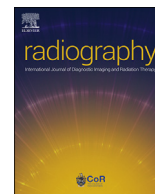




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## Systematic Review

# The global impact of the COVID-19 pandemic on clinical radiography practice: A systematic literature review and recommendations for future services planning



T.N. Akudjedu <sup>a,\*</sup>, N.A. Mishio <sup>b</sup>, W. Elshami <sup>c</sup>, M.P. Culp <sup>d</sup>, O. Lawal <sup>e</sup>, B.O. Botwe <sup>f</sup>,  
A.-R. Wuni <sup>g</sup>, N. Julka-Anderson <sup>h</sup>, M. Shanahan <sup>i</sup>, J.J. Totman <sup>a</sup>, J.M. Franklin <sup>a</sup>

<sup>a</sup> Institute of Medical Imaging & Visualisation (IMIV), Department of Medical Science & Public Health, Faculty of Health & Social Sciences, Bournemouth University, UK

<sup>b</sup> Department of Psychology, University of Ghana, Ghana

<sup>c</sup> Department of Medical Diagnostic Imaging, College of Health Sciences, University of Sharjah, United Arab Emirates

<sup>d</sup> Department of Radiology, School of Medicine, The University of North Carolina at Chapel Hill, USA

<sup>e</sup> Department of Allied Health Professions, Midwifery and Social Work, School of Health and Social Work, University of Hertfordshire, UK

<sup>f</sup> Department of Radiography, School of Biomedical & Allied Health Sciences, College of Health Sciences, University of Ghana, Ghana

<sup>g</sup> Department of Imaging Technology & Sonography, University of Cape Coast, Ghana

<sup>h</sup> Radiotherapy Department, Imperial College Healthcare NHS Trust, UK

<sup>i</sup> Faculty of Health, University of Canberra, Bruce, ACT, Australia

## ARTICLE INFO

## Article history:

Received 6 March 2021

Received in revised form

29 June 2021

Accepted 3 July 2021

Available online 12 July 2021

## Keywords:

Radiography

Radiotherapy

COVID-19

Personal-protective equipment

Workplace-related stress

Well-being

## ABSTRACT

**Introduction:** Worldwide, reports and experiences indicate that there has been extensive re-organisation within diagnostic imaging and radiotherapy departments in response to the COVID-19 pandemic. This was necessary due to changes in workload and working practice guidelines that have evolved during the pandemic. This review provides a comprehensive summary of the global impact of the COVID-19 pandemic on radiography practice, service delivery and workforce wellbeing.

**Methods:** A systematic review methodology was adopted to obtain data from primary studies of qualitative, quantitative, and mixed methods designs from databases (PubMed, Science Direct, Cumulative Index of Nursing and Allied Health Literature [CINAHL], and SCOPUS: all 2020 to present). The included articles were subjected to information extraction and results-based convergent synthesis.

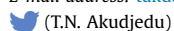
**Results:** The electronic database search yielded 10,420 articles after removal of duplicates. Of these, 31 articles met the final inclusion criteria with some (n = 8) fully focussed on radiotherapy workforce and service delivery. The pandemic impact on radiography practice is broadly themed around: training, communication, and information dissemination; infrastructure, technology, and clinical workflow; and workforce mental health and well-being.

**Conclusion:** Globally, most radiographers received inadequate training for managing COVID-19 patients during the initial acute phase of the pandemic. Additionally, there were significant changes to clinical practice, working patterns and perceived increase in workload due to surges in COVID-19 patients and the consequent strict adherence to new infection protocols. These changes, coupled with fear emanating from the increased risk of the workforce to contracting the infection, contributed to anxiety and workplace-related stress during the pandemic.

**Implications for practice:** Local pandemic response strategies must be appropriately developed from standard protocols in readiness for safe clinical practice and well-being management training of practitioners.

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\* Corresponding author. Institute of Medical Imaging & Visualisation, Bournemouth University, Bournemouth Gateway Building, St Paul's Lane, Bournemouth, BH8 8GP, UK.  
E-mail address: [takudjedu@bournemouth.ac.uk](mailto:takudjedu@bournemouth.ac.uk) (T.N. Akudjedu).



(T.N. Akudjedu)

## Introduction

In the initial acute phase of the pandemic, chest imaging emerged as one of the key diagnostic and monitoring tools for patients with COVID-19.<sup>1–6</sup> Consequently, the diagnostic radiology workforce came under extreme pressure with the surge in patient numbers.<sup>7–14</sup> Diagnostic imaging modalities employed for direct COVID-19 patient management (general X-ray [CXR] including mobile systems) and computed tomography (CT) were perceived to have been under increased procedural pressure while other elective/non-urgent diagnostic and screening services were paused in some settings globally.<sup>7,9,10,15,16</sup> Staff were reassigned to modalities with anticipated increase in pressure such as CXR and CT.<sup>7,9,14</sup> Worldwide, reports and experiences indicate that there has been extensive re-organisation within radiology and radiotherapy departments to conform with the COVID-19 guidelines to effectively manage the anticipated pandemic-related workload increases while keeping workflows safe.<sup>1,16–19</sup> In some settings, additional radiography practice modifications were required to reduce cross-infection, such as X-raying through room windows<sup>20,72,73</sup> with both the digital image receiver/cassette and mobile X-ray machine secured with layers of polythene sheets.<sup>21,22</sup>

Clinical radiotherapy practice was indirectly impacted globally with several reports<sup>23–28</sup> indicating a decline in patient volumes, although almost all departments were operational during the pandemic. The rapidly evolving situation<sup>29</sup> resulted in the regular release of recommendations from national and international authorities including the International Society of Radiographers and Radiological Technologists (ISRT), National Cancer Research Institute (NCRI – UK), European Society for Radiotherapy and Oncology (ESTRO) and the American Society for Radiation Oncology for safe clinical care of cancers.<sup>30–33,60</sup> In line with these recommendations, radiotherapy departments underwent resource and technical re-organisation to allow the continuation of daily cancer care provision.<sup>23–28,34,61,62</sup> The recommendations included the implementation of strict hygiene protocols to guarantee the safety of cancer patients, many of whom are generally immunocompromised and at increased risk of COVID-19 complications, and of staff administering the treatments. Additionally, strict triage systems and the use of hypofractionation protocols designed for specific cancers were rapidly implemented<sup>30–33</sup> to allow cancer care continuation during the pandemic. For example, a recent study<sup>23</sup> reported a substantial increase in bladder, oesophageal and rectal cancer radiotherapy during the pandemic, potentially due to reduced surgical capacity. Adoption and implementation of these protocols were largely influenced by institutional and/or national practices and resource availability.<sup>8,34–37</sup>

The nature of clinical radiography practice requires working in close proximity to patients for radiotherapy treatment or diagnostic imaging. The need for adequate personal protective equipment (PPE) for safe practice became critical during the pandemic.<sup>9–11,38–40,76</sup> A recent prospective study among frontline healthcare workers (HCW) from the United Kingdom (UK) and the United States of America (USA),<sup>41</sup> found that HCW are approximately three times at risk for contracting the infection compared to the general population. This further highlights the need for appropriate PPE in all clinical settings. Reports of perceived inadequate availability of PPE during phases of the pandemic in different countries and settings have been noted.<sup>7–9,14,42,43</sup> Fear of contracting the infection was widely reported among the radiography workforce across all resource settings.<sup>7–10,12–14,40,42,44</sup> This contributed poorly to the mental health (including workplace-related stress and anxiety) and general well-being of all HCWs, including the radiography workforce.<sup>7–10,12–14,40,45–49</sup>

The body of evidence reporting the impact of the pandemic on radiography practice is diverse and variable in terms of its scope (see [Supplementary Tables 1 and 2](#)). This systematic review aims to integrate available evidence to provide a comprehensive summary of the global impact of the COVID-19 pandemic on diagnostic and therapeutic radiography practice. This will provide a reference resource for policy formulation and recommendations for radiography education and training.

## Methods

A mixed-method systematic review methodology<sup>17,68–71</sup> was adopted to obtain data from primary studies of qualitative, quantitative, and mixed methods designs in accordance with the Cochrane Collaboration guide<sup>50</sup> whilst also utilising an adapted version of the Preferred Reporting Items for Systematic Review (PRISMA: see [Fig. 1](#)) statement.<sup>53</sup> The PRISMA adaptation include our inability to register the search protocol of this systematic review *a priori*. This was due to the quickly evolving nature of the pandemic, the urgency, and the necessity of generating robust findings to inform COVID-19 policy for safe practice. Taken together, this methodologically inclusive approach is deemed appropriate to broaden the conceptualisation and synthesis of available evidence on the topic. Ethical approval is not required for literature reviews.

### Eligibility criteria

Articles were included if they were published in English and explored the impact of the COVID-19 pandemic on diagnostic radiography and/or radiotherapy practice in relation to changes in workload and service delivery, staff well-being, infection control protocols and other relevant pandemic-related changes. Opinion reports, preprints, commentaries, literature reviews and primary studies with a multidisciplinary focus outside of radiography practice were excluded.

### Sources

The following database records: PubMed, Science Direct, CINAHL (Cumulative Index of Nursing and Allied Health Literature, and SCOPUS were identified and searched to ensure all relevant studies are captured. A manual search of google scholar and the “COVID-19 article collection” of key radiography journals (including, *Radiography*, *Journal of Medical Imaging & Radiation Sciences (JMIRS)*, *Journal of Medical Radiation Sciences (JMRS)* and *Radiologic Technology*) was conducted for relevant publications. In addition, the reference list of relevant primary studies and review articles were also searched for other relevant publications that fulfil the eligibility criteria.

### Search strategy

A systematic search strategy (certified as satisfactory by an expert librarian) was employed to identify studies in each of the databases independently. The MeSH (Medical Subject Heading) was used to identify and develop keywords for the literature search. Using this search strategy, an independent electronic literature search was carried out by two researchers (NAM/WE) from November, 2020 to January 31st 2021 to identify relevant articles. A further search was conducted on June 29th 2021 to update the results. Boolean operators (OR, AND) and keywords/MeSH terms combinations: [“Radiography” OR “Medical Radiation Science” OR “Radiologic Technologist” OR “Radiotherapy” OR “Radiation

Therapist” OR “Imaging” OR “Radiographer well-being” OR “workplace stress” AND “COVID-19” OR “pandemic”) were employed for the search. To increase the sensitivity to the databases and minimise the risk of missing relevant studies, the search combinations were refined to include appropriate subject headings, abbreviations and/or truncated syntax in accordance with the specifications of each database. A combination of Microsoft Excel 2019 for Mac and the RefWorks (ExLibris, ProQuest) referencing software was used to manage the screening process and search outputs.

#### Study selection and data extraction

In accordance with the predetermined search strategy, the final inclusion and quality of included studies were assessed by three members of the research team (NAM/WE/BOB) after the initial independent review of titles, abstracts, and full text. In addition, the lead investigator (TNA), reviewed the screening decisions for consistent application of the predetermined criteria at all stages of the screening exercise. Due to the diverse nature of the study designs, and to ensure a consistent critical appraisal of the relevant studies, the Quality Assessment Tool for Studies with Diverse Designs (QATSDD)<sup>51</sup> was employed to evaluate the studies. Any differences in quality assessment scores were discussed and consensus opinion achieved among the research team. As previously,<sup>52</sup> studies were categorised as *high quality* if an aggregate score in excess of 70% is achieved, *moderate quality* for those scored between 50 and 70%, and *low quality* for those scored less than 50%. These aggregate quality scores were not a part of the article exclusion criteria. The omission of studies with low aggregate scores could potentially limit the global essence of the review considering that some findings relate specifically to certain geographical regions. All the included studies were subjected to a data extraction process that included the completion of a template with fields to capture the study methods, aims and outcomes (the findings and conclusions drawn).

#### Data synthesis approach

A results-based convergent synthesis design strategy<sup>17,68–71</sup> was employed to integrate findings from included studies of varied designs. Briefly, this strategy involve the independent analyses and presentation of findings from the included studies in a tabular format (See [Supplementary Tables 1 and 2](#)). The findings are then integrated to generate summary outcomes using textual narrative synthesis after qualitisising the quantitative component of the findings.<sup>17,68–71</sup> The synthesised findings/outcomes broadly provide a global overview of the pandemic impact on clinical radiography practice as highlighted in the aim of the study. This approach is deemed appropriate as it allows a robust and reproducible synthesis of existing and current evidence.

## Results

The electronic database search yielded 10,420 articles after removal of duplicates from the following records: PUBMED (n = 5806), CINAHL (n = 749), SCOPUS (n = 2484), Science Direct (n = 8212) and manual searches (n = 73). After the first and second screening exercises based on titles and abstracts, 6243 and 4092 articles were excluded, respectively. Following this exercise, 85 articles were retained for full-text assessment of eligibility. [Fig. 1](#) details the search procedure using an adapted PRISMA chart.<sup>53</sup> Full-text screening based on the predetermined strategy resulted in 35 articles being included in the review. Further articles (n = 4) were excluded at a consensus during the data extraction and article

summary generation stages of the review process. [Fig. 1](#) details the reasons for article exclusion. Thirty-one articles met the final inclusion criteria with some (n = 8) fully focused on radiotherapy workforce and service delivery. Quality scores ranged from low to high (40.5–84.6%). Of note, the included studies comprise of four previous publications<sup>7,8,10,14</sup> from our research team that fulfilled both the search criteria and the critical appraisal exercise (using the QATSDD tool).

The articles identified for this literature review encompass a broad spectrum of clinical radiography professionals with a global geographic representation from low- and middle-income countries (LMIC) and high-income countries (HIC). In this review, the term “radiographer” refers to diagnostic radiographers or technicians, therapeutic radiographer/radiotherapist, and medical imaging technologists and/or radiation therapy professionals depending on the region where the included primary studies were conducted. Additionally, our findings represent perspectives from radiographers at private radiology/oncology/radiotherapy centres, private hospitals, public hospitals, and other off-site clinical facilities. See [Supplementary Tables 1 and 2](#) for the study characteristics including the geographical spread of the included studies, methodological approaches adopted, and summary of the findings.

Three broad themes emerged across varied clinical settings globally: Theme 1 – training, communication, and information dissemination; Theme 2 – infrastructure, technology, and clinical workflow; and Theme 3 – workforce mental health and well-being. The term “mental health” is employed as an umbrella terminology in this context to describe known and specific mental health and well-being disruptors such as stress, anxiety, emotional/psychological dilemma, burnout (emotional exhaustion and depersonalisation) emerging from the review synthesis.

## Discussions

Our findings highlight prior knowledge to indicate that radiography practice varies widely across different settings and among countries, often due to differences in both expert human and physical resource availability.<sup>8,34–37,61,74</sup> As medical imaging has played an important role in both the diagnosis and management of COVID-19 patients, the pandemic has highlighted existing global discrepancies in radiography resource availability.<sup>35,37,61,74</sup> The findings suggest that the knowledge-base of radiographers about the pandemic has improved over time. For example, Kotian and colleagues<sup>11</sup> reported relatively low knowledge of COVID-19 among India’s radiography workforce at the initial stages of the pandemic (March, 2020), similar to the baseline findings reported among their Irish counterparts at approximately the same period of the pandemic.<sup>9</sup> Available longitudinal data<sup>9</sup> to-date from the Irish radiography workforce showed improvements and a feeling of preparedness for new practices, protocols, and procedures after a 6-week follow-up among 56% of respondents relative to an initial 33%. Similarly, diagnostic radiographers in Singapore have demonstrated resilience and improvements over the past year to transition through the numerous clinical practice challenges.<sup>75</sup> These improvements are attributable to improved communication, training, and public campaigns on the pandemic.<sup>7–10,74,75</sup>

#### Theme 1: Training, communication, and information dissemination

Reports from varied settings indicate that there was none or limited training about COVID-19 infection control, prevention and patient management approaches within the radiology and radiotherapy departments in the initial acute phase of the pandemic.<sup>7–9,42,66</sup> For instance, in Ghana, 73.1% of radiographers who participated in a study by Akudjedu and colleagues<sup>8</sup> contended that

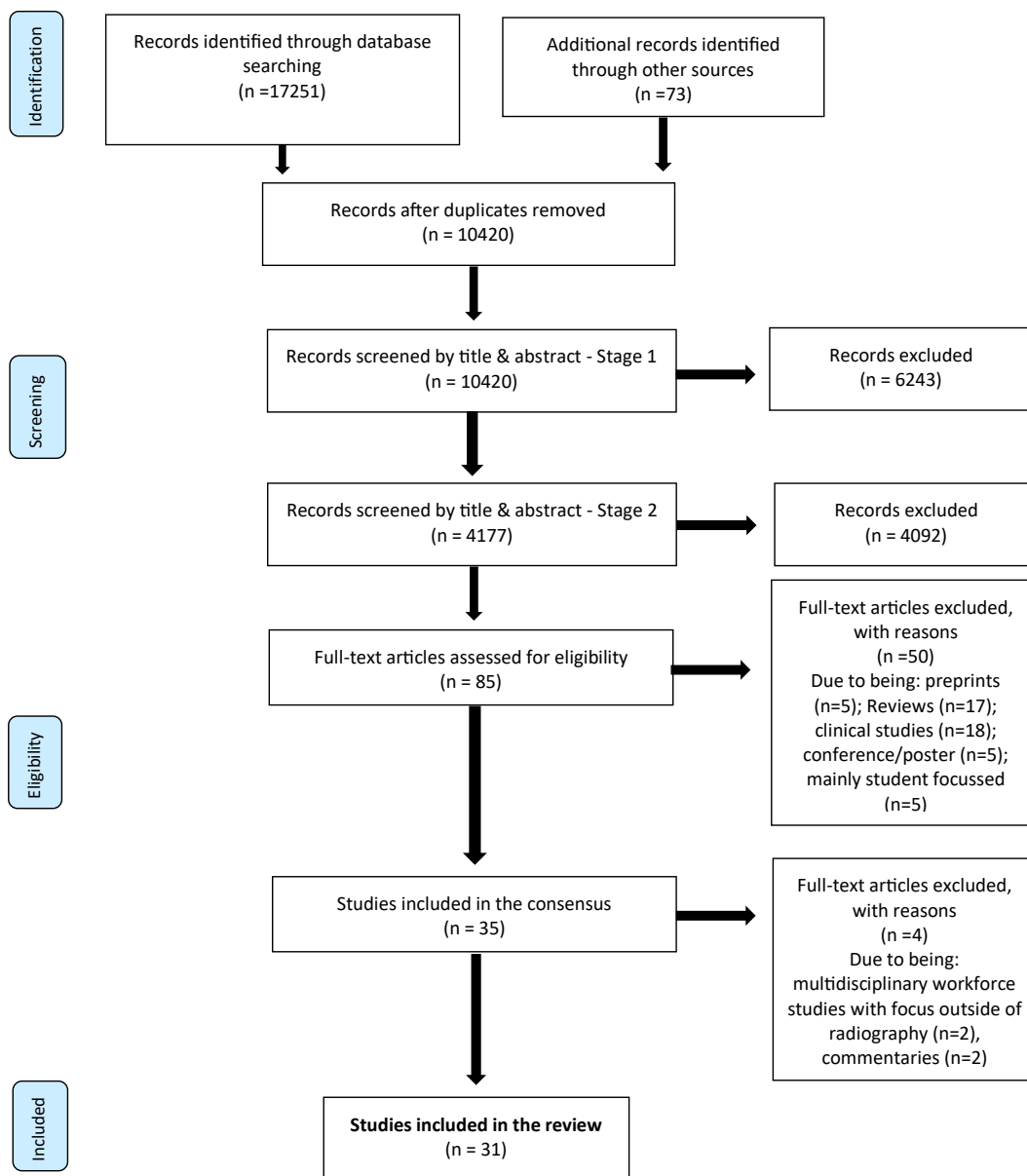


Figure 1. PRISMA flow diagram- search strategy.

they were not given any prior training and the necessary communication/information to manage COVID-19 patients at the onset of the pandemic. Education regarding appropriate infection control processes is essential in the safe management of the pandemic within radiography departments.<sup>10</sup> In part, the lack of training and information was due to the rapid and unexpected evolution of the global pandemic.<sup>7,8,26,36</sup> Lack of understanding about appropriate infection control procedures during the pandemic is linked to reported fear and anxiety across the radiography workforce from several settings<sup>7–10,40</sup> and feeling of a lack of preparedness.<sup>23,26,28,42,43</sup> This is consistent with findings reported in a large, multidisciplinary cohort of HCW (including radiographers) in China.<sup>47,48</sup>

Ruiz and colleagues<sup>40</sup> argued that understanding the science of what PPE is needed to mitigate transmission is essential information. As COVID-19 was a novel version of the coronavirus, it took the scientific community time to understand its transmission and recommend universal pandemic precautions that minimise

transmission. That period of learning did play into the time in which there was uncertainty and fear regarding infection control and transmission. Foley and colleagues<sup>9</sup> reported that almost 50% of respondents in their study were inadvertently exposed to positive cases without appropriate PPE due to poor communication protocols within the healthcare services. Once the World Health Organisation and related healthcare authorities became clear on their advice, quick and clear communication, and dissemination regarding the process for infection control and emergency response protocol were impactful for mitigating fear and returning power to the healthcare professional. Repeatedly throughout the literature, a theme that uncertainty causes stress and clarity leads to confidence, in other words, knowledge is power is demonstrated clearly.<sup>7–11,34,36,42,44</sup> With emerging clarity on the process for infection, a trend of reported increase in knowledge and compliance with these infection control procedures are being observed<sup>28,34,36</sup> due to appropriate communication within healthcare units including the radiography departments.



## Theme 2: Infrastructure, technology, and clinical workflow

Globally, radiographers have reported a perceived increase in imaging workload volume during the pandemic, particularly for chest X-ray and CT.<sup>1–6,8,64</sup> Similarly, the radiotherapy workforce also faced increase in treatment of some specific cancers with radiotherapy during the pandemic,<sup>23</sup> likely due to reduced surgical capacity.

Repeatedly, radiographers state that changes to operations and procedures occurred during the pandemic.<sup>7,8,12,14,26,64</sup> In some cases, there were staff redeployments and extended shift hours to cover the increased imaging demand.<sup>8,12–14,45</sup> For example, in the national UK survey, 12.5% of respondents were redeployed mostly to CT and general X-ray from departments responsible for elective imaging which were paused to create extra capacity.<sup>7</sup> Another example from a large Singapore radiography service, was the implementation of a new 12-h working shift system as a pandemic strategy to manage clinical workflows, which reflected poorly on radiographer well-being.<sup>45</sup> Adapting to the “new way of work”, did not only affect professional work dynamics, but it also affected home/family routines and well-being of radiographers.<sup>12</sup> Further adding to workplace-related stress, Ossama and colleagues<sup>13</sup> share that a shortage of medical imaging professionals further exacerbated stressors related to clinical workflow changes. However, the workforces’ positive attitude, resilience and dedication to their profession, and initiation of unique coping strategies helped to mitigate these challenges.<sup>12,26,75,77</sup> Notwithstanding, there was a reported decline in patient volume (about 60%) and staff numbers (57%) in some departments due to the COVID-19 pandemic in relation to family care responsibilities (29%), staff COVID-19 illness (26%) and staff redeployment to other non/clinical areas (13%).<sup>49</sup>

Infrastructural and technical resource needs included access to COVID-19 testing for healthcare workers, adequate availability of related PPE and supply chain, and standardised policy support for infection control in relation to the local settings, training needs, and consistency of enforcement protocols.<sup>9,43,59,75–77</sup> In some cases, where appropriate, information technology was used to support the workforce with research and the conduct of some of their clinical duties remotely. For example, some therapeutic radiographers were completing their contouring assignments remotely. Of note, these new clinical initiatives including the use of information technologies to enhance remote working in clinical radiotherapy follow-up consultations and planning are not universal.<sup>8,12,13,21,34,42,61,62,75,77,78</sup> Further highlighting the need for adaptation of established global strategies for use within local settings.

## Theme 3: Workforce mental health and well-being

Despite the major impact of the COVID-19 pandemic on healthcare services, and in the face of uncertainties and changes in clinical work patterns, radiology personnel along with other healthcare professionals have continued to provide committed clinical services.<sup>54–56</sup> The healthcare workforce has to balance strict measures to protect both patients, colleagues, and the general public from contracting COVID-19, while not compromising on the access, availability and quality of healthcare service.<sup>57,58,65,67</sup> These demands have placed a toll on the healthcare workforce worldwide.

The global radiography workforce populations that responded to the various surveys included in this review reported burnout symptoms, emotional/psychological dilemma, anxiety, and workplace-related stress resulting from fear of contracting the virus, increase and/or changes to clinical workload and workflow.<sup>7–9,12,23,75,77</sup> Ruiz et al.<sup>40</sup> and Maraga et al.<sup>46</sup> documented

that radiographers reported fear about infecting their own family members, patients, and other co-workers particularly at the onset of the pandemic. Additionally, radiographers observed that their own work-related stress was transferred to their family, partners, and friends.<sup>7,8,14,40,42,44,46,48</sup> Some redeployed radiographers also reported being stressed due to the need to adjust to new working environments and technologies.<sup>7,75,77</sup> Anxiety from these stressors was a commonly reported theme.<sup>5–9,24,25,46,75,77</sup> In the Irish study of radiographers, 40% of respondents reported burnout symptoms due to the COVID-19 crisis and 30% reported considering changing jobs or retiring since the COVID-19 outbreak.<sup>9</sup> Consequently, some radiographers considered the potential for career change or early retirement as a result of working conditions.<sup>9</sup> These findings are consistent to those reported in other national surveys from the UK, Middle East, Australia and Africa.<sup>7,8,10,12–14</sup> The psychological and well-being impacts of the pandemic are striking. There have been recommendations<sup>7–9,12,23,75,77</sup> for the establishment of both system and institution level intervention mechanisms to support radiographer well-being and workforce resilience and to address mental health implications.

## Limitations

This study is potentially limited by the inclusion of only primary research published in English thereby missing grey literature and studies published in other languages. However, the reports included in this review are diverse, representing low, intermediate, and higher resource settings, and multiple and varied healthcare systems. We would therefore anticipate the themes addressed to be generalisable. There is large heterogeneity associated with the methodological approaches and designs of the included studies which may be considered a limitation to the synthesis of the findings. However, a standardised synthesis approach and critical appraisal tool was employed to assess the quality of included studies to gauge the weighting to be placed on study recommendations that informed our discussions. We acknowledge that our search protocols were not published *a priori* as recommended for the conduct of systematic reviews. This was mainly due to the quickly evolving nature of the pandemic, the urgency, and the necessity of generating robust findings to inform COVID-19 policy for safe practice.

## Conclusions

This review provides a global snapshot of the pandemics’ impact on clinical radiography practice across different settings of varied resource availability. Worldwide, most radiographers received inadequate training to specifically manage COVID-19 patients during the initial acute phase of the pandemic. Additionally, there were significant changes to clinical practice (e.g., implementation of hypofractionation and protection procedures), working patterns (e.g., implementation of new 12-h working shift systems) and perceived increase in workload due to the surge in COVID-19 patients and the consequent strict adherence to infection prevention and control measures. These changes and personal fear of the virus contributed to anxiety and workplace-related stress during the pandemic. It has also highlighted the challenges and the dynamics of clinical workflows and the coping mechanisms adopted during the various stages of the pandemic globally.

## Recommendations for future service planning

Following the current global pandemic, radiography departments will require extensive re-organisation and re-structuring using key lessons from the pandemic in readiness for post-COVID service

delivery. Our findings suggest a number of best practice recommendations including:

- i. **Development and implementation of post-pandemic working protocols:** Revision of existing and/or establishment of new protocols in line with lessons from the pandemic is crucial. Protocols for future pandemic response or other types of crisis events are essential considerations for all radiology and radiotherapy departments moving forward. Local pandemic response strategies must be developed from standard protocols in readiness for safe practice during emergencies. This is necessary to mitigate the burden of extra workload and anxiety in relation to redeployment and the heightened risk of an infection in an attempt to balance radiographer safety, well-being, and patient care.
- ii. **Continuous professional development activities:** These should include simulated case scenarios of pandemics in relation to infection prevention and control, efficient communication, and information dissemination approaches during crisis events. Other activities in relation to efficient management and/or adaptation of diagnostic imaging protocols and mental health and well-being training will be critical.
- iii. **Resource Acquisition:** At a departmental and/or institutional level, a robust supply chain for resource acquisition, including appropriate PPE and other clinical consumables, should be ensured.
- iv. **Hybrid Workforce:** Some changes to conventional workforce planning and practice are proposed. These include promotion of a limited form of role hybridisation<sup>63</sup> or adoption of a form of regulated staff rotation system across various modalities as a departmental workforce development strategy to enhance the redeployment experience of practitioners when necessary.
- v. **Remote Working:** Relative to radiotherapy service delivery, remote working in diagnostic radiography has been very limited during the pandemic. Thus, implementation of the emerging remote scanning technologies (e.g., virtual cockpit technology) will improve access to imaging services in more settings while enabling flexible radiographer deployment across multiple locations at a single time.

#### Conflict of interest statement

None.

#### Acknowledgements

We would like to thank all of the radiographers and other healthcare workers who took time off their busy schedules in such an unprecedented time to participate in all surveys that resulted in the included studies for this review. Dr Theophilus Akudjedu received support from the NIHR Applied Research Collaboration ARC Wessex and Health Education England South East and was funded by an NIHR ARC Wessex and Health Education England South East Researcher Enhancement Award grant. The views expressed are those of the authors and not necessarily those of the NIHR or HEE SE.

#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.radi.2021.07.004>.

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