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Research Article

An insight into the current perceptions of UK radiographers on the future impact of AI on the profession: A cross-sectional survey

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ABSTRACT

Introduction: As a profession, radiographers have always been keen on adapting and integrating new technologies. The increasing integration of artificial intelligence (AI) into clinical practice in the last five years has been met with scepticism by some, who predict the demise of the profession, whilst others suggest a bright future with AI, full of opportunities and synergies. Post COVID-19 pandemic need for economic recovery and a backlog of medical imaging and reporting may accelerate the adoption of AI. It is therefore timely to appreciate practitioners' perceptions of AI used in clinical practice and their perception of the short-term impact on the profession.

Aim: This study aims to explore the perceptions of AI in the UK radiography workforce and to investigate its current AI applications and future technological expectations of radiographers.

Methods: An online survey (Qualtrics®) was created by a team of radiography AI experts. The survey was disseminated via social media and professional networks in the UK. Demographic information and perceptions of the impact of AI on several aspects of the radiography profession were gathered, including the current use of AI in practice, future expectations and the perceived impact of AI on the profession.

Results: 411 responses were collected (80% diagnostic radiographers (DR); 20% therapeutic radiographers (TR)). Awareness of AI used in clinical practice is low, with DR respondents suggesting AI will have the most value/potential in cross sectional imaging and image reporting. TR responses linked AI as having most value in treatment planning, contouring, and image acquisition/matching. Respondents felt that AI will impact radiographers' daily work (DR, 79.6%; TR, 88.9%) by standardising some aspects of patient care and technical factors of radiography practice. A mixed response about impact on careers was reported.

Conclusions: Respondents were unsure about the ways in which AI is currently used in practice and how AI will impact on careers in the future. It was felt that AI integration will lead to increased job opportunities to contribute to decision making as an end user. Job security was not identified as a cause for concern.

RÉSUMÉ

Introduction: En tant que profession, les radiographes ont toujours été désireux de s'adapter et d'intégrer les nouvelles technologies. L'intégration croissante de l'intelligence artificielle (IA) dans la

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pratique clinique au cours des cinq dernières années a été accueillie avec scepticisme par certains, qui prédisent la disparition de la profession, tandis que d'autres suggèrent un avenir brillant avec l'IA, plein d'opportunités et de synergies. La nécessité de relancer l'économie après la pandémie de COVID-19 et l'accumulation d'images et de rapports médicaux pourraient accélérer l'adoption de l'IA. Il est donc opportun d'apprécier la perception qu'ont les praticiens de l'IA utilisée dans la pratique clinique et leur perception de l'impact à court terme sur la profession.

But: Cette étude a pour but d'explorer les perceptions de l'IA au sein de la profession de radiographe au Royaume-Uni et d'étudier les applications actuelles de l'IA et les attentes technologiques futures des radiographes.

Méthodologie: Une enquête en ligne (Qualtrics®) a été créée par une équipe d'experts en radiographie avec IA. L'enquête a été diffusée via les médias sociaux et les réseaux professionnels au Royaume-Uni. Des informations démographiques et des perceptions de l'impact de l'IA sur plusieurs aspects de la profession de radiographe ont été recueillies, notamment l'utilisation actuelle de l'IA dans la pratique, les attentes futures et l'impact perçu de l'IA sur la profession.

Résultats: 411 réponses ont été recueillies (80 % de radiographes diagnostiques (RD); 20 % de radiographes thérapeutiques (RT)). La connaissance de l'IA utilisée dans la pratique clinique est faible, les répondants RD suggérant que l'IA aura le plus de valeur/potentiel dans l'imagerie transversale et le rapport d'image. Les réponses des RT indiquent que l'IA a le plus de valeur dans la planification du traitement, le contourage et l'acquisition/la correspondance des images. Les répondants ont estimé que l'IA aura un impact sur le travail quotidien des radiographes (RD, 79,6 %; RT, 88,9 %) en standardisant certains aspects des soins aux patients et des facteurs techniques de la pratique de la radiographie. Les réponses concernant l'impact sur les carrières sont mitigées.

Conclusions: Les répondants ne sont pas certains de la manière dont l'IA est actuellement utilisée dans la pratique et de l'impact qu'elle aura sur les carrières à l'avenir. Le sentiment général est que l'intégration de l'IA conduira à une augmentation des opportunités d'emploi pour contribuer à la prise de décision en tant qu'utilisateur final. La sécurité d'emploi n'a pas été identifiée comme une source d'inquiétude.

Introduction and background

Artificial intelligence (AI) has attracted attention and debate in the imaging community, in particular, the emergence of 'modern AI' i.e. the use of machine learning (ML) and deep learning (DL) technologies in medicine, which clinicians are unfamiliar with. The practice of radiology as we know it today would not exist without technology [1]. However, the integration of these modern AI solutions has become a divisive topic, with some studies reporting clinicians' hesitancy [2] and others expounding the merits of a future with AI [3,4]. Hesitancy may be due to uncertainty of the impact of AI on clinical practice, the rapid rate of development of newer technologies and the impact this will have on jobs and career prospects. AI is already present in healthcare and new applications are evolving which have the potential to affect clinical practice further [5–8]. However, it is yet to be fully established if the use of advanced AI will benefit or hinder clinical workflow.

The current landscape and 'near-future' of AI in radiography

There is limited data available on the opinions of radiographers on the future of radiography with AI, however, several studies report positive attitudes of radiographers to a technology enhanced future [4,9]. Use of technology and change have been an accepted part of radiography practice [1,9], although modern AI using DL is presenting its own unique challenges and it is anticipated that an even greater degree of adaptability may be required [6], particularly in the post-COVID era, where additional applications of AI are used to support workflows and minimise reporting backlogs [10,11].

Applications of AI are present in current radiography practice, ranging from workflow assistance to assisted diagnosis and treatment planning [3,6,8,12]. These systems are based on complex computer algorithms and their functionality is not always easily understood by the clinical end-users. This may be due, in part, to variation in the terminology used in the AI literature, with many different architectures and performance metrics employed, which clinicians are not familiar with [13]. Lack of understanding may contribute to clinicians' heightened awareness of the potential system idiosyncrasies, potential for machine error, and ethical, legal and trust issues in the medical imaging community [4,9,14–16].

Reimagining the future of radiography roles with AI

It has been predicted that AI will change professions, roles will be reimagined, and more mechanistic tasks may be entirely replaced [6–14]. A negative depiction of AI in the media together with dichotomy of opinion regarding AI in the literature may influence the perceptions of clinicians and may impact the attractiveness of radiology as a career [5,17,18]. However, it is important to note that there is a paucity of information in the published literature regarding radiographers' perceptions on this topic. Sit et al. [17], found that approximately 50% (n = 242) of UK medical students felt that AI would make them less likely to consider radiology as a specialism, and that some roles would be entirely replaced by AI within their lifetime. Similar results are reported in Canada and America, with 48.6% of respondents responding that they 'felt anxious' about choosing radiology as a specialism [18,19].

Further understanding is needed about radiographers' perceptions of the impact of AI on radiography as a career, to

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ensure adequate recruitment and retention of the workforce. It has been postulated that there will be dramatic changes in both healthcare planning and job roles [6]; new roles will emerge in AI development and implementation pathways, which will have an impact on workforce planning and develop enhanced roles. Recent research suggests that successful implementation of AI can be facilitated by the provision of clinical AI 'champions' [20] i.e. staff who are well educated and proficient in the use of AI systems. This is supported by professional recommendations from the UK Society of Radiographers (SoR) and in a joint statement from International Society of Radiographers and Radiological Technologists (ISRRT) and European Federation of Radiographer Societies (EFRS), where generation of new roles for the future of the profession is suggested [21,22]. The formation of new expert groups, involving developers, clinical end users and service users in each stage of the development process to enhance trust in and integration of new technologies has been recommended [23]. This has been facilitated in the UK with the recent formation of the SoR Artificial Intelligence Advisory Group (https://www.sor.org/about/get-involved/advisory-groups/artificial-intelligence-advisory-grouph). Yet, to the authors' knowledge, there is no current research around the ability of radiographers to promote, direct and champion the effective implementation of AI technologies within clinical settings. As the rate of development and implementation of clinically useful AI solutions are predicted to accelerate [6], these roles will be essential to ensure the safe, efficient integration of AI into clinical radiography [20].

Shifting the paradigm to radiographer' perceptions in relation to AI

AI solutions are now trialled increasingly on patient-facing tasks e.g. ascertaining patient identification, auto-positioning, dose optimisation, calculating contrast agent dose and flow rate [1,12,24,25]. Therefore, one could wonder what the future holds for radiographers [26]. Radiographers are technologically adept and proficient at coping with rapid changes in technology [1,25,27]. As key patient-facing users of the technology, they are in a prime position to advise on the most effective use of AI and to critically engage with and champion new technology. However, many studies report that radiographers feel that they are not knowledgeable enough with respect to newer forms of AI, using machine and deep learning. The results of the first part of this survey found that 57% of diagnostic radiographers (DR) and 49% of therapeutic radiographers (TR) felt that they were not adequately trained in AI to be able to implement it in the clinical setting [28]. This finding was similar to other national surveys of radiographers in the United Arab Emirates (UAE), Australia and Ireland [2,3,9]. Several professional guidance documents for radiography seek to ensure the workforce is prepared for the future with AI, with direction provided for educators, employers and pertinent research outlined [21,22,29].

Rationale and aims

This paper reports the second part of a larger survey, which attempts to provide a snapshot of the current landscape in UK radiography. The main aim is to investigate the perceived impact of AI on radiography as a profession. The objectives are 1) to investigate the current perceptions of the UK radiographers on practice of AI and 2) explore their future expectations of the impact that AI will have on radiography as a profession.

Methods

Questionnaire design and recruitment of participants

A Qualtrics® e-survey was designed based on the available literature, refined, and revised by a team of experts in AI in radiography representing clinical, academic and research fields. It incorporates themes presented in SoR AI Guidance Document for Clinical Imaging and Therapeutic Radiography Professionals [22]. The study was structured and reported to adhere to a Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [30]. Ethical permission was gained from City, University of London Research Ethics Committee (ETH1920-1989).

Participants were recruited via dissemination of an e-link to authors' professional networks and publicised further on LinkedIn® and Twitter®, therefore convenience snowball sampling was employed to recruit respondents [31]. The survey was open from the 12th February to the 6th April 2021.

On accessing the survey, background information, rationale, aims, and objectives were presented to participants. Explicit consent was sought by asking participants to read the information and click an icon to gain access to the survey. Each participant was asked to confirm that they were a practicing radiographer by selecting their current role from a drop-down list. There were no incentives given to complete the survey. Participants were permitted to navigate back to previous questions, although a full overview of responses was not given. Participants were permitted to leave and return to the survey to maximise completion rate. A final slide notified participants when the survey had been submitted.

The survey instrument

The full survey was divided into six blocks with 91 questions in total – (i) demographics, (ii) AI knowledge, (iii) skills and confidence in AI, (iv) perceptions of the impact of AI on clinical practice, (v) expectations of the future of radiography with AI and (vi) the effect AI may have on image perception and reporting (reporting radiographers only in this section of the survey.). This paper presents and discusses the results of sections (i), (iv) and (v) of the survey, with the remaining presented in a separate publication [28].

The mixture of multiple choice (yes, no, maybe; yes, no, unsure) and Likert scale questions was piloted with 12 radiographers, including clinicians, academics, researchers, and students. Feedback was sought on the technical aspects of the survey, ensuring face validity, and understanding and appropriate-

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Table 1
Respondents' demographic details.

		Diagnostic radiography	Therapeutic radiography
Region of UK where respondents currently work/%	England	56.7 ($n = 183$)	88.2 ($n = 67$)
	Scotland	30 ($n = 97$)	9.2 ($n = 7$)
	Northern Ireland	11.1 ($n = 36$)	1.3 ($n = 1$)
	Wales	1.9 ($n = 6$)	1.3 ($n = 1$)
	Channel Islands	0.3 ($n = 1$)	0 ($n = 0$)
Years practicing radiography/%	0-2 years	22.7 ($n = 75$)	23.4 ($n = 18$)
	3-5 years	10.6 ($n = 35$)	16.9 ($n = 13$)
	6-10 years	13.9 ($n = 46$)	11.7 ($n = 9$)
	11-20 years	23.0 ($n = 76$)	23.4 ($n = 18$)
	> 20 years	27.5 ($n = 91$)	22.1 ($n = 17$)
	Not practicing	1.2 ($n = 4$)	1.3 ($n = 1$)
	Retired	1.3 ($n = 4$)	1.3 ($n = 1$)
Age range/%	18-25 years old	19.3 ($n = 63$)	23.7 ($n = 18$)
	26-35 years old	28.4 ($n = 93$)	26.3 ($n = 20$)
	36-45 years old	27.2 ($n = 89$)	25.0 ($n = 19$)
	46-55 years old	12.5 ($n = 41$)	18.4 ($n = 14$)
	56-65 years old	11.3 ($n = 37$)	6.6 ($n = 5$)
	> 65 years old	1.2 ($n = 4$)	0 ($n = 0$)
Highest academic qualification/%	A-level	14.9 ($n = 48$)	11.8 ($n = 9$)
	BSc	24.2 ($n = 78$)	35.5 ($n = 27$)
	PgCert	19.9 ($n = 64$)	1.3 ($n = 1$)
	PgDip	13.0 ($n = 42$)	6.6 ($n = 5$)
	MSc	19.6 ($n = 63$)	36.8 ($n = 28$)
	PhD/EdD/DProf or equivalent	1.9 ($n = 6$)	3.9 ($n = 3$)
	Other	6.5 ($n = 21$)	3.9 ($n = 3$)
Clinical setting/counts (respondents were permitted more than one selection)	University teaching hospital	$n = 195$	$n = 50$
	District general hospital	$n = 103$	$n = 19$
	Private sector	$n = 12$	$n = 2$
	Poly-trauma unit	$n = 30$	$n = 0$
	Other	$n = 14$	$n = 5$
	Mobile unit	$n = 4$	$n = 0$
	I do not work in the clinical setting	$n = 25$	$n = 4$
Current role/%	Clinical radiographer	39.1 ($n = 126$)	38.2 ($n = 29$)
	Undergraduate radiography student	19.6 ($n = 63$)	13.2 ($n = 10$)
	Advanced practitioner	15.8 ($n = 51$)	17.1 ($n = 13$)
	Radiology/ Radiographer/ radiotherapy manager	6.2 ($n = 20$)	6.6 ($n = 5$)
	Consultant radiographer	4.3 ($n = 14$)	13.2 ($n = 10$)
	Academic in radiography: teaching and research	3.7 ($n = 12$)	0 ($n = 0$)
	Other	3.1 ($n = 10$)	6.6 ($n = 5$)
	Clinical academic/ lecturer:practitioner	3.1 ($n = 10$)	1.3 ($n = 1$)
	Assistant practitioner radiographer	1.2 ($n = 4$)	0 ($n = 0$)
	Research radiographer	0.9 ($n = 3$)	2.6 ($n = 2$)
	Academic in radiography: teaching only	0.9 ($n = 3$)	1.3 ($n = 1$)
	Retired radiographer	0.9 ($n = 3$)	0 ($n = 0$)
	PhD researcher radiographer	0.6 ($n = 2$)	0 ($n = 0$)
	Industry partner	0.3 ($n = 1$)	1 ($n = 0$)

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Table 1 (*continued*)

		Diagnostic radiography	Therapeutic radiography
Diagnostic radiography Sub-specialism/ counts (respondents were permitted more than one selection)	General radiography inc. emergency, theatre and fluoroscopy	$n = 207$	
	CT	$n = 100$	
	Reporting	$n = 63$	
	MRI	$n = 56$	
	Education	$n = 54$	
	Interventional	$n = 44$	
	Mammography	$n = 32$	
	Ultrasound	$n = 25$	
	Other (diagnostic)	$n = 22$	
	Radiology manager	$n = 20$	
	Policy maker/professional advocate	$n = 11$	
	PACS administrator	$n = 9$	
	DEXA/DXA	$n = 5$	
	PET/CT	$n = 3$	
	PET/MRI	$n = 1$	
Therapeutic radiography Sub-specialism/ counts (respondents were permitted more than one selection)	Treatment delivery		$n = 54$
	Pre-treatment, simulation, contouring, immobilisation		$n = 35$
	Patient information/ support/ review		$n = 23$
	Treatment planning		$n = 15$
	Management		$n = 10$
	Educator		$n = 7$
	Research		$n = 7$
	Quality assurance/ Quality improvement		$n = 7$
	Other (therapeutic)		$n = 7$
	DEXA/DXA clinical applications		$n = 0$

ness of the questions posed, thereby ensuring content validity. Post hoc Cronbach's alpha was calculated to confirm internal consistency on the Likert scale questions [32], where acceptable internal reliability was found for both professions ($\alpha = 0.792$ and $\alpha = 0.852$ for DR and TR respectively).

Available data and data analysis

Following cleaning of the data (removal of blank surveys or where only the demographic section was completed), the responses from 411 surveys remained for analysis. Of the 411, all data recorded was included in the analysis, even if the survey had not been fully completed.

Data were imported from Qualtrics® into IBM SPSS® (version 23) to complete analysis. Descriptive statistics are reported for many of the responses except one question asking participants to rate the areas of radiography where respondents felt there is most scope for development. Otherwise, percentages are reported for questions where a single response per participant is possible and counts/frequency for questions allowing multiple choices. There were no weightings applied to any individual questions.

Demographic information

Demographic details of respondents are detailed in Table 1. There were responses from both professions in all UK regions, except therapeutic radiographers in the Channel Islands. Most age ranges are represented except the over 65 age group in TR group. Respondents with a range of years' experience responded to the survey (Table 1).

The approximate ratio of TR to DR respondents was 1:4 ($n = 77$, $n = 332$, TR and DR) respectively, including students, broadly representative of the UK workforce [33]. There were two respondents practicing both DR and TR. Male and female radiographers responded to the survey, with a split which is broadly representative of the UK workforce (1:3, male:female radiographers) [34]. There was also an option for non-binary/third gender and 'prefer not to say' ($n = 2$, $n = 4$ respectively in DR responses only, $n = 0$ for both non-binary/third gender and 'prefer not to say' in TR responses).

Perceptions of current practice of AI in radiography

Initial questions explored awareness and applications of AI in the clinical setting. Many respondents were unsure if AI was used currently in their clinical setting (43.1% and 44.6%, DR and TR respectively). Of the remainder, a greater proportion of TR indicated that AI was being used in their practice (TR using AI 33.8%; not using AI 18.5%), with the converse true for DR respondents (DR using AI 20.6%; not using AI 35.6%). When asked where AI will have the greatest impact, DR respondents indicated reporting ($n = 145$) with treatment plan-

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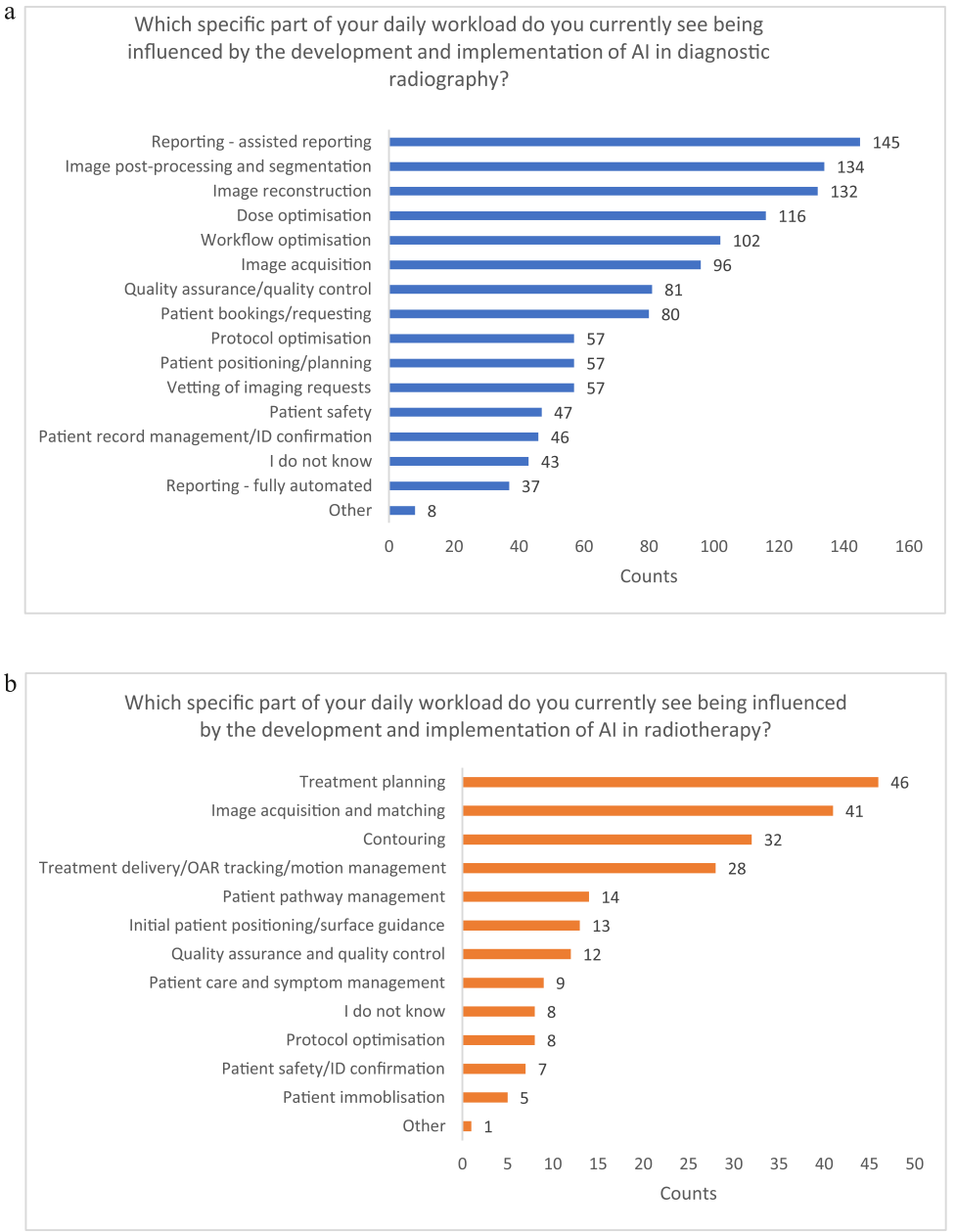

Fig. 1. **a.** Which part of daily work do you currently see being influenced by the development and implementation of AI in radiography (diagnostic)? (counts), **b.** Which part of daily work do you currently see being influenced by the development and implementation of AI in radiography (therapeutic)? (counts).

ning suggested in TR ($n = 46$) (Fig. 1 a and b). Free text answers in the DR responses included examples of the use of AI e.g. "screening AAA (abdominal aortic aneurysm)" and "stroke recognition", "recognition and warnings that systems are about to fail", "education" and "research". One TR respondent commented "treatment planning will become more complex with the influence of AI".

Participants were asked to identify which areas of radiography they thought had the greatest scope for the development of AI solutions in the future. Participants could select from several options (Fig. 2a and b) and rate them in order of preference, from 5 – 0 (where 5 represents most preferred to 0 representing least preferred). A mean score is calculated from the number of responses for each score in the chosen option. The response with the highest mean score in the DR responses was 'CT' followed by 'reporting', 'MRI' and 'mammography'. The highest mean score in the TR responses was in the 'treatment planning/optimisation/adaptive planning' option, followed by 'contouring' and 'image acquisition/matching'. Half of the DR respondents using the free text option indicated they can only comment on their own area of expertise ($n = 3$, out of a total of 6 free text responses). Others commented that AI will have scope for dose and image quality optimisation ($n = 1$), requesting and vetting ($n = 1$) and one respondent commented that

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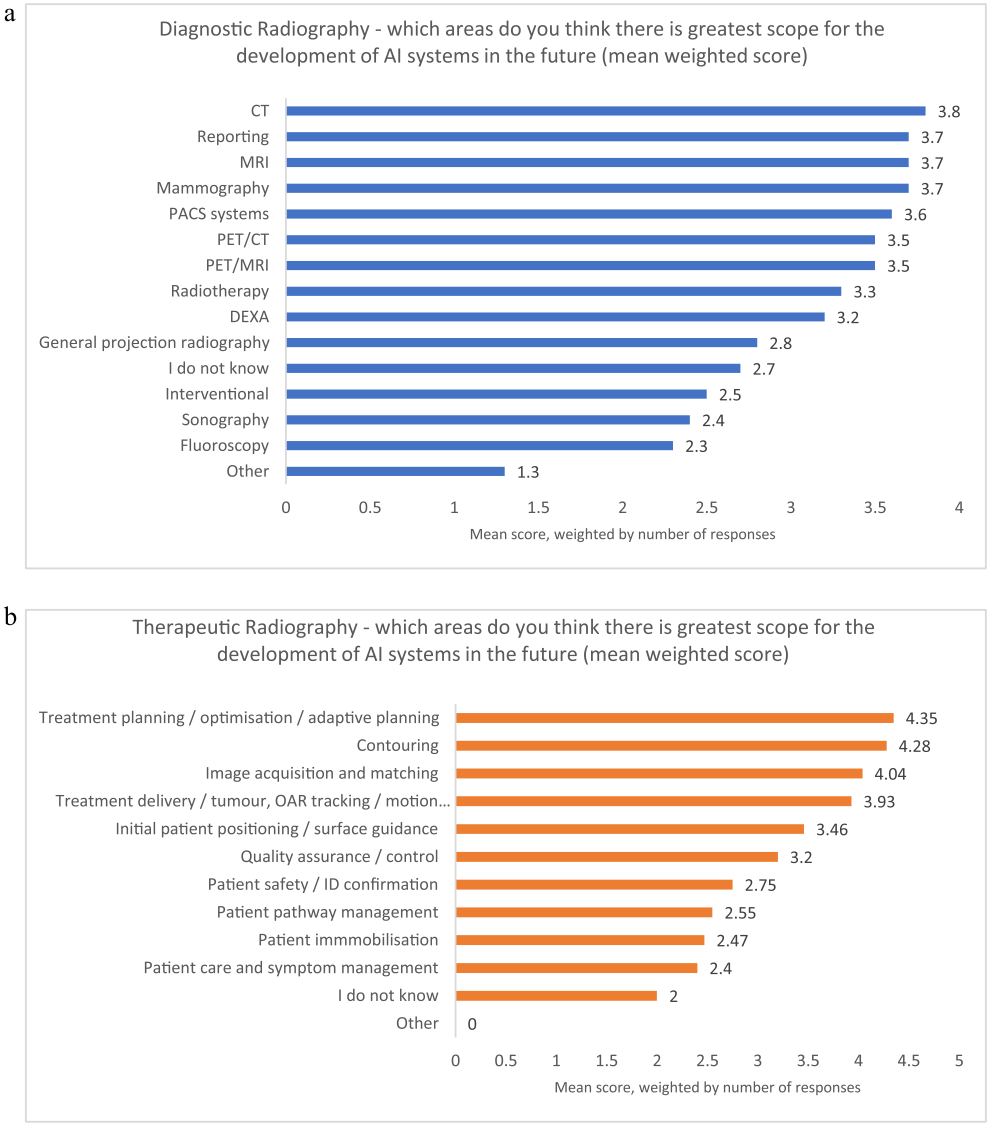

Fig. 2. **a.** Which areas of radiography (diagnostic) do you think there is the greatest scope for the development of AI systems in the future (mean score)? **b.** Which areas of radiography (therapeutic) do you think there is the greatest scope for the development of AI systems in the future (mean score)?

AI has scope for development in all modalities ($n = 1$). There were no free text answers to this question in the TR responses.

Expectations of the impact of AI on the future of radiography

Likert scale questions were used to gain insight into the respondents' perceptions on how AI might impact radiography and professional practice in the future. The majority in both professions indicated they agreed that AI would change daily clinical practice, with an aggregate agreement (strongly agree, agree, somewhat agree) of 79.6% and 88.9% for DR and TR respectively (Fig. 3). A less definitive perception was noted in response to the question of AI reducing radiographers' workload with an aggregate agreement of 43.5% and 54.0% and an aggregate disagreement of 27.3% and 27.0% DR and TR respectively (Fig. 4). An even smaller degree of difference in agreement and disagreement aggregates was noted in response to the statement 'AI will make my practice more patient centered', with agreement aggregates of 36.6% and 45.9% and disagreement aggregates of 22.4% and 27.0% for DR and TR respectively (Fig. 5). The greatest proportion of responses to this statement were recorded in the 'neither agree nor disagree' choice.

Most respondents agreed that AI would provide more consistent patient safety standards in radiography (aggregate agreement 68.3%, 73.0%, aggregate disagreement 7.1% and 9.6% DR and TR respectively) (Fig. 6). Similar results were also noted in response to the statement 'AI will allow for more consistent patient care pathways', with an aggregate agreement of 62.5% and 58.6% and an aggregate disagreement of 6.0% and 9.6% DR and TR respectively (Fig. 7).

Specific statements were presented to each individual profession (DR and TR) regarding the impact of AI on profession-specific areas of practice (Figs. 8 and 9). The DR respondents were asked to what extent they agreed that 'AI will improve and

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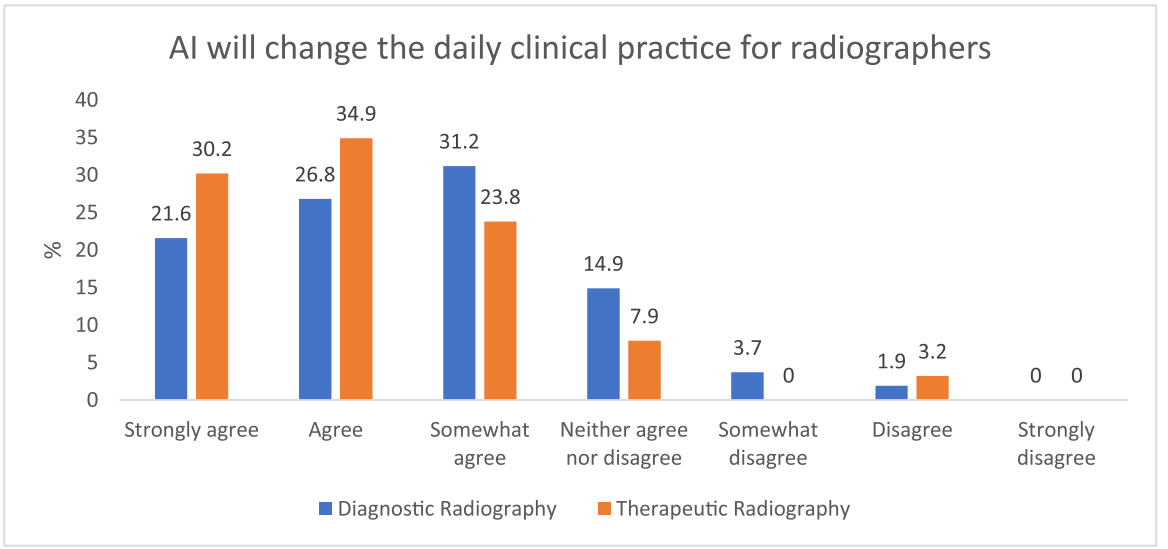

Fig. 3. AI will change the daily clinical practice for radiographers (diagnostic and therapeutic). (%).

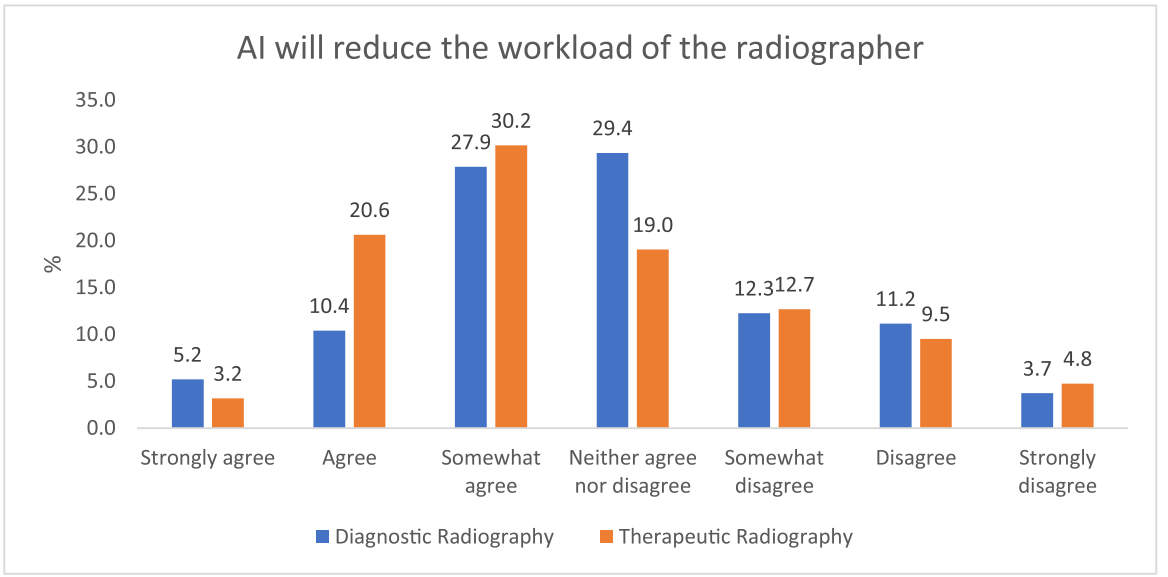

Fig. 4. AI will reduce the workload of the radiographer (diagnostic and therapeutic). (%).

standardise image quality during data acquisition in diagnostic radiography'. The majority (75.7%) selected an 'agree' option, few respondents (6.4%) selected any 'disagree' option (Fig. 8a). A greater difference between aggregate agreement and disagreement was noted in response to the statement 'AI will improve and standardise pre and post processing in diagnostic radiography', with 81.6% agreeing and only 2.2% indicating some level of disagreement with this statement (Fig. 8b).

In response to a statement regarding AI improving and standardising treatment planning in radiotherapy, most TR respondents (88.9%) indicated some level of agreement, while very few respondents selected one of the disagreement options (3.2%) (Fig. 9a). There were similar levels of agreement regarding AI improving treatment delivery, with agreement and disagreement aggregates of 81.0% and 6.4% respectively (Fig. 9b).

A series of statements regarding the potential specific impact on radiography as a profession were presented to the respondents. The top three choices were the same for both DR and TR, namely, 'it will create different specialist roles', 'AI will support role development' and 'the type of work I am doing will change' (Fig. 10a, and b). With the exception of the 'other' option, 'it will deskill my profession' was the least popular selection across both professions ($n = 78$, $n = 19$, DR and TR respectively). The 'other' option was chosen by 20 DR respondents and responses indicated that many were not sure about the impact AI would have on jobs ($n = 5$), whilst others felt that AI would promote advanced practice and role development ($n = 5$). Other responses included indication that AI would deskill the workforce ($n = 3$) and two respondents indicated that they felt there would be no change in the near future

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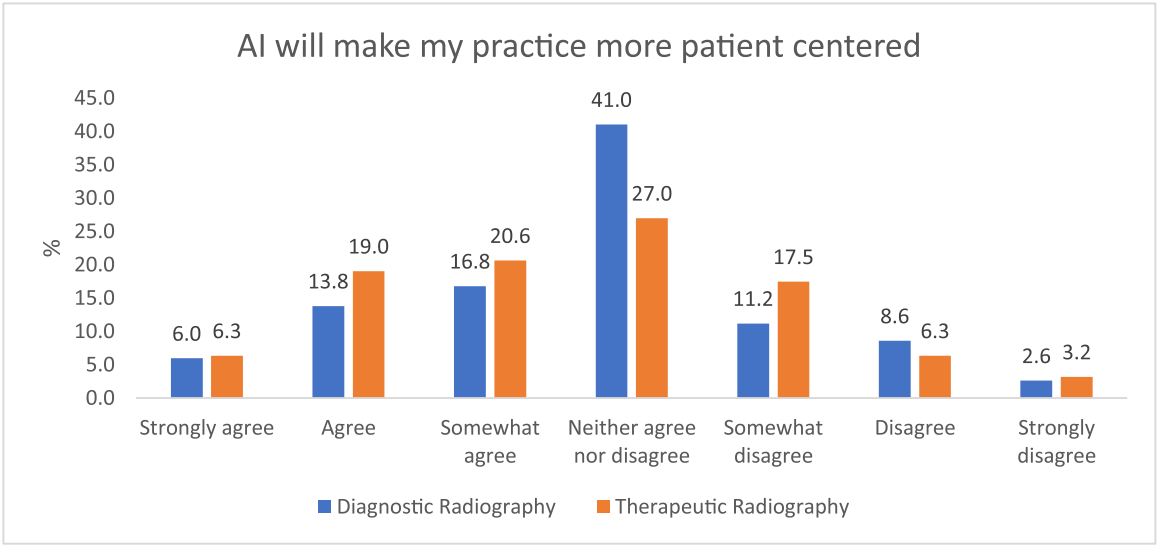

Fig. 5. AI will make my practice more patient centered. (%).

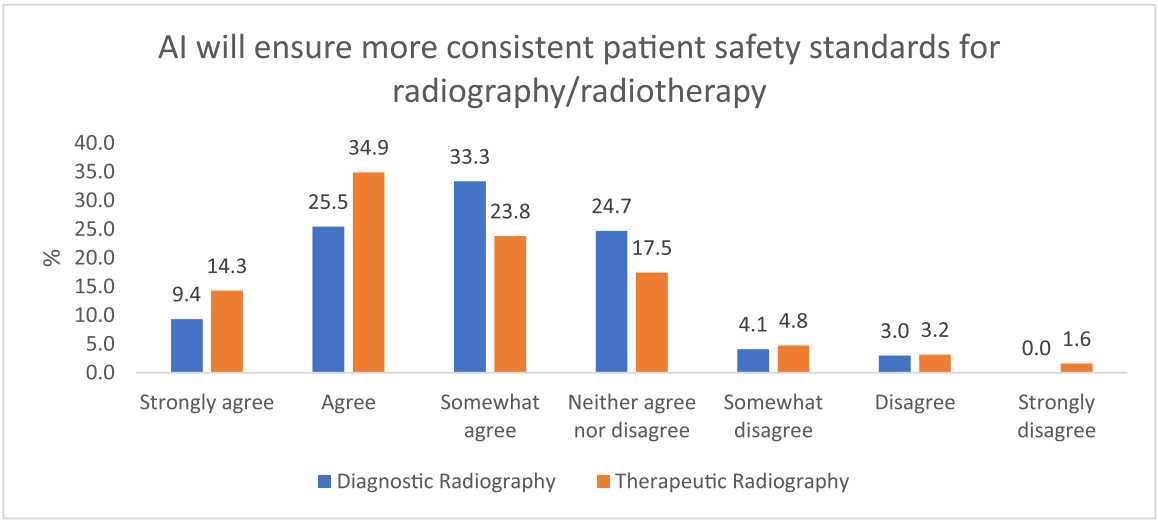

Fig. 6. AI will ensure more consistent patient safety standards for radiography (diagnostic and therapeutic). (%)

($n = 2$). Of the TR responses, two felt that AI would deskill the workforce, two indicated that AI would allow the treatment of more patients and three were concerned about the impact that AI would have on patient contact.

Most radiographers were unsure if AI would reduce career opportunities, with the 'neutral' response selected most frequently by respondents from both professions (29.6% and 25.4%, diagnostic and therapeutic radiography respectively) (Fig. 11).

Discussion

Definitions of AI

The availability of AI solutions for use in radiology is increasing [8] but many respondents to this survey indicated that they were not aware of AI being used in the clinical setting (Fig. 1). This may indicate some confusion regarding what we define as 'AI'. Technology enabled assistance is already present in many aspects of general clinical practice, for instance in the digitisation and archiving of images to computer assisted diagnosis, although many of these applications may not represent what we understand by 'modern AI', such as deep and machine learning systems [25]. Supporting this notion, although respondents to this survey indicated that they were not sure if AI was being used in their daily practice, most were able to identify areas where AI was being used, for example, in 'reporting' and 'treatment planning'. These areas are commonly identified in current literature [3,8,25]. Although there has been inconsistent use of the term or concept of AI in literature, respondents do appear to have explored some AI literature related to those areas which interest them, albeit awareness of the uses of AI in practice was low in the survey. Radiography literature about AI should be clear about how the term AI is being used.

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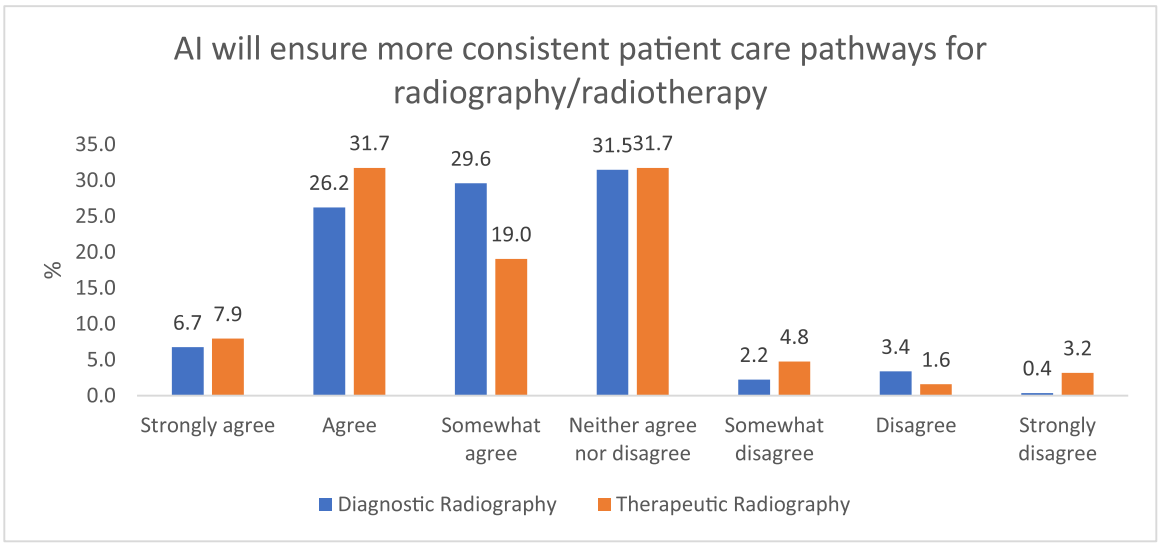
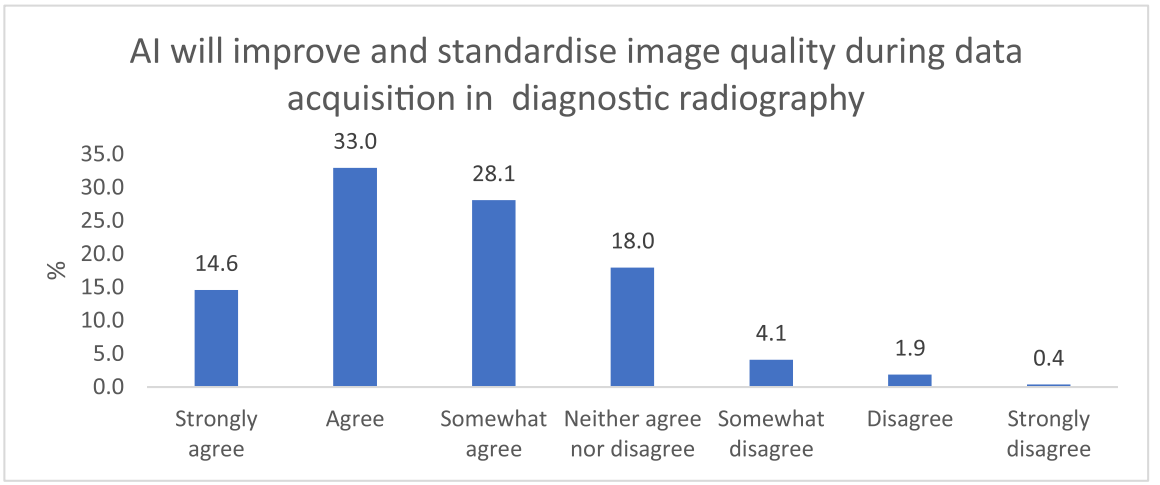


Fig. 7. AI will ensure more consistent patient care pathways for radiography (diagnostic and therapeutic). (%).



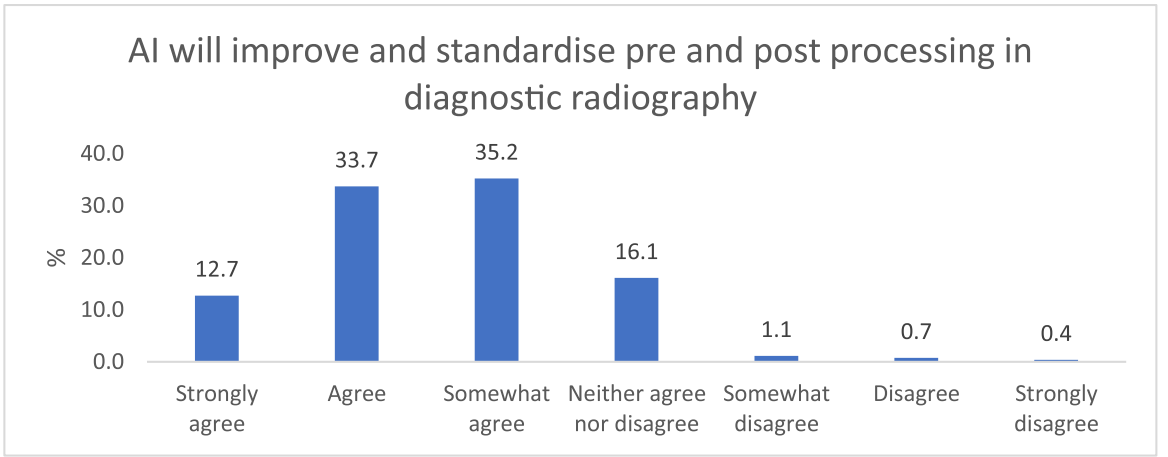


Fig 8. a and b. Diagnostic radiography: Impact of AI on resultant image quality (acquisition to processing). (%).

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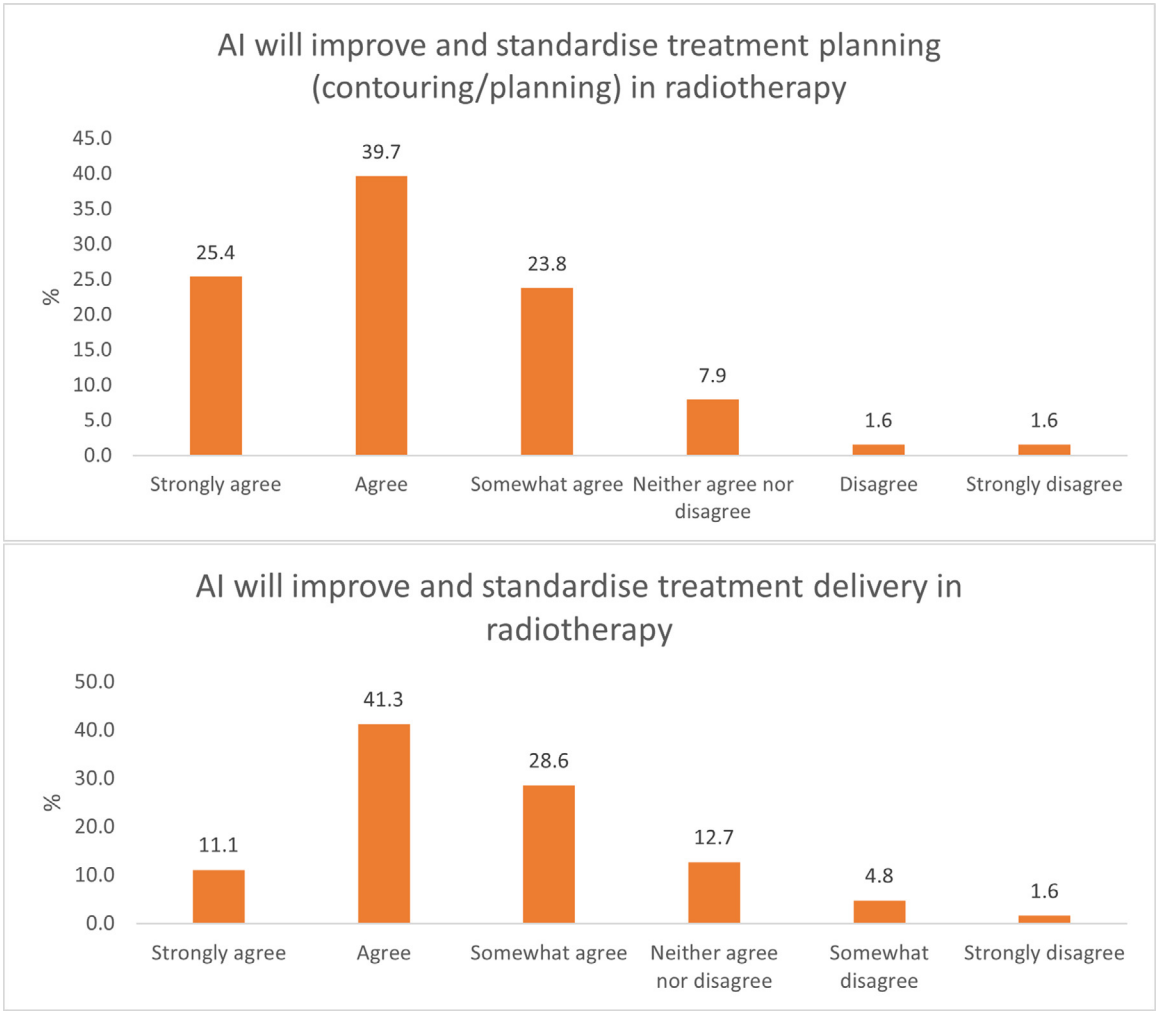

Figs 9. a and b. AI will improve radiotherapy treatment (planning and delivery). (%).

Awareness of potential applications of AI

AI currently pervades many avenues of radiography. A worldwide study [8] identified the current state of development and availability of AI application in radiology, finding that most applications were in MRI (29%), CT (28%), and 'x-ray' (17%). DR respondents to this UK survey indicated an awareness of potential applications of AI in those areas, also ultrasound and mammography, which were evident to a lesser extent in the worldwide study [8]. UK respondents also felt that 'reporting' would be an area with scope for development in the future. Inclusion may reflect that reporting is an area of focus within the scope of reporting radiographers in the UK. It is possible that the sub specialism of the respondents impacted on the choice of preference options, indeed, several respondents stated that they were only aware of developments in their immediate field.

The responses from the TR cohort appeared to agree with other research [3], with respondents indicating plan optimisation, contouring and plan checking and quality assurance were areas which show scope for the future [3]. This suggested that TR respondents were also exploring the evidence with regards to advances in their field.

Perceived impact on radiographer workload

Most respondents indicated that they believed daily clinical practice would change with the introduction of AI (Fig. 3) and radiographers' workload would decrease. This reflects the results of other surveys [4,16]. Respondents therefore appeared to agree that AI would 'ease' the work of the radiographer [4]. This perception may be influenced by claims made in literature and companies developing AI solutions, but a word of caution: whilst it is predicted that AI may allow for individual patient time efficiencies, with AI speeding up or taking over tasks, this may be counterbalanced by increased patient throughput, as found in study conducted in the Netherlands in 2017 [27]. Indeed, there is some controversy over what exactly AI can do to help service delivery in clinical departments, with suggestion that AI may cause an increase in false positives which will re-

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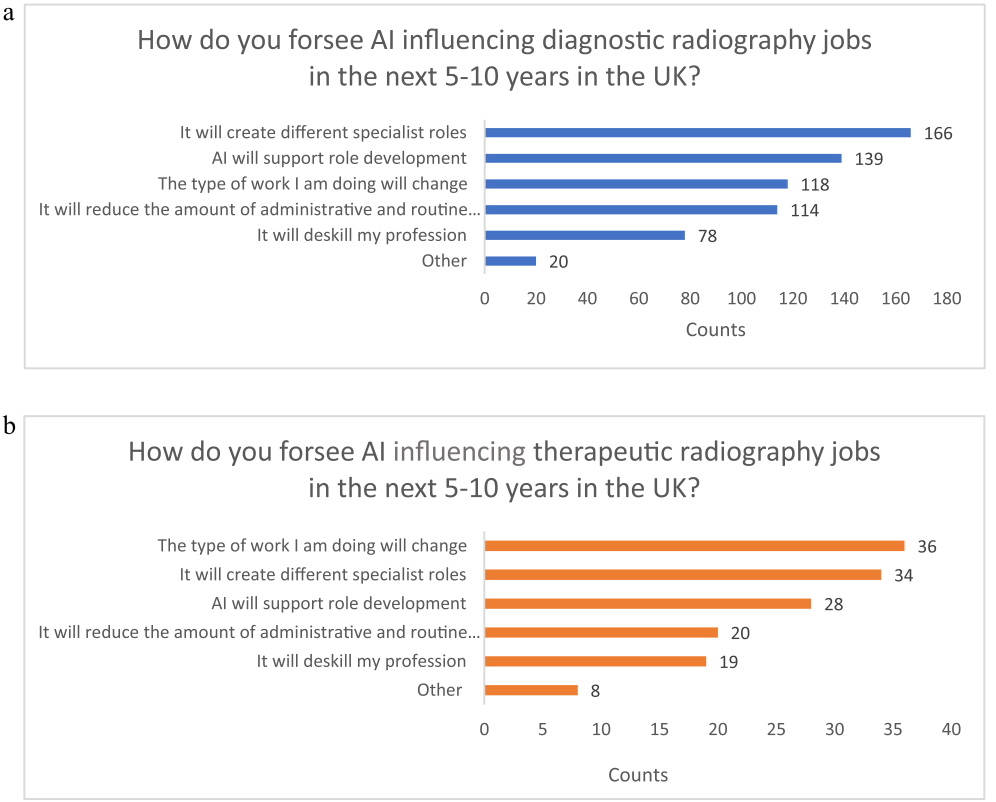

Fig 10. a. Influence of AI on diagnostic radiography jobs in the near future (counts). Fig 10. b. Influence of AI on therapeutic radiography jobs in the near future (counts).

quire review, or decreased trust causing the clinician to 're-do' the interpretation of the AI [27].

Perceived impact on radiography practice: care, safety, service delivery

Despite AI literature expounding the merits of AI in reallocating time to patient care [1,35], respondents to the UK survey indicated that they were unsure of the impact of AI on the patient-centeredness of radiography practice.

There is the hope that the integration of AI will foster more streamlined, consistent practice [35,36] but it is important to note that consistent practice is not necessarily patient-centred care, tailored to the needs of the person, their family and carers. AI may target the mundane, repetitive work of the radiographer, allowing clinicians to perform the tasks which are not automatable, for instance patient contact and care [35], time to talk with patients and families, time for professional study, education, and lifelong learning. All are important points to focus on because it has been reported that radiographers felt the introduction of advanced technology meant some staff are using less of their knowledge for their professional work [27]. Care should be taken to ensure radiographers do not experience 'burn out', decreased job satisfaction and loss of morale in response to an increased examination speed and patient throughput [1].

UK radiographers perceived that AI would have a positive impact on standardising safety, image quality, image processing, contouring/planning and treatment delivery. These are areas of practice where there is already some impact from AI and UK respondents may, therefore, be noticing the benefits of the technology. Similarly, for example, a recent survey of Ghanian radiographers indicated that 68.8% of respondents felt that AI would allow dose reduction whilst maintaining image quality [4]. Also adding to evidence of positive perceptions, a survey of therapeutic radiographers in Australia found that 66% of respondents felt that automation in radiotherapy planning would change the primary tasks of some aspects of professional practice and 55% of respondents felt it would allow staff to accomplish the rest of their work more effectively [3].

Potential impact of AI on workflow optimisation

Perceptions of the impact of AI in clinical radiology workload appear to vary worldwide. A study in the UAE reported that 94.8% of respondents disagreed that AI will be used in image production and other applications. This is at odds with the results of this UK survey; perhaps related to the understanding of the international respondents, where 40% reported they had no idea about AI and 30% indicating they have only a basic understanding [2]. This uncertainty is reflected at a period when, considering the recent global COVID-19 pandemic, there is still much debate about the future service delivery of healthcare; with remote care, infection risk, increasing patient numbers and staffing shortages driving change [10,11]. Hesitancy

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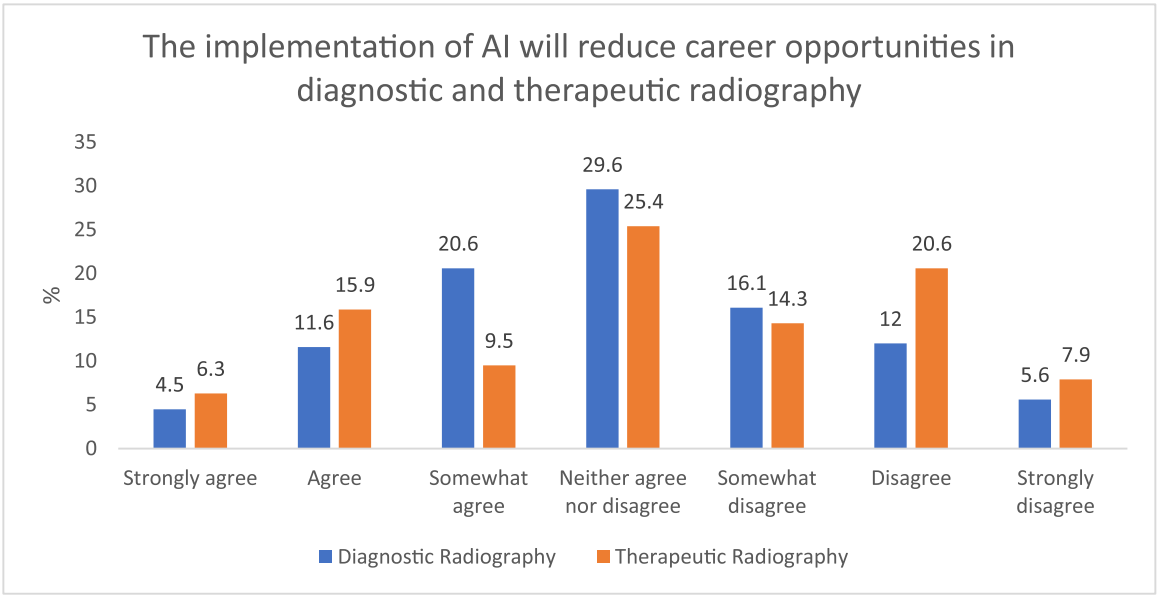

Fig. 11. The implementation of AI will reduce career opportunities in radiography (diagnostic and therapeutic). (%).

about the use of AI is, however, not unanimous, with a contrasting international study reporting that only 10% of respondents indicated that AI would have no image-based role [16]. Respondents to this UK survey were clear that they did view AI as having capability to optimise workflow.

Perceived impact on workforce recruitment and radiography careers

The prevalence of neutral responses to some questions suggests that UK radiographers are unsure how AI might impact on radiography in terms of recruitment and the appeal of the profession to prospective professionals. Responses to this survey indicate that respondents are optimistic about the future of the profession using AI, with many indicating that they feel that AI will create different specialist roles and that AI will support role development.

There have been similar findings among radiologists [2], where 66% of respondents indicated that they were 'excited' about a future with AI and radiographers' attitudes to AI in Ghana where 87.4% of radiographers responded that AI would have a positive impact on medical imaging practice [4]. With respect to career progression, post-registration therapeutic radiographers in Australia also reported that 65% of respondents felt that automation in radiotherapy planning would create new advanced practice roles [3].

Previous concern regarding the negative impact that AI might have on the future of radiology, has been modified recently. This also appears to be the case for radiographers, with evidence from the literature including the results of this UK survey indicating that the advent of AI in radiography may present diverse career opportunities, from technology development to clinical 'champions'. It is encouraging to note that job security was not identified as a cause for concern.

Limitations and future research

Respondents to the survey were UK radiographers, therefore, findings will not be representative of the worldwide radiographer population where educational provisions, clinical practice, roles within radiography may vary.

The response rate of DR and TR was representative of the ratio of DR and TR registered in the UK, accordingly there were a smaller number of respondents in the TR category. Similarly, there were fewer respondents who identified themselves as male, although the proportion of male: female respondents was also broadly representative of the UK radiography population.

We propose that to counter the limitations of an exploratory survey method, future international focus groups should be carried out, using purposive sampling techniques, to gain further understanding of radiographers' perceptions on the topics addressed by this paper.

Conclusions

Respondents were unsure of the impact of the increasing use of AI in clinical practice and uncertain about its future impact on radiography careers, but a majority agreed that AI will have an impact on the daily clinical practice of the radiographer. This uncertainty is reflected at a period when, considering the recent global COVID-19 pandemic, there is debate about the future service delivery and needs of healthcare. Four main conclusions are drawn from the UK survey:

First, there is awareness of the ways in which AI technology is used currently and could potentially be used in the future. 'Reporting' in diagnostic radiography and 'treatment planning' in therapeutic radiography were areas which respondents thought were heavily influenced by AI. Respondents also felt those areas would be further developed in the future.

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Second, because respondents to this survey were unsure of the impact of AI on their career, it was unclear to them whether this will herald a new type of radiographer with different roles, or whether certain areas of the profession will gradually disappear, and new ones will emerge, defined by patients' clinical need and technological innovation. Only a small minority of respondents to this survey indicated that AI would deskill their jobs.

Third, radiographers may be unsure of the future with AI and the impact this will have on patient centredness, but the majority agree that AI will allow for standardisation of some elements of patient care and safety as well as the technical aspects of the radiographers' work. It is essential that this is considered with a critical awareness of the functions and capability of AI, to allow for quality of service to be maintained or improved.

Finally, the survey suggests that AI is being used actively in medical imaging and radiotherapy. It is vital and timely for radiographers, as the key professionals who bridge the knowledge and practice between patients and technology, to shape a future with AI. This can be made possible by empowered members of the profession who at current times of change re-imagine clinical practice in the future, innovate, and secure the position of radiography as a technology adept profession with future-ready professional roles.

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Contributors

Dr Malamateniou and Dr McFadden have contributed equally to this work and share last authorship. All authors have contributed to the conception and design of this work. All authors have contributed to drafting and/or commenting on this work and have given their approval to the final version.

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Competing interests

Authors report no competing interests. Dr Woznitza declares consultancy fees for InHealth Reporting and NIHR AAC funding unrelated to the current submission.

Ethical approval

Ethical permission was granted from City, University of London Research Ethics Committee (ETH1920-1989).

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