

IMPACT OF THE COVID-19 PANDEMIC ON CLINICAL RADIOGRAPHY EDUCATION: PERSPECTIVE OF STUDENTS AND EDUCATORS FROM A LOW RESOURCE SETTING

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**IMPACT OF THE COVID-19 PANDEMIC ON CLINICAL RADIOGRAPHY
EDUCATION: PERSPECTIVE OF STUDENTS AND EDUCATORS FROM A LOW
RESOURCE SETTING**

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Abstract

Introduction: The COVID-19 pandemic has had significant impact on clinical radiography educational activities including teaching, research, and clinical placement. The study aimed to investigate the impact of the COVID-19 pandemic on clinical radiography education in a low-resource setting from the perspectives of students and educators.

Methods: A cross-sectional online survey was conducted between December 2020 and March 2021. Participants included student radiographers and educators from six clinical radiography training institutions in Ghana. Conventional descriptive statistics, frequency, and thematic text analysis were undertaken.

Results: 291 valid responses were received involving 277 students and 14 educators. Most of the respondents, predominantly students did not find the online platforms for learning user-friendly. Key challenges to clinical radiography training during the pandemic included poor internet connectivity (73.8%), inadequate time for academic discussions (50.9%), and the reluctance of health facilities to accept students for clinical placement (51%). Challenges with data collection and the provision of supervision were issues associated with research activities.

Discussion: The findings suggest the COVID-19 pandemic has had significant impact on clinical radiography education in Ghana and other countries of similar resource availability.

Conclusion: Clinical radiography training institutions need to customize approaches to education. Adopting blended learning approaches as well as the use of simulation to augment practical placement opportunities are new modes of instruction that will maximize learning experience.

Résumé

Introduction : La pandémie de COVID-19 a eu un impact significatif sur les activités éducatives cliniques en radiographie, notamment l'enseignement, la recherche et les stages cliniques. L'étude visait à examiner l'impact de la pandémie de COVID-19 sur l'enseignement clinique de la radiographie dans un environnement à faibles ressources du point de vue des étudiants et des éducateurs.

Méthodologie : Une enquête transversale en ligne a été menée entre décembre 2020 et mars 2021. Les participants comprenaient des étudiants et des éducateurs en radiographie de six établissements de formation clinique en radiographie au Ghana. Des statistiques descriptives conventionnelles, des fréquences et une analyse textuelle thématique ont été entreprises.

Résultats : 291 réponses valides ont été reçues, provenant de 277 étudiants et de 14 éducateurs. La plupart des répondants, principalement des étudiants, n'ont pas trouvé les plateformes d'apprentissage en ligne conviviales. Les principaux obstacles à la formation clinique en radiographie pendant la pandémie sont la mauvaise connectivité Internet (73,8 %), le manque de temps pour les discussions académiques (50,9 %) et la réticence des établissements de santé à accepter les étudiants en stage clinique (51 %). Les difficultés liées à la collecte de données et à la supervision étaient des problèmes associés aux activités de recherche.

Discussion : Les résultats suggèrent que la pandémie de COVID-19 a eu un impact significatif sur l'enseignement de la radiographie clinique au Ghana et dans d'autres pays disposant de ressources similaires.

Conclusion : Les établissements de formation clinique en radiographie doivent personnaliser leurs approches d'enseignement. L'adoption d'approches d'apprentissage mixtes ainsi que l'utilisation de la simulation pour augmenter les possibilités de stages pratiques sont de nouveaux modes d'enseignement qui maximiseront l'expérience d'apprentissage.

Keywords: COVID-19, students, educators, virtual learning, radiography

Introduction

The impact of the COVID-19 pandemic on clinical radiography practice and education has been enormous globally.¹⁻³ Noteworthy are reports of increased workplace stress among healthcare workers, including radiographers.^{1,2,4,5} Interruptions in educational delivery due to the COVID-19 pandemic have been reported elsewhere and are known.^{2,3,6,7} The pandemic has profoundly altered academic radiography activities in teaching, research, and practical training.^{3,8-11} Ghana, like most other countries, went into full lockdown in March 2020 with the closure of all educational institutions.¹² In accordance with government directives, all forms of in-person teaching and learning activities were suspended,¹² consequently leading to a disruption in the normal academic calendar. In Ghana, a delayed start meant that the new academic year commenced in January 2021 instead of September 2020. These disruptions to clinical radiography training activities appear to be similar to the occurrences of other countries. Several recent reports,^{2,3,6,7} mostly from developed countries, have highlighted the challenges and experiences of radiography students and/or educators¹³ as well as changes to teaching and learning activities in the pandemic. In most developed countries, following the lockdown, teaching and learning activities transitioned to online platforms.^{2,3,6,7,13,14} Clinical training activities were mostly by simulation and/or well-coordinated (in accordance with local COVID-19 protocols) hands-on activities.^{2,15,16} These changes, although not always ideal, enhanced the teaching and learning experience of both educators and students, respectively, of clinical radiography.^{2,3,6,7,13,14}

In low resource settings such as Ghana, internet connectivity, an essential requirement for online teaching delivery and learning, remains a challenge. As of 2020, only 48% of the Ghanaian population had access to internet services due to inadequate infrastructure.^{17,18} Thus the delivery of teaching and learning through virtual platforms were unlikely to be effective.¹³ For financial and logistical reasons, no radiography training institution implemented the use of online teaching and learning in the pre-COVID era. Thus, both educators and students

were not technically well-versed in handling online teaching delivery and learning methods respectively.⁹ While simulation-based learning has been suggested as an alternative tool for practical training,^{2,15,16} it was not feasible in many low-resource settings including Ghana. This is mostly attributed to the high costs of simulation software as well as high fidelity anatomical phantoms/mannequins and other resources including inadequate internet connectivity infrastructure.

Although not unique to low resource settings, remote working for staff was one of the approaches adopted by educational institutions to manage the viral spread during the pandemic.¹³ This approach potentially affected research activities, especially with data collection and research supervision.^{13,19} Previous studies^{2,3,7,13,14,20} reported the experiences of radiography students mostly from developed and well-resourced settings. However, to the best of our knowledge, no study to date has reported the experiences of students and educators in low resource settings including Ghana, in relation to clinical radiography training and education delivery during the pandemic. The current study aimed to investigate the impact of the COVID-19 pandemic on clinical radiography education in Ghana from the perspectives of students and educators. This will serve as a blueprint for future educational policy formulation in radiography training in low-resource settings.

Methods

A cross-sectional online survey was carried out across the six (6) radiography training institutions in Ghana. A non-probability purposive sampling method was employed for data collection and involved student radiographers and educators from the training institutions. The research instrument comprised of 22 closed-ended questions and 3 free-text options for comments relating to changes to the classroom delivery, research, and clinical training activities. The free-text sections were to allow respondents to include more information,

including their understanding of the subject at hand. Some of the questions required responses from only the educators and respondents from institutions who transitioned to online learning/teaching. These were indicated in the data collection instrument. The instrument was developed by three radiography academics with 3-8years of experience and was built on the foundation of key literature^{2,3,13} and their experiences during the pandemic. Prior to distribution, the instrument was piloted among three (3) students and two (2) educators to ensure its appropriateness, relevance, and clarity of the questions.²¹

Modifications were made to the data collection instrument based on comments from the pilot study, prior to its distribution for the actual data collection. Comments and feedback in relation to the content validity and functionality/ease of use across various computer devices/operating systems were used to improve the instrument.

The survey was active online between December 2020 and March 2021. The respondents were provided with electronic links to the survey via the WhatsApp platforms of the various training institutions. Monthly reminders were also circulated through the WhatsApp medium to draw respondents' attention to completing the questionnaire. The online instrument was designed to allow each respondent to complete the questionnaire only once to avoid duplication of responses. The study was granted exemption from a full ethical review by the Local Institutional Ethics Review Committee (GHS-ERC/2020/075) due to the anticipated low-risk nature of the study to participants and the urgency of such investigation to inform educational policy. All participants provided informed consent for participation electronically. To ensure confidentiality, the participants' responses were kept anonymous and stored on a password-encrypted laptop. Data obtained were analyzed using the IBM Statistical Package for Social Sciences (SPSS) version 22.0. Thematic textual analysis of the free-text comments was also conducted.

Results

Demographic Distribution

A total of 291 valid responses were received within the specified response timeframe involving 277 students and 14 educators. There were more males (60.1%) in the study than females (39.9%). The students were at varying stages of their education: Year 1 (n=81, 29.2%), Year 2 (n=66, 23.8%), Year 3 (n=55, 19.9%), Year 4 (n=71, 25.6%), and recent graduates (n=4, 1.4%). Most of the educators (71.4%) had practiced for less than five years. None had practiced beyond 10 years. Table 1 details the distribution of respondents across the radiography programs (i.e., diagnostic, therapy, sonography) within the participating institutions.

Impact on classroom/theoretical delivery and research activities

Five out of the six training institutions migrated teaching and learning activities to virtual/online platforms in August 2020. A total of 14 educators and 265 students from the five institutions were involved in online teaching and learning activities respectively. Of the respondents, 92.9% of educators and 35.5% of students had prior experience or training in online teaching and learning, respectively, before the transition. Only 27.5% of the students indicated they were conversant with online learning platforms. However, all the educators were conversant with the use of the online teaching platforms. When asked about the general experiences of the students on the use of the online learning approach, 44% rated their experiences as fair and 25.2% as either poor or very poor. On the contrary, all the educators rated their experiences with the online teaching platform as either excellent or good.

Key issues among the numerous challenges encountered by the respondents with the use of the online platform included internet connectivity challenges (73.8%) and inadequate time for academic discussion (50.9%) (Figure 1). Table 2, shows that most of the respondents (92.8%) either strongly agreed or agreed that the pandemic had caused significant changes to the

academic calendar. Similar responses were also revealed concerning the effect of the pandemic on research activities with all the educators/final year students either strongly agreeing or agreeing to this. A common theme identified from the free text comments is indicative of the significant disruption to research during the pandemic as highlighted.

“Research activities for both students and faculty delayed because the ethical review board could not meet as expected. Also, due to difficulties with data collection, most of the students’ works were converted into long essays for assessment”

[Respondent ID: 5, educator]

“Research work was a challenge. Because of the ban and restrictions, I could not complete my data collection, hence a delay in my research work”.

[Respondent ID: 237, medical sonography student]

The imposition of Covid-19 restrictions were legal limits prohibiting people from participating in activities that had the potential to increase the spread of the virus.

Impact on clinical training

Table 2 shows a higher proportion of the respondents (90.1%) either strongly agreed or agreed that the pandemic had affected the clinical placement of students. The majority of respondents (83.8%) were not on clinical training/supervision during the first peak (March-August 2020) of the pandemic. Of the respondents, 51% either strongly agreed or agreed that health facilities were reluctant in accepting students for clinical training (Table 2). A review of the free-text comments suggests the reluctance of health facilities to take on radiography students for clinical placement in the pandemic as a dominant theme in relation to the impact of the pandemic on clinical training.

“The pandemic has negatively impacted clinical placement and training activities because facilities are unwilling to accept placements. For instance, as a Level 200 student, I was supposed to acquire some practical knowledge to equip myself in two courses this semester. I am however finding difficulties with the courses because I could not acquire those practical training”.

Respondent ID: 63, diagnostic radiography student]

“It was heartbreaking that Facility A(anonymized) refused me for clinical placement because of the COVID-19”

[Respondent ID: 102, diagnostic radiography student]

“Many health facilities didn't permit students to have their clinical practice in their facilities causing some students not to partake in the clinical sessions”

[Respondent ID: 136, diagnostic radiography student]

Discussion

The COVID-19 pandemic continues to pose a serious challenge to educational systems worldwide.¹⁻³ The consequent changes within the educational sector, including the transition to online teaching and learning, and restricted movement as a result of the lockdown has impacted clinical radiography education in low resource settings including Ghana.¹² This has widely affected academic, research, and clinical activities in most health training institutions.^{5,9} This research is the first, to the best of our knowledge, to report on the impact of COVID-19 on clinical radiography education from a low resource setting in the Sub-Saharan Africa region with Ghana as a case study. Low resource setting in this context refers to those settings, irrespective of their location, without modern teaching and learning infrastructure.

Distribution of the survey responses

There was male dominance noted from the response to this study, which is reflective of a poor response rate from female students and educators. Furthermore, this could be explained by the low female-to-male ratio when considering radiography as a career choice in Ghana which is underpinned by perceived fear of possible biological effects of radiation exposure as reported previously.²²

Currently, all the six radiography training institutions in Ghana offer diagnostic radiography programs at different levels, which may have accounted for the high number of diagnostic radiography students recorded in the study. Half of the training institutions offer medical sonography programs. However, there is currently only one training institution offering therapy radiography education in Ghana²² that admits students biennially, accounting for the low response recorded from therapy radiography students.

An Emergency Response Team is a group of internal first responders who consist of several disciplines and specialties and are competently trained to prevent an emergency from escalating. Following the declaration of COVID-19 as a global pandemic by the World Health Organization (WHO) in March 2020, countries and institutions set in place emergency response teams in line with the WHO guidelines to prevent, detect and respond to the threat posed by COVID-19 and strengthen national systems for public health preparedness.^{23,24}

Schools, just like other public places have also instituted safety measures to help curb the pandemic. Majority of the respondents (75.3%) were aware of the establishment of COVID-19 emergency response teams in their respective institutions during the pandemic, consistent with local and international guidelines.²⁵ The Noguchi Memorial Institute for Medical Research of the University of Ghana, and the University of Health and Allied Sciences, are

two educational institutions in Ghana that served as COVID-19 testing centers and had robust emergency response teams in place.^{26,27}

Impact of the pandemic on classroom and research activities

Almost all the respondents (92.8%) indicated that the pandemic had caused significant changes to the academic calendar, similar to other studies.^{3,5,15,28} Findings from this study suggested changes in teaching patterns during the pandemic as the regular face-to-face teaching instructions were replaced with online learning, consistent with earlier studies.^{1,13,29–}

³¹ However most of the respondents, predominantly students, did not find the platform user-friendly. This is because the virtual learning system might not have been part of the traditional face-to-face teaching system before the outbreak. A careful analysis of the data revealed 9 out of the 11 respondents who rated their experiences with the use of the virtual platform as “excellent” were educators, who likely had previous exposure to the use of such electronic platforms in the course of their training or teaching at a higher level. Almost all the educators (92.9%) had previous exposure to online education delivery. The sudden outbreak of the pandemic and the abrupt shutdown of schools may not have allowed the educational institutions the opportunity to effectively train students on such new systems of teaching and learning.

In this study, 64.5% of the students from institutions that transitioned to online education had no prior experience/training. The transition to online teaching and learning requires a lot of preparation, thought and, time.³² Visual factors, user interface characteristics, and the lack of prior experience/training may have contributed to why the students found the online system not user-friendly.^{33–35} This was contrary to an earlier study among second-year radiography students which found online teaching of experimental research as positive learning and development despite the lack of face-to-face interaction.²⁰

Poor internet connectivity, affordability, and inadequate time for discussions were key challenges to the implementation of the online teaching and learning system. As of 2020, only 48% of the Ghanaian population had access to internet services¹⁷ which is heavily centered in the urban areas due to inadequate infrastructure.¹⁸ This is lower than that of advanced countries such as South Africa (56.3%)³⁶, U.K (97%)³⁷ and the European Union countries (91%).³⁷ Internet data is expensive in Ghana with the price for 1GB of mobile data volume just over 2% of an average monthly income.¹⁸

All the educators and year 4 students undertaking research dissertations were of the view that the pandemic had affected research activities. This may be a result of most researchers having to work remotely. A study by Aczel and colleagues¹⁹ aimed at assessing the challenges of remote working by academic researchers revealed that the pandemic decreased the work efficiency of half of the researchers, citing the loss of touch with team members, inability to share thoughts with team members, and data collection challenges. Fourth-year radiography students in Ghana are required to submit a research dissertation in partial fulfillment for the award of Bachelor of Science degree in Radiography. Data collection challenges and lack of supervision from research supervisors were challenges faced by the students during the pandemic.

With COVID-19, students continuously struggled with data collection from the clinical areas while other students' research works had to be converted into long essays and reviews in order to meet deadlines.

Impact of the pandemic on clinical training

Clinical training is an integral part of any professional health training program. Globally, there still exist challenges in implementing clinical training for health trainees amidst the COVID-19 pandemic.² The closure of schools implies that students could not be adequately

placed for clinical activities. Despite the lift of the ban, clinical periods have reduced drastically.¹⁴ This is because health facilities were reluctant in accepting students for clinical placement. Effective precautions and safety measures are required in clinical practice during such pandemics. Decongestion of radiology departments of human activities, enforcing of social distancing and safety protocols, conservation of personal protective equipment, and the potential vector transmission from students were possible reasons for the non-acceptance of students during the pandemic.^{38,39} The perceived increase in workload might have also restricted the available time of hospital staff to supervise students.⁴⁰ Moreover, students may lack training on effective infection prevention and control practices and handling of COVID-19 imaging procedures.

Challenges of accommodation, isolation from family, and traveling for clinical placements may have also influenced the non-placement of students for clinical practice in adherence to the lockdown protocols. The impact of the pandemic is not peculiar to radiography training with similar trends observed with the training of other healthcare professionals.^{5,28,40,41} In a recent study, Robbins et al.⁴¹ highlighted the negative impact of the pandemic on clinical activities of radiology resident training including reduced clinical training hours.⁴¹ The use of simulation software and phantoms serve as an alternative tool for practical clinical training.² However, access to such alternative tools remains a challenge for institutions in low-resource settings like Ghana.

Limitations

The study did not evaluate the type of virtual learning platforms, the assessment format of such platforms, and how it influences the learning and teaching experiences of the respondents. Some students may not have had access to the survey through the WhatsApp

medium used while others may also not have had access due to challenges with internet availability or quality. The survey required internet connectivity, which was listed as one of the challenges with online learning, and therefore could have been a limitation for respondents. The quantitative nature of the study may have led to limited in-depth responses from the respondents on the subject matter.

Conclusion

COVID-19 has certainly impacted radiography education in Ghana, similar to other countries especially those considered to be of low resource setting. While virtual learning platforms seem to have replaced most traditional face-to-face teachings, students are not conversant with its use. Key challenges to clinical radiography training in the pandemic included poor internet connectivity, inadequate time for academic discussions, and the reluctance of health facilities to accept students for clinical placement during the period.

Challenges with data collection and the provision of supervision were issues associated with research activities. Clinical practice, an essential component of health training programs has been heavily affected by the pandemic. Clinical radiography training institutions need to customize approaches to education. Adopting blended learning approaches as well as the use of simulation to augment practical placement opportunities are new modes of instruction that will maximize learning experience. The findings of the study will future proof training institutions in Ghana in delivery of quality education in the event of another pandemic or major disruption in the academic calendar.

Table 1: Distribution of student respondents across the various training institutions by type of specialist radiography pathway

Program of study	Training Institutions						Total (%)
	A	B	C	D	E	F	
Medical sonography	0	20	14	0	0	32	66 (23.4%)
Diagnostic radiography	30	32	2	107	12	24	207 (74.5%)
Therapy radiography	4	0	0	0	0	0	4 (1.4%)
Total	34	52	16	107	12	56	277 (100%)

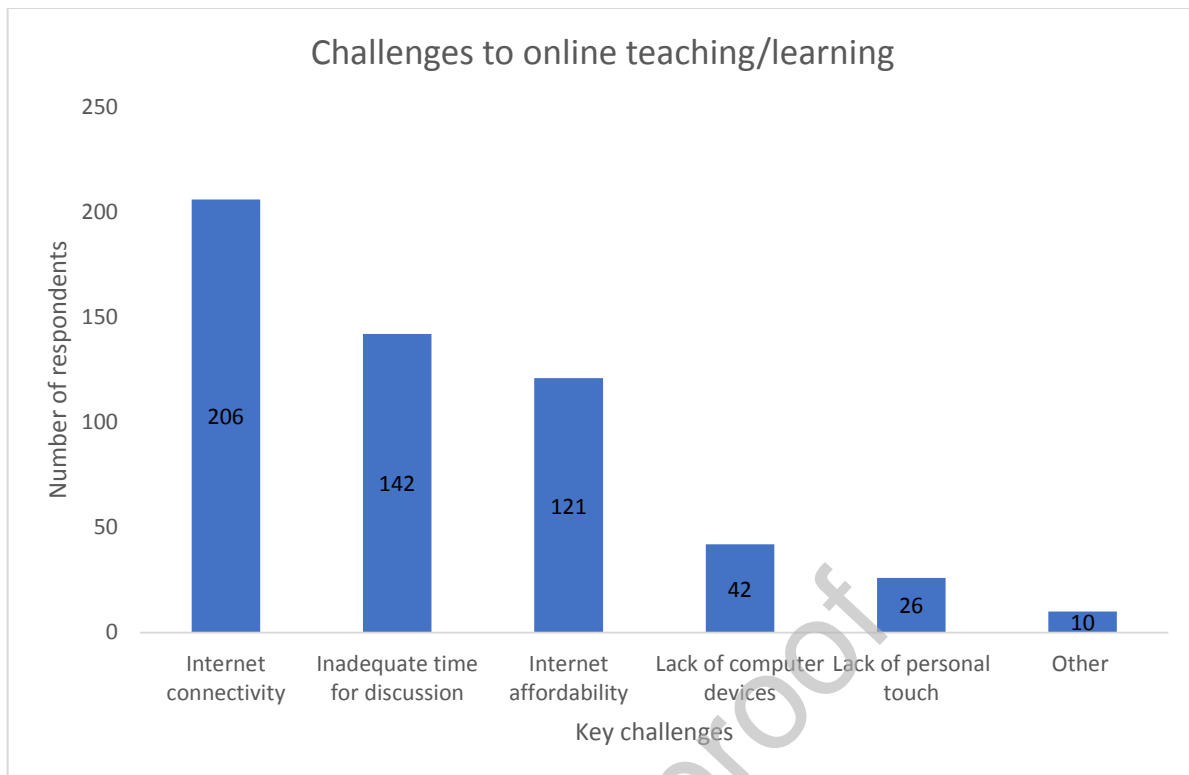


Figure 1: Challenges experienced by respondents on the use of online/virtual learning platforms

Other: distractions during online studies, home responsibilities, lack of audios and videos to explain concepts.

Table 2: Perspective of respondents on the impact of the pandemic on the classroom, research, and clinical placement activities

Statements	Responses n (%)				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The outbreak has caused significant changes to the academic calendar (N=291)	185 (63.6%)	85 (29.2%)	18 (6.2%)	1 (0.3%)	2 (0.7%)
The outbreak has affected attendance to academic sessions (N=285)	113 (39.6%)	120 (42.1%)	36 (12.6%)	13 (4.6%)	3 (1.1%)
The outbreak has affected the placement of students for clinical training (N=263)	130 (49.4%)	107 (40.7%)	23 (8.7%)	3 (1.1%)	0
Health facilities were not willing to accept students during the pandemic (N=267)	33 (12.4%)	103 (38.6%)	79 (29.6%)	37 (13.9%)	15 (5.6%)
*The pandemic has affected general research activities and output (N=85)	69 (81.2%)	16 (18.8%)	0	0	0
** My institution has adopted remote working options for staff (N=14)	14 (100%)	0	0	0	0
	Yes		Somewhat		No
Were you conversant with the use of the online/virtual platform? (N=232)	74 (31.9%)		78 (33.6%)		80 (34.5%)
	Excellent	Good	Fair	Poor	Very poor

In general, what was your experience with online/virtual learning? (N=232)	11 (4.7%)	73 (31.5%)	96 (41.4%)	43(18.5%)	12 (5.1%)
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*Educators and year 4 students only

**Educators only

References

1. Akudjedu TN, Mishio NA, Elshami W, Culp MP, Lawal O, Botwe BO, et al. The global impact of the COVID-19 pandemic on clinical radiography practice: A systematic literature review and recommendations for future services planning. *Radiography* [Internet]. 2021;(xxxx). Available from: <https://doi.org/10.1016/j.radi.2021.07.004>
2. Tay YX, Sng LH, Chow HC, Zainuldin MR. Clinical placements for undergraduate diagnostic radiography students amidst the COVID-19 pandemic in Singapore: Preparation, challenges and strategies for safe resumption. *J Med Imaging Radiat Sci* [Internet]. 2020;51(4):560–6. Available from: <https://doi.org/10.1016/j.jmir.2020.08.012>
3. Rainford LA, Zanardo M, Buissink C, Decoster R, Hennessy W, Knapp K, et al. The impact of COVID-19 upon student radiographers and clinical training. *Radiography* [Internet]. 2021;27(2):464–74. Available from: <https://doi.org/10.1016/j.radi.2020.10.015>
4. Akudjedu TN, Lawal O, Sharma M, Elliot J, Stewart S, Gilleece T, et al. Impact of the COVID-19 pandemic on radiography practice : findings from a UK radiography workforce survey. *BJR Open* [Internet]. 2020;2:1–11. Available from: [doi.org/ 10. 1259/ bjro. 20200023](https://doi.org/10.1259/bjro.20200023)
5. Alvin M, George E, Deng F, Warhadpande S, Lee S. The Impact of COVID-19 on Radiology Trainees. *Radiology* [Internet]. 2020;296:246–8. Available from: doi.org/10.1148/radiol.2020201222
6. Ng CKC. Evaluation of academic integrity of online open book assessments implemented in an undergraduate medical radiation science course during COVID-19 pandemic. *J Med Imaging Radiat Sci* [Internet]. 2020;51(4):610–6. Available from: <https://doi.org/10.1016/j.jmir.2020.09.009>
7. Cushen-Brewster N, Strudwick RM, Doolan C, Driscoll–Evans P. An evaluation of the experiences of radiography students working on the temporary HCPC register during the COVID-19 pandemic. *Radiography* [Internet]. 2021;(xxxx). Available from: <https://doi.org/10.1016/j.radi.2021.03.003>
8. Giacalone A, Rocco G, Ruberti E. Physical Health and Psychosocial Considerations During the Coronavirus Disease 2019 Outbreak. *Psychosomatics* [Internet]. 2020;61(6):851–2. Available from: <https://doi.org/10.1016/j.psym.2020.07.005>

9. Surkhali B, Garbuja K. Virtual Learning during COVID-19 Pandemic : Pros and Cons. *J Lumbini Med Coll* [Internet]. 2020;8(1):19–20. Available from: <https://doi.org/10.22502/jlmc.v8i1.363>
10. Lu W. Psychological status of medical workforce during the COVID-19 pandemic : A cross-sectional study. *Psychiatry Res* [Internet]. 2020;288(January). Available from: doi.org/10.1016/j.psychres.2020.112936
11. World Health Organization (WHO). Mental health and psychosocial Considerations During the COVID-19 outbreak [Internet]. 2020. Available from: <https://www.who.int/docs/default-source/coronaviruse/mental-health-considerations.pdf>
12. MedicalXpress. Ghana closes schools, bans gatherings over corona virus [Internet]. 2020 [cited 2020 Dec 9]. Available from: <https://medicalxpress.com/news/2020-03-ghana-schools-coronavirus.html>
13. Currie G, Hewis J, Nelson T, Chandler A, Nabasenja C, Spuur K, et al. COVID-19 impact on undergraduate teaching: Medical radiation science teaching team experience. *J Med Imaging Radiat Sci* [Internet]. 2020;51(4):518–27. Available from: <https://doi.org/10.1016/j.jmir.2020.09.002>
14. Teo LW, Pang T, Ong YJ, Lai C. Coping with COVID-19: Perspectives of Student Radiographers. *J Med Imaging Radiat Sci* [Internet]. 2020;51(3):358–60. Available from: <https://doi.org/10.1016/j.jmir.2020.05.004>
15. Rajhans V, Memon U, Patil V, Goyal A. Impact of COVID-19 on academic activities and way forward in Indian Optometry. *J Optom* [Internet]. 2020;13(4):216–26. Available from: <https://doi.org/10.1016/j.optom.2020.06.002>
16. Sani I, Hamza Y, Chedid Y, Amalendran J, Hamza N. Understanding the consequence of COVID-19 on undergraduate medical education: Medical students' perspective. *Ann Med Surg* [Internet]. 2020;58(September):117–9. Available from: <https://doi.org/10.1016/j.amsu.2020.08.045>
17. Simon K. Digital 2020: Ghana [Internet]. 2020 [cited 2021 Jul 2]. Available from: <https://datareportal.com/reports/digital-2020-ghana>
18. DW Akademie. Despite Ghana's commitment to Internet expansion, problems persist [Internet]. 2020 [cited 2020 Dec 11]. Available from: <https://www.dw.com/en/despite-ghanas-commitment-to-internet-expansion-problems-persist/a-46508524>
19. Aczel B, Kovacs M, Van Der Lippe T, Szaszi B. Researchers working from home: Benefits and challenges. *PLoS One* [Internet]. 2021;16(3 March):1–13. Available from: <http://dx.doi.org/10.1371/journal.pone.0249127>
20. Higgins R, Murphy F, Hogg P. The impact of teaching experimental research on-line: Research-informed teaching and COVID-19. *Radiography* [Internet]. 2021;27(2):539–45. Available from: <https://doi.org/10.1016/j.radi.2020.11.014>
21. Snaith B, Hardy M. Radiographer abnormality detection schemes in the trauma environment- An assessment of current practice. *Radiography* [Internet]. 2008;14(4):277–81. Available from: [doi:10.1016/j.radi.2007.09.001](https://doi.org/10.1016/j.radi.2007.09.001)
22. Anim-Sampong S, Arthur L, Nkansah JA, Botwe BO. Women in radiography practice in Ghana: Motivating and demotivating factors. *Radiol Technol*. 2018;89(4):337–43.

23. World Health Organization (WHO). Action plan to improve public health preparedness and response in the WHO European Region 2018-2023 [Internet]. 2019. Available from: <http://www.euro.who.int/pubrequest>
24. World Health Organization (WHO). Covid-19 Strategic Preparedness and response plan. 2021.
25. Quakyi NK, Agyemang Asante NA, Nartey YA, Bediako Y, Sam-Agudu NA. Ghana's COVID-19 response: The Black Star can do even better. *BMJ Glob Heal*. 2021;6(3):1–5.
26. University of Health and Allied Sciences (UHAS). Government names UHAS lab as COVID-19 testing facility [Internet]. 2020 [cited 2021 Apr 12]. Available from: <https://uhas.edu.gh/en/public/news/government-names-uhas-lab-as-covid-19-testing-facility.html>
27. Noguchi Memorial Institute for Medical Research (NMIMR). University of Ghana emergency preparedness updates on COVID- 19 outbreak [Internet]. 2020 [cited 2021 May 15]. Available from: <https://www.noguchimedres.org/index.php/component/content/article/95-events/186-updates-on-covid-19-outbreak?Itemid=437>
28. Gallo G, Trompetto M. The Effects of COVID-19 on Academic Activities and Surgical Education in Italy. *J Investig Surg* [Internet]. 2020;33(7):687–9. Available from: <https://doi.org/10.1080/08941939.2020.1748147>
29. Nguyen LH, Drew DA, Graham MS, Joshi AD, Guo C, Ma W, et al. Articles Risk of COVID-19 among front-line health-care workers and the general community : a prospective cohort study. *Lancet* (London, England) [Internet]. 2020;5:475–83. Available from: 10.1016/S2468-2667(20)30164-X
30. Kanne J, Little BP, Chung JH, Elicker B, Ketai LH. Essentials for Radiologists on COVID-19: An Update—Radiology Scientific Expert panel. *Radiology*. 2020;
31. Yasha G. Residents remaining flexible during COVID-19 pandemic [Internet]. 2020 [cited 2020 Dec 9]. Available from: <https://www.theabr.org/blogs/residents-remaining-flexible-during-covid-19-pandemic>
32. Katy K. Graduate studies and campus closure [Internet]. 2020 [cited 2021 Jul 8]. Available from: <https://www.insidehighered.com/advice/2020/03/24/challenges-facing-grad-students-due-coronavirus-opinion>
33. Srichanyachon N. The barriers and needs of online learners. *Turkish Online J Distance Educ*. 2014;15(3):50–9.
34. Luongo N. An examination of distance learning faculty satisfaction levels and self-perceived barriers. *J Educ Online* [Internet]. 2018;15(2). Available from: 10.9743/JEO.2018.15.2.8
35. Vonderwell S, Zachariah S. Factors that influence participation in online learning. *J Res Technol Educ*. 2005;38(2):213–30.
36. STATISTA. Internet user penetration in South Africa from 2015 to 2025 [Internet]. 2021 [cited 2021 Jul 10]. Available from: <https://www.statista.com/statistics/484933/internet-user-reach-south-africa/>
37. STATISTA. Share of households with internet access in the UK and EU 2009-2020 Published by Statista Research Department, May 10, 2021 In 2020, the overall share of households in the United Kingdom (UK) that had access to the internet was 97 percent. This constitute

[Internet]. 2021 [cited 2021 Jul 10]. Available from: <https://www.statista.com/statistics/275043/percentage-of-households-with-internet-access-in-the-uk-and-eu/>

38. Kim EA. Social Distancing and Public Health Guidelines at Workplaces in Korea: Responses to Coronavirus Disease-19. *Saf Health Work* [Internet]. 2020;11(3):275–83. Available from: <https://doi.org/10.1016/j.shaw.2020.07.006>
39. Rehani B, Rodriguez JA, Nguyen JK, Patel MM, Ammanuel SG, Winford E, et al. COVID-19 Radiology Preparedness, Challenges & Opportunities: Responses From 18 Countries. *Curr Probl Diagn Radiol* [Internet]. 2020;(January). Available from: <https://doi.org/10.1067/j.cpradiol.2021.03.017>
40. Ulenaers D, Grosemans J, Schrooten W, Bergs J. Clinical placement experience of nursing students during the COVID-19 pandemic: A cross-sectional study. *Nurse Educ Today* [Internet]. 2021;99(December 2020):104746. Available from: <https://doi.org/10.1016/j.nedt.2021.104746>
41. Robbins JB, England E, Patel MD, DeBenedictis CM, Sarkany DS, Heitkamp DE, et al. COVID-19 Impact on Well-Being and Education in Radiology Residencies: A Survey of the Association of Program Directors in Radiology. *Acad Radiol* [Internet]. 2020;27(8):1162–72. Available from: <https://doi.org/10.1016/j.acra.2020.06.002>