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Nordic radiographers' and students' perspectives on artificial intelligence – A cross-sectional online survey

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ABSTRACT

Introduction: The integration of artificial intelligence (AI) into the domain of radiography holds substantial potential in various aspects including workflow efficiency, image processing, patient positioning, and quality assurance. The successful implementation of AI within a Radiology department necessitates the participation of key stakeholders, particularly radiographers. The study aimed to provide a comprehensive investigation about Nordic radiographers' perspectives and attitudes towards AI in radiography.

Methods: An online 29-item survey was distributed via social media platforms to Nordic students and radiographers working in Denmark, Norway, Sweden, Iceland, Greenland, and the Faroe Islands including items on demographics, specialization, educational background, place of work and perspectives and knowledge on AI. The items were a mix of closed-type and scaled questions, with the option for free-text responses when relevant.

Results: The survey received responses from all Nordic countries with 586 respondents, 26.8% males, 72.1% females, and 1.1% non-binary/self-defined or preferred not to say.

The mean age was 37.2 with a standard deviation (SD) of ±12.1 years, and the mean number of years since qualification was 14.2 SD ± 10.3 years. A total of 43% (n = 254) of the respondents had not received any AI training in clinical practice. Whereas 13% (n = 76) had received AI during radiography undergrad training. A total of 77.9% (n = 412) expressed interest in pursuing AI education. The majority of respondents were aware of the potential use of AI (n = 485, 82.8%) and 39.1% (n = 204) had no reservations about AI.

Conclusion: Overall, this study found that Nordic radiographers have a positive attitude toward AI. Very limited training or education has been provided to the radiographers. Especially since 82.8% reports on plans to implement AI in clinical practice. In general, awareness of AI applications is high, but the educational level is low for Nordic radiographers.

Implication for practice: This study emphasises the favourable view of AI held by students and Nordic radiographers. However, there is a need for continuous professional development to facilitate the implementation and effective utilization of AI tools within the field of radiography.

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Introduction

Artificial intelligence (AI) has shown promise and accelerated implementation within the domains of radiology and radiography with the potential to improve areas such as diagnostic accuracy, image processing, workflow efficiency, patient positioning, patient care and quality assurance.[1] The diagnostic aspects are prevalent within image interpretation, with algorithms offering diagnosis based on radiographs and multiplanar imaging.[2–5] The presence of AI in the radiography has recently emerged, in the form of algorithms supporting with image quality improvement, reconstruction and patient safety.[6,7] It is expected that the implementation of AI will alter current practice, potentially requiring new skills and further education.[6] Consequently, there is a disruptive aspect to AI, where tasks and roles may radically change or even become redundant in areas where AI can automate practice previously managed by radiographers.[6,8] It is anticipated that the increasing use of AI in radiography will bring new opportunities and role expansion, as highlighted in a recent study with radiographers from the United Kingdom (UK).[9] The study revealed a consensus among 79–89% of respondents who agreed that AI would change daily clinical practice.

Despite the advantages of AI implementation in medical imaging, there is uncertainty about the impact AI may have on roles and responsibilities in daily clinical practice.[10] It has been reported that the transformation of AI's integration into healthcare has discouraged medical students in the UK, Canada, and America from selecting radiology as their specialisation.[11–13] Radiographers' perceptions, perspectives, and experiences with AI, such as career opportunities, job prospects, and perceptions of the future and development of the profession have been explored in various sites across the world.[9,10,14,15] Currently, there is to the best of our knowledge, no such evidence available on how the Nordic radiographers perceive AI. Exploring radiographers' perception regarding the implementation of AI in the field of radiography, can help facilitate tailored governance, employability strategies and educational programs that can enable the successful implementation of AI in clinical practice.

The overall aim of this study was to investigate the perspectives, engagement, understanding, and views of Nordic radiographers on AI.

Methods

Survey

A cross-sectional online survey was designed, and the content was a mix of newly developed items while other items were informed by current literature,[9,16] and aligned with the professional and educational context of the Nordic countries. The survey included a mix of closed-type questions, some with opportunity to add free-text responses, and Likert-scale questions ranging from "*strongly agree*" to "strongly *disagree*" or ranking the importance of a statement on a 1-to-5-point Likert scale, for Fig. 5 we used a 4-point Likert scale.

The survey was pilot tested from December 2022 to January 2023. To prevent information bias associated with a particular healthcare group, the pilot involved a combination of eight international radiographers and one medical doctor. Danish, Swedish, Norwegian, British, and Finnish radiographers piloted the survey. The pilot study was used to assess and adapt the content, delivery, flow, length, language barriers, response time, and overall quality of the survey. The pilot identified minor editorial errors including spelling mistakes, and added extra response options, namely "other" and "all of the above". Additionally, we found that the average completion time was approximately 15 min.

The survey was open for 12 weeks in the period between mid-March to mid-June 2023. The online 29-item survey was distributed to Nordic radiographers working in Denmark, Norway, Sweden, Iceland, Greenland, and the Faroe Islands. The link was distributed online using social media (LinkedIn, Facebook, Instagram, and Twitter) and shared with Nordic e-mail contacts by the authors. The survey included sections on a) respondent demographics (age, sex, specialisation, educational qualification, and AI education); b) barriers and enablers towards AI implementation; c) perspectives and experiences of AI; and d) knowledge of AI in relation to radiography. All text was in English to ensure minimal misunderstandings for all participants between the different Nordic languages. Participants could omit questions not applicable to their context.

Ethics approval

The study was approved by the Research Ethics Committee at the University of Southern Denmark (ID: 22-58485) in October 2022. Prior to the online survey, participants were informed through a short message that the study data would be shared publicly and by participating it was not possible to withdraw from the study since all data were completely anonymised. Participants had to provide an informed consent declaration statement before entering the survey. All data were recorded in the secure database Research Electronic Data Capture (REDCap),[17,18] hosted by the Danish Open Patient Data Explorative Network (OPEN).

Statistical analysis

Descriptive statistics were performed to present the demographics of respondents. Continuous variables were summarised with means and standard deviation (SD). The Chi-square test was used to explore differences between male and female respondents. All analyses were performed in STATA version 18 BE (College Station, TX, USA). P-values of ≤ 0.05 were considered statistically significant.

Results

Demographic information

In total 656 respondents commenced the survey, with four declining consent. Three hundred and seventy-two respondents answered all the questions, while the remaining respondents answered a decreasing number of questions as the survey progressed. Seventy respondents answered only demographic questions and were subsequently excluded from analysis. Partially completed surveys were included, to minimize selection bias. Thus, 586 respondents were included, with their demographics shown in Table 1.

All Nordic countries participated, but responses from Iceland, Greenland, and the Faroe Islands were collated due to low numbers of radiographers in these countries thereby ensuring anonymity.

Both males (26.8%) and females (72.1%) participated with a ratio of male to female radiographers of 1–2.7. There was an option for non-binary/self-defined gender ($n = 2$) and prefer not to say ($n = 4$).

Level of qualification included student, diploma in radiography, Bachelor, Master/Master of Science and Ph.D. An option to include "other educational background" was provided, and included PgCert graduates, subject-specialised courses, nurses upskilled to radiography, and diplomas in management.

Table 1
Summary of demographics (n = 586). * includes Greenland, the Faroe Islands, and Iceland.

	n	(%)
Gender		
Female	422	72.1
Age range		
≤29	192	32.9
30–39	161	27.6
40–49	127	21.7
50–59	78	13.4
60+	26	4.4
Country		
Denmark	379	64.7
Norway	120	20.5
Finland	45	7.7
Sweden	27	4.6
Other*	15	2.5
Level of qualification		
Diploma	52	8.9
Bachelor	312	53.2
Master or Master of Science	70	11.9
Ph.D	14	2.4
Student/other	138	23.6
Specialisation (multiple answers allowed)		
Students	138	23.5
Digital X-ray	268	45.7
CT	259	44.2
MRI	149	25.4
Ultrasound	48	8.2
Interventional/Fluoroscopy	59	10.1
Mammography	21	3.6
DEXA	7	1.2
Research	27	4.6
Reporting Radiographer	20	3.4
Management	42	7.2
Nuclear Medicine	24	4.1
Radiation Therapy	21	3.6
Education/Teaching	33	5.3
Quality assurance	24	4.1
Workplace		
Private clinic/hospital	13	2.2
Medical Industry	6	1.0
Public clinic/hospital	442	75.4
Governmental organisation	14	2.4
Educational/University	101	17.2
Other	10	1.8
Years of qualifications		
<5 years	89	19.9
5–9 years	89	19.9
10–14 years	77	17.2
15–19 years	69	15.4
≥20 years	125	27.6

The respondents' age ranged from 20 to 70 years, with a mean of 37.2 SD ± 12.1 years. Mean years of qualification was 14.2 SD ± 10.3 years. The respondents were asked to list their primary radiographic area of specialty, and multiple answers were allowed as many have more than one specialisation. Predominantly, the respondents specialised within digital X-ray with 45.7% (n = 268), CT with 44.2% (n = 259), and MRI with 25.4% (n = 149).

Interest in AI between Nordic countries

Overall, there was a low level of concern regarding AI and the radiography profession, see Table 2.

Approximately 88% (n = 412) of the respondents were interested in attending AI education. From Denmark 59.8% of the respondents (n = 122) had no reservations on AI, but this finding differed between the Nordic countries. Regarding reporting, 26.1% (n = 135) thought that AI would improve reporting, 17% believed AI would create more time for patient care (n = 88) and 15% that radiation dose would decrease (n = 77). Table 3 shows differences between males and females in selected variables. More males were specialised in CT ($p = 0.012$) and MRI ($p < 0.01$) compared to females.

Radiographers' knowledge on AI

The majority of respondents were aware of the potential uses of AI in medical imaging (n = 485, 82.8%), and the remaining replied no or did not know (n = 101, 17.2%), see Fig. 1. A total of 306 (54.2%) indicated that they had no knowledge of their workplace having plans to implement AI. Fig. 2 illustrates where the respondents' have gained training and knowledge about AI, and the sources through which they find or have found information on AI.

Many of the responses indicated to have received no training in AI (n = 254), whereas approximately 26% (n = 155) had received some kind of training on the job. Fig. 3 illustrates the sources from which the respondents found information on AI outside work. Most respondents seek information in articles (n = 269). In the category "Other" the most frequent responses were online resources (n = 14), YouTube videos (n = 8), followed by friends and relatives (n = 7) working with AI.

Out of 386 responses, 48.9% (n = 189) indicated using AI daily, of which 11.1% (n = 43) felt very confident about AI, 30% (n = 116) were confident and 7.8% (n = 30) were not confident using AI and 2.2 % (n = 8) did not know.

Radiographers' opinion on how AI can influence the radiography profession

In general, Nordic radiographers seem to have a positive opinion on AI as 387 expressed that they strongly or somewhat agreed that AI can optimise patient dose whereas only 14 reported to strongly or somewhat disagree. Among the 453 responses, the topic of using AI for patient identification received a high count of strongly disagree or somewhat disagree responses with n = 112 (24.7%), as shown in Fig. 4.

The question concerning views on the future of AI was answered by 387 respondents (Fig. 5). The majority, namely 91.7% (n = 355) agreed or strongly agreed that AI-generated reports should be read by a radiologist or a reporting radiographer prior to the release of an imaging report.

Discussion

This study was designed to capture perspectives on AI among Nordic radiographers. Overall, we found a positive attitude towards AI in medical imaging, but also a lack of educational opportunities. With limited educational and clinical training available, the radiographers instead sought information through articles and online sources e.g., using videoclips e.g., YouTube. The use of video channels and reliance on unverified online content for educational purposes poses the risk of misinformation, due to potentially unreliable content, lacking basic pedagogic principles. With the availability of new technology such as AI, it is important to ensure the wider provision of suitable and reliable education. This is also supported by findings in recent studies, highlighting a demand for AI education within radiography.[6,16] Regarding the educational aspect, Botwe et al. found that 80.8% of the respondents agreed that AI would improve medical imaging education.[19] This raises important questions regarding responsibility for dissemination of AI knowledge. Should universities or "universities of applied sciences" provide dedicated AI courses for radiographers, or should AI training primarily be integrated into clinical practice? Considering the complex nature of AI, there is a need for a collaborative

Table 2
Interest and concern about AI expressed by yes (response options were yes or no).

	All (%)	Denmark	Norway	Sweden	Finland	Other
Variable about radiographers interest in AI	n (%)	n	n	n	n	n
Would you be interested in attending lectures and training in AI use?	412 (77.9)	258 (62.6)	87 (21.1)	21 (5.1)	35 (8.5)	11 (2.7)
In your opinion is AI a useful tool in radiography	452 (85.9)	287 (63.5)	98 (21.7)	21 (4.6)	38 (8.4)	8 (1.8)
I have no reservation on the use of AI	204 (39.1)	122 (59.8)	43 (21.1)	8 (3.9)	25 (12.3)	6 (2.9)
I fear that patient complaints will increase	17 (3.2)	11 (64.7)	4 (23.5)	1 (5.9)	0	1 (5.9)
I fear that the profession will become redundant when everything becomes automated	82 (15.7)	60 (73.2)	10 (2.2)	6 (7.3)	4 (4.9)	2 (4.3)
I fear that my work as a radiographer will be less interesting	53 (10.2)	39 (73.6)	10 (18.9)	3 (5.7)	1 (1.9)	0
I fear that there will be less focus on individual patients	77 (14.8)	54 (70.1)	16 (20.8)	1 (1.3)	4 (5.2)	2 (2.6)
I fear that there will be less cooperation with radiologists	50 (9.6)	30 (60.0)	13 (26.0)	3 (6.0)	3 (6.0)	1 (2.0)

approach on dissemination of AI knowledge within healthcare and radiography. Educational institutions can play an important role in providing a comprehensive theoretical foundation, as well as an introduction to practical skills in medical imaging. By offering a structured program, students and future radiographers will gain a deeper understanding of AI and its application in clinical practice. However, it is important to incorporate clinical practice in the educational curriculum due to the increased use of AI in the hospital setting. In line with this, students who have studied about AI have reported feeling more prepared to work with AI tools in comparison to those who did not receive such training.[11] The importance of AI training is supported by Lewis et al.,[20] who describe potential future roles for radiographers, such as building quality imaging biobanks, designing imaging protocols, AI optimising, and analysing radiomic features for routine clinical practice. However, a significant number of these complex tasks will require a substantial level of education and clinical training. This is also acknowledged by the fact that less than 5% of respondents in the current study did not feel that AI should be an integrated part of the radiography curriculum. In a recent study, the need for AI education within radiography was expressed as “urgent” by 77% of the respondents.[15]

Approximately 65% of the respondents in this study stated that they agreed or strongly agreed that AI will influence radiology more than radiography. The reality demonstrates the wealth of operational radiography tasks that are impacted by AI is increasing. Consequently, this raises the question of how to motivate and encourage radiographers to actively engage with AI technologies, so they can be prepared to safely use them for the benefit of the patients. AI may have the potential to enhance the role of

Table 3
Participants characteristics.

Variable(s)	Male		Female		p
	n	%	n	%	
Age					0.212
<40 years	88	(56.1)	260	(61.8)	
≥40 years	69	(43.9)	161	(38.2)	
Years since qualifications					0.299
<15 years	79	(60.3)	172	(54.9)	
≥15 years	52	(39.7)	141	(45.1)	
Aware of use of AI in medical imaging					0.01
Yes	144	(91.7)	336	(79.6)	
No	11	(7.0)	43	(10.2)	
Dont know	2	(1.3)	43	(10.2)	
Interested in attending AI lectures and training					0.435
Yes	112	(77.2)	295	(78.0)	
No	14	(9.7)	25	(6.6)	
I dont know	19	(13.1)	58	(15.4)	
Country					0.572
Denmark	109	(69.4)	267	(63.3)	
Norway	29	(18.5)	90	(21.3)	
Sweden	7	(4.5)	19	(4.5)	
Finland	4	(2.5)	10	(2.4)	
Other (Greenland, Iceland and Faroe Islands)	8	(5.1)	36	(8.5)	
Specialisation (multiple responses allowed)					
Digital X-ray	78	(49.7)	188	(44.6)	0.271
CT	83	(52.9)	174	(41.2)	0.012
MRI	60	(38.2)	87	(20.6)	<0.001
Is AI a useful tool in medical imaging					<0.001
Yes	77	(51.0)	204	(50.0)	
No	57	(37.8)	91	(22.3)	
I dont know	17	(11.2)	113	(27.7)	
Reservations about AI					0.021
I have no reservations	65	(45.1)	138	(37.1)	
Number of Patient complaints will increase	6	(4.2)	11	(3.0)	
I fear that the profession will become redundant	17	(11.8)	63	(16.9)	
I fear that my work as a radiographer will be less interesting	15	(10.4)	37	(10.0)	
I fear that there will be less focus on individual patients	10	(7.0)	66	(17.7)	
I fear that there will be less cooperation with radiologist	19	(13.2)	31	(8.3)	
Other	12	(8.3)	26	(7.0)	

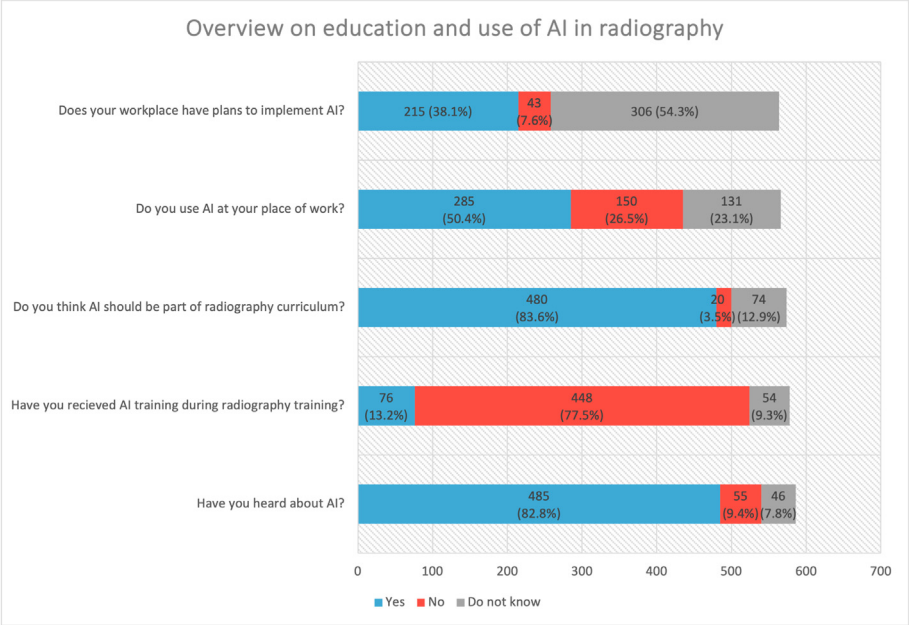

Figure 1. Overview on education and use of AI in radiography.

radiographers, improve patient care, and to increase the efficiency of healthcare services.[21] Therefore, it is important to involve radiographers and provide the theoretical underpinning of AI as a tool that may help to automate routine tasks allowing not only radiologists but also radiographers to focus on more complex tasks. Radiographers should perceive the advancement of AI as an opportunity for professional development and advanced practice and realise that they should embrace AI and take on a leading role in the implementation, validation, and quality assurance of AI technologies.

To what extent is AI currently assuming an important role in imaging? Abuzaid et al. found that 96% of the participants either agreed or strongly agreed that AI would play an important role.[22] This suggests that radiographers are not only aware of AI but also recognise its potential benefits for practice. According to the results in the current study, AI has already been implemented in many medical imaging departments, with 50% (n = 285) reporting current active utilization of AI in their workplace. Furthermore, 92% were aware of the presence of AI in their work setting (n = 485). These findings show the growing integration of AI into the daily work of radiography. The high level of awareness and adaption observed reflects a broader trend in the healthcare industry. Radiographers' recognition of AI's importance is an indicator of their readiness to embrace AI, provided that educational and opportunities will match the fast pace of applications in clinical practice.

Addressing gender imbalances can be a sensitive topic. In this study, we found that males generally exhibited higher awareness of AI compared to females. Additionally, we identified variations in specialty preferences, with a higher proportion of males working with CT and/or MRI. This could be random or influenced by social or cultural factors in the different workplace settings. Perhaps AI is perceived as a male-dominated area as there are currently few female role models or mentors in this field. This is also observed among 213 radiologists in the study by Alcaide-Leon et al.[23] that explored gender differences in radiology practice and found that female radiologist had a narrower scope of practice compared to the males. Furthermore, a recent study by Nightingale and colleagues observed gender recruitment strategies in radiography students and found that a specific strategy and mentorship for recruitment of males in therapeutic radiography was needed.[24] The

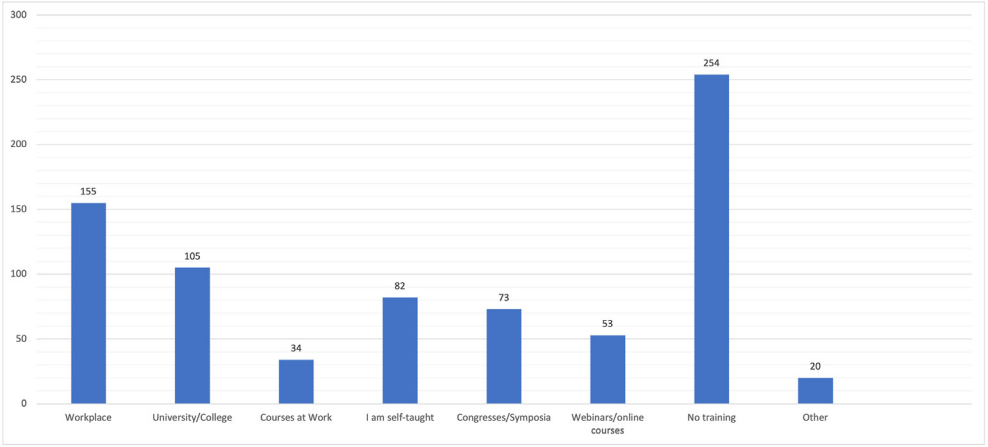

Figure 2. Information on where radiographers have gained knowledge about AI.

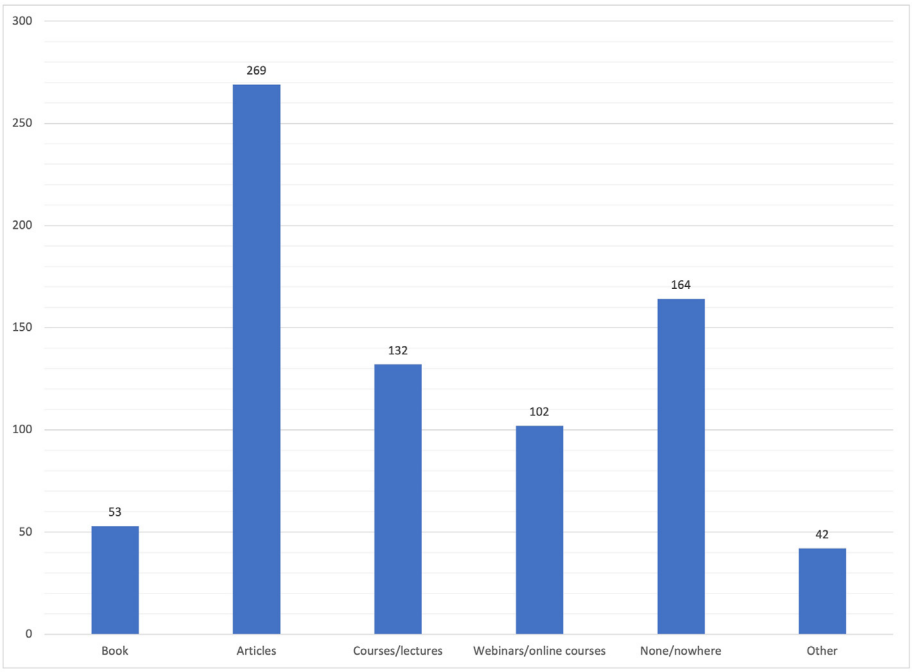

Figure 3. Information about how radiographers have gained knowledge about AI outside work.

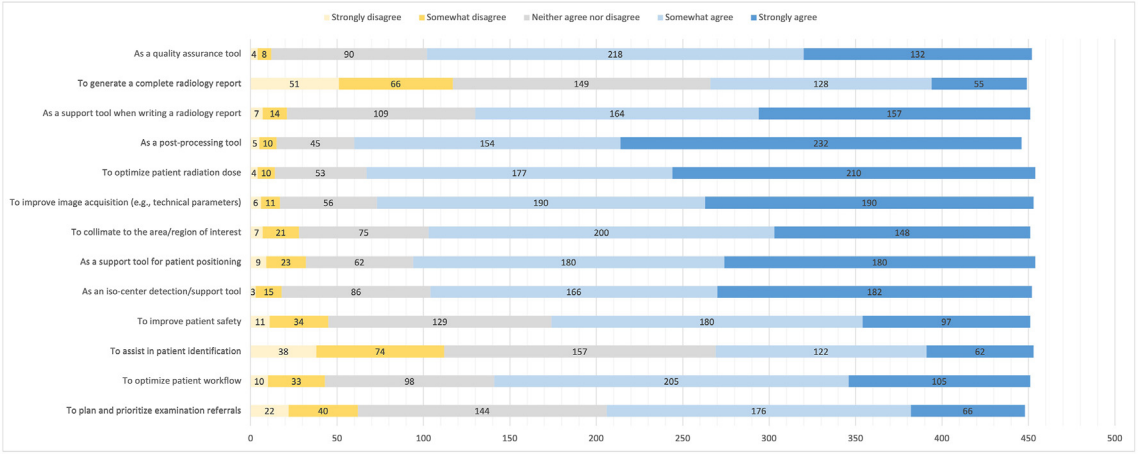

Figure 4. Radiographers' opinion on how AI can influence the radiography profession.

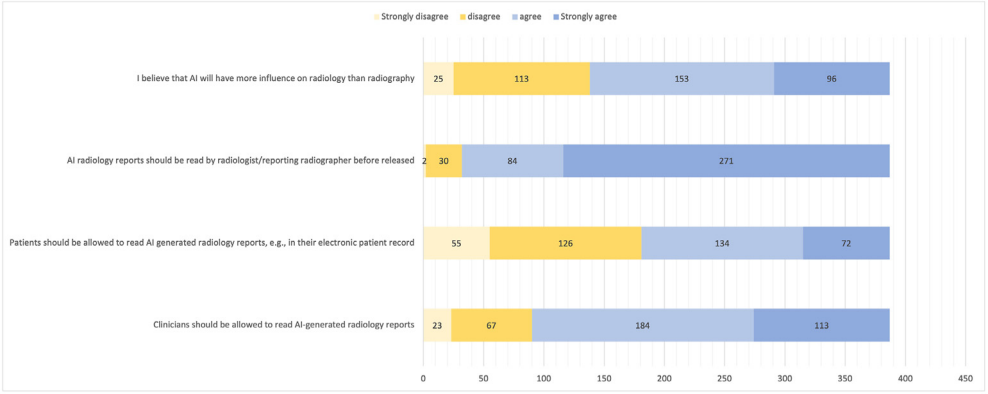

Figure 5. Perspectives on AI and the future of the radiography profession.

study found more of the male respondents were involved in modalities such as CT and/or MRI compared to females. Generally, there tends to be a gender bias in favor of males in the field of AI, which often is unconsciously manifested. This could pose a serious threat in a profession like radiography, which is female dominated, so proportionate action to support female radiographers should be in place both in providing education and in creating a positive culture in clinical and research settings.

To enable a successful implementation of AI in clinical practice specific strategies are needed concerning governance, employability, and education. A collaborative framework within the Nordic countries including radiographers, radiologist, policy makers and AI industry could be established to ensure governance strategies specific to the Nordic healthcare set-up systems. Also, ethical Nordic guidelines with focus on patient safety, data privacy and responsibility could be formulated. Continuous Professional Development is currently not implemented in any Nordic countries, but with a program with focus on AI and education this may be an opportunity to introduce CPD in clinical practice. Education in AI may include practical training in clinical practice, but it is important to have AI incorporated in radiography curriculum. These recommendations aim to create a successful implementation and future for AI in clinical practice, while supporting professional adaptability and technological advancement.

Strengths and limitations

Limitations of this study include language barriers as this survey was provided in English. Most Nordic radiographers speak, read, and write English very well. Yet, when it come to complex sentences in English there is a higher risk of skipping items, survey drop out, language misunderstanding or misinterpretation. We had a skewed geographical distribution with two-thirds of respondents from Denmark. Furthermore, it is a limitation that a high proportion of participants did not fully complete the survey, which is a cause for concern as it can potentially skew the results with selection bias, and negative impact of findings. However, the high number of responses (n = 586) and their geographical diversity is a substantial strength. Similar response rates were reported in other survey studies exploring AI perspectives in radiography.[11,15,16,19,22] Therefore, we assume that the large number of responses achieved in the current study allows for valid interpretation and some trends to be observed. Despite, that we don't have any possibility to investigate non-response bias due to the survey online design. We are aware that there is a risk of the order of questions (sequencing bias) may influence the responses, with the first items being answered and later items being skipped.

Moreover, the sample size may not always be representative of the populations. We chose to distribute the survey on online platforms, which can be a limitation, as not all radiographers use social media, thereby potentially introducing selection bias. However, it is becoming a standard of practice to use social media in survey studies.[15,19,25–28] Furthermore, there are currently 2500 active radiographers in Denmark[29] (inclusive Faroe Island and Greenland), 2800 in Norway,[30] 3000 in Finland,[31] 113 in Iceland[32] and unreported numbers from Sweden.

Conclusion

Overall, the survey revealed that radiographers are positive towards AI in medical imaging. Although up to 26% expressed a concern about AI, reported by the participants as lack of expertise and knowledge. This study emphasizes the need for a concerted effort of integrating AI curricula in educational institutions, as well as structured clinical hands-on training.

Author contribution

MRP led the project, applied for research ethical approval, and wrote the first draft. All authors contributed substantially to the design of the questionnaire and progress of the project. All authors read and approved the final manuscript.

Conflict of interest statement

None.

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