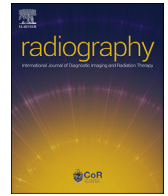




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Impact of COVID-19 on service delivery in radiology and radiotherapy

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ABSTRACT

Introduction: The COVID-19 pandemic has had a profound impact on radiography services globally. The reshaping of service delivery continues to impact patient management and the experience of the radiography workforce should be evaluated to determine how effective service delivery can be maintained in the ongoing and post-pandemic world.

Methods: A mixed methods approach was adopted. Questionnaires, designed using Qualtrics (Qualtrics, Provo, UT) online survey software, were used to survey radiographers throughout Northern Ireland (NI). Semi-structured interviews were conducted with radiography service managers in the NHS and private sector in NI. All interviews were digitally recorded, transcribed and coded independently by 2 researchers.

Results: A total of 106 Radiographers completed the online survey i.e. 82 Diagnostic and 24 Therapeutic. Variations were reported regarding staff concern for contracting COVID-19 and passing it on. Clinical workload was reported to fluctuate during the early period of the pandemic, however, both diagnostic and therapeutic radiographers reported workloads which were higher than normal at the time of the data collection. Nine service managers participated in the interviews plus two band 8 superintendent radiographers. Staff faced many challenges whilst delivering services due to COVID-19. The two most frequently cited challenges included issues related to (i) Implementation of PPE and (ii) Changes to work practices.

Conclusion: A pre-prepared pandemic plan should be established and stress tested for the future. The plan should be devised in consultation with both the public and private sector to determine the very best use of resources.

Implications for practice: The radiography workforce has worked continuously throughout the pandemic and needs to be supported to deal with the potential increase in demand for services in the post-pandemic world.

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Introduction

The most recent viral outbreak “COVID-19” was first reported in China in December 2019, when a new strain of coronavirus emerged. On 11th March 2020, COVID-19 was officially classified by the World Health Organisation (WHO) as a pandemic.¹ In the UK attempts were made to protect the National Health Service (NHS) from the potential surge in patients falling critically ill from COVID-19. Resources within the NHS were largely directed to fighting the

pandemic and as a direct result, many outpatient clinics were temporarily suspended and some surgical procedures postponed to facilitate reskilling and redeployment of staff to areas anticipated to need support. The reshaping of the NHS was designed to enable the service to manage the crisis in 2020 and the altered service delivery is still being felt in January 2022^{2–5}.

The three UK cancer screening programmes for breast, bowel and cervical cancer were temporarily suspended with invitations and follow-up appointments delayed.^{6,7} Diagnostic radiology departments were restructured to facilitate care for both COVID-19 and non-COVID patients which included patients suffering from acute emergency conditions in addition to all non-elective presentations to the hospital. Routine surgery has been delayed intermittently over the duration of the pandemic while radiology departments struggled to meet an unprecedented demand for

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medical imaging to confirm COVID-19 diagnosis and extent of disease.⁸

In addition to COVID-19 affecting screening, diagnostic radiography and imaging services, therapeutic radiographers (TRs) working in regional Cancer Centres, were managing and implementing changes in radiotherapy protocols. An international specialist consensus statement was released recommending short-course radiotherapy as a means of delaying surgical excision for rectal cancers instead of the routine protocol.⁹ For breast cancer radiotherapy the timely publication of the FAST-Forward trial results,¹⁰ enabled treatment duration to be shortened to one week as opposed to the established three-week delivery protocol.¹¹ Patients with prostate cancer, also felt the impact of COVID-19 as radiotherapy for localised disease was deferred for three months in most centres¹² to create capacity for radiotherapy referrals emanating from the reduction in surgery and the cautious approach to systemic anti-cancer therapy interventions during the pandemic.

Contingency planning and the reshaping of oncology services within radiotherapy departments has clearly made a considerable impact on patient treatments. Healthcare professionals, including radiographers, have adapted both their personal lifestyle and their professional working protocols and practices.¹³ Akudjedu et al.'s,^{14,15} collected survey data from March–May 2020 (first wave of COVID-19 in the UK), and highlighted that COVID-19 resulted in changes to clinical working patterns and service delivery in the UK and Ghana with a corresponding increase in work related stress. Elshami et al.¹⁶ reiterated this in their study of radiology workers (May–June 2020) in the Middle East, North Africa and India, their results indicating a workload increase specifically in general x-ray and Computed Tomography as these were the main modalities used for the diagnosis of COVID-19 and follow-up investigations. Further work by Ooi et al.¹⁷ suggested the need for better organisational structure, resources and education to help the workforce deal with these difficulties whilst Shanahan et al.¹⁸ highlighted the need for further strategies to support and enhance staff well-being during subsequent waves of the pandemic. The experience of the Diagnostic Radiography (DR) and TR workforce should be evaluated in order that effective service delivery can be maintained, not only for the ongoing and future waves of the COVID-19 pandemic, but also for future challenges presented by delayed treatments, late presenting disease, and staff shortages/burn-out. The paucity of information available on radiographers' experience of service delivery in daily clinical practice during a pandemic provides a strong rationale for the design of a dedicated study.

This study aims to explore the experiences and perceptions of radiography managers and staff regarding changes to workload, workflow and protocols in diagnostic radiography and radiotherapy departments in Northern Ireland (NI) one year into the pandemic.

Methodology

This was a mixed methods exploratory study investigating the opinions of DRs, TRs and radiography service managers using an online survey and semi structured interviews. A mixed methods approach was used to help explain the quantitative results. This enabled the study to give a voice to the radiographers and ensure that the research findings are grounded in the radiographers lived experiences. Phase 1 and Phase 2 were carried out independently and the findings of Phase 1 helped to inform the interview questions in Phase 2. Ethical approval for this study was obtained from the Nursing and Health Research Ethics Filter Committee in Ulster University and the NHS Research Ethics Committee in December 2020 (project ID 287032).

Phase 1: A multimedia electronic survey was created on Qualtrics® and promoted via social media (Twitter®/LinkedIn®). Participation was voluntary and the survey was designed and reported to adhere to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES).¹⁹ The survey was open to all radiographers throughout NI (Diagnostic and Therapeutic) and ran from 26th February 2021 to 20th April 2021. Participants were recruited by snowball sampling. The link to the survey was also sent to the Radiology Service Managers throughout NI for dissemination to all colleagues, therefore ensuring maximum reach. The survey collected responses that were fully anonymous, hence, neither IP addresses or any other identifying information was collected. The start of the survey gave participants information regarding the study aims and rationale, informed participants of the approximate time commitment (10 min) to complete the survey and enabled them to give their consent to proceed. At the end of the survey respondents were notified that their responses had been submitted.

The questionnaire consisted of 46 questions in total, divided into five main sections or 'blocks' – 1. Professional/Personal Demographics, 2. Infection control measures, 3. Workforce and remote working, 4. Imaging procedures/radiotherapy treatments, 5. Learning from the COVID-19 experience. Most questions were either in multiple choice format or used a Likert scale with some free text options to allow for more detailed responses. Eleven questions permitted an open response. "Skip logic" was used at question 26 to filter responses specific to Radiotherapy treatments and Imaging procedures (see appendix 1). Only the results of the first four sections of the survey are discussed in this paper; the remaining will be presented in further publications to adhere within word limitations and allow in-depth exploration of the data.

Initially, the questionnaire was piloted amongst a panel of experts in the medical imaging and radiotherapy fields which included 8 qualified radiographers and academics, with a range of clinical experience from less than five years to greater than 30 years. Changes to the final survey were made following a review of the feedback to correct minor formatting issues, ambiguous questions and errors in Qualtrics involving the use of "skip logic". The content of the survey was also ensured by its design being based on the most relevant current research evidence and Department of Health guidelines.^{20–22} All issues were corrected before final dissemination of the survey.

Phase 2: Ten radiography service managers across all five Health and Social Care (HSC) trusts and independent sectors in NI were invited via email to participate in an interview. The interview guide (see appendix 2) was developed by the research team who are comprised of Diagnostic and Therapeutic academic radiographers. The questions in the interview guide were guided by preliminary data from Phase 1. Managers were shown the interview guide in advance of the interview and encouraged to discuss it with their modality leads to maximise the richness of the data received. All interview dates and times were agreed via email. Semi-structured online video interviews were conducted with the aid of Microsoft Teams by one experienced researcher who is trained in conducting semi-structured interviews. The interview guide was used for all interviews and questions were asked in a consistent order. Interview data was digitally recorded, transcribed and coded independently by 2 researchers. Interviews were conducted during March and April 2021 until data saturation was reached i.e. analysis of the data revealed that no new information was being introduced. Confidentiality was guaranteed at the outset. Participants had access to the participant information sheet at the time of invitation, and consent was obtained before the interview (both written and audio-recorded for the online interviews).

Data analysis

IBM SPSS (version 27) was used for analysis of the data²³ and providing descriptive statistics. Qualitative data from both the survey and the interviews was transcribed verbatim, checked for accuracy and then analysed in NVivo²⁴ using an iterative approach following Braun & Clarke's²⁵ six stage framework for thematic analysis i.e. Step 1: Become familiar with the data, Step 2: Generate initial codes, Step 3: Search for themes, Step 4: Review themes, Step 5: Define themes, Step 6: Write-up. Two researchers independently coded the interviews, as recommended by Cuttcliffe & McKenna,²⁶ finding an alignment of over 90% with coding comparison in NVivo prior to any discussion. Through discussion, the researchers reached agreement on all remaining coding and worked together to place codes into appropriate categories and themes.

Results

Phase 1: staff survey

Professional/Personal Demographics

A total of 106 survey responses were available for analysis. i.e. 82 DR and 24 TR (See Table 1).

Table 1
Respondents' demographic details.

		Diagnostic radiographers % and number of participants ^a	Therapeutic radiographers
Hospital where currently work	Belfast HSC Trust	33% (n = 27)	54% (n = 13)
	South Eastern HSC Trust	2% (n = 2)	0% (n = 0)
	Western HSC Trust	20% (n = 16)	42% (n = 10)
	Northern HSC Trust	0% (n = 0)	0% (n = 0)
	Southern HSC Trust	34% (n = 28)	0% (n = 0)
	Private sector	11% (n = 9)	4% (n = 1)
Years in radiography practice	0< years	20% (n = 16)	17% (n = 4)
	5–10 years	17% (n = 14)	21% (n = 5)
	11–15 years	16% (n = 13)	4% (n = 1)
	16–20 years	9% (n = 7)	17% (n = 4)
	>20 years	20% (n = 16)	21% (n = 5)
Gender	No response	18% (n = 16)	21% (n = 5)
	Male	18% (n = 15)	21% (n = 5)
	Female	79% (n = 65)	79% (n = 19)
	Other	1% (n = 1)	
Ethnicity	Preferred not to say	1% (n = 1)	
	White	99% (n = 81)	100% (n = 24)
Age range	Black, Asian and minority ethnic (BAME)	1% (n = 1)	0% (n = 0)
	20–30 years old	38% (n = 31)	33% (n = 8)
	31–40 years old	35% (n = 29)	46% (n = 11)
	41–50 years old	22% (n = 18)	13% (n = 3)
	51–60 years old	5% (n = 4)	8% (n = 2)
Current area of specialism/role	>61 years old	0% (n = 0)	0% (n = 0)
	General radiographer	22% (n = 18)	
	CT	18% (n = 15)	
	Dental	1% (n = 1)	
	DEXA	2% (n = 2)	
	Fluorography	1% (n = 1)	
	Education/Governance	1% (n = 1)	4% (n = 1)
	Intervention	2% (n = 2)	
	Mammography	6% (n = 5)	
	Management	7% (n = 6)	4% (n = 1)
	MRI	21% (n = 17)	
	Nuclear Medicine	1% (n = 1)	
	Paediatrics	4% (n = 3)	
	Reporting radiographer	4% (n = 3)	
	Ultrasound	5% (n = 4)	
Clinical Specialist Radiotherapy		17% (n = 4)	
Radiotherapy		67% (n = 16)	
No response	4% (n = 3)	8% (n = 2)	

^a Percent has been rounded to the nearest whole number so may not always equal 100% in each column.

A range of years of experience was indicated in both diagnostic radiography and radiotherapy. All age groups were represented except for the over 61 years old group.

The ratio of therapeutic to diagnostic radiographers broadly represents the UK workforce ratio of 3794 therapeutic to 20,231 diagnostic radiographers.²⁷ In May 2021, there were 1348 radiographers in NI registered with the Health and Care Professions Council (HCPC) although it is unclear how many of these radiographers are currently employed in radiography departments in NI (this data was obtained directly from the Health and Care Professions Council through the Freedom of Information Act 2000).

The male/female distribution was comparable to the UK radiographer workforce, which has an approximate 1:3 ratio of male to female.²⁷ In total 18, 49, 28 and 11 respondents were graded as Band 5, Band 6, Band 7 and Band 8 respectively (according to the Agenda for Change Pay Structure) of Radiographers.²⁸

Infection control measures

Respondents reported varying levels of experience working with infectious patients prior to the pandemic and different levels of concern over contracting the virus at work or at home (See Table 2).

Overall, 78% (n = 83) of all respondents reported that they did receive additional training in infection control measures since the pandemic started (66 DR, 17 TR). 93% (n = 98) of all respondents (DR and TR) reported that they felt “confident and comfortable” working in the department during the pandemic but 17% (n = 18) of all respondents identified that they would like further training in infection control measures in case another wave of COVID-19 happened. Free text responses for suggestions included:

“Yes as PPE guidance changes regularly I would like specific evidence to support each change and not just cost effectiveness”.

“All our training has been online for infection control. it has been very difficult to find time to do online training as we have

been short staffed and CPD time has been difficult to gain due to increased pressures. A lot of this training has had to be done outside of work hours, which is not practical”.

Participants were asked to retrospectively scale their level of satisfaction with access to PPE each month from March 2020 to February 2021 (See Table 3).

Workforce and remote working

Almost 30% of all respondents (n = 31) had taken sick leave at some stage since March 2020 that was not attributed to the pandemic (23 DR, 8 TR). A further 70% (n = 73) reported that they had contact with asymptomatic patients who had subsequently been

Table 2
Experience working with infectious patients and concerns about contracting COVID-19.

		None	A little	A moderate amount	A lot	A great deal	Not specified
		% and number of participants ^a					
Prior to the COVID-19 pandemic how much experience did you have working with infectious patients ?	Diagnostic Radiographers	1% (n = 1)	37% (n = 30)	45% (n = 37)	10% (n = 8)	7% (n = 6)	0% (n = 0)
	Therapeutic Radiographers	4% (n = 1)	63% (n = 15)	29% (n = 7)	0% (n = 0)	0% (n = 0)	4% (n = 1)
At home, how concerned are you that you may contract or pass on COVID-19 to your family, because of your working environment?	Diagnostic Radiographers	12% (n = 10)	21% (n = 17)	33% (n = 27)	17% (n = 14)	17% (n = 14)	
	Therapeutic Radiographers	17% (n = 4)	37% (n = 9)	13% (n = 3)	4% (n = 1)	25% (n = 6)	4% (n = 1)
At work, how concerned are you that you may contract or pass on COVID-19?	Diagnostic Radiographers	13% (n = 11)	33% (n = 27)	29% (n = 24)	16% (n = 13)	9% (n = 7)	
	Therapeutic Radiographers	21% (n = 5)	29% (n = 7)	25% (n = 6)	13% (n = 3)	8% (n = 2)	4% (n = 1)

^a Percent has been rounded to the nearest whole number so may not always equal 100% in each row.

Table 3
Level of satisfaction with access to PPE each month from March 2020 to February 2021.

How do you rate your access to appropriate personal protective equipment (PPE) during the pandemic		Dissatisfied	Less than satisfied	Satisfied	Very satisfied	Unspecified
		% and number of participants ^a				
March 2020	Diagnostic Radiographers	22% (n = 18)	24% (n = 20)	32% (n = 26)	15% (n = 12)	7% (n = 6)
	Therapeutic Radiographers	8% (n = 2)	38% (n = 9)	29% (n = 7)	21% (n = 5)	4% (n = 1)
April 2020	Diagnostic Radiographers	16% (n = 13)	27% (n = 22)	33% (n = 27)	15% (n = 12)	10% (n = 8)
	Therapeutic Radiographers	8% (n = 2)	25% (n = 6)	38% (n = 9)	25% (n = 6)	4% (n = 1)
May 2020	Diagnostic Radiographers	7% (n = 6)	16% (n = 13)	43% (n = 35)	26% (n = 21)	9% (n = 7)
	Therapeutic Radiographers	4% (n = 1)	13% (n = 3)	38% (n = 9)	42% (n = 10)	4% (n = 1)
June 2020	Diagnostic Radiographers	2% (n = 2)	16% (n = 13)	43% (n = 35)	31% (n = 25)	9% (n = 7)
	Therapeutic Radiographers	0% (n = 0)	13% (n = 3)	29% (n = 7)	54% (n = 13)	4% (n = 1)
July 2020	Diagnostic Radiographers	1% (n = 1)	11% (n = 9)	45% (n = 37)	34% (n = 28)	9% (n = 7)
	Therapeutic Radiographers	0% (n = 0)	8% (n = 2)	38% (n = 9)	46% (n = 11)	8% (n = 2)
August 2020	Diagnostic Radiographers	1% (n = 1)	9% (n = 7)	49% (n = 40)	38% (n = 31)	4% (n = 3)
	Therapeutic Radiographers	0% (n = 0)	4% (n = 1)	33% (n = 8)	58% (n = 14)	4% (n = 1)
September 2020	Diagnostic Radiographers	0% (n = 0)	6% (n = 5)	52% (n = 43)	38% (n = 31)	4% (n = 3)
	Therapeutic Radiographers	0% (n = 0)	0% (n = 0)	29% (n = 7)	67% (n = 16)	4% (n = 1)
October 2020	Diagnostic Radiographers	0% (n = 0)	4% (n = 3)	51% (n = 42)	42% (n = 34)	4% (n = 3)
	Therapeutic Radiographers	0% (n = 0)	0% (n = 0)	33% (n = 8)	63% (n = 15)	4% (n = 1)
November 2020	Diagnostic Radiographers	0% (n = 0)	4% (n = 3)	50% (n = 41)	43% (n = 35)	4% (n = 3)
	Therapeutic Radiographers	0% (n = 0)	0% (n = 0)	33% (n = 8)	63% (n = 15)	4% (n = 1)
December 2020	Diagnostic Radiographers	0% (n = 0)	5% (n = 4)	48% (n = 39)	45% (n = 37)	2% (n = 2)
	Therapeutic Radiographers	0% (n = 0)	4% (n = 1)	29% (n = 7)	63% (n = 15)	4% (n = 1)
January 2021	Diagnostic Radiographers	0% (n = 0)	4% (n = 3)	50% (n = 41)	44% (n = 36)	2% (n = 2)
	Therapeutic Radiographers	0% (n = 0)	0% (n = 0)	33% (n = 8)	63% (n = 15)	4% (n = 1)
February 2021	Diagnostic Radiographers	0% (n = 0)	6% (n = 5)	48% (n = 39)	44% (n = 36)	2% (n = 2)
	Therapeutic Radiographers	0% (n = 0)	0% (n = 0)	33% (n = 8)	63% (n = 15)	4% (n = 1)

^a Percent has been rounded to the nearest whole number so may not always equal 100% in each row.

confirmed as COVID-19 positive (56 DR, 17 TR). 66% (n = 70) indicated that their department was able to facilitate remote working and networking if required (49 DR, 21 TR). Of these 15, 40% (n = 6) had difficulty adapting to working remotely (2 DR, 4 TR) (See Table 4).

10 DRs were redeployed as a result of the COVID-19 pandemic, 6 of whom would like to continue in the new role either full time or part time after the pandemic subsides. Of the 10 redeployed, 3 were moved to an area/role where they did not have prior experience and 1 respondent felt they did not receive any additional training for the new role. Overall, confidence working in the new role was recorded as “confident” to “very confident”.

Table 4
Shielding and remote working.

		Yes	No	Don't know	Unspecified
		% and number of participants ^a			
At any time since March 2020 were you shielding/had suspected COVID-19/had confirmed COVID-19/need to take sick leave due to COVID-19?	Diagnostic Radiographers	38% (n = 31)	62% (n = 51)	N/A	
	Therapeutic Radiographers	54% (n = 13)	42% (n = 10)	N/A	4% (n = 1)
At any time since March were you on sick leave for an unrelated illness or health reason?	Diagnostic Radiographers	28% (n = 23)	72% (n = 59)	N/A	
	Therapeutic Radiographers	33% (n = 8)	63% (n = 15)	N/A	4% (n = 1)
Have you been categorised as someone who should be shielding during the pandemic?	Diagnostic Radiographers	4% (n = 3)	96% (n = 79)	N/A	
	Therapeutic Radiographers	4% (n = 1)	96% (n = 23)	N/A	
Have you been categorised as “belonging to a high-risk category”?	Diagnostic Radiographers	5% (n = 4)	95% (n = 78)	N/A	
	Therapeutic Radiographers	12% (n = 3)	88% (n = 21)	N/A	
Do you have caring responsibilities or live with someone in your household who is shielding or high-risk?	Diagnostic Radiographers	20% (n = 16)	80% (n = 66)	N/A	
	Therapeutic Radiographers	13% (n = 3)	83% (n = 20)	N/A	4% (n = 1)
Have you been able to adopt social distancing measures in the workplace?	Diagnostic Radiographers	85% (n = 70)	15% (n = 12)	N/A	
	Therapeutic Radiographers	83% (n = 20)	17% (n = 4)	N/A	
Is the IT department in your department capable of facilitating remote working and networking?	Diagnostic Radiographers	60% (n = 49)	9% (n = 7)	32% (n = 26)	
	Therapeutic Radiographers	88% (n = 21)	4% (n = 1)	4% (n = 1)	4% (n = 1)
At any time since March 2020 were you working from home?	Diagnostic Radiographers	7% (n = 6)	93% (n = 76)	N/A	
	Therapeutic Radiographers	38% (n = 9)	58% (n = 14)	N/A	4% (n = 1)

^a Percent has been rounded to the nearest whole number so may not always equal 100% in each row.

Table 5
Impact of the pandemic on workload in departments.

During the pandemic, did your workload noticeably increase, decrease or stay the same?		Increased	Decreased	Stayed the same	Unspecified
		% and number of participants ^a			
March 2020	Diagnostic Radiographers	17% (n = 14)	54% (n = 44)	15% (n = 12)	15% (n = 12)
	Therapeutic Radiographers	46% (n = 11)	4% (n = 1)	29% (n = 7)	21% (n = 5)
April 2020	Diagnostic Radiographers	17% (n = 14)	57% (n = 47)	9% (n = 7)	17% (n = 14)
	Therapeutic Radiographers	46% (n = 11)	13% (n = 3)	21% (n = 5)	21% (n = 5)
May 2020	Diagnostic Radiographers	33% (n = 27)	34% (n = 28)	16% (n = 13)	17% (n = 14)
	Therapeutic Radiographers	54% (n = 13)	13% (n = 3)	13% (n = 3)	21% (n = 5)
June 2020	Diagnostic Radiographers	43% (n = 34)	22% (n = 18)	18% (n = 15)	18% (n = 15)
	Therapeutic Radiographers	38% (n = 9)	17% (n = 4)	25% (n = 6)	21% (n = 5)
July 2020	Diagnostic Radiographers	43% (n = 35)	16% (n = 13)	24% (n = 20)	17% (n = 14)
	Therapeutic Radiographers	25% (n = 6)	21% (n = 5)	33% (n = 8)	21% (n = 5)
August 2020	Diagnostic Radiographers	48% (n = 39)	15% (n = 12)	26% (n = 21)	12% (n = 10)
	Therapeutic Radiographers	21% (n = 5)	13% (n = 3)	46% (n = 11)	21% (n = 5)
September 2020	Diagnostic Radiographers	55% (n = 45)	11% (n = 9)	21% (n = 17)	13% (n = 11)
	Therapeutic Radiographers	17% (n = 4)	17% (n = 4)	46% (n = 11)	21% (n = 5)
October 2020	Diagnostic Radiographers	57% (n = 47)	10% (n = 8)	21% (n = 17)	12% (n = 10)
	Therapeutic Radiographers	21% (n = 5)	17% (n = 4)	42% (n = 10)	21% (n = 5)
November 2020	Diagnostic Radiographers	56% (n = 46)	12% (n = 10)	20% (n = 16)	12% (n = 10)
	Therapeutic Radiographers	29% (n = 7)	13% (n = 3)	38% (n = 9)	21% (n = 5)
December 2020	Diagnostic Radiographers	62% (n = 51)	12% (n = 10)	15% (n = 12)	11% (n = 9)
	Therapeutic Radiographers	29% (n = 7)	17% (n = 4)	33% (n = 8)	21% (n = 5)
January 2021	Diagnostic Radiographers	65% (n = 53)	11% (n = 9)	13% (n = 11)	11% (n = 9)
	Therapeutic Radiographers	50% (n = 12)	4% (n = 1)	25% (n = 6)	21% (n = 5)
February 2021	Diagnostic Radiographers	56% (n = 46)	12% (n = 10)	21% (n = 17)	11% (n = 9)
	Therapeutic Radiographers	54% (n = 13)	0% (n = 0)	21% (n = 5)	25% (n = 6)

^a Percent has been rounded to the nearest whole number so may not always equal 100% in each row.

Imaging procedures/radiotherapy treatments

Respondents were asked to retrospectively determine how their workload had been impacted from March 2020–February 2021 (See Table 5).

Diagnostic radiography

73% of DRs (n = 60) report that patients are now receiving routine diagnostic appointments again with 40% of respondents (n = 33) indicating that imaging protocols have changed since COVID-19.60% (n = 49) believe the changes in imaging protocols

Table 6
Impact of the pandemic on patient appointments.

		None at all	A little	A moderate amount	A lot	A great deal	Unspecified
		% and number of participants ^a					
How concerned are you about patients' imaging procedures/treatment being delayed or disrupted at your centre?	Diagnostic Radiographers	10% (n = 8)	23% (n = 19)	29% (n = 24)	18% (n = 15)	10% (n = 8)	10% (n = 8)
	Therapeutic Radiographers	33% (n = 8)	25% (n = 6)	13% (n = 3)	8% (n = 2)	0% (n = 0)	21% (n = 5)
If you had contact with patients, how concerned are they about their treatment being delayed or disrupted?	Diagnostic Radiographers	6% (n = 5)	26% (n = 21)	33% (n = 27)	16% (n = 13)	9% (n = 7)	11% (n = 9)
	Therapeutic Radiographers	8% (n = 2)	25% (n = 6)	21% (n = 5)	17% (n = 4)	4% (n = 1)	25% (n = 6)

^a Percent has been rounded to the nearest whole number so may not always equal 100% in each row.

will remain for the foreseeable future; the majority indicating that they are likely to return to pre-COVID-19 status.

80% (n = 66) of DRs expressed some level of concern regarding patient imaging disruption with 83% (n = 68) reporting that patients themselves had expressed concern (See Table 6).

Free text responses identified that respondents perceived that oncology patients, screening services and orthopaedic patients were most affected. At the time of the survey 73% of respondents (n = 60) thought these patients were now receiving appointments again but with a delay of approximately 3–5 months.

40% (n = 33) of respondents thought that imaging/scanning protocols had changed since COVID-19 started. Examples of modifications identified through the free text response included the following:

“All appointment times have been extended. CT Colon patients now require a negative PCR test prior to appointment and must follow isolation protocols before their scan. The room is then deep cleaned and time added between appointments for air changes. Image guided injection patients attending the DPU follow same pathway. Patients who have been vaccinated must wait 2 weeks before steroid injections”.

“In CT stroke patients must have an unenhanced chest prior to carotid imaging or the stroke service will not accept their referral for thrombectomy”

“Abdomen scans for CT are required to take oral contrast 1 h before the scan; this is not being done in 2/3 sites in the trust as there is not enough space to social distance and remove a mask to drink the contrast.”

7% (n = 6) of DRs reported experiencing atypical referrals, e.g. patients receiving alternative imaging modalities due to COVID-19 creating an increased demand on CT services. Examples of alternative imaging were identified through free text

“Large increase in CT pulmonary angiograms; V/Q scans were unavailable for a long time”

“In nuclear medicine we are doing increasing numbers of MPI heart scans, as they are the only diagnostic cardiac service being offered in the trust. We have also increased our SPECT lung numbers”.

Radiotherapy

71% (n = 17) of TR respondents reported treating patients who might otherwise have been referred for surgery or systemic anti-cancer treatment.

96% (n = 23, 1 non-responder) of TRs reported that patients had treatments disrupted, altered, or postponed since the outbreak of the pandemic. 46% (n = 11) of TRs expressed concern regarding patient treatment disruption, with 67% (16) of TRs reporting that patients themselves had expressed some level of concern (see Table 6). As of June 2021, 63% (n = 15) of TRs, reported that patients

were now receiving pre-COVID-19 treatment protocols again. 71% (n = 17) of TRs thought that the modified treatment protocols are now likely to remain in place for the future.

Free text responses identified commonly cited changes to protocols;

‘Breast treatment protocols shortened as a result of a trial whose results were published at the start of COVID. I think these regimes would have been amended but maybe just not quite as quickly.’

Pancreatic 15 fraction regimes and 5 fraction high dose “SABR” regimes

‘Head & Neck protocol shorted to 30#s. Prostate protocol shorted to 20#s. Usual length protocols still in place but when possible, the shorter prescriptions are used.’ (# - an abbreviation for fraction)

Phase 2: interviews

A total of 10 radiography service managers were invited from across the five Trusts and Independent sector in Northern Ireland. 9 of the 10 service managers participated in interviews. The managers expressed the need to include the opinions of team leads in different modalities also, hence, two band 8 superintendent radiographers were also interviewed. Many of the managers were given time to discuss the research with other team leads which enabled them to provide additional comments during the interview (this included the leads of all modalities and a paediatric superintendent radiographer). Interviews lasted from 45 min to 1.5 h. In total 11 interviews and one written reply were analysed.

Two central themes arose regarding challenges encountered by managers to service provision;

- 1 Implementation of PPE
- 2 Changes to work practices

Implementation of PPE

Almost exclusively, managers felt that the most challenging aspect at the start of the pandemic was the implementation of PPE. Implementation was challenging due mainly to a) insufficient and changing PPE guidance a, b) availability of PPE and c) the impact of PPE on staff/patient communication (Fig. 1).

Insufficient and changing PPE guidance. Insufficient and changing PPE guidance was cited most frequently by managers as being their greatest challenge during the initial period of the pandemic. They described having to create COVID-19 departmental response plans themselves based on very little guidance including preparation of action plans and trigger points in the department e.g. loss of 25% of CT staff would mean the closure of one CT scanner.

Managers described PPE decisions being made within the trust, without their input which were not suitable for their radiography

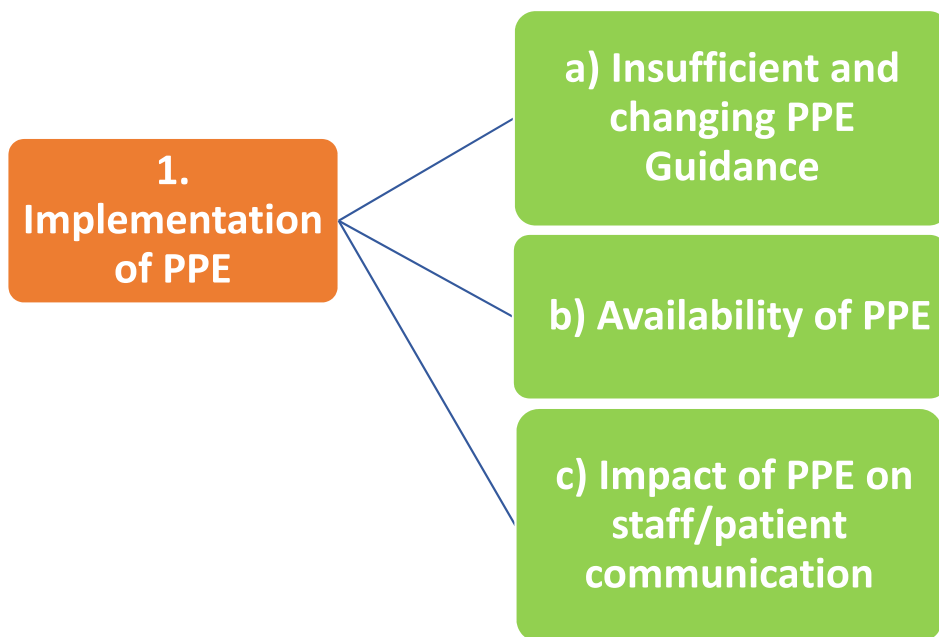


Figure 1. Theme 1 with sub-categories (highlighted in green).

team e.g. the standard introduction of visors for all patients which had the potential to increase physical injury when worn continuously while performing imaging techniques and also impact the accuracy of imaging assessment.

Managers felt that support for and access to PPE within their departments was sub optimal until the Society of Radiographers (SOR) issued guidance on the 20th April,²⁹ indicating that if staff did not have access to appropriate PPE then they would support them in refusing to work (Table 7).

Availability of PPE. As the need for and specifications for PPE became firmly established, managers felt that overall, they experienced few issues with PPE supply though availability was ‘tight’ in the early stages (Table 8).

The impact of PPE on staff communication with patients. Managers indicated that staff found communicating with patients, especially children, while wearing a mask difficult. The

paediatric superintendent indicated that, initially, paediatric radiographers felt that children were quite nervous of staff wearing PPE and they found it difficult to balance reassuring the child against wearing sufficient and appropriate PPE. The superintendent felt that as the pandemic progressed, children became more familiar with PPE (sometimes wearing their own) but that children remained anxious when staff wore ‘Red PPE’ for Aerosol Generating Procedures (AGP) procedures. To minimise anxiety, the team had incorporated child friendly posters throughout the department explaining PPE. They described the use of a ‘toe tap’ which quickly replaced a ‘high five’. Additional challenges to service delivery for paediatric patients included maintaining a clean waiting area for children as children rarely sit in one place for long. Additionally, the superintendent indicated that the team had to remove the toys and play area for children waiting for imaging to reduce the risk of cross-contamination and have not been able to reinstate these toys yet (Table 9).

Table 7
Managers' perspectives regarding PPE Guidance.

'Infection prevention and control were brilliant but were in demand.. we were doing all our risk assessments.. it was difficult to communicate the message because it kept changing at the start.. our key thing was to keep everyone safe, to avoid an outbreak, which would render us unable to cope.. it was difficult to think things through, because we were just flat out trying to keep the service going.' (Manager 1)

'We as managers .. literally we took a day where we went in and wrote up COVID protocols.. we mapped out our zones for treatment; red, amber and green zones.. we had training sessions with the staff, .. people felt more confident.' (Manager 2)

'The mask and visors have presented challenges for us, where we monitor repeats of our mammograms.. we are a screening programme, our whole adage is do no harm.. we try and keep our repeats to a minimum.. across the board, including England, there has been a marked increase in the numbers of repeats.. various reasons, including wearing these shields or goggles, which is changing the perspective of what you are looking at when doing a mammogram.' (Manager 3)

Table 8
Managers discuss the availability of PPE in the early stages of the pandemic.

'In the first wave we were literally going to the fit testing team to say, listen, we've got a CT on call service this weekend. There's X people on it. Or we need X number of masks. It was as tight as that .. as we moved forward in the weeks and months to follow, that seemed to become less of an issue.' (Manager 4)

'PPE wasn't the concern. We were able to get enough PPE. Well sorry, it was a concern for the hospital, for me, but for the frontline staff, they were buffered from that.. they always had a supply. They were never rationed. Staff had everything they needed.' (Manager 5)

Table 9
Discussion of communication issues associated with wearing PPE.

'Face to face. That's been a big thing, even. Communication behind the masks has been difficult.' (Manager 6) *Pre-pandemic we would have close interactions with our patients (playing with them/showing them how equipment works etc). It has been difficult to maintain that whilst maintaining the safety of staff as majority of our patients cannot wear masks.'* (superintendent radiographer 1)

Changes to working practices

All managers consistently described the need to implement changes to working practice. These changes included a) increasing working hours, b) restructuring of staff and resources and c) changes to general departmental protocols (Fig. 2).

Increasing working hours. All managers indicated that their teams were under increased time pressures due the additional time needed for donning and doffing PPE and cleaning between patients. Managers felt that this additional time per procedure/treatment, resulted in a need to adapt shift patterns in their radiography services. Subsequently, many diagnostic services increased to a 24/7 service with others adding an on-call rota to provide an out-of-hours service. While many diagnostic managers anticipated that they would need to move towards a 7-day service prior to the pandemic, they felt that COVID-19 had significantly accelerated this transition. Managers with smaller teams described the challenges of implementing an on-call rota, often asking for volunteers rather than introducing compulsory on-call.

Radiotherapy managers spoke of the positive impact of the publication of the 'The Fast Forward trial' early on in the pandemic resulting in implementation of shorter breast radiotherapy

protocols increasing capacity in both radiotherapy centres in Northern Ireland. Managers indicated that this helped to combat the extra time needed for PPE and cleaning between patients. While the breast fraction reduction aided the workflow, shifts were extended in both radiotherapy centres initially to accommodate the increased time needed for PPE and cleaning. Additionally, managers indicated that delays/postponement of cancer surgery resulted in increased numbers of patients with certain cancers receiving radiotherapy as their primary treatment. Post-radiotherapy reviews were moved to a telephone format to help to manage the changes in workload (Table 10).

Restructuring of staff and resources. Staffing levels in smaller departments were particularly vulnerable during the pandemic and managers were concerned that having multiple staff members contract COVID-19 or become "close contacts", would result in the need to self-isolate, potentially having a large impact on service delivery. At the end of May 2020 the UK government launched the NHS Test and Trace strategy with the aim of reducing the spread of COVID-19. This involved guidance for the public sector and recommended the download of an NHS app to identify close contacts with possible COVID-19 infection, enabling people to isolate as

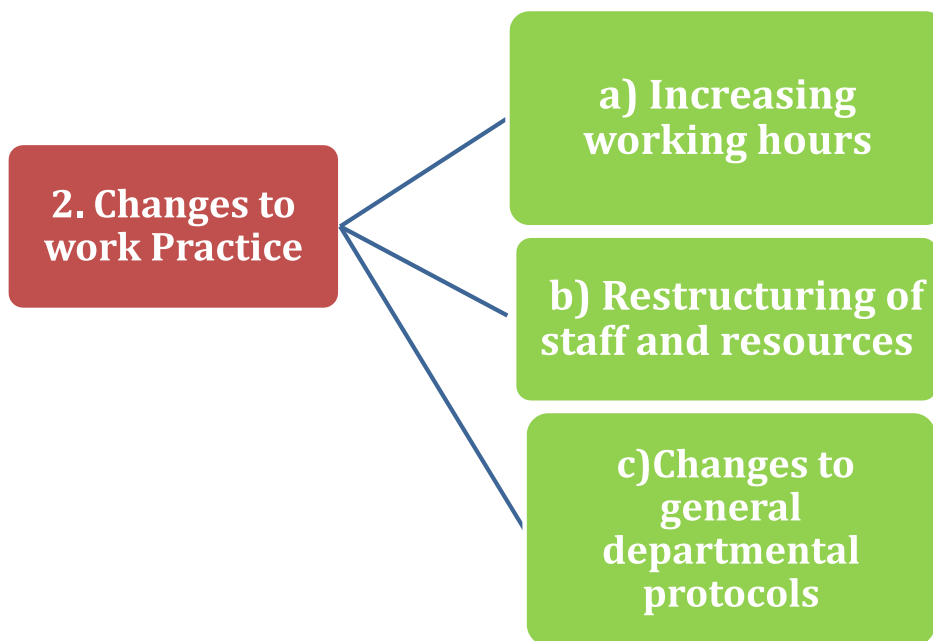


Figure 2. Theme 2 with sub-categories (highlighted in green).

Table 10
Managers describe the impact of the pandemic to staff working hours.

'I suppose the fact that the patients actually are ventilated or they have to have the red PPE, which means that when we are finished there, the room has to be closed for an hour for things to settle, and then it's cleaned. So we have the same volume of patients, but it is taking three times as long to try and get them done.' (Manager 7)
'We went to a four-day week for a bit.. we had slightly longer days and then everybody had one day off a week. We were trying to facilitate childcare but also minimise the number of times the staff were coming into the department. So we could work across two machines, but on a longer day. And then everybody got a day off.. that worked. We did that throughout the first lockdown, then everybody was keen to return to normal working hours.' (Manager 2)
'In the beginning, head and neck cancer patients weren't going for surgery or chemo. So they would have come for their radiotherapy initially.. we certainly had more oesophagus patients and pancreatic patients.' (Manager 2)

Table 11
Managers discuss impact of the pandemic on staffing and resources.

“whenever that track and trace system came in, that’s when we suffered the most with staff shortages.. there was a Friday afternoon there was just one radiographer and another had just got pinged on the app; it was horrendous. That was a worse time for us, in October, than the initial stages of COVID.” (Manager 1)

“We retrained people who probably hadn’t taken an x-ray in a number of years. A lot of the ultrasonographers wouldn’t have done any x-rays or mobile imaging. We did a crash course .. it was good for the rest of the radiographers to see those staff out on the floor.. it wasn’t just limited to radiographers who work in A&E or general x-ray.” (Manager 8)

“Then after that, some of my staff were redeployed.. we still maintained our red flag breast services, so there was a retained team kept. TRs who worked in mammography lacked the transferable skills to be moved to other diagnostic scanning units and therefore were retained as part of the core breast screening service.” (Manager 3)

“Through the ED we noticed a significant increase in attendances from outside Belfast, with some patients travelling 2 h to attend. Parents stated they were unable to get an appointment with their local GP and were nervous of attending their local adult hospital (or advised to skip local hospital). This had an obvious impact on the volume of work.” (Manager 9)

early as possible.³⁰ UK guidance, which also applied to radiographers, stated that close contacts should isolate until a Polymerase Chain Reaction (PCR) test is completed at which point the person can return to normal activities if negative or self-isolate for 10–14 days from the positive result.³¹ Managers indicated that staffing was most severely impacted when the “Test and Trace” strategy was implemented rather than during the initial stages of the pandemic. Managers described their departments as operating with a ‘skeleton staff’ at times.

Diagnostic radiography managers explained how some of their radiographers were redeployed to completely new sites. Breast screening teams were particularly affected due to the cessation of screening services in the initial stages of the pandemic until July 2020 although a higher risk breast screening programme was maintained.

Managers explained that redeployment meant that radiographers often needed some refresher training as their skills had decreased in some areas of their practice over time. Diagnostic departments often needed to split their staff between sites – those where COVID-19 positive patients would attend e.g. emergency departments and those where COVID-19 negative patients would attend.

A number of radiography managers, as well as the paediatric superintendent, provided an insight into how paediatric radiography service provision was impacted by the pandemic. One manager explained how the pandemic resulted in the need for the paediatric age limit for one trust site to increase from 14 years to 16 years. This involved the introduction of different types of trauma imaging which meant that X-ray and CT protocols were adjusted to meet the needs of this cohort. Other managers described the increased numbers of children attending for radiography procedures through the emergency department (ED) (Table 11).

Changes to general departmental protocols. Managers described the prioritisation of additional training in Infection Control for all staff at the start of the pandemic with some departments training staff over weekends to ensure 100% completion. Changing protocols and guidelines needed to be quickly disseminated to and signed off by all radiographers.

Managers described how some mandatory training was postponed at the beginning of COVID-19 but that one year on,

mandatory training is generally running on course though some managers expressed a backlog starting to form again. A significant portion of the training was transferred to an online format which managers felt worked well where there was a strong IT infrastructure but was more challenging for smaller departments where physical space and resources were an issue. The social distancing guidelines also resulted in fewer available spaces in face-to-face training over the year resulting in delays. Not all training was offered online as explained by manager 2:

Managers explained how appointment systems that were previously used to book patients, no longer worked with new social distancing requirements. Departments that had already adopted Microsoft Teams or similar software, were able to transfer appointments/reviews over to this media more efficiently (Table 12).

Discussion

Radiography service provision faced many challenges during the first year of the COVID-19 pandemic. Managers reported that their greatest challenge was establishing and maintaining a safe environment for their staff and patients. During a time of delayed, conflicting and often inappropriate PPE/COVID-19 guidance, radiography managers demonstrated their strong leadership skills by creating and adapting guidance and protocols to ensure maximum protection for their radiographers and patients. These findings are consistent with Naylor et al.’s qualitative study of diagnostic radiographers, who also highlighted frustration with changing government guidance in the early stages of the pandemic.³² While the frustration felt as a result of this lack of government guidance was not limited to radiography,³³ the pandemic highlighted a lack of understanding by other healthcare professionals, regarding the role of the radiographer and the need for unique PPE and safety guidance at a departmental level to account for specialist procedures within each area of the department. Almost fifty percent of radiographers surveyed were dissatisfied with access to PPE in the early stages of the pandemic aligning closely with Zervide et al.’s figures from May 2020.³⁴

Inevitably, the workforce was directly impacted by the pandemic with forty-two percent of surveyed radiographers indicating that they had to take time off work as a result of COVID-

Table 12
Managers’ discuss changes to general departmental protocols.

“Basic life support, the tricky bit with that is getting the dolls in order to do the training, so the resuscitation, the Resusci Anne dolls.. it’s more about making sure they are cleaned properly, because obviously you’ll have multiple people using them. So some of that training has been adapted to try and reduce the actual practical application of the doll.” (Manager 2)

“We use a smart clinic, which uses statistical probabilities to book things.. rather than waste appointments whenever people are not statistically likely to attend, they overbook on top of someone who is more statistically likely to attend. So that itself created a problem with social distancing.” (Manager 3)

“We have a small waiting area which serves x-ray, fluoroscopy (x2), ultrasound, CT, nuclear medicine and DEXA. To maintain social distancing we had to coordinate all modalities (so booking a slot into the waiting area rather than a modality slot). This involved a huge amount of coordination and consideration for the different time demands of each area (e.g. nuclear medicine). Clinics which required x-ray imaging were particularly difficult as previously the service was a walk-in service, so clinics did not need to coordinate with Radiology.” (Manager 10)

19 due to illness or needing to isolate. This increased pressure on the workforce resulted in the majority of radiography departments extending their hours temporarily with many diagnostic departments changing their hours of work permanently. However, Ooi et al. caution that while extending radiography shifts to 12 h can be effective in the short-term, in the long-term this work pattern is likely to result in burnout.¹⁷ Establishing remote working and training is vitally important at this time to enable radiographers who are isolating or shielding to continue to work from their home. However, only sixty-seven percent of radiographers surveyed felt that their department could facilitate remote working. The implementation of a strong IT infrastructure within all radiography departments is essential to ensure that the workforce is somewhat resistant to future waves of the pandemic. Management also need to prioritise the continued adaptability of the workforce by ensuring that specialist radiographers maintain competencies to enable them to move quickly into clinical roles when required.

One year into the COVID-19 pandemic, perceived workload by both DR and TR is higher than normal though many protocols have returned to pre-pandemic times. PPE standards are now well-established within departments and ninety-five percent of staff are satisfied with access to PPE. However, the procedure/treatment time needed per patient continues to be high due to the continued need for PPE and risk-assessed cleaning between patients.

The UK has emerged from a new wave of the pandemic due to the emergence of the Omicron variant, which appears to have a greater ability to evade immunity from prior infection.³⁵ Every COVID-19 positive patient who is admitted to hospital will require the expertise of a radiographer and around half of all people with a cancer diagnosis will receive radiotherapy.³⁶ Given the lengthy hospital waiting lists in Northern Ireland that pre-date COVID-19, any efforts to provide efficient and timely services to the public that not only clear the COVID-19 backlog, but address the legacy issues, will require substantial funding. With approximately 90% of both therapeutic and diagnostic radiographers indicating that patients had expressed concern about their treatment being delayed or disrupted, it is becoming even more difficult to reassure our patients that their health is not being impacted by the pandemic.

Limitations of this study include the small number of radiographers and responses to the survey in NI. The authors highlight caution that the findings may not be generalisable beyond the study sample. A response rate is not available as snowball sampling was used and respondents were recruited via social media. The sample of respondents included little diversity in terms of ethnicity. In addition, due to time and financial constraints the participants were not offered the possibility to review and/or validate the transcribed interview data. It is also possible that the perceptions of radiographers regarding events which occurred several months prior to the survey e.g. availability of PPE, may not be as accurate as collecting the data earlier on in the pandemic at the time of the PPE shortage.

Conclusion

While departments are undoubtedly more prepared for future waves, the workforce continues to face pressure with unpredictable long-term outcomes for both staffing levels and service efficiency for some time to come. Radiographers, and other health staff, have remained at the “coal front” throughout the pandemic despite fears of shortages of PPE, reacting promptly to changing government guidelines and managing changing duties and shift patterns effectively. Even though the hard work of radiographers has clearly helped to maintain service delivery in these adverse conditions, NHS professionals still perceive that the “Northern Ireland health system is one step from chaos”.³⁷

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Conflict of interest statement

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.radi.2022.03.009>.

References

1. World Health Organisation. *Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV) 2020* Available at: [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus). 2019-ncov. . [Accessed 18 January 2022].
2. Neal RD, Nekhlyudov L, Wheatstone P, Koczwara B. Cancer care during and after the pandemic. *Br Med J* 2020;**370**:m262. <https://doi.org/10.1136/bmj.m2622>. Published. . [Accessed 2 July 2020].
3. Bhangu A, Glasbey J, Ademuyiwa A, Adisa A, AlAmeer E, Arnaud AP, et al. Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumour types in 61 countries: an international, prospective, cohort study. *Lancet Oncol* 2021;**22**:1507. [https://doi.org/10.1016/S1470-2045\(21\)00493-9](https://doi.org/10.1016/S1470-2045(21)00493-9). 17 Published Online October 5, 2021.
4. Alderwick H, Dunn P, Gard T, Mays N, Dixon J. Will a new NHS structure in England help recovery from the pandemic? *Br Med J* 2021;**372**:n248. <https://doi.org/10.1136/bmj.n248>. Published. . [Accessed 3 February 2021].
5. British Medical Association. *The hidden impact of COVID-19 on patient care in the NHS in England*. July 2020. the-hidden-impact-of-covid_web-pdf.pdf (bma.org.uk). . [Accessed 19 January 2022].
6. Cancer Research UK. *Cancer statistics for the UK*. Available at: <https://www.cancerresearchuk.org/health-professional/cancer-statistics-for-the-uk#heading=Zero>, 2020. [Accessed 22 June 2022].
7. Cancer Research UK. *Cancer screening and coronavirus (COVID-19) | cancer research UK*. Cancer screening and coronavirus (COVID-19). 2020. Available at: . [Accessed 20 June 2022].
8. World Health Organisation. *COVID-19 Use of chest imaging in COVID-19 a rapid advice guide*. https://apps.who.int/iris/bitstream/handle/10665/332336/WHO-2019-nCoV-Clinical-Radiology_imaging-2020.1-eng.pdf, 11 JUNE 2020. [Accessed 1 January 2022].
9. Marjinen CAM, Peters FP, Rödel C, Bujko K, Haustermans K, Fokas E, et al. International expert consensus statement regarding radiotherapy treatment options for rectal cancer during the COVID-19 pandemic. *Radiother Oncol* 2020;**148**:213–5.
10. Brunt AM, Haviland JS, Wheatley DA, Sydenham MA, Alhasso A, Bloomfield DJ, et al. Hypofractionated breast radiotherapy for 1 week versus 3 weeks (FAST-Forward): 5-year efficacy and late normal tissue effects results from a multi-centre, non-inferiority, randomised, phase 3 trial. *Lancet* 2020;**395**(10237):1613–26.
11. Coles CE, Aristei C, Bliss J, Boersma L, Brunt AM, Chatterjee S, et al. International guidelines on radiation therapy for breast cancer during the COVID-19-19 pandemic. *Clin Oncol* 2020;**32**(5):279–81.
12. Obek C, Doganca T, Argun OB, Kural AR. Management of prostate cancer patients during COVID-19 pandemic. *Prostate Cancer Prostatic Dis* 2020;**23**:398–406. <https://www.nature.com/articles/s41391-020-0258-7>. [Accessed 1 October 2021].
13. Simcock R, Thomas TV, Mercy CE, Filippi AR, Katz MA, Pereira JJ, et al. COVID-19: global radiation oncology's targeted response for pandemic preparedness. *Clin Transl Radiat Oncol* 2020;**22**:55–68.
14. Akudjedu TN, Botwe Bo Wuni, Mishio NA. Impact of the COVID-19 pandemic on clinical radiography practice in low resource settings: the Ghanaian radiographers' perspective. *Radiography* 2021 May;**27**(2):360–8. <https://doi.org/10.1016/j.radi.2020.10.013>. Epub.2020.Oct.27.
15. Akudjedu T, Lawal O, Sharma M, Elliott 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* 2020;**2**(1). <https://doi.org/10.1259/bjro.20200023>. Published Online:2 Sep.
16. Elshami W, Akudjedu TN, Abuzaid M, David LR, Tekin HO, Cavli B, et al. The radiology workforce's response to the COVID-19 pandemic in the Middle East, North Africa and India. *Radiography* May 2021;**27**(2):360–8. <https://doi.org/10.1016/j.radi.2020.09.016>. Published online 2020 Sep. 23.
 17. Jwl Ooi, Er ATW, Chong CM, Tsai KT, Chong MC. Knowledge, attitudes and perceptions of radiology healthcare workers during the COVID-19 pandemic. *Proc Singapore Healthc* 2021 May 18. <https://doi.org/10.1177/20101058211015801>.
 18. Shanahan MC, Akudjedu TN. Australian radiographers' and radiation therapists' experiences during the COVID-19 pandemic. *J Med Radiat Sci* 2021;**68**:111–20. <https://doi.org/10.1002/jmrs.462>. 15 February 2021.
 19. Eysenbach G. Improving the quality of web surveys: the checklist for reporting results of Internet E-surveys (CHERRIES) (2004). *J Med Internet Res* 2004. <https://doi.org/10.2196/jmir.6.3.e34>.
 20. Streiner DL, Norman GR, Cairney J. *Health Measurement Scales: a practical guide to their development and use*. 5th ed. England: Oxford University Press; 2015.
 21. COVID-19: guidance for health professionals. In: *COVID-19: guidance for health professionals*. UK Health Security Agency and Department of Health and Social Care . Published 10 January; 2020. GOV.UK, www.gov.uk. [Accessed January 2022].
 22. Stogiannos N, Fotopoulos D, Woznitza N, Malamateniou C. COVID-19 in the radiology department: what radiographers need to know. *Radiography* 2020 Aug;**26**(3):254–63. <https://doi.org/10.1016/j.radi.2020.05.012>. Published online 2020 Jun 4.
 23. IBM Corp. *IBM SPSS statistics for windows, version 27.0*. Armonk, NY: IBM Corp; 2020. Released.
 24. QSR International Pty Ltd. *NVivo (Version 12)*. <https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home>; 2018.
 25. Braun V, Clarke V Using thematic analysis in psychology. *Qual Res Psychol* 2006;**3**:77–101.
 26. Cutcliffe JR, McKenna HP. Expert qualitative researchers and the use of audit trails. *Journal of advanced nursing*, 45(2), pp.126-133. 2021 May *Radiography* 2004;**27**(2):443–52. <https://doi.org/10.1016/j.radi.2020.10.013>. Published online 2020 Oct 27.
 27. HCPC. *Number of therapeutic radiographers on the HCPC Register*. Available at: <https://www.hcpc-uk.org/resources/freedom-of-information-requests/2018/number-of-therapeutic-radiographers-on-the-hcpc-register-may-2018/>, 2018. [Accessed 15 January 2022].
 28. NHS. *Agenda for change - pay rates*. <https://www.healthcareers.nhs.uk/working-health/working-nhs/nhs-pay-and-benefits/agenda-change-pay-rates/agenda-change-pay-rates>. [Accessed 15 January 2022].
 29. The Society of radiographers PPE. *Urgent update for members*. <https://covid19.sor.org/infection-control-and-ppe/ppe-urgent-update-for-members/>, 20/04/2020. [Accessed 1 October 2021].
 30. Briggs AD, Fraser C. Is NHS test and Trace exacerbating COVID-19 inequalities? *Lancet* 2020 Dec 19;**396**(10267):1972.
 31. McVeigh J, Super J, Jeilani M. Eradicating inconsistencies in isolation guidance for NHS healthcare workers. *Publ Health* 2021 Feb 19. <https://doi.org/10.1016/j.puhe.2020.12.011>.
 32. Naylor S, Booth S, Harvey-Lloyd J, Strudwick R. Experiences of diagnostic radiographers through the Covid-19 pandemic. *Radiography* 2021;**28**(1): p187–92. <https://doi.org/10.1016/j.radi.2021.10.016>. Oct 28.
 33. Bennett P, Noble S, Johnston S, Jones D, Hunter R. COVID-19 confessions: a qualitative exploration of healthcare workers experiences of working with COVID-19. *BMJ Open* 2020 Dec 1;**10**(12):e043949.
 34. Zervides C, Sassi M, Kefala-Karli P, Sassis L. Impact of COVID-19 pandemic on radiographers in the Republic of Cyprus. A questionnaire survey. *Radiography* 2021 May 1;**27**(2):419–24.
 35. Pulliam JR, van Schalkwyk C, Govender N, von Gottberg A, Cohen C, Groome MJ, et al. Increased risk of SARS-CoV-2 reinfection associated with emergence of the Omicron variant in South Africa. *medRxiv* 2021 Jan 1.
 36. *What is Radiotherapy?*. <https://www.actionradiotherapy.org/radiotherapy-info>. [Accessed 1 September 2021].
 37. Connolly ML, McKeown LA. Covid-19: Northern Ireland health system 'one step from chaos'. <https://www.bbc.com/news/uk-northern-ireland-58465147>.