception by identifying subtle findings that were previously undetectable to the naked eye (4,5). As a result, MI is undergoing a transformative shift from a subjective, skill-based discipline to a more objective and scientifically led specialty. This evolution is marked by the use of accurate, efficient, and reproducible image analysis techniques (4,5). Through the amalgamation of AI and advanced MI methods, healthcare professionals can now provide more precise diagnoses and significantly improve patients' outcomes by adapting medicine to the patients' needs (4–6). Healthcare information technology (IT) systems with AI technology hold promise to reduce personnel burden in healthcare institutions, by streamlining workflows and allocating resources more effectively and efficiently (6–9).

The radiographers' clinical practice is becoming more automated with AI, which could result in a reduction on the current radiographer roles and responsibilities (10). However, this change is not without risks, since the AI's potential liabilities are not yet fully understood or appropriately managed. Furthermore, the databases are often built-up without thorough validation processes, which require audits and evaluations to verify the decision-making process and to ensure optimal outcomes (11,12). This change also means the radiographer's role needs to be adapted and, consequently, with support of education and training to be better integrated in the transformed clinical practice. Recent studies (7,13) have reported the perspectives and attitudes of radiographers with regards to the integration of AI in medical imaging practice and education in other countries. Results showed a positive attitude but with concerns due to the lack of understanding of AI technologies and AI training, which can lead to insecurity in their workplace or even resistance to the implementation of these new technologies. To better prepare this transformation in clinical practice, meticulous follow up is required as well as the involvement of all key stakeholders involved in the process. To address this gap, this study aimed to explore the possible impact AI on radiographers' practice and profession in Switzerland based on perspectives from clinical radiographers, teaching-staff, students and physicians (radiology, nuclear medicine (NM) and radiation oncology (RO)), to better adapt radiographers' training for the market needs.

Methodology

A cross-sectional survey was developed to collect data on perspectives from radiographers, teaching staff, students and physician (radiologists, nuclear medicine specialists and radiation oncologists) on the possible impact of AI on radiographers' activities and profession in Switzerland.

Data collection

Data was collected between February and May 2022 using an online survey on Microsoft Forms® and included 34 questions and sub-questions across 6 pages addressing participants' demographics, AI-knowledge, skills, confidence, training in AI and their perceptions about the impact of AI on clinical practice. Participants could go back over their answers while filling in the questionnaire using a back button. Snowball sampling was performed by distributing the survey through the Swiss Association of Radiographers (ASTRM), different professional bodies linked to the physicians and social media (Instagram®, Facebook® and LinkedIn®). To encourage more radiographers to participate in the study, the link was also sent out to the head of departments and clinical tutors that are in contact with the respective universities of applied sciences.

Survey

The survey collected medical imaging professionals' AI-knowledge, skills, training, confidence in AI and their perceptions about the impact of AI on clinical practice. This tool was first developed by Rainey et al in 2021 (14) who demonstrated internal consistency ranging from 0.736-0.777. The authors also ascertain the validity of this survey, grounded on AI expert reviews from Society of Radiographers (SCoR), other AI experts reviews, and key literature (8,14).

The original instrument was available in English and was translated to French and German as necessary, as well culturally adapted to the Swiss context and structures. A comprehensive translation process was conducted to ensure conceptual equivalence between both versions. The process involved several steps, including forward translation, expert panel back-translation, pre-testing and feedback (15). Forward translation was performed by two individuals ensuring conceptual and contextual equivalence and then two other individuals processed to translate back to English. The two English versions were then compared, with content equivalence determined to be adequate by the reviewer. To maintain face and content validity of the survey through its translation, and ensure the comprehension of the statements, a pilot study was conducted by sharing the survey with the Swiss AI steering committee of the ASTRM and three imaging physicians, each representing one specialty. Based on the results from the pilot study, suggestions were integrated when appropriate. Reliability of the scale was determined by calculating internal consistency for all Likert scale questions in the survey.

Data analysis

Data management and data analysis was carried out using Stata, version 17.0 (StataCorp LP, College Station, Texas) and Microsoft Excel. Descriptive statistics were used to analyse the data, presenting the results in terms of absolute numbers and frequencies. Qualitative data acquired through the three open questions of the survey was analysed using thematic analysis following the Braun & Clarke Framework (2006) (16). The data underwent a cleaning process to eliminate partially complete responses and were then prepared for analysis according to predefined strategies. These included the inclusion of only fully complete participant responses and the exclusion of duplicates identified by Internet Protocol (IP) addresses. Additionally, invalid test responses were removed.

Ethics

Under Swiss Law, the current project/questionnaire does not fall under the regulations for research involving human subjects, and as such, does not require authorisation from any federal or cantonal ethics committee. To comply with ethical standards (LRH, 2011)(17) and the Swiss constitution, art. 118b (1999) (18), an enclosure letter was presented on the first page of the online survey. This letter provided a clear explanation of the study's purpose, context, and an estimation of the completion time. Participants were assured of the anonymous nature for the study and no associated risks or compensation for participating. Additionally, a letter including contact details, allowing participants to seek further information available to participants. Participants were notified that study findings may be shared publicly or presented in scientific conferences. To confirm their agreement to participate, participants were required to check a box to signify consent. The data collected was stored on a password-protected computer to which only the first three authors had access.

Results

A total of 242 participants (89% radiographers and 11% physicians) agreed to participate in the study. The demographic characteristics of these participants are presented in Table 1.

Table 1: Participant's profiles

		Percentage [%] (Frequencies)		
		Radiographers (n=215)	**Physicians** (n=27)	***Total*** *(n=242)*
Gender	Female	50.7 (n=109)	29.6 (n=8)	*48.3 (n=117)*
	Male	46.5 (n=100)	66.7 (n=18)	*48.8 (n=118)*
	Transgender	-	3.7 (n=1)	*0.4 (n=1)*
	Prefer not to say	2.8 (n=6)	-	*2.5 (n=6)*
Age	18-25	11.6 (n=25)	-	10.3 (n=25)
	26-35	34 (n=73)	11.1 (n=3)	31.4 (n=76)
	36-45	22.8 (n=49)	40.7 (n=11)	24.8 (n=60)
	46-55	19.1 (n=41)	33.3 (n=9)	20.7 (n=50)
	> 56	12.6 (n=27)	14.8 (n=4)	12.8 (n=31)
Swiss Region	French part	80.5 (n=173)	25.9 (n=7)	74.4 (n=180)
	German part	19.5 (n=42)	-	17.4 (n=42)
	Not Known	-	74.1 (n=20)	8.3 (n=20)
Institution Type	University Hospital	22.3 (n=48)	33.3 (n=9)	23.6 (n=57)
	Cantonal Hospital	18.1 (n=39)	29.6 (n=8)	19.4 (n=47)
	Area/Regional Hospital	17.2 (n=37)	14.8 (n=4)	16.9 (n=41)
	Private Clinic	6.5 (n=14)	22.2 (n=6)	8.3 (n=20)
	Medical imaging centre/institute	12.6 (n=27)	-	11.2 (n=27)
	University College	19.5 (n=42)	-	17.4 (n=42)
	University College & Cantonal Hospital	0.5 (n=1)	-	*0.4 (n=1)*
	Industry	3.3 (n=7)	-	2.9 (n=7)
Role	Head Radiographer	21.9 (n=47)	-	19.4 (n=47)
	Clinical Radiographer	52.1 (n=112)	-	46.3 (n=112)
	Research Radiographer	3.3 (n=7)	-	2.9 (n=7)
	Lecturer	5.6 (n=12)	-	5 (n=12)
	Industry	3.3 (n=7)	-	2.9 (n=7)
	Bachelor Student	10.7 (n=23)	-	9.5 (n=23)
	Master Student	0.5 (n=1)	-	*0.4 (n=1)*
	Lecturer and Radiographer	1.4 (n=3)	-	1.2 (n=3)
	Master Student & Radiographer	0.5 (n=1)	-	*0.4 (n=1)*
	Master Student & Lecturer	0.5 (n=1)	-	*0.4 (n=1)*
	Lecturer; Radiographer; Master Student	0.5 (n=1)	-	*0.4 (n=1)*
	Physicians	-	100 (n=27)	11.2 (n=27)
Years experience	0-2	16.7 (n=36)	3.7 (n=1)	15.3 (n=37)
	3-5	14.9 (n=32)	3.7 (n=1)	13.6 (n=33)
	6-10	10.7 (n=23)	18.5 (n=5)	11.6 (n=28)
	11-20	25.1 (n=54)	48.1 (n=13)	27.7 (n=67)
	> 20	32.6 (n=70)	25.9 (n=7)	31.8 (n=77)
Use of AI in daily practice	Yes	44.2 (n=95)	40.7 (n=11)	43.8 (n=106)
	No	35.3 (n=76)	55.6 (n=15)	37.6 (n=91)
	Don't know	15.3 (n=33)	3.7 (n=1)	14 (n=34)
	Non applicable	5.1 (n=11)	-	4.5 (n=11)
Participant expertise modalities & disciplines (n=619)	Radiography	25.4 (n=157)	NA	NA
	Computed Tomography	24.4 (n=151)	NA	NA
	Magnetic Resonance Imaging	20.8 (n=129)	NA	NA

	Nuclear Medicine	9.5 (n=59)	NA	NA
	Radiation Oncology	8.1 (n=50)	NA	NA
	Interventional Radiology	7.6 (n=47)	NA	NA
	Ultrasound	4.2 (n=26)	NA	NA

Internal consistency

Cronbach alphas were calculated for all Likert scale variables for each population. The results showed adequate to low internal consistency with alpha's ranging from 0.692 for the radiographers and 0.717 for the physicians.

AI impact on radiographers' activities

Radiographers indicated that Computed Tomography (CT) (83%) and Magnetic Resonance Imaging (MRI) (80%)examinations are the main activities impacted by AI. In contrast, NM therapy (11%), NM radiopharmacy (10%), and management (2%) and are less impacted by AI intervention. Results were similar to those from the physicians except for a higher impact on mammography (59%) and Picture archiving and communication system (PACS) (48%) compared to radiographers' perspective (Figure 1).

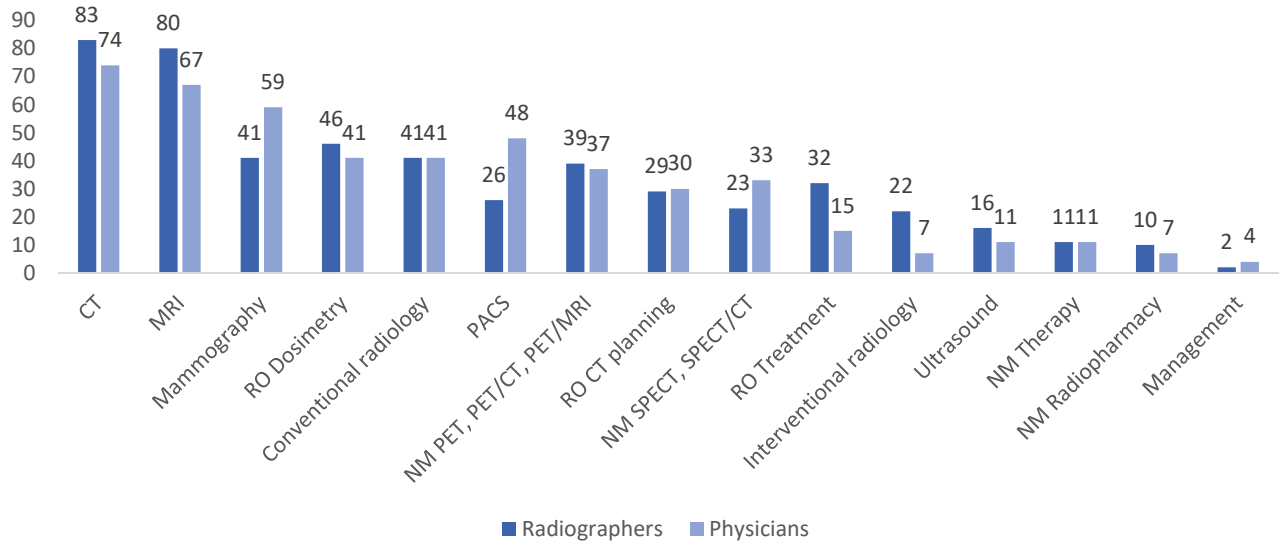

Figure 1: Radiographers' and Physicians' opinion on the possible impact of AI on medical imaging and radiation therapy specialities

Technical tasks, such as image reconstruction (85%), post-processing (68%) and dose reduction (59%) are, according to the radiographers, most affected by AI. While patient appointment management (29%), patient file management (34%), patient positioning (36%), patient safety/identification confirmation (37%), checking patient examinations (38%) are less impacted. Personalised patient care

(7%) was presented as an area little impacted by AI in the radiographer's daily routine. Physicians' results are generally similar to those from the radiographers (Figure 2).

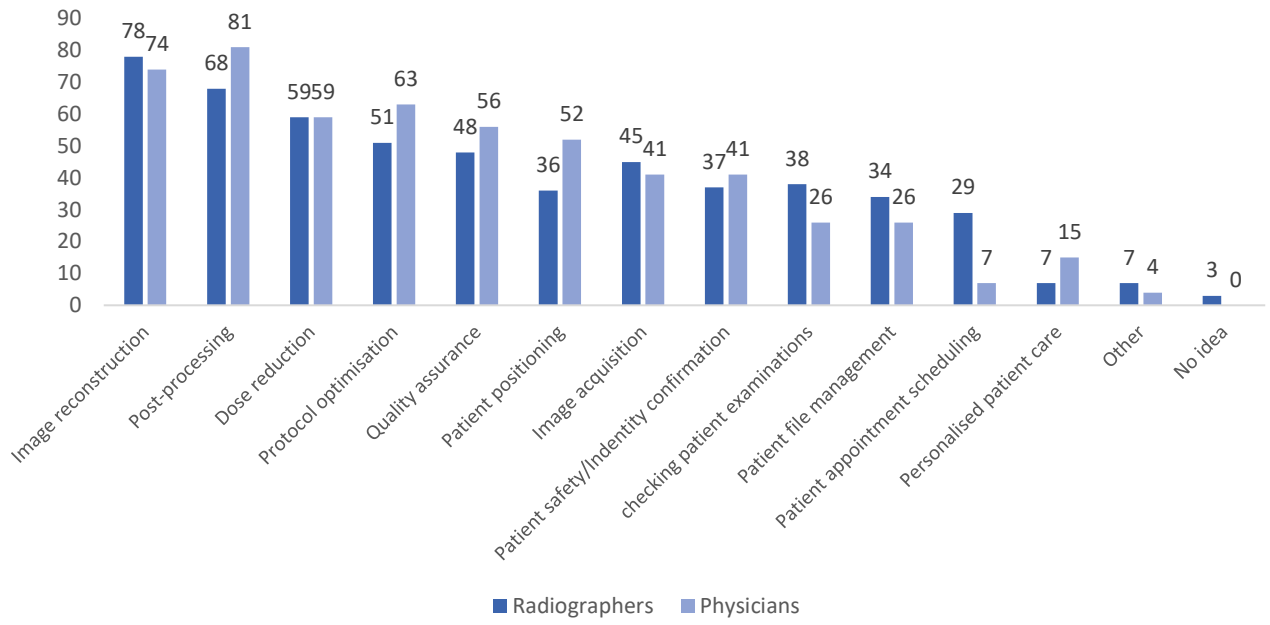

Figure 2: Radiographers' and Physicians' opinion on the possible impact of AI concerning radiographers' daily tasks

Radiographers mostly agree that the implementation of AI is going to induce change in their clinical practice or that it will improve image quality, where 80% and 90% respectively either expressed "somewhat agree" and "agree"/ "strongly agree", without perceiving it as a threat to their profession (65%). On the other hand, 60% of them expressed "negative perspectives" when asked if AI will help reduce workload and 65% indicated that if AI was a threat to the profession. Appeal for the profession showed more divided opinions where 56% scored "somewhat disagree", "disagree" or "strongly disagree" and 44% referred "positive feelings" (Figure 3a).

For all physicians (100%), image quality was also considered as something that would be improved by AI. They also agreed that better consistency on care would be found, where 93% "somewhat agree", "agree" or "strongly agree". However, as for radiographers 67% of physicians either "somewhat disagree", "Disagree" or "Strongly disagree" when asked if AI was a threat for the profession (Figure 3b).

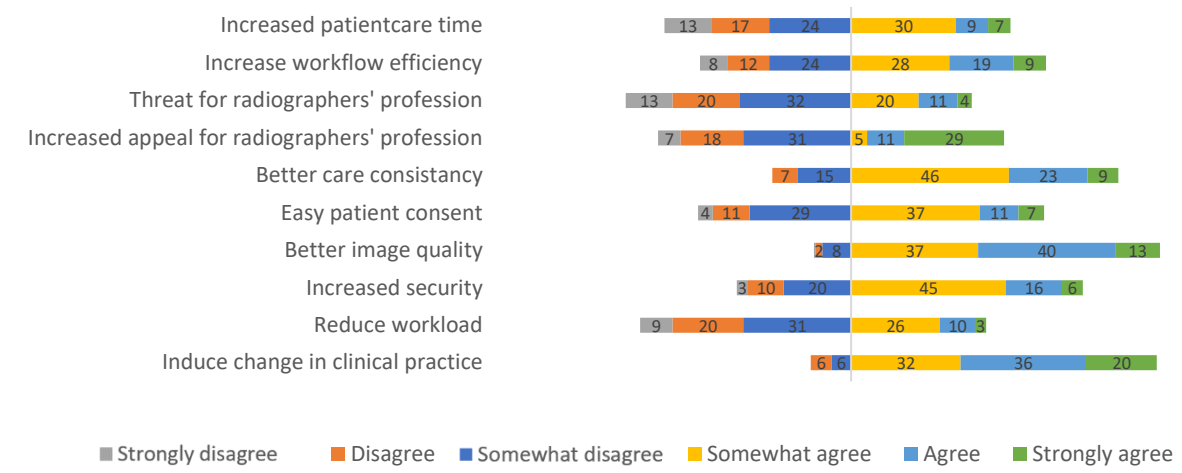

Figure 3a: Radiographers' opinion expressed as frequencies on the impact of AI on the profession (n=242)

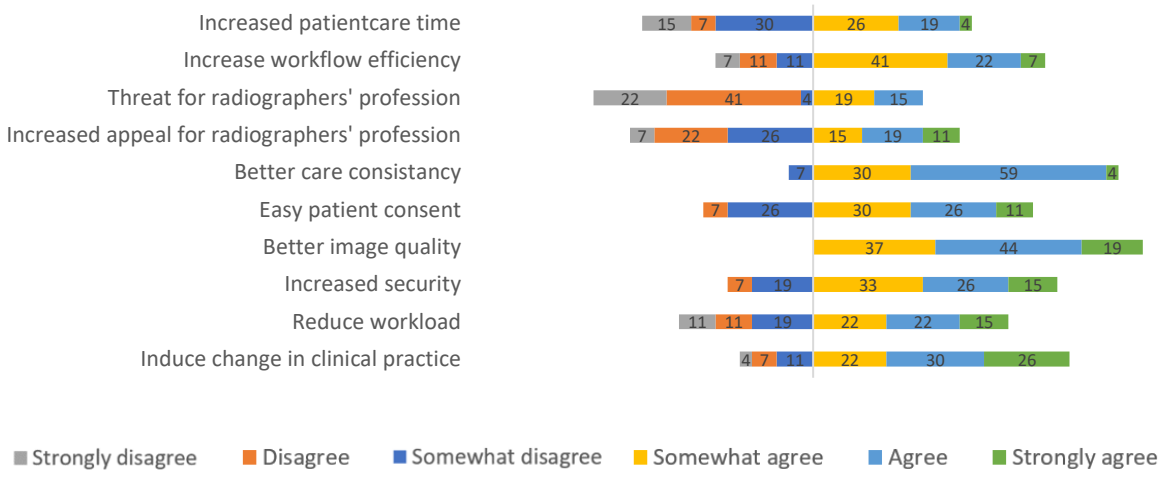

Figure 3b: Physicians' opinion expressed as frequencies on the impact of AI on the radiographer's profession (n=27)

Confidence, Knowledge, and training

Radiographers were "very confident" or "confident enough" with the use of AI technology in clinical practice (76%) (Figure 4a). However, when physicians where asked the same question regarding the confidence that radiographers have in using AI technology, much less of them seem to feel "very confident" or "confident enough" (23%) (Figure 4b). When asked how confident participants felt with the understanding of AI terminology, 66% of radiographers and 93% of physicians, expressed being "somewhat confident" or "not confident at all" (Figures 4a and 4b).

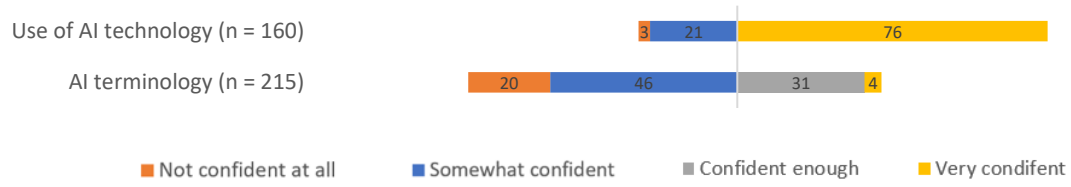

Figure 4a: Radiographers' confidence expressed as frequencies in using AI technology or understanding AI terminology

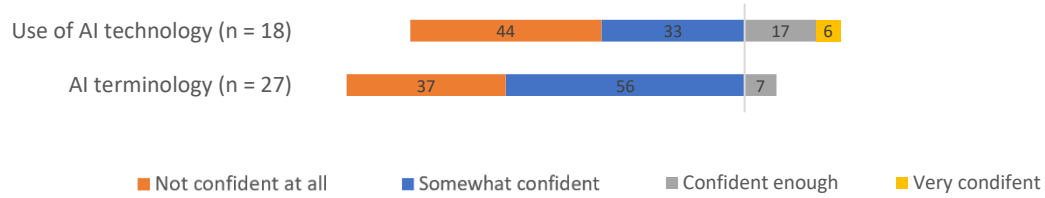

Figure 4b: Physicians' confidence expressed as frequencies in using AI technology or understanding AI terminology

Radiographers and physicians all agree that AI training should be included in the Bachelor education programs with 93% (n=225/242) of them indicating that they "somewhat agree", "agree" or "strongly agree" with this statement. Majority of them did not agree (88%) with the fact that there are sufficient existing training programs for AI. Slightly more divided opinions were found when asked about if they felt that they had sufficient training, where 69% indicated not agreeing and 31% that they did.

Radiographers indicated that AI education should be mainly delivered through Bachelor's programmes (80%), continuing education offered by the employer (69%), while e-learning or webinar (48%), thematic day (47%) and certifying continuing education (35%), were also indicated as useful resources. The survey participants indicated that Master's programmes (28%) were less popular as a means of AI education. Physician perspectives were slightly different from radiographers' opinions (Figure 5).

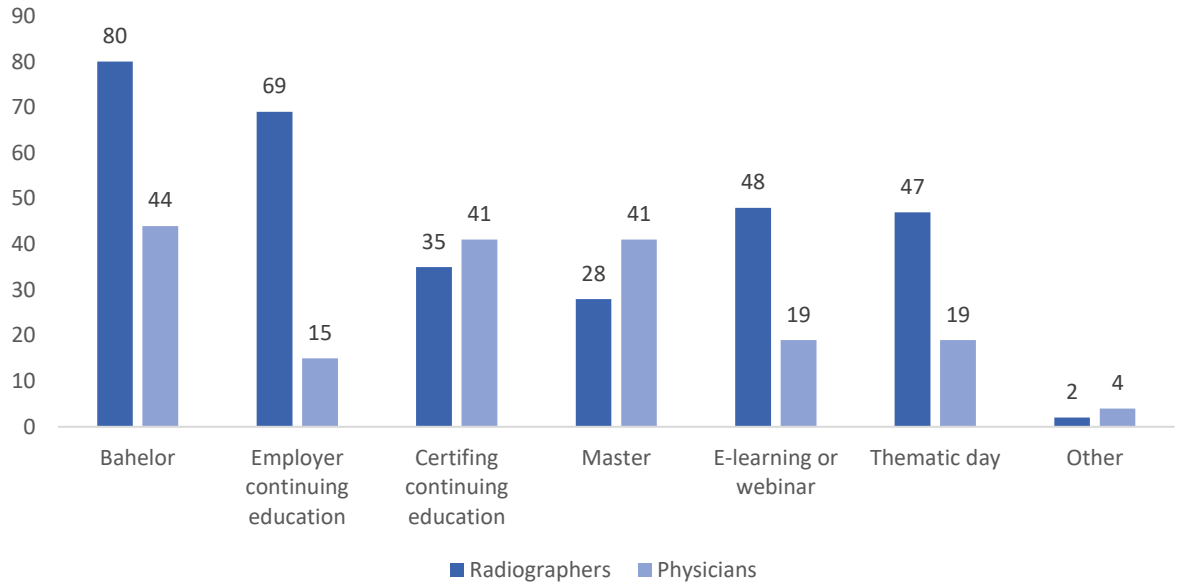

Figure 5: Radiographer and Physician opinion on how to implement AI education for Radiographers

AI: Opportunity or threat to radiographers?

More than half of the radiographers (58%) and physicians (52%) indicated that the number of workplaces will remain stable in the future, some of radiographers (15%) and physicians (30%) believed that workplaces would increase, while others (15% physicians; 24% radiographers) considered that job opportunities will decrease (Figure 6a). For both surveyed populations (radiographers: 56% ; physicians: 67%), AI is perceived more as an opportunity that a threat for the radiography profession (Figure 6b).

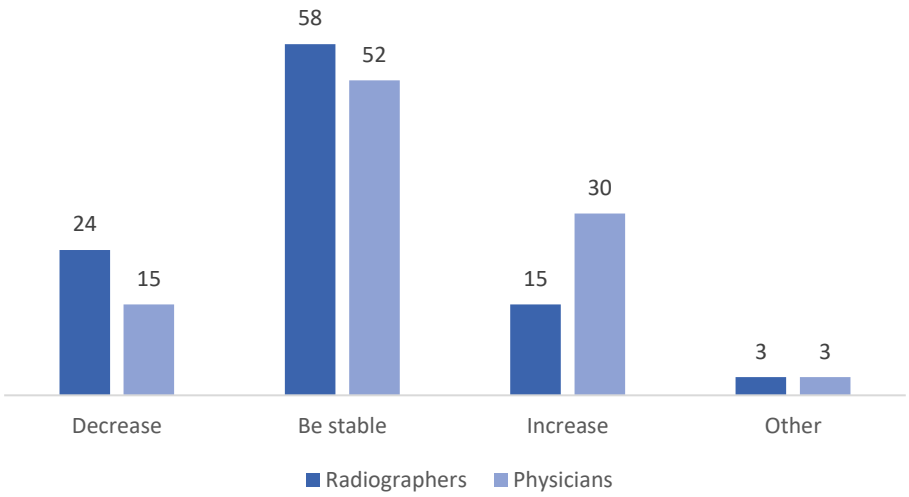

Figure 6a: Radiographers and Physicians opinion on the possible impact of AI radiographer work prospects

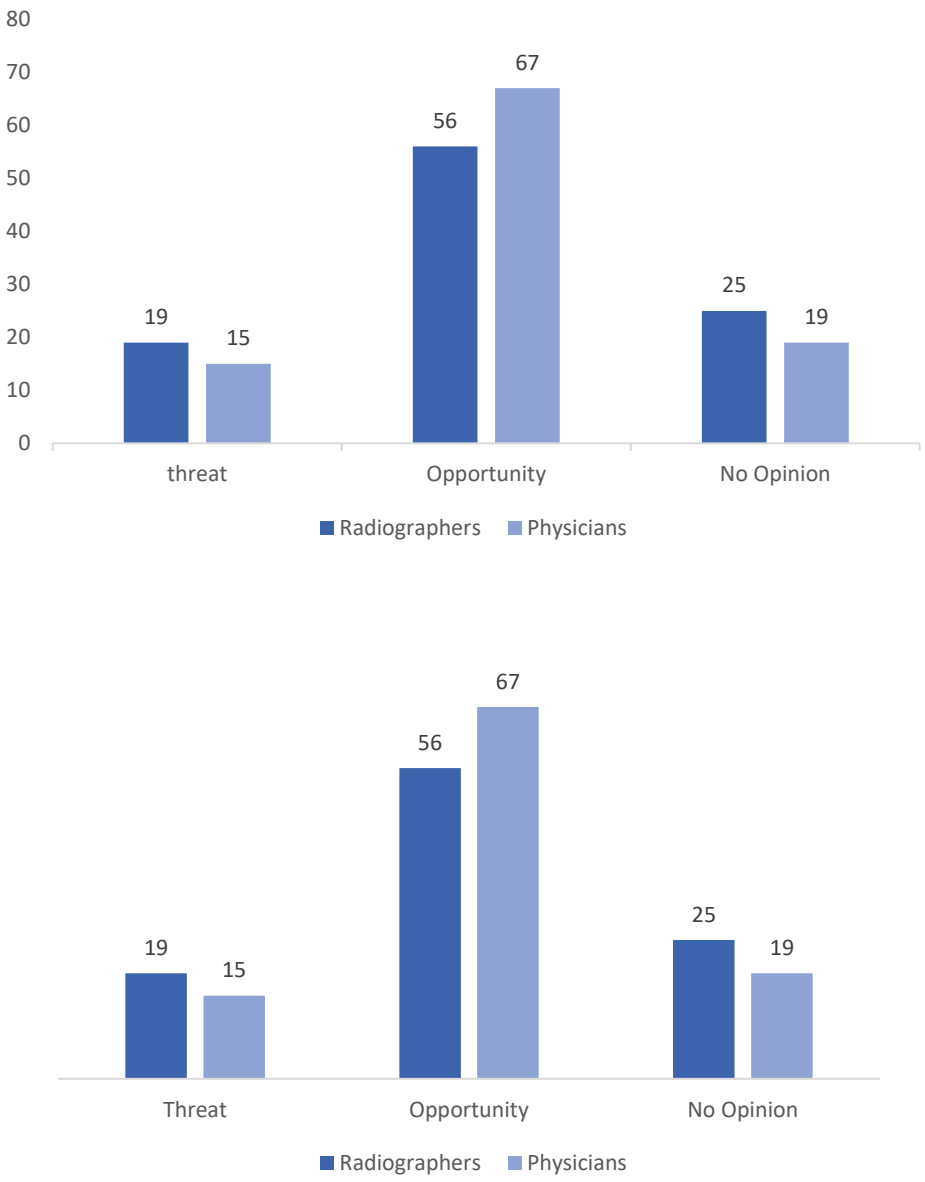

Figure 6b: Radiographers and Physicians opinion on the possible impact of AI radiographer work prospects

Qualitative Data

Open-ended questions were used to explore respondents' perception of the implementation of AI in practice (medium/long-term changes) and whether it is considered as a threat or an opportunity.

Five themes emerged from the thematic analysis: (i) **competences**, (ii) **patient centred care**, (iii) **feelings**, (iv) **professional policy** and (v) **professional practice**. All themes covered both negative and positive aspects in relation to AI, as expressed by the participants. However, an additional theme appeared as uniquely an opportunity and was titled (vi) **new perspectives**. This theme contained more codes coming from physicians namely innovation, research, advanced practice, and new responsibilities (Figure 7). Thirty codes for radiographers and 15 for physicians were identified on the

positive implications of AI, including 9 identical codes (education, personalised-care, attractive profession, reduction repetitive tasks, practice standardization, security, transformation, reduced errors, and optimisation). Thirty-two codes were identified for radiographers and 4 for the physicians on the negative implications of AI, 3 of which were identical (number of post reduction, increase number of procedures and automatisation) (Figure 7).

Medium/long term changes from the development and implementation of AI on the profession

Content and quotes from the 6 themes are described below, as well as more detailed codes in Appendix I.

Some codes were similar (autonomy, responsibility, time with patient, attractiveness of the profession) for opportunities and threats, meaning that what is seen as an opportunity for some participants was also seen as a threat by others.

Theme 1: Professional practice

Radiographers acknowledged several benefits that AI could provide for professional practice. For instance, they highlighted wordings linked to "quality", "security", "ergonomy", "justification" and "optimisation" as aspects that could be improved by AI tools. The physicians also identified positive impacts, similar to those identified by the radiographers. Some examples of radiographers and physicians' responses are shown in Appendix II.

Theme 2: Professional policy

Radiographers indicated mainly a negative future repercussion over their activities with a "*reduction of the number of job positions*", "*hiring unqualified and cheaper professionals*", "*fewer resources*", "*salary reduction*", and even the "*possible disappearance of the radiographer profession* ".

While some participants pointed out a potential negative impact of AI, others viewed it as a chance to expand patient care by reaching more individuals. They also saw it as a positive development with the potential to reshape the healthcare system, possibly leading to changes in the role of radiographers in the future. Some examples of radiographers and physicians' responses are shown in Appendix III.

Theme 3: Feelings

Radiographers expressed rather negative ***feelings*** about the development of AI in their clinical practice, mentioning for example the increase of "panic", "stress", "burn out", "pressure", "divestment", "disempowerment" and "boredom". Some examples of radiographers and physicians' responses are shown in Appendix IV.

Theme 4: Patient-centred care

Radiographers' opinion was balanced between negative and positive statements concerning the implementation of AI for patient-centred care and how it could improve this area. Positive impacts,

such as “*more time with the patient*”, “more personalized examinations tailored to the patient”, or the “development of new skills or responsibilities”, increasing the patient experience and satisfaction. Some examples of radiographers and physicians’ responses are shown in Appendix V.

Theme 5: Competences

Radiographers raised concerns about a possible negative impact in their competences due to the implementation of AI in the clinical practice, compromising their “expertise, reflexivity and decision-making ability in protocol adaptation”.

"[...] Additionally, there will be power outages, and we won't be able to use AI, and we'll feel sorry for ourselves about not knowing how to function without it." **(radiographer)**

Other radiographers stated AI use as an opportunity to acquire “new competences, responsibility, knowledge, skills”, leading to an increase in “autonomy”, highlighting the need of a better “education, CPD and specific AI training”. Some examples of radiographers and physicians’ responses are shown in Appendix VI.

Theme 6: New perspectives

Participants emphasised also the possibility of a positive impact of AI implementation in advancing practice in different fields such as “complex tasks accessibility, diagnostic tasks development with AI assistance or pre-reporting, medical tasks delegation, AI data/quality manager position, research, increased autonomy, diversification of profession either in patient related task or equipment related task”. Some examples of radiographers and physicians’ responses are shown in Appendix VII.

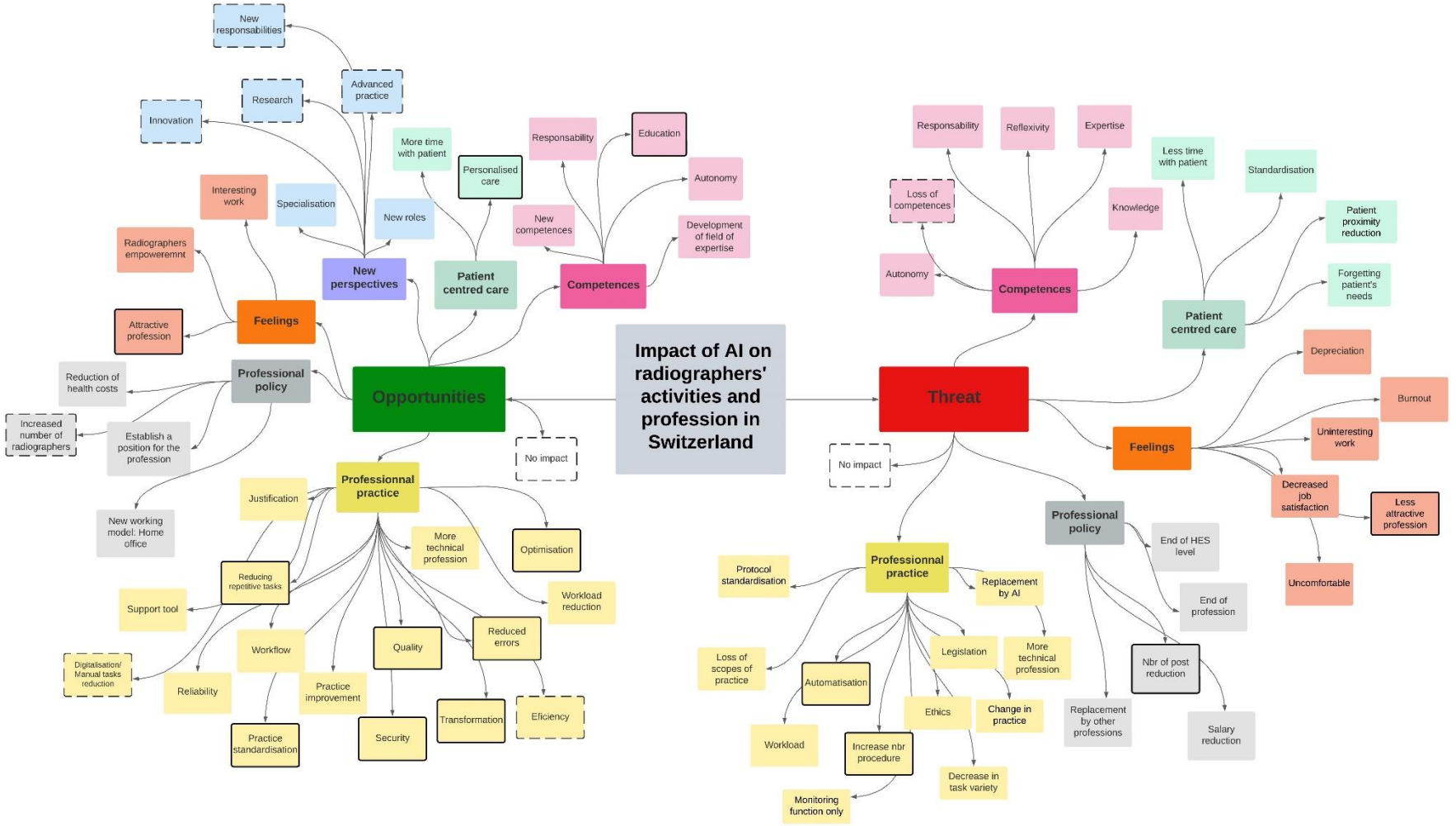

Figure 7: Radiographers & Physicians extracted themes concerning impact of AI as threat or opportunity for radiographers' activities and profession in CH

Note: Codes in the boxes that have the border highlighted by (- - -) are the codes given by physicians only, the non-highlighted boxes are the codes emerging from radiographers and codes with a solid line are common codes identified by both professions

Discussion

The study aimed to explore the perspectives of radiographers and physicians regarding the impact of AI on radiographers' profession in both fields of medical imaging and radiation therapy. Our results, based on 242 responses (89% radiographers, 11% physicians), indicate that while 43% use AI in clinical practice, 63.8% lack confidence in AI terminology. Participants predominantly view AI as an opportunity (57.2%) but also as a threat (18.5%), with concerns about job reduction (22.6%) and automation bias (16.4%). A significant majority (68.3%) feel unprepared for AI implementation due to the absence of specific training (87.6%), and 93% believe AI education should be integrated into undergraduate programs.

AI Application and its impact on medical imaging modalities and specialties

Participants believe that AI will mainly have an impact on CT and MRI, the two modalities in which participants had the most experience. When asked about their expectations regarding the impact of AI on various aspects of their daily activities, radiographers as well as physicians, believed that the technical part of their job, such as image reconstruction, post-processing, and protocol optimisation, would be the main areas impacted by this technology. Both populations surveyed agree that AI will induce changes in clinical practice, with positive aspects such as better image quality and enhanced safety, including reduced radiation doses for patients and better support for managing patient data.

However, radiographers and physicians seem to disagree on the impact of AI on workload, with physicians being more positive and believing that AI will reduce the workload. This discrepancy may partly be attributed to the limited sample size of physicians. Additionally, the payment system applied in Switzerland, considering that physicians are paid per "act", while radiographers receive a salary that does not take in account the work volume (19). Other studies (20,21) have also indicated a positive attitude towards AI among physicians, most likely due to the AI support in reducing the interpretation time. However, this increase in workload can impact on the accuracy of radiologists. According to Alexander at al. (22), a minimum time should be required to avoid the detection and interpretation errors since it is one of the main issues in lawsuits currently in USA for malpractice in Radiology. The authors advocate that studies must be conducted to identify how many examinations or images radiologists can review in any period of time (number of studies per day or images per unit time) while maintaining accuracy not to compromise the medical imaging outcome. The aim is to provide an examination that supports adequately the choices made regarding follow up and treatment for the patient to achieve the best outcome and quality of life.

Confidence, Knowledge & training

Radiographers exhibited a comparatively high level of confidence in the practical application of AI technology (76%), yet they experienced lower confidence levels when it came to comprehending AI terminology (66%). In contrast, physicians showed lower confidence levels in both aspects using AI technology (23%). This may be linked to the access to education and training, participation in conferences or closer contacts with industry, which is more limited for radiographers (21).

Regarding education, participants considered that it should be mainly delivered through the Bachelor's program, 69% of radiographers indicated that their employers should offer them a specific training program, and 15% of physicians agree to this. This difference in opinion is partly explained by the role of clinicians in Switzerland, who, as department heads, decide whether they can afford the training provided to radiographers. Indeed, since the costs of training are borne by the department, physicians may hesitate to incur these expenses for budgetary reasons.. Similar observations were identified in other countries (13,14,23–29) when compared to the Swiss context. Switzerland also faces a deficiency of AI training programs. This has been included in the design of the new Bachelor's degree program being offered in Western Switzerland, and the AI steering committee is already planning to offer a continuing development program to radiographers who are currently practicing in clinical centres. Similar programmes have now started to begin in Europe for radiographers (7). This aligns with The Society and College of Radiographers guidance for AI (30,31) and recommendations available in the literature (32), showing a tendency in Switzerland to evolve in this direction.

Opportunity & Threats for future

Both populations (radiographers: 56%; physicians: 67%) considered AI as an opportunity for the radiography profession, but also mentioned fears. Physicians were more positive than radiographers about its impact on the profession. They even suggested that the implementation of AI would induce a possible increase in the number of workplaces for radiographers (physicians 30% versus radiographers 15%). In comparison to 56% of radiographers, 67% of physicians thought that AI represents an opportunity for the radiographer profession as the development of new responsibilities, involvement in research and innovation, and advanced practice. This view corresponds to what radiographers should be doing in the future according to the various recommendations already published (30–32). Swiss radiographers need to position themselves, with the support of professional associations and medical doctors, in taking a proactive, collaborative role in the deployment, evaluation and monitoring of AI in clinical practice with the specific competences in image analysis, quality, and safety that are part of the radiographer's roles (33).

The thematic analysis revealed a striking duality in radiographers' perceptions since certain aspects were identified as both opportunities and threats. One illustrative example is the person-centred care. Radiographers suggested that the introduction of AI holds the promise of relieving the burden of repetitive and time-consuming tasks, enabling professionals to allocate more time and attention to

patients. On the other hand, radiographers' perception about AI's potential to expedite examinations could lead to a reduction on the interaction with patients, driven by higher workload and promoting impersonalised healthcare within the profession. This workload, which is already present in the departments, intimidates radiographers who fear that it will increase even more, leading to burnout or to quit the job (34). In addition, the fear that less qualified people will be hired was highlighted, devaluing the level of radiographers' profession, for both technical and human competences and skills. These concerns emphasise the importance of ongoing discussion and collaboration among stakeholders, including radiographers, physicians, educators and policymakers. This collective effort will be essential in harnessing AI's potential to elevate clinical practice, ensuring patient-centred care, and navigating in the evolution of healthcare landscape.

Internal consistency

The assessment of the internal consistency of this survey was low, according to According to Tavakol & Dennick (2011) (35), an insufficient number of questions, inadequate inter-item correlations or the presence of heterogeneous constructs can potentially have an impact on Cronbach's alpha coefficient. In addition, the translation of the survey resulted in responses in different languages, and some participants responded in a non-native language, which may affect the consistency of the scale. The lower score compared with the study by Rainey et al, (14) which used the same questionnaire could be due to differences in stratification (physicians and all modalities and disciplines radiographers versus diagnostic & therapeutic radiographers) or to differences in level of training, given that in Switzerland only one region has Bachelor's level training.

Study limitations

Despite the valuable information it provides, this study is subject to certain limitations. The fact that the survey was conducted in several languages, while could introduce variability into the responses owing to not fully covering the country's four official languages. Variations in response rates, particularly among physicians, could introduce biases and affect the generalisability of the results. Moreover, relying on self-reported scales has potential limitations related to respondent understanding and bias. However, the credibility of our study is enhanced by the pilot study that was conducted before dissemination, involving both radiographers and physicians from a variety of backgrounds taking into account these limitations to improve the validity of the results.

Implications for practice and future research

To maximize the potential of AI in healthcare, several key recommendations emerge. Alongside, the integration of AI into the Bachelor's curriculum and offering CPD, there is a strong emphasis on promoting interdisciplinary collaboration. This collaboration should be extended by involving

radiographers, physicians, patients, and engineers. By fostering joint educational initiatives, particularly between radiographers and physicians, a deeper understanding of perspectives can be achieved, enhancing teamwork within AI-driven healthcare environments. This approach ensures a holistic implementation of AI, aligning with patient-centric care and overall healthcare improvement.

Exploring the patient perspective on AI could be a domain fully explored by future research. This exploration could shed light on patients' perceptions and expectations of AI in healthcare, providing valuable insights into potential benefits and concerns from an end-user perspective and by applying explainable AI tools. Furthermore, in order to develop training programmes that meet the clinical needs of professionals, it would be useful for future studies to examine this area in greater depth and to question them on this subject.

Conclusion

The impact of AI on radiographers' profession and activities is multifaceted and presents both opportunities and challenges. The study highlights the need for comprehensive AI training to be integrated into radiography/medical radiation science education, collaboration between stakeholders to adapt to the roles that are changing, and proactive measures to address concerns around job stability, competences and skills retention. By leveraging this knowledge, radiographers can better prepare for the changing healthcare landscape driven by AI technology.

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Appendix I: Medium/long term changes from the development and implementation of AI on the profession

		Professional practice	Professional Policy	Competences	Patient centred care	Feelings	New perspectives
Radiographers (n=215)	**Positive impacts**	• Support tool •Development/adaptation/transformation • Optimisation (dose reduction, protocol, post-processing, ttt plan, patient positioning) • Optimisation appointment scheduling • Change and evolution of the role • Better patient identity surveillance • Modification of the terms of reference • Reduction of administrative tasks • Facilitated work • Better workflow and workflow control • Post-processing reduction • Better Image reconstruction, artefact reduction, ttt planning, segmentation. • Less like physicians' assistants • Ergonomy • Security • Quality • Better medical records management • Time saving (exam, analysis) • No impact • Protocols diversity • Reduction of unnecessary examinations • Reduction of exam repetition • Justification • Errors reduction • Inter & Intraprofessional collaboration • Repetitive tasks reduced • New way to work • Better reproducibility • More time • Complexity reduction • Better organization • To be seen • Change in practice • Job more technological • More radiographers specialists by modalities • Increased number of patients • Precision • Better data transmission • Investment required (otherwise radiographers will become mediocre) • Improvement in working conditions • Job revolution • More IT management • Patient-computer interface	•Radiographer role modification • Professional development •Independence relative to the physician • Change in profession • New positions • New profiles of students • More recognition • New profession with many specialisations	•New competences • New responsibilities • Education (CPD & specific Master) • More IT based training • Autonomy • Improved and new knowledge • Expertise related to AI in imaging • AI integrated into Basic Training (Bachelor level) • Dosimetry more accessible in radio oncology • Contour organs at risk more accessible • Better communication • Better interdisciplinarity • Developing skills for more complex tasks	• More time allocated to patients • Personalized care • Person-centred care • Change in patient management • Time saving for patients • Improved quality of care • Increased caregiver aspects • Interface between the patient and the AI (explain) / mediator between AI-patient • Patient focus • Personalized examination/protocol • Radiographer still needed for patient care • More accurate diagnosis • Decrease of waiting time before examination • Mainly human job	•Attractivity • Valorisation profession • Solidarity • No fear	•Complex tasks more accessible • Images reading/reporting with CAD (screening mammography, emergency) • Medical delegation • Data manager position • Advanced practice • Responsibilities with access to non-radiographers' tasks • Research • Pre-diagnostic • Pre-reporting • Independence (relative to physicians) • Opening of radiology center • Radiographers consultation • 2 different cursus: patient or programming • 2 different curricula: patient or programming • Physician's associate radiographer (no longer a subaltern) • Privileged links with clinicians or emergency unit • New positions: Quality assurance manager for AI-based systems or AI-mediator/explainer, algorithm design and training • Collaboration with engineer • Transfer of medical tasks to radiographers (post-processing, reading, and reporting)

	Negative impacts	• Procedures establishment needed • Replaced by AI • Increased workload • Increased work pace • Many tests to do for AI implementation (comparison with and without AI) • Bugs and problems • No time savings => AI errors • Relevant? Still under development • Automatisation / robotisation • IT work => new profession • More technological work • Image quality reduction • Asymmetry between centers with and without AI • Benefits to be demonstrated • Less contact with physicians • Technical problems and delays • Radiographer will have their "AI-assistant" • Practice less centred on image and image quality • Workflow • Time of adaptation and understanding needed • Fewer general radiographers • Do more with less	• Positioning radiographers' profession to avoid disappearing • Lobbying • No lobby (prof. group too small): big loss (salary...) • Reduction of the number of jobs positions • Legitimacy • Costs /economic efficiency • Shortage radiographers • Replacement and hiring of medical assistant /specialized nurses (eg: for radiography) • Hiring unqualified and cheaper people • Fewer resources (staff, time...) • Expanded radiographer activities but performed by other professionals • Trained radiographers = enhanced engagement • Job description modified • IT staff in the departments needed • Salary reduction • Facilitated training of medical assistants for cross-sectional imaging • End of profession • New sub-category of radiographers • Employer: find new tasks • Reassignment of radiographers to new positions • Justification of radiographers' positions • AI technologist • Two levels of radiographers: position patients/care givers & monitor function	• Loss of competences • Loss of decision-making ability (protocol choices and adaptation) • Loss of expertise • Level regression • Loss of reflexivity • Button Pusher • Consideration of the ecological crisis: blackout that will prevent the use of AI (we will complain about not knowing how to do without) • Monitoring function only • Loss of technical skills • Loss of identity for our profession	• Explain AI to patient needed • Changes in patient interaction • Patients' needs, expectations and problems are forgotten • Loss of caregiver role • Deterioration of the person's care • Reduction in patient comfort • Increased risk to the patient • Radiographer profile less human • Decrease in quality and comfort (factory +++)	• Panic • Divestment • Disempowerment • Lack of interest • Fear • More stress • Less involvement • Burn out • Resign • Factory +++ • Diseases of youth: trial and error and uncertainty • Benefits to be demonstrated • Discouragement • Team exhaustion • CT and MRI: boring job • Fatigue • More trust in AI than in radiographers • Loss of motivation • Discouragements • Pressure	
Physicians (n=27)	**Positive impacts**	• Support tool • Increased work pace • Repetitive and boring tasks reduced • Facilitated work • No impact (more for physicians) • Standardization • Quality (quality insurance, protocol, images, diagnostic performance, …) • No specific idea • Security • Optimization (time, images, efficiency, triage) • Simplification of complex tasks • Progressive improvement • Evolution of the profession in data science • New/better workflows • Transformation • More and more tasks performed by softwares	• Professional development (as nurses) • Job description modified • Increased role of radiology in the health care system	• New competences • Education (CPD) • New knowledges • New experiences • Responsibilities • Improved radiographers' performance • Better skills	• Focus to patients with specific needs • More time allocated to patients care	• Hype • Confidence • Adaptation • More interesting work • More involvement	• CADx, Pre-CADx • Image reading assistant for physicians

	Negative impacts	• Controller function • Automatisation / robotisation • Overtime: duplication (human and AI) • No reduction in workload	• Reduction of the number of jobs positions • Death of the profession in 50 years • Replacement by non-radiographers professional	• Software dependency • Generational (or trained) radiographer shift • Algorithm transparency • Creative power decrease (software)	• Less time allocated to patient • AI will set the standard	• Slow adaptation • Confusion and difficulties	

Note: AI: Artificial Intelligence - CAD: Computer aided detection - CADx : Computer aided diagnosis - CPD : Continuing professional development - CT: Computed tomography – MRI: Magnetic resonance imaging – TTT: treatment

Appendix II: Participants' opinions about medium- and long-term impact of AI in clinical practice related to professional practice (theme 1)

"I don't see AI as a substitute, but as additional help and safety for patients" **(radiographer)**

On the other hand, the participants raised concerns about the negative impact that AI can have on radiographers' practice, resulting for instance in an increase in workflow impacting care quality, critical thinking and de-skilled healthcare professionals leading to safety and ergonomic related issues.

"[...] If AI allows for more patients to be seen in the same amount of time, then employers will seize the opportunity..." ***(*****radiographer)**

"Radiographers will become increasingly reliant on software and will gradually become slowly more robotic." **(physician)**

Appendix III: Participants' opinions about medium- and long-term impact of AI in clinical practice related to professional policy (theme 2)

"AI will allow employers to hire medical assistants or unskilled individuals at a lower cost to replace radiographers for routine exams." **(radiographer)**

"AI will take over many tasks currently performed by radiographers. Consequently, the demand for radiographers will decrease drastically, along with significant changes in daily practice." **(radiographer)**

"Increase in the number of patients but be cautious as I believe the risk of professionals leaving the field is also higher, and there's a risk of having exhausted teams if the workload increases." **(radiographer)**

"To this question, I feel like saying "let's be bold": Opening independent radiology centers with only radiographers who outsource the interpretation of exams to radiologists located abroad. The technologists will be able to perform any type of exam, whether it's CT, MRI, or X-ray, ensuring no emergencies at the end of the exam." **(radiographer)**

"The profile of individuals who will choose the profession will change." **(physician)**

Appendix IV: Participants' opinions about medium- and long-term impact of AI in clinical

practice related to feelings (theme 3)

"[...] Always trying to do more in a minimum amount of time, even if it leads to a shortage of radiographers (burnout, resignations, etc.). This is already the case currently. [...]" **(radiographer)**

"*In conventional radiography, not much will change! In CT scans and MRI, working at the console might become tedious for the radiographer*." **(radiographer)**

The physicians expressed more moderate feelings regarding the impact of AI on radiographers' activities, mentioning the "need for involvement", "slow adaptation", "potential confusion", and "some challenges". However, they also identified the opportunity to make the "work more interesting".

Appendix V: Participants' opinions about medium- and long-term impact of AI in clinical practice related to patient-centred care (theme 4)

"I believe our profession will no longer be solely technical but will be more focused on patientcare and building relationships with the patients." **(radiographer)**

On the other hand, negative perspectives such as a "*deterioration of patient care*" due to a "*time reduction with the patient*", "*forgetting about the patient's needs, problems and expectations*", which could impair patient-centred care were also mentioned.

"There's a risk of forgetting our role as caregivers and that we have a human being in front of us with all their expectations and issues." **(radiographer)**

"Probably the radiographer will become more technical in aspects like data science and algorithms. And on the other hand, the time spent in patient facing activities will reduce." **(physician)**

Appendix VI: Participants' opinions about medium- and long-term impact of AI in clinical practice related to competences (theme 5)

"We'll see the emergence of profiles of radiographers who are experts in AI. The profession will expand its areas of expertise. Radiographers will be able to collaborate with engineers in designing various algorithms related to the field." **(radiographer)**

"[...] Radiographers could be responsible for the quality assurance of AI-based systems, acting as communicators to both team members and patients to explain AI concepts. The shift of technological aspects towards AI might also strengthen the radiographers' caregiving skills." **(radiographer)**

Appendix VII: Participants' opinions about medium- and long-term impact of AI in clinical practice related to new perspectives (theme 6)

"We can develop new roles and positions, such as advanced practice, research, and serving as mediators between AI and patients through radiographer consultations." **(radiographer)**

"Probably a reorganization of radiographers' practices, more radiography-related research, and increased expertise in AI imaging. Plus, new types of positions." **(radiographer)**

"A greater involvement of radiographers in diagnostic imaging with increased responsibilities, similar to the evolution of the nursing profession." **(physician)**