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Radiographers' perspectives on the emerging integration of artificial intelligence into diagnostic imaging: The Ghana study

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Abstract

Introduction: The integration of artificial intelligence (AI) systems into medical imaging is advancing the practice and patient care. It is thought to further revolutionise the entire field in the near future. This study explored Ghanaian radiographers' perspectives on the integration of AI into medical imaging. **Methods:** A cross-sectional online survey of registered Ghanaian radiographers was conducted within a 3-month period (February-April, 2020). The survey sought information relating to demography, general perspectives on AI and implementation issues. Descriptive and inferential statistics were used for data analyses. **Results:** A response rate of 64.5% (151/234) was achieved. Majority of the respondents (n = 122, 80.8%) agreed that AI technology is the future of medical imaging. A good number of them (n = 131, 87.4%) indicated that AI would have an overall positive impact on medical imaging practice. However, some expressed fears about AI-related errors (n = 126, 83.4%), while others expressed concerns relating to job security (n = 35, 23.2%). High equipment cost, lack of knowledge and fear of cyber threats were identified as some factors hindering AI implementation in Ghana. **Conclusions:** The radiographers who responded to this survey demonstrated a positive attitude towards the integration of AI into medical imaging. However, there were concerns about AI-related errors, job displacement and salary reduction which need to be addressed. Lack of knowledge, high equipment cost and cyber threats could impede the implementation of AI in medical imaging in Ghana. These findings are likely comparable to most low resource countries and we suggest more education to promote credibility of AI in practice.

Introduction

The field of medical imaging is highly reliant on technology, without which, radiographers cannot acquire diagnostic images or deliver care.[1] One of the recent emerging technological trends relates to the integration of artificial intelligence (AI) in medical imaging practice for patient care and research.[2,3]

AI refers to the theory and development of computer systems capable of performing tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making and language translation.[4] The concept of AI in medical imaging was envisaged in the 1960s, however, inadequate technological advancements during the period prevented any rapid progress.[5] AI in medical imaging gained more widespread recognition with the introduction of complex computer systems and development of artificial neural network systems as well as machine learning technologies in the 1980s.[5]

Although image interpretation is possibly the most well-researched task of AI in medical imaging in an attempt to improve the detection of pathologies[3,4,6], current studies are focussed on its application beyond this

scope to broadly support imaging professionals in achieving optimal results with ease.[1,7–11] Particularly, AI tools are being used as clinical decision support enhancers and supportive systems for improving imaging workflow, image acquisition, disease identification, research efficiency, radiation exposures and delivering high-quality care.[1,6,9] A recent meta-analysis demonstrated that the diagnostic performance of these technologies is equivalent to that of healthcare professionals.[3]

Despite the aforementioned benefits, scarcity of technical expertise, data-right frameworks, public policies and latest physical resources have impeded the adoption of AI in medical imaging in Ghana and other low- and middle-income countries.[8] Notwithstanding, there are strong attempts by Governments and other non-governmental organisations (e.g. RAD-AID) to promote and integrate the use of AI technologies in medical imaging in relatively low resource environments.[8] For the AI systems to be well integrated in medical imaging, there would be a need for radiographers to support the integration process since they are the interface between the technology and their patients. However, limited studies exist involving radiographers and AI systems. Although some studies explored the perspectives of radiographers regarding AI, the views of the radiography workforce in resource-limited settings such as Ghana, still remain unclear. This study was consequently prompted by this gap and therefore sought to comprehensively explore the perspectives of radiographers practicing in Ghana, on the integration of AI into diagnostic medical imaging practice in order to support policy development to enhance the AI implementation strategy for Ghana.

Method

Ethical considerations

Ethical clearance for the study was first sought and approved by the Ethics and Protocol Review Committee of the School of Biomedical and Allied Health Science, University of Ghana. Permission was also sought from the Ghana Society of Radiographers, the professional body of radiographers in Ghana, to engage its membership for the study.

Study design, setting and sample size

A cross-sectional survey design utilising a questionnaire was employed for this study. This design allowed the collection of the required data within a short time (3-months). At the time of the study, there were 234 radiographers registered with the Allied Health Professions Council (the national regulatory body) to practice in Ghana. The required minimum sample size ($n = 146$) for the study was calculated using the G*Power version 3.1.9.7.

Research instrument development

The questionnaire used in the study was developed after review of relevant literature relating to AI in medical imaging. The initial questionnaire was put together by a 2-member committee with experience in survey instrument development for radiography research. To eliminate the risk of biased responses, the questions were developed to generate acceptable positive or negative answers. This was to help the respondents to think more about their responses. The questionnaire went through several rounds of reviews before it was approved by the committee. The questionnaire had 37 items including closed-ended questions and 5-point Likert Scale statements (1 = strongly disagree to 5 = strongly agree). The questionnaire sought information in relation to (1) demography (6 closed-ended questions), (2) attitudinal perspectives on clinical application of AI (6 Likert Scale statements), (3) perspectives on impact of AI in medical imaging (17 Likert Scale statements), (4) potential AI implementation issues (4 Likert Scale statements), (5) decision-making in the presence of AI (4 Likert Scale statements) and (6). free text/open responses option for additional commentary. A panel of academics with 7- and 10-years' experience in radiography research and practice subsequently assessed and approved the questionnaire for the study (See Supporting Information for details of the questionnaire). During the questionnaire evaluation phase, assessors were given a categorical rater scale (important or not important) to rate the importance of each question/item in the study. The raters were also tasked to make recommendations to improve the questionnaires where applicable. All the questions were rated important for the achievement of the main objective of the study. However, corrections regarding typographical errors were recommended and addressed. A test-retest analysis was conducted using the Interclass Correlation Coefficient (ICC) test to assess the reliability of the questionnaire which was considered to be acceptable (ICC score = 0.85, $P < 0.001$). Subsequently, a pilot study was conducted among radiographers ($n = 3$) at the Korle Bu Teaching Hospital, Accra to further address any unforeseen issues and to ensure the questionnaire was explicit and clear. No issues and/or recommendations were made from the pilot study for changes to the questionnaire.

Data collection procedure

Google Forms (Google, Mountain View, CA) was used to host the questionnaire electronically. Participants were mainly reached via the Ghana Society of Radiographers' official social media platforms, including WhatsApp and Facebook to maximise response. Radiographers who wanted to participate in the study but did not have access to these online platforms were emailed the questionnaires. Hard copies of the questionnaire were also handed in person to a few ($n = 3$) of radiographers who requested. The first page of the questionnaire (both electronic and hard copy) contained an introductory information sheet that explained the purpose, the risk, benefit, study duration and what AI was about to radiographers. It also explained the opportunity to withdraw from the study at any time. They were also informed the questionnaire was only opened to radiographers practicing in Ghana who consented to participate in the study. Moreover, the first page of the questionnaire required each radiographer to electronically consent their participation for access to the survey. The security features of the online portal were designed to allow single participation from a radiographer and for those who preferred hardcopies, the researchers asked specific questions to enforce single participation in the study. Once an online questionnaire was completed, it was automatically sent to the survey platform hosted by one of the researchers for collation. For the hard copies, a research team member visited and collected the completed questionnaires sealed in an envelope from the participants. These responses were copied and added to the electronically acquired data for analyses. The survey was opened for a 3-month period (February-April, 2020) during which colleagues' networks were also employed to promote the study. To ensure anonymity and protection of rights, participants' identities were not sought. Participants were automatically assigned codes in Google Forms, rather than the use of personal identification details to ensure anonymity. Data obtained were encrypted with a password for safety and confidentiality.

Data analysis

Both descriptive and inferential statistics were used to analyse the data obtained. The descriptive statistics were used to generate frequencies, percentages and means while inferential statistics were used to generate association/correlation coefficients and *P*-values. The Statistical Package for Social Sciences (SPSS) version 23 (SPSS Inc., Chicago, IL, USA) was used for data analyses. The response to rating questions/items were assigned scores (1–5) on the Likert scale, corresponding to responses (strongly agree = 5, agree = 4, neutral = 3, disagree = 2, strongly disagree = 1) and aggregate mean scores (MS) were generated for the study themes/components. Spearman correlation was used to assess the relationship between radiographers' perspectives about AI and demographic characteristics. Mann-Whitney U test was used to independently test the perspective variables against gender and age categories since the data variables were non-parametric. A *p*-value of less than 0.05 was considered statistically significant. For easy presentation of results in Tables, the strongly agree and agree responses were grouped together, similarly, responses for strongly disagree and agree were grouped together. The free text/open responses were grouped into themes and their frequencies presented graphically using bar charts.

Results

A response rate of 64.5% ($n = 151$) was obtained, comprising of 73.5% ($n = 111$) males and 26.5% ($n = 40$) females of the registered radiography workforce in Ghana during the study period. The mean age ($\pm$ standard deviation) of the respondents was 33.6 $\pm$ 7.3 years. Respondents' demographic details are presented in Table 1. Generally, the respondents scored AI an average of 3.7 on a scale of 1–5, to suggest a very positive attitude towards the integration of this technology in medical imaging. The findings (Table 2) show that a good number ($n = 122$, 80.8%) of the respondents embrace AI technology as the future of medical imaging. A similarly large majority of respondents ($n = 132$, 87.4%) indicated that AI would have an overall positive impact on medical imaging practice. Others ($n = 104$, 68.8%) also indicated that AI will reduce radiation dose levels while maintaining optimal image quality (Table 3). Table 4 shows the respondents' perspectives on the negative impacts of AI in medical imaging where the majority expressed fears about potential machine errors associated with the used of AI-integrated equipment in radiography practice ($n = 126$, 83.4%). Table 5 further presents the respondents' perspective in relation to factors that can affect AI implementation and decision-making with AI in medical imaging. High equipment cost ($n = 118$, 78.1%), lack of knowledge ($n = 125$, 82.8%) and perceived cyber threats ($n = 109$, 72.2%) were some of the factors identified to hinder AI implementation in Ghana (Table 5). Figure 1 presents some themed free-text comments provided by respondents relating to AI in medical imaging practice.

There was no statistically significant difference in gender in terms of attitude towards AI ($P = 0.066$), perspective on the positive impact of AI ($P = 0.112$) and

Table 1. Demographic distribution of respondents.

Variables	*n* (%)
Age (years)[+]	
20–29	51 (33.8)
30–39	70 (46.4)
40–49	27 (17.9)
50 and above	3 (2.0)
Gender	
Male	111 (73.5)
Female	40 (26.5)
Years of experience[+]	
0–5	52 (34.4)
6–10	43 (28.5)
11–15	32 (21.1)
16–20	18 (11.9)
21–25	4 (2.6)
Above 25	2 (1.3)
Educational level	
Diploma	15 (9.9)
Bachelor's degree (BSc)	93 (61.6)
Master's degree (MSc)	37 (24.5)
Doctor of Philosophy (PhD)	3 (2.0)
Other	3 (2.0)
Equipment used by participants*	
Dental x-ray	40 (26.5)
General x-ray	128 (84.7)
Computed tomography (CT)	78 (51.7)
Magnetic resonance imaging (MRI)	33 (21.9)
Fluoroscopy	35 (23.2)
Mammography	40 (26.5)
Ultrasound	39 (25.8)
Other (mineral densitometry bone mineral densitometry, nuclear medicine, electrocardiography and academia	7 (4.6)
Work setting	
Government sector	93 (61.6)
Private sector	34 (22.5)
Military setting	7 (4.7)
Quasi-government	17 (11.3)

[+] Response percentages may exceed or not add up to 100% due to rounding.

* Since multiple options were selected, the total response percentages may exceed 100%.

perspective on the negative impact of AI ($P = 0.449$). Furthermore, the study observed no statistically significant difference between those < 40 years and ≥ 40 years in terms of their attitudes towards AI ($P = 0.771$), perspective on the positive impact of AI ($P = 0.965$) and perspective on the negative impact of AI ($P = 0.261$). Table 6 presents the results of tests of associations between respondents' demographic characteristics and their perspectives towards AI.

Discussion

This is the first study that has examined the perceptions of radiographers practicing in Ghana on the potential impact of AI in medical imaging. A good response rate of 64.5% (151/234) was achieved suggesting a representative sample. This response rate was similar to that of previous studies[12,13] conducted with this workforce cohort that obtained 64.3% and 57.3%, respectively. In general, radiographers reported positive attitudes about the potential benefits of AI, however, concerns around AI-related errors, cyber security, data protection and decision-making issues were identified.

Specifically, majority of respondents (86.1%) expressed an awareness of AI as an emerging trend in the field of medical imaging with 80.8% of them embracing it as the future of the discipline. This finding is comparable to the work of Sarwar et al[14] in which majority of the respondents (80.6%) predicted full integration of AI within the next five to ten years. Generally, the respondents scored AI an average of 3.7 on a scale of 1–5, to suggest a very positive attitude towards AI in medical imaging. However, no apparent statistically significant association between respondents' attitudinal perspectives and their demographic parameters such as age ($P = 0.761$), years of work experience ($P = 0.938$) and level of education ($P = 0.370$) was observed. Furthermore, the observed attitudinal perspectives exhibited by the respondents did not vary by gender ($p = 0.066$) or by the age categories: below 40 years and

Table 2. Respondents' attitudinal perspectives on clinical application of AI in medical imaging.

Statements	Response			Overall mean score (MS)
	Agreement	Neutral	Disagreement	
I am aware of AI as an emerging trend in medical imaging.	130 (86.1%)	17 (11.3%)	4 (2.6%)	MS* = 3.7
AI is emerging in Ghana's radiography sector.	69 (45.7%)	60 (39.7%)	22 (14.5%)	
I am concerned about the integration of AI into medical imaging.	97 (64.2%)	32 (21.1%)	22 (14.5%)	
I am excited about the emergence of AI in medical imaging.	120 (79.4%)	22 (14.6%)	9 (5.8%)	
I believe most patients would be excited about the use of AI technology in their care.	102 (67.6%)	34 (22.5%)	15 (9.9%)	
I embrace AI technology as the future of medical imaging.	122 (80.8%)	22 (14.6%)	7 (4.5%)	

MS* = mean score out of an aggregated total of 5 on the attitudinal perspectives on AI in medical imaging. AI = artificial intelligence.

Table 3. Respondents' perspectives on the positive impact of AI in medical imaging.

statements	Responses			Overall mean score (MS)
	Agreement	Neutral	Disagreement	
AI would have an overall positive impact in medical imaging.	132 (87.4%)	14 (9.3%)	5 (3.3%)	MS^{+} = 4.1
AI would be an assistive tool to ease my work as a radiographer.	125 (82.8%)	22 (14.6%)	4 (2.6%)	
AI would increase access to care in places where radiologists are inaccessible.	132 (87.4%)	15 (9.9%)	4 (2.6%)	
AI would improve decision-making on diagnostic results of patients.	136 (90.1%)	9 (5.90%)	6 (3.9%)	
AI technology would improve quality assurance through its efficiency in diagnosis.	132 (87.4%)	13 (8.60%)	6 (3.9%)	
The introduction of AI in medical imaging provides avenue for more research productivity in radiology.	137 (90.7%)	9 (6. 0%)	5 (3.3%)	
AI would help to reduce radiation dose levels while maintaining optimal image quality in medical imaging.	104 (68.8%)	31 (20.5%)	16 (10.6%)	
AI would improve education in medical imaging.	122 (80.8%)	21 (13.90%)	8 (5.2%)	
AI would have increased levels of accuracy in detecting and diagnosing diseases.	126 (83.4%)	14 (9.3%)	11 (7.2%)	
AI would effect a change of role of radiographers in the radiography unit.	81 (53.6%)	43 (28.50%)	27 (17.8%)	

MS^{+} = mean score out of an aggregated total of 5 on the positive impact of AI in medical imaging. AI = artificial intelligence.

Table 4. Respondents' perspectives on the negative impact of AI in medical imaging.

Statement	Responses			Overall mean score (MS)
	Agreement	Neutral	Disagreement	
The integration of AI would limit the work of the radiographer in the unit.	69 (45.7%)	41 (27.2%)	41 (27.2%)	
Most radiologists will be negatively affected by the introduction of AI in diagnostic image interpretation.	81 (53.6%)	44 (29.1%)	26 (18.2%)	
I have a concern that AI would displace me of my job someday.	35 (23.2%)	56 (37.1%)	60 (40.1%)	
I believe AI, as an assistive tool, can potentially cause a reduction of my basic salary.	32 (21.2%)	57 (37.7%)	62 (41.1%)	$MS^{\#}$ = 2.7
I acknowledge the possibility of machine errors associated with AI-induced equipment in the radiography unit.	126 (83.4%)	18 (11.9%)	7 (4.6%)	
AI might curtail patients' right to privacy and confidentiality through the storage of personal information alongside clinical data.	68 (45.1%)	41 (27.2%)	42 (27.8%)	
The use of AI tools could lead to unethical utilisation of patient data for unwarranted commercial quests.	58 (38.4%)	54 (35.8%)	39 (25.8%)	

$MS^{\#}$ = mean score out of an aggregated total of 5 on the negative impact of AI in medical imaging. AI = artificial intelligence.

40 years and above ($p = 0.771$). These findings suggest that the observed attitudes towards AI were independent of respondents' demographic parameters. Contrary to these findings, Sarwar et al[14] found that those above 40 years old were more positive about AI than their counterparts below 40 years. The regional and economic backgrounds of the two groups of respondents could potentially account for the observed difference.

In relation to the positive impact of AI, majority of the participants reported that AI could be an assistive tool to ease their work as radiographers (82.2%), optimise radiation dose levels (68.8%) and have an overall positive impact in medical imaging (87.4%) in line with several other previous studies.[1,7,9,15] The fact that AI-related decision support systems can accurately produce diagnostic results through triaging and flagging of abnormal images of patients[3,6] suggests that its integration in medical imaging is improving practice and has the capacity to help more patients without access to prompt radiological interpretation, like the rural parts of Ghana and other resource poor regions of the world.[8] This is believed to increase the levels of accuracy in diagnosing diseases in a short time and improve decision-making on diagnostic results of patients and quality assurance in many aspects of radiography practice. In academia, AI tools are also thought to improve education in medical imaging and promote research productivity in radiology which supports the findings of Sarwar et al.[14]

Table 5. Perspectives on factors that can affect the AI implementation and decision-making in medical imaging.

Statements	Responses		
	Agreement	Neutral	Disagreement
Perspectives on factors that can affect the implementation of AI in medical imaging			
AI implementation in Ghana will be hindered by its high costs of implementation.	118 (78.1%)	24 (12.6%)	9 (6.0%)
I acknowledge that the lack of knowledge on the emergence of AI technology poses a significant barrier in AI implementation.	125 (82.8%)	19 (12.6%)	7 (4.6%)
The implementation of AI can easily be affected by cyber threat.	109 (72.2%)	37 (19.2%)	5 (3.3%)
In an environment with lack of robust cyber security measures, AI can be manipulated by cyber criminals.	117 (77.5%)	29 (19.2%)	5 (3.3%)
Perspectives on decision-making in the presence of AI			
Diagnostic decision making should remain a human task.	75 (49.7%)	27 (17.9%)	49 (32.4%)
Diagnostic decision making should be shared equally with AI algorithm.	111 (73.4%)	27 (17.9%)	13 (8.6%)
Diagnostic decision making should be handled by the artificial intelligence algorithm.	29 (19.2%)	50 (33.1%)	72 (47.7%)
In the event of misdiagnosis due to an error attributable to the AI-tool software, who should be held responsible?	Response		
	35 (23.2%)	The radiographer in charge	
	80 (53.0%)	The machine manufacturers	
	15 (9.9%)	The referring radiologist	
	21 (13.9%)	Others, for example, AI administrators, handlers and health facility	

AI = artificial intelligence.

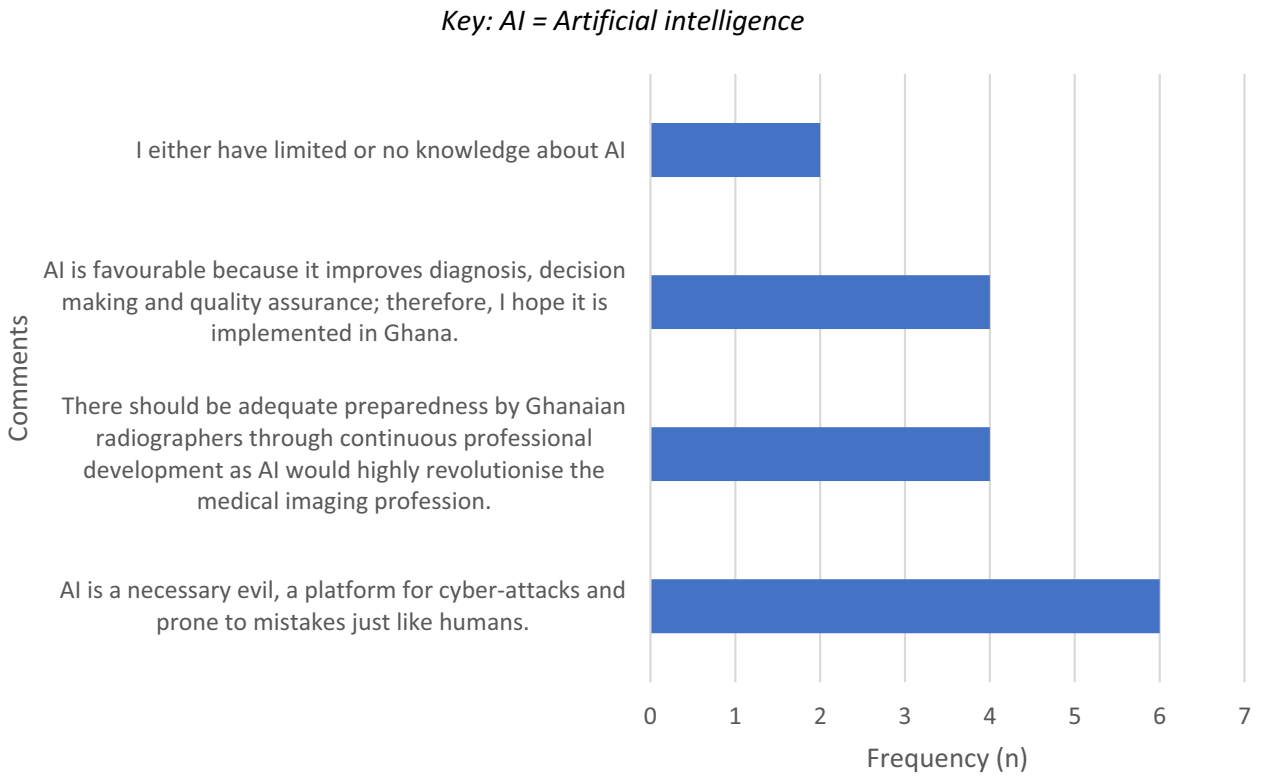

Figure 1. Responses provided by respondents in the comment section of the questionnaire on the integration of AI in medical imaging.

Table 6. Associations between respondents' demographic characteristics their perspectives towards AI.

	Education		Years of working experience		Age	
Variable	r_s	*P-value*	r_s	*P-value*	r_s	*P-value*
Perspective on attitudes towards AI	0.073	0.370	0.006	0.938	0.025	0.761
Perspective on positive impact of AI	0.055	0.506	0.016	0.844	0.010	0.902
Perspective on negative impact of AI	0.114	0.163	−0.015	0.856	−0.044	0.595

AI = artificial intelligence.

These assertions reflected in a very high total positive impact mean score of 4.1/5. Furthermore, we observed no statistically significant association between respondents' perspectives on the positive impact of AI and their demographic parameters (P-values > 0.05) (Table 6).

Despite the above benefits of AI, respondents scored the technology a mean of 2.7 on a negative impact scale ranging from 1–5 to indicate that they have concerns about it which need to be addressed. Particularly, some respondents (83.4%) were worried about the possibility of AI system errors affecting practice. However, a recent meta-analysis has demonstrated that AI tool are reliable.[3] The dichotomy between the perspective and literature could be due to a lack of knowledge on the operations and functions of AI tools. In free text comments (Figure 1), some respondents (n = 6) further demonstrated that AI tools are a necessary evil and are prone to mistakes just like humans. Greater assurance and education on the safe use of AI is needed to help alleviate some of these concerns. Moreover, the majority of respondents (53.6%) believed that most radiologists will be negatively affected by the introduction of AI in diagnostic imaging. This is a widely held belief because image interpretation is the most well-researched task of AI in medical imaging to find a way to quickly flag the numerous pathologies that are often encountered.[3,4,6] Sit and colleagues[16] reported that a significant number (49% of the 484 studied) of UK medical students (from 19 UK medical schools) do not consider radiology as a possible career choice due to the introduction of AI. The perception is that AI would take over the job of image interpretation. Of note, a small majority of respondents (45.7%) in this current study also thought that the integration of AI would limit the work of the radiographer; a speculative assertion which has not been presently substantiated.[6] These professionals would still be required to approve the results of AI systems as they are supporting tools and would rather create new positions and increase employment prospects in medical imaging.[9,17] Some respondents (38.4%) also expressed concerns that the use of AI tools could lead to unethical utilisation of patient data for unwarranted commercial purposes. This notion could stem from the fact that current AI-driven machines require patient data for the purpose of training deep learning algorithms to automate tasks,[4,6,11] and if data 'truthfulness' and ethical measures are not adhered to, data of patients could be compromised.[10] Meanwhile, there were no apparent statistically significant associations between respondents' perspective on the negative impacts of AI and demographic parameters (P-values > 0.05) (Table 6), which implies that all radiographers would require similar training, irrespective of age or gender to alleviate some of their negative perspectives about AI.

With respect to the factors that can affect the implementation of AI in medical imaging, the majority of the respondents acknowledged that the lack of robust cyber security measures (77.5%) and knowledge on the emergence of AI technology (82.2%) in Ghana poses a significant barrier in AI implementation. Similarly, Sit and colleagues[16] reported that respondents who had received some form of education in AI felt more ready to work with these tools. This suggests that medical imaging equipment manufacturing firms and hospitals must initiate frequent organisation of workshops and conferences aimed at enlightening professionals on cyber security issues and the clinical applications of AI tools in practice.[18] In addition, 78.1% of respondents believed that the high cost of AI systems could limit its implementation in Ghana. Already, technological advancements in healthcare continues to be a challenge for Ghana's healthcare sector[19] and many other developing countries, therefore, their assertion may be true.

As to who make decisions in the use of AI tools, the majority (73.4%) of the respondents agreed that diagnostic decision-making should be a shared responsibility between the AI algorithm and practitioners (73.4%). In contrast, the findings from Sarwar et al[14] indicate that diagnostic decision-making should predominantly remain a human task.[2] This could be because the AI tools are just supportive systems.[2] When respondents were asked about who should be held responsible in the event of misdiagnosis due to an error

attributed to the AI tools, some believed that machine manufacturers (53%), radiological staff including radiographers-in-charge (23.2%) and the supervising radiologist (9.9%) should be held accountable. Greenemeier[20] argued that if an institutions' AI is completely autonomous, the blame could be solely placed on the manufacturer when an error occurs. Otherwise, non-autonomous AI institutions could have in place policies and guidelines which would direct the appropriate handling of the technology in order to identify the cause of the error if the guidelines were not followed by the operators. The findings relating to shared responsibility in the case of AI misdiagnosis is thought-provoking and therefore requires attention in future studies.

One limitation of the study is that it was not reported how many of the study participants use AI in their clinical practice. Therefore, findings from this study cannot be used solely for future AI implementation strategies.

Conclusion

The radiographers practicing in Ghana that responded to this survey demonstrated positive attitudes about the potential benefits of AI in medical imaging. However, concerns around AI-related errors, cyber security, data protection and decision-making issues were identified. Lack of knowledge/technical expertise, high equipment cost and cyber threats were identified as potential barriers affecting the implementation of AI in medical imaging in Ghana. We suggest the implementation of a rigorous AI education programme modelled after that of other successful organisations to promote the credibility and adoption of AI in practice in Ghana. Future research on the educational needs of radiographers relating to AI is highly recommended to inform the radiography education and training curricula/programmes.

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Conflict of Interest

The authors declare that they have no competing interests.

References

1. Hardy M, Harvey H. Artificial intelligence in diagnostic imaging: impact on the radiography profession. *Br J Radiol* 2020; **93**: 20190840.
2. Morozov S, Ranschaert ER, Introduction Algra PR. Game changers in radiology. In: Ranschaert ER, Morozov S Algra PR (eds). Artificial Intelligence in Medical Imaging: Opportunities, Applications and Risks. Springer, Cham, 2019; 3–5.
3. Liu X, Faes L, Kale AU, et al. A comparison of deep learning performance against health-care professionals in detecting diseases from medical imaging: a systematic review and meta-analysis. *Lancet Digital Health* 2019; **1**: e271–e97.
4. Ranschaert ER, Duerinckx AJ, Algra P, Kotter E, Kortman H, Morozov S. Advantages, challenges, and risks of artificial intelligence for radiologists. In: Ranschaert ER, Morozov S Algra PR (eds). Artificial Intelligence in Medical Imaging: Opportunities. Springer, Applications and Risks, Cham, 2019; 329–46.
5. Fazal MI, Patel ME, Tye J, Gupta Y. The past, present and future role of artificial intelligence in imaging. *Eur J Radiol* 2018; **105**: 246–50.
6. Murphy A, Liszewski B. Artificial intelligence and the medical radiation profession: how our advocacy must inform future practice. *J Med Imaging Radiat Sci* 2019; **50** (4S2): S15–19.
7. Chaix B, Bibault JE, Pienkowski A, et al. When chatbots meet patients: one-year prospective study of conversations between patients with breast cancer and a Chatbot. *JMIR Cancer* 2019; **5**(1): e12856.
8. Mollura DJ, Culp MP, Pollack E, et al. Artificial intelligence in low- and middle-income countries: innovating global health radiology. *Radiology* 2020, 201434. https://doi.org/10.1148/radiol.2020201434
9. Lewis SJ, Gandomkar Z, Brennan PC. Artificial Intelligence in medical imaging practice: looking to the future. *J Med Radiat Sci.* 2019; **66**: 292–295.
10. Geis JR, Brady A, Wu CC, et al. Ethics of artificial intelligence in radiology: summary of the joint European and North American multisociety statement. Insights. *Imaging.* 2019; **10**: 101.
11. Jarrett D, Stride E, Vallis K, Gooding MJ. Applications and limitations of machine learning in radiation oncology. *Br J Radiol.* 2019; **92**: 20190001.
12. Akudjedu TN, Botwe BO, Wuni AR, Mishio NA. Impact of the COVID-19 pandemic on clinical radiography practice in low resource settings: the Ghanaian radiographers' perspective. *Radiography (Lond).* 2020:S1078-8174(20)30223-6. https://doi.org/10.1016/j.radi.2020.10.013
13. Ashong Ggna, Rogers H, Botwe Bo, Anim-Sampong S. Effects of occupational stress and coping mechanisms adopted by radiographers in Ghana. *Radiography* 2016; **22**: 112–17.
14. Sarwar S, Dent A, Faust K, et al. Physician perspectives on integration of artificial intelligence into diagnostic pathology. *NPJ Digit Med* 2019; **26**: 28.

15. Laï MC, Brian M, Mamzer MF. Perceptions of artificial intelligence in healthcare: findings from a qualitative survey study among actors in France. *J Transl Med.* 2020; **18**: 14.
16. Sit C, Srinivasan R, Amlani A, et al. Attitudes and perceptions of UK medical students towards artificial intelligence and radiology: a multicentre survey. *Insights Imaging.* 2020; **11**: 14.
17. International Society of Radiographers and Radiological Technologists, The European Federation of Radiographer Societies. Artificial Intelligence and the Radiographer/ Radiological Technologist Profession: A joint statement of the International Society of Radiographers and Radiological Technologists and the European Federation of Radiographer Societies. *Radiography (Lond)* 2020; **26**: 93–95.
18. Ongena YP, Haan M, Yakar D, Kwee TC. Patients' views on the implementation of artificial intelligence in radiology: development and validation of a standardized questionnaire. *Eur Radiol* 2020; **30**: 1033–1040.
19. Addae-Korankye A. Challenges of Financing Health Care in Ghana: The Case of National Health Insurance Scheme (NHIS). *Int J Asian Soc Sci* 2013; **3**: 511–522.
20. Greenemeier L.Intelligent to a fault: when ai screws up, you might still be to blame. Retrieved from https://www.scientificamerican.com/article/intelligent-to-a-fault-when-ai-screws-up-you-might-still-be-to-blame1/ (accessed February 20 2020).

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1 Section A: Demographics.
Section B: Attitudinal perspectives on clinical application of artificial intelligence (AI) in medical imaging.
Section C: Perspectives on impact of artificial intelligence (AI) in medical imaging.
Section D: Perspectives on factors that can affect the implementation of artificial intelligence (ai) in medical imaging.
Section E: Decision-making in the presence of AI.