The impact of the COVID-19 pandemic on radiotherapy services in England, UK: a population-based study from the National Radiotherapy Dataset

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ABSTRACT

Background:

The indirect impact of the coronavirus disease 2019 (COVID-19) pandemic on cancer outcomes is of increasing concern. However, it is unclear the extent to which key treatment modalities have been affected. This population-based study aimed to assess the impact of the pandemic on radiotherapy activity in England.

Methods:

Data relating to all radiotherapy delivered for cancer in the English NHS, between February 4th 2019 and June 28th 2020 was extracted from the National Radiotherapy Dataset (RTDS). Changes in average-weekly radiotherapy courses, attendances (reflecting fractions) and fractionation patterns following UK lockdown were compared to equivalent months in 2019 overall, for specific diagnoses and across age groups. The significance of changes at lockdown was examined using interrupted time-series (ITS).

Results:

Average weekly radiotherapy courses fell by 19·9% in April 2020, 6·2% in May and 11·6% in June. A relatively greater fall was observed for attendances (29·1%, 31·4% and 31·5% in April, May and June respectively). These changes were significant on ITS ($p<0.0001$). The largest reduction in treatment courses was seen for patients aged ≥70 years (34·4% vs. 7.3% in April) and for prostate and non-melanomatous skin (up to 77·0% and 72·4% respectively) cancers. Conversely, radiotherapy courses increased by up to 71·3% in oesophageal, 143·3% in bladder, and 36·3% in rectal cancer. Increased use of ultra-hypofractionated breast radiotherapy (0·2% to 60·0% of courses; ITS $p<0.0001$)) substantially contributed to the observed reduction in attendances.

Conclusions:

Radiotherapy activity fell significantly whilst use of hypofractionated regimens rapidly increased in the English NHS during the first peak of the COVID-19 pandemic. An increase in treatments for some cancers suggests that radiotherapy compensated for reduced surgical activity. These data will assist healthcare providers in understanding the indirect consequences of the pandemic and the role of radiotherapy services in minimising these.

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RESEARCH IN CONTEXT

Evidence before this study

The indirect consequences of the COVID-19 pandemic on the care of patients with cancer are of concern. However, the extent to which radiotherapy services were affected is unclear. To identify studies reporting on changes in radiotherapy activity during the COVID-19 pandemic, we searched PubMed for articles published in English between 1st January 2020 to 1st October 2020 using the search terms ("cancer" or "malignancy") AND ("radiation therapy" OR "radiotherapy") AND ("COVID-19" OR "coronavirus" OR "SARS-CoV-2"). To date only analyses of radiotherapy activity across single or small numbers of centres, or larger survey-based studies assessing changes to radiotherapy practice have been undertaken. These are at risk of responder bias and are not sufficiently comprehensive to detail changes in radiotherapy activity or prescriptions for individual cancers, nor to quantify how these have varied as the pandemic has progressed.

Added value of this study

To our knowledge, this is the first comprehensive, nationwide analysis of radiotherapy activity during the first wave of the COVID-19 pandemic. We demonstrate an overall fall in radiotherapy activity in the English NHS over this period. This is predominantly attributable to a reduction in treatments for prostate and non-melanomatous skin cancer; malignancies for which there is evidence for the safety of treatment delay. In contrast, treatments for oesophageal, bladder and rectal cancers have markedly increased. We also demonstrate a dramatic increase in the use of hypo-fractionated regimens. Radiotherapy activity remained suppressed in to June 2020 which may reflect delays in cancer diagnostic pathways.

Implications of all the available evidence

Whilst radiotherapy activity fell during the first wave of the pandemic, these data suggest that the overall impact of this is likely to be modest. In addition, radiotherapy appears to have mitigated against some of the indirect harms of the pandemic by maintaining curative treatment options despite the challenges facing surgical services. As COVID-19 infections again rise, these data are critical for modelling indirect harms of the pandemic and establish a new baseline for radiotherapy treatments from which to plan for the ongoing delivery of care throughout subsequent pandemic waves and into the recovery beyond. They also reinforce the need to address any persisting delays in cancer diagnostic pathways.

BACKGROUND:

The indirect consequences of the coronavirus disease 2019 (COVID-19) pandemic are of increasing concern. The United Kingdom (UK) was one of the most severely affected countries in Europe during the first wave of COVID-19. As cases escalated in March 2020, the National Health Service (NHS) restructured in anticipation of large numbers of inpatients requiring respiratory support.[(1)] Similar steps were taken by healthcare providers globally.[(2)]

The impact of this pivot towards COVID-19 for patients with cancer is of particular concern given their need for timely diagnosis, treatment and symptom palliation. Alongside surgery and systemic anti-cancer therapy, radiotherapy plays a major role both as a curative treatment and in the palliation of localised symptoms from advanced disease. It is estimated that a third of all patients with cancer in the UK will receive radiotherapy during their disease course.[(3)] At the outset of the pandemic, all three modalities were affected by constraints on COVID-19 testing and staff shortages. Surgical services faced additional pressure as a consequence of the adaptation of theatre space for the care of acutely unwell patients requiring ventilation.

In response to these pressures, service providers, commissioners and professional bodies within the UK and internationally issued revised guidance for cancer care. Drawing on evidence and expert consensus these also addressed concerns about in hospital COVID-19 transmission and the potentially heightened risk of cancer treatment in the midst of a pandemic.[(4,5)] Within these site-specific guidelines suggestions included treatment omission or delay, the use of radiotherapy to replace or to bridge to surgery, and the wider use of short, high daily dose (hypofractionated) radiotherapy.[(5)]

As cases of COVID-19 rise again, it is important to understand the indirect consequences of the first pandemic peak. However, at present our understanding of changes to radiotherapy practise are limited to a small number of surveys of radiation oncology centres in Europe and the Americas.[(6–8)] These are at risk of responder bias, have limited information about individual cancers and regimen use, and are not able to quantify longitudinal changes during the pandemic. In the absence of this information, the indirect harms of the pandemic cannot be accurately modelled. Such data are also required by service providers, commissioners and clinicians to mitigate against these indirect consequences. This includes through identifying cohorts of patients for whom treatment has been modified and who as a consequence may require tailored clinical follow-up, and through establishing a new baseline for radiotherapy treatment patterns from which planning for a second wave and for the longer-term recovery of cancer services can be developed.

In England, all NHS radiotherapy providers submit data directly from their treatment delivery systems to Public Health England (PHE) on a monthly basis to form the National Radiotherapy Dataset (RTDS).[9] This contains information on greater than 135,000 courses of radiotherapy delivered across the English NHS each year. In this study, we used the RTDS to explore changes in radiotherapy activity during the first peak in COVID-19 cases.

METHODS

Study design

This national population-based study analysed radiotherapy activity across all 52 English NHS radiotherapy providers over the year prior to the pandemic, during the first wave of cases from the date of the UK lockdown and through to the reduction of the UK's COVID-19 alert level in June 2020. PHE routinely collect data on the diagnosis and treatment of patients with cancer within the NHS under section 251 of the Health and Social Care act (2006). Study specific ethical approval was not sought for this work which was considered to be operational research within PHE's core remit.

Data:

We extracted data for all external beam radiotherapy courses (episodes) and attendances (which closely align to fractions) delivered for cancer between 4th February 2019 – 28th June 2020. All ages and tumour sites were included. There is limited radiotherapy capacity in England outside of these NHS centres.

Data items from RTDS used within this analysis were: the diagnosis for which the treatment was delivered (defined using the International Classification of Disease (ICD) 10th edition)[10] allocated to clinically appropriate groupings (e.g. head and neck cancer) as detailed in Appendix page 1; patient age and sex; treatment intent (defined by the treating clinician (curative (including both primary/radical and adjuvant), palliative, other (including those where intent was not submitted)); planned dose in Gray (Gy); planned fractionation; date of course start; attendance dates; and provider organisation.

Analysis:

Analysis of courses and attendance numbers:

Radiotherapy courses were allocated to the week in which they started and attendances (fractions) to the week in which they occurred. Weeks were defined using International Organisation for Standardisation (ISO) calendar and allocated to the month in which they began. Radiotherapy activity was defined by the average (mean) weekly number of treatment courses and attendances per month. Percentage change in activity for each month between February and June 2020 was calculated compared to the equivalent month in 2019 (ordinarily limited year-on-year variation in activity is anticipated). This approach ensured minor weekly fluctuations were smoothed across each month and that comparisons recognised seasonality and bank holiday periods. During the study period between one and four providers per month had not submitted data at the time of data extraction (Appendix page 1). In order to adjust for this additional activity was incorporated based on the proportion of activity delivered by the missing centres in months where complete data were available.

The differences in courses and attendances compared to 2019 were examined by provider, treatment intent, age, patient sex and individual diagnoses. Given the known increase in risk of adverse COVID-19 outcomes with age,[11] data were dichotomised at 70 years in line with UK shielding advice.[12]

The statistical significance of the change in activity following lockdown was assessed using interrupted time-series (ITS) analysis with multi-variable generalised linear regression models.[13] The pandemic lockdown and recovery were specified as binary variables, applied to all time points beyond 23rd March 2020 (the date of lockdown) and 1st June 2020 (when English schools returned) respectively. These terms were interacted with time to parameterise the slope beyond initial lockdown and lockdown easing. Adjustment was made for weeks which included a bank holiday, Christmas 2019 (parameterised separately as this week includes two bank holidays) and seasonal variation (incorporated using Fourier terms)(Appendix page 2).[13] Newey-West errors were used to recognise auto-regressive errors and heteroscedasticity. Model predictions are presented graphically alongside the observed weekly course/attendance numbers. Separate models were fitted to both the adjusted (recognising missing data) and observed data. Statistical significance was defined as $p<0.05$. The ITS model was used to predict the reduction in courses delivered between 23rd March and 28th June 2020 based on data following adjustment for missing with confidence intervals defined based upon the linear model predictions.

Analysis of the change in use of hypofractionation:

Change in treatment fractionation was assessed for patients aged 18 years and older for specified diagnoses (see Appendix page 1). Radical treatments were grouped into categories based on the prescribed dose per fraction (less than 2Gy per fraction, standard fractionation (2-2·49Gy/fraction), mild-moderate hypofractionation (2.5-4·9Gy per fraction) and ultra-hypofractionation (>=5Gy per fraction)). The proportion of activity delivered using each categorisation was assessed by diagnosis. Palliative treatments delivered to these diagnoses were separately grouped as single fraction, two to five fractions, six to ten fractions and greater than ten fractions, then analysed similarly.

Based on the extensive changes observed in fractionation patterns delivered for breast cancer, these were investigated further using ITS analysis. This was conducted as detailed previously using a Poisson distribution to allow recognition of the small number of courses per week for some regimens.

All statistical analyses were carried out using StataIC 64, version 16. Data are presented graphically using Stata1C 64, Tableau and Excel.

No study specific funding was sought and no funding organisation had a role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all of the data extracted from PHE and the final responsibility to submit for publication.

RESULTS:

The average weekly number of radiotherapy courses delivered across the English NHS in 2019 was 2,570 (SD 246). This fell 502 (-19·9%) in April 2020 from 2,526 (SD 178·2) in April 2019 (Table 1 and Appendix page 2). A fall of 151 (-6·2%) from 2,425 (SD 172·1) was observed in May and 307 (-11·6%) from 2,633 (SD 59·6) in June 2020. In comparison, greater reductions, of 10,290 (-29.1%) from 35,332 (SD 2,543·8), 10,573 (-31.4%) from 33,665 (SD 2776·1) and 11,380 (-31·5%) from 36130 (SD 232·7), were observed for treatment attendances (approximating to fractions) in April, May, and June 2020 respectively when compared with equivalent months in 2019.

Substantial variation was seen across radiotherapy providers in both the direction and magnitude of change in average weekly courses, ranging from -53·5% to +13·3% in April 2020, -45·7% - +15·4% in May 2020 and -28·7% to +31·9% in June 2020 (see Appendix page 8). All regions of the country saw a fall in activity in April with subsequent recovery, though the extent of this varied (Appendix page 9).

On ITS analyses lockdown was associated with a significant reduction in courses and treatment attendances ($p<0.001$ for all pandemic terms). Model outputs are presented in Fig.1 and Appendix pages 4-5. Between 23rd March and 28th June a predicted 3,263 (95% CI 2,936-3,590) fewer treatment courses and 119,050 (95%CI 112,632-125,470) fewer attendances were delivered in England than would have been expected had the pandemic not occurred.

Changes in average weekly curative treatment courses and attendances for individual diagnoses, are provided in Table 2 and Appendix page 10. The largest reduction was observed in prostate cancer (in April, May and June 2020 falls of 266 (-77·0%) from 346(SD43·3), 198 (-58·0%) from 342(SD24·9) and 75 (-13·7%) from 360(SD17·0) respectively were observed compared to the equivalent months in 2019) and non-melanoma skin cancer (NMSC; falling 58 (-72·4%) from 80(SD16.2), 47 (-57·8%) from 81(SD19·7) and 26 (-28·4%) from 90(SD16·5) for the same periods). Conversely, marked increases were seen in other diagnoses: bladder cancer courses increased 18 (64·2%) from 27(SD5·1), 32 (143·3%) from 23(SD4·5) and 4 (17·1%) from 24(SD2·1); oesophageal cancer (14 (41·2%) from 32(SD9·6), 18 (71·3%) from 25(SD3·2) and fell 1 (-3·2%) from 29(SD3·0); and rectal cancer (increased 25 (36·3%) from 69(SD10.9), 15 (22·3%) from 65(SD9·2) and then fell 31 (-43·7%) from 72(SD10·4)) in April, May and June 2020 respectively.

The average weekly number of treatment courses delivered to patients aged 70 years and over in April 2020 fell 403; (34·4%) from 1,171 (SD 94·4) in April 2019. A smaller reduction was seen in those under 70 (99 (-7.3%) from 1,355 (SD 91·5) in April 2019. Of these, a weekly average of less than 12 courses was delivered to patients under the age of 18 throughout the study period. Given these small numbers, temporal changes over time were not assessed.

The differential impact of age was most marked in breast cancer (average weekly courses falling 59 (-32·5%) from 182(SD25.1) in those aged 70 and over versus increasing 1 (0·3%) from 513(SD42·0) in those under 70), and NMSC (57 (-71·0%) from 80.2(SD14·0) and 6 (-52·9%) from 12(SD4·1) respectively)((Appendix page 12-14).

In April 2019, 60.9% of curative courses delivered to patients of 18 years and over used a mild-moderately fractionated regimen (2·5-4·9 Gy per fraction). This fell to 38.9% in April 2020 and remained low in May and June 2020 (39.9% and 43.4% respectively). In contrast, ultra-hypofractionation (>=5Gy per fraction) increased from 9·4% in April 2019 to 39.9%, 40·0% and 34·0% in April, May and June 2020. Figure 2 and Appendix page 6 show these results for individual diagnoses.

A major contributor to this was the increased use of 26Gy in 5 fractions for adjuvant breast cancer treatment. Whilst in April 2019 0·2% of courses were delivered using this regimen, this increased to 60·6% in April 2020. Conversely the use of 40Gy in 15 fractions fell from 91·5% to 33·0% on the same comparison. ITS regression confirmed the statistical significance of these changes (Figure 3 and Appendix page 7).

The proportion of palliative treatment courses delivered using a single fraction rose from a an average weekly of 223 (39·3%) of 568(SD36·8) in April 2019 to 233 (50·3%) of 463(SD62·3) in April 2020, with a corresponding fall in treatments delivered using more than five fractions over the same period (125 (22·0%) of 568(SD36·8) to 74 (16·0%) of 463(SD62·3)).

DISCUSSION:

We demonstrate that the number of patients receiving radiotherapy in the English NHS fell significantly during the first wave of the COVID-19 pandemic. When compared to a year previously, a 20% reduction in radiotherapy courses was seen immediately after the UK national lockdown in April 2020. Recovery was not complete by June 2020 (12% reduction), despite the easing of lockdown and decrease in number of NHS inpatients with COVID-19. We project that compared to the same period a year previously (23rd March – 28th June 2020), 3,263 fewer treatment courses were delivered with 119,050 fewer treatment attendances across the English NHS. The disproportionately greater fall in treatment attendances reflects a rapid increase in the use of hypofractionated treatment regimens across a number of tumour sites.

These analyses are based on a comprehensive national dataset. However, the reduction in activity that we report compares favourably to the more limited surveys of radiation oncology departments undertaken following the first pandemic peak in both the United States of America (USA) and Europe.[(7,8)] An approximate 25% reduction in patient volume was for instance reported for centres in Europe, including the UK, with patient volume in the USA predicted to be a third lower. In contrast, at 8% the reported median reduction in patient volume in Latin America is far more modest than observed here.[(6)]

Beyond overall changes in radiotherapy activity, we also highlight how these changes varied by age group and diagnosis. At the onset of the pandemic, a number of professional bodies issued guidance for safely maintaining radiotherapy services.[(4,5)] A key concern at the time related to the potential for hospitals to act as a reservoir for SARS-CoV-2,[(14)] and for a potentially heightened risk from COVID-19 for patients with cancer, particularly for those aged 70 years and older.[(11)] Reflecting this, many guidelines advocated the deferral of treatment where it was safe to do so, or where the potential risks of treatment outweighed the benefits.

We demonstrate that treatment courses fell by a much a greater degree in patients aged 70 years and older. This may partly be a consequence of decisions made by clinicians and patients to defer treatment in this higher-risk group. It may also in part reflect the age profile of prostate cancer and NMSC, where falls greater than anticipated from European surveys were observed. In prostate cancer, randomised evidence supports delay of up to six months using androgen deprivation therapy, or even for active surveillance in low-risk disease.[(15,16)] The extent to which evidence supports treatment delays in NMSC is less well defined, although for small basal cell carcinomas delay is unlikely to change the likelihood of cure.[(17)] Additionally, a differential effect was seen in breast cancer, potentially reflecting altered clinical decision-making based on an assessment of risk and informed by the results of the PRIME-II trial.[(18)] Similarly, specific concerns for adverse COVID-19 outcomes in patients with lung cancer may have contributed to the reduction in 2Gy per fraction treatments (often delivered with concurrent chemotherapy) in favour of mild-moderate hypofractionation.

In contrast, a rise in curative courses was observed for rectal, bladder, oesophageal and head and neck cancers during April and May 2020; cancers in which disease biology precludes significant treatment delays. The increase observed here may reflect the use of radiotherapy as an alternative definitive treatment approach to surgery. A number of modelling studies have estimated large numbers of excess deaths due to limitations to surgical services.(19,20) However, these studies have not taken into account the use of radiotherapy in place of surgery as appears to be demonstrated here. Equally, whilst equipoise exists between radiotherapy and surgery for the treatment of bladder cancer and oesophageal squamous cell carcinoma, surgery is superior in oesophageal adenocarcinoma.(21,22) For rectal cancer, radiotherapy offers a mechanism to support delayed surgery with the potential for a substantial minority to avoid resection entirely. One immediate consequence of this shift in treatment patterns should be an urgent review of post-treatment surveillance protocols to ensure that patients who received an alternative treatment approach, and for whom cancer recurs can, where appropriate, be swiftly identified and referred for salvage resection. In the long-term, analysis of the outcomes of those who have undergone radiotherapy in place of surgery, for reasons unrelated to their individual baseline condition, may provide valuable comparative data in settings where randomisation between surgery and radiotherapy has historically been challenging.(21)

In line with guidance advocating reductions in hospital visits, treatment attendances fell significantly post-lockdown as a consequence of the wider use of hypofractionated radiotherapy. Most strikingly, the results of the FAST-Forward trial were incorporated into national guidelines supporting rapid and widespread adoption of a 26Gy in five fractions regimen in place of the previous 40Gy in 15 fractions standard for adjuvant breast cancer radiotherapy.(23,24) In this context, the decision in March 2020 to move away from a per-attendance tariff for national radiotherapy commissioning is likely to have supported providers in rapidly adopting this new evidence base.(1) In addition, as a UK-wide study the experience of delivering these quality-assured hypofractionated regimens within a trial setting will likely have aided its rapid implementation.(23) These changes demonstrate that at least for some indications, the pandemic has beneficially catalysed the adoption of a new evidence base.

An increase in hypofractionation was also seen for palliative treatments, with half of these delivered as a single fraction in April 2020. This change is appropriate and in keeping with evidence for most palliative indications. However, the concomitant reduction in the number of palliative treatment courses is concerning given the role of these treatments in improving quality of life for patients with localised symptoms due to advanced incurable cancer.[25]

Finally, in keeping with centres 'catching up' on deferred treatments, prostate and NMSC treatments were returning to baseline in June 2020. Across a range of other diagnoses, despite lesser falls during lockdown, a reduction in activity was observed in June compared to the previous year. For some diagnoses (e.g. cervix cancer) the temporary reduction/cessation of screening programmes may have played a role. However, NHS waiting time data demonstrate that in June 2020, referrals for possible symptomatic cancer remained 21% below those in June 2019. New diagnoses were suppressed by 26%, which is likely a key contributor to the ongoing suppression in radiotherapy activity through June 2020.[26] Consistent with this, there was limited change in compliance with the 31-day treatment targets in radiotherapy, which remained above 95% throughout the study period.[27] The time between diagnosis and commencing treatment may have limited the impact of the pandemic in May (compared to April and June), as previously diagnosed patients began their treatment. These results reinforce concerns about the impact of the COVID-19 pandemic on cancer diagnostic pathways and, in turn, outcomes.[28,29] This will require examination in future, once complete cancer registration data are available.

This is the first comprehensive national analysis of changes in cancer treatment provision during the first wave of the COVID-19 pandemic. Nevertheless, it does have limitations. Data were only available for England and a lag in data collection and availability (of approximately 2-3 months) means more contemporaneous data are not available, so that longer-term changes in radiotherapy activity beyond the first wave of the pandemic cannot yet be seen. In addition, data were missing from four centres which had not completed their activity submission in June. However, having adjusted for this within our analyses it is unlikely to significantly impact on the conclusions reached. A small number of private providers deliver radiotherapy in England. Data from these providers are not routinely collected, so we cannot comment on the role of the private sector. Due to the limitations of and longitudinal changes in COVID-19 testing in England it is extremely challenging to interpret the relationship between regional COVID-19 prevalence and radiotherapy delivery and as such this was not attempted. Finally, whilst the RTDS provides robust data on the changes in courses and attendances for radiotherapy, it does not provide data on why these changes were made. Whilst assumptions can be made for the population as a whole, the data cannot provide definitive information on an individual patient level. Data relating to individual patient treatment decisions made during the COVID-19 pandemic will be collated by the National Cancer Research Institute Clinical and Translational Radiotherapy Research Working Group (NCRI CTRad) COVID RT initiative, and will be linked with other national datasets to determine the impact on patient outcomes.[30]

Conclusions:

Radiotherapy activity in the English NHS fell significantly during the first wave of the COVID-19 pandemic. This occurred predominantly in cancers where treatment may be safely delayed and through the use of hypofractionation. In contrast, increased activity in specific diagnoses suggests that radiotherapy was used to compensate for reduced surgical activity. Overall, the impact on cancer outcomes of changes in radiotherapy activity during the first pandemic peak is likely to be modest, and an increase in radiotherapy utilisation may have helped to mitigate against the loss of surgical capacity. However, the continued suppression in radiotherapy activity through June 2020 supports an urgent need to restore diagnostic pathways.

Contributors

KS led the design of the study, carried out data analysis, developed figures, interpreted data and developed the initial manuscript draft. CMJ contributed to the design of the study and figure development, interpreted data and contributed to the manuscript. RG, CR, MS, and SL contributed to the design of the study, data extraction and verification, interpretation and contributed to the manuscript. RS contributed to the design of the study and data analysis, interpreted the data and reviewed the manuscript. LM contributed to the design of the study, data extraction, figure development and reviewed the final manuscript. PL, ME, DSM and TR contributed to the interpretation of the results and development of the manuscript. EM contributed to the study design, data analysis and interpretation and development of the manuscript.

Declaration of interests

We declare no competing interests.

Data sharing:

The aggregate data and meta-data used in this analysis are available at: http://www.ncin.org.uk/cancer_type_and_topic_specific_work/topic_specific_work/covid19

Further information and data access to patient-level data is available from: https://www.gov.uk/government/publications/accessing-public-health-england-data/about-the-phe-odr-and-accessing-data

The data presented here are available to NHS clinicians and service managers via Public Health England's Cancerstats2 dashboard (https://cancerstats.ndrs.nhs.uk/) where they will be updated regularly. We look forward to working with clinicians to use these data in order to inform the process of recovery, restoration and, where necessary, reconfiguration over the coming months.

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Table 1. Average weekly courses and attendances in the months following lockdown. Average weekly numbers are displayed with % change compared to corresponding month of 2019 displayed below. "Other" intent reflects those where the intent was not specified, numbers in this group dropped steeply in 2019 with improvements to data collection, although given their low frequency this change is unlikely to have had a significant impact upon the results more widely.

		Courses					Attendances				
		Feb-20	**Mar-20**	**Apr-20**	**May-20**	**Jun-20**	**Feb-20**	**Mar-20**	**Apr-20**	**May-20**	**Jun-20**
Total	Observed	2631	2449	2024	2274	2130	36121	34716	25042	23092	22631
	Adjusted	2659	2449	2024	2274	2326	36489	34716	25042	23092	24750
	Std dev.	107.4	238.8	226.0	246.1	59.1	514.2	2459.9	1016.9	1664.9	594.4
	% change	-2.9	-7.8	-19.9	-6.2	-11.6	-2.4	-8.5	-29.1	-31.4	-31.5
Palliative	Observed	847	827	653	789	788	3593	3380	2270	2623	2771
	Adjusted	855	827	653	789	861	3629	3380	2270	2623	3030
	Std dev.	32.9	59.9	75.1	112.7	65.0	161.6	415.2	228.2	355.1	240.8
	% change	1.0	-1.8	-20.1	-1.5	-5.3	0.7	-7.0	-35.7	-20.9	-20.4
Radical	Observed	1774	1614	1362	1474	1332	32426	31227	22684	20376	19792
	Adjusted	1793	1614	1362	1474	1454	32756	31227	22684	20376	21645
	Std dev.	83.0	205.5	151.9	136.9	15.7	569.7	2053.7	949.9	1354.9	364.0
	% change	-3.1	-9.3	-19.4	-8.7	-15.2	-2.2	-8.2	-28.3	-32.6	-32.9
Other	Observed	11	9	9	10	10	103	108	88	93	68
	Adjusted	11	9	9	10	11	104	108	88	93	75
	Std dev.	5.4	3.3	3.8	1.0	2.0	14.1	8.1	11.4	15.0	13.8
	% change	-74.3	-74.5	-54.4	2.5	36.5	-62.9	-61.6	-50.2	-26.2	-16.4
Female <70	Observed	848	829	797	839	718	12196	11691	8974	8382	7459
	Adjusted	857	829	797	839	784	12320	11691	8974	8382	8157
	Std dev.	47.2	49.8	99.4	100.7	19.1	142.5	516.4	400.2	743.1	229.1
	% change	-2.6	-2.8	-2.2	5.3	-8.2	3.0	-7.3	-23.4	-25.7	-33.6
Female ≥70	Observed	487	471	339	419	349	5464	5241	3526	3347	3100
	Adjusted	492	471	339	419	381	5520	5241	3526	3347	3390
	Std dev.	30.6	48.4	21.3	66.5	5.3	106.7	443.0	233.4	362.0	136.2
	% change	-2.3	-1.8	-25.8	-2.1	-18.9	-2.9	-6.9	-31.9	-32.6	-36.1
Male <70	Observed	584	518	459	508	488	9159	8905	6885	6560	6590
	Adjusted	590	518	459	508	533	9252	8905	6885	6560	7207
	Std dev.	19.8	49.4	73.5	38.9	26.7	283.8	723.2	227.4	345.9	362.2
	% change	0.3	-10.0	-15.1	-2.7	-6.7	-2.8	-6.8	-22.8	-23.0	-19.2
Male ≥70	Observed	713	631	429	508	575	9302	8878	5657	4803	5483
	Adjusted	720	631	429	508	628	9397	8878	5657	4803	5996

	Std dev.	44.6	126.8	42.0	55.8	61.6	125.0	819.7	365.2	285.5	584.9
	% change	-6.1	-15.6	-39.9	-25.1	-14.8	-8.0	-12.5	-40.6	-46.1	-37.7

Table 2. Average weekly number of radical episodes and attendances by month for individual diagnoses. Observed weekly average, weekly average adjusted for missing data and percentage change compared to the equivalent month in 2019 based on adjusted data presented. Where smaller diagnoses are considered the adjustment for missing data must be interpreted with caution. NMSC = Non-melanomatous skin cancer.

		Courses					**Attendances**				
		Feb-20	**Mar-20**	**Apr-20**	**May-20**	**Jun-20**	**Feb-20**	**Mar-20**	**Apr-20**	**May-20**	**Jun-20**
Anal	Observed	22	25	23	20	11	615	614	635	598	382
	Adjusted	22	25	23	20	12	622	614	635	598	418
	Std dev	5.8	5.4	6.6	3.9	0.5	45.3	25.3	27.0	48.8	63.5
	% change	-4.4	21.5	9.7	2.6	-48.9	11.2	8.7	16.7	12.5	-27.2
Bladder	Observed	20	28	45	55	26	370	521	730	992	674
	Adjusted	20	28	45	55	28	373	521	730	992	737
	Std dev	4.8	3.4	4.8	11.1	6.2	29.4	61.3	124.7	84.9	132.8
	% change	-7.3	-1.4	64.2	143.3	17.1	-27.9	3.7	37.4	87.0	48.8
Brain	Observed	58	51	43	42	41	1325	1145	948	845	817
	Adjusted	58	51	43	42	45	1338	1145	948	845	893
	Std dev	8.8	7.2	7.4	4.4	6.7	75.5	67.4	54.8	80.1	65.7
	% change	-10.6	-24.7	-19.9	-28.4	-22.6	10.6	-20.0	-26.7	-25.1	-33.0
Breast	Observed	634	597	570	618	493	9617	9289	6036	5400	4828
	Adjusted	640	597	570	618	539	9715	9289	6036	5400	5279
	Std dev	41.4	42.5	91.8	90.3	35.0	361.8	556.3	347.1	639.7	325.9
	% change	1.3	-4.5	-4.5	6.6	-12.5	2.8	-5.7	-34.8	-39.9	-45.4
Cervix	Observed	21	21	22	17	13	520	471	563	464	360
	Adjusted	21	21	22	17	14	525	471	563	464	394
	Std dev	4.2	7.3	4.8	4.7	3.9	47.9	29.6	15.3	49.1	18.1
	% change	-10.9	6.3	0.7	-37.7	-32.7	-9.9	-16.6	12.2	-19.3	-37.6
Head and Neck	Observed	122	120	132	116	80	3249	3337	3415	3319	2467
	Adjusted	124	120	132	116	87	3282	3337	3415	3319	2698
	Std dev	13.7	15.8	23.5	23.0	3.2	98.1	62.4	147.3	204.7	249.4
	% change	-0.2	4.2	9.7	4.0	-25.6	-6.6	-2.9	5.1	3.4	-18.8
Lung	Observed	135	140	139	147	102	1955	2089	1893	1884	1350
	Adjusted	136	140	139	147	111	1974	2089	1893	1884	1476
	Std dev	7.0	13.1	13.3	21.7	19.1	76.6	72.2	79.8	154.6	158.4
	% change	6.8	8.5	-1.9	10.8	-11.5	8.2	9.0	-5.8	-0.1	-21.5
Lymphoma	Observed	55	52	40	49	45	760	706	523	497	556
	Adjusted	56	52	40	49	49	768	706	523	497	608
	Std dev	5.0	9.1	7.0	8.7	3.9	31.4	55.9	48.0	83.9	5.2
	% change	5.9	-5.5	-19.2	23.1	-1.7	12.2	-10.8	-25.1	-14.2	-7.9
Oesophageal	Observed	24	30	46	43	25	519	621	735	1110	658
	Adjusted	25	30	46	43	28	524	621	735	1110	720
	Std dev	1.7	7.6	17.0	11.1	1.9	18.7	17.9	142.0	80.9	108.9
	% change	-14.8	1.9	41.2	71.3	-3.2	-9.1	-7.3	9.5	79.8	18.8
Other dx	Observed	148	124	107	113	115	2642	2284	1858	1837	1886
	Adjusted	149	124	107	113	125	2668	2284	1858	1837	2062
	Std dev	14.3	7.9	19.1	11.5	10.2	92.6	221.3	96.3	92.2	117.4
	% change	2.4	-8.0	-17.8	2.3	-3.6	9.5	-11.0	-19.2	-15.9	-10.2
Prostate	Observed	372	285	80	144	285	8471	7958	3706	2174	4595
	Adjusted	375	285	80	144	311	8557	7958	3706	2174	5025

	Std dev	30.1	114.8	10.5	53.7	44.5	248.7	976.5	852.3	223.6	1124.5
	% change	-10.9	-25.3	-77.0	-58.0	-13.7	-12.4	-14.3	-55.7	-72.5	-39.7
Rectal	Observed	72	76	94	80	37	1435	1445	1252	907	602
	Adjusted	73	76	94	80	41	1449	1445	1252	907	658
	Std dev	6.7	8.8	24.1	14.4	8.6	29.9	68.0	81.8	170.7	40.6
	% change	-5.2	-5.7	36.3	22.3	-43.7	9.5	0.2	-8.6	-29.3	-55.8
Skin	Observed	94	65	22	34	59	949	747	389	352	618
	Adjusted	94	65	22	34	64	959	747	389	352	676
	Std dev	18.0	23.9	2.7	8.3	6.1	84.0	132.9	55.7	59.4	104.3
	% change	-12.7	-29.2	-72.4	-57.8	-28.4	-8.5	-24.7	-52.5	-56.7	-28.8

Figure 1a) courses and b) attendances of radiotherapy delivered within the English NHS over the year preceding and period following UK lockdown for the COVID-19 pandemic. Grey dots represent the observed weekly numbers and orange dots weekly numbers after adjustment for missing data. The grey line shows the model predictions of weekly courses from the interrupted time-series model fitted to the adjusted data, the blue line the predicted number of courses and attendances in the absence of the pandemic and the orange line the predicted number of courses/attendances in the absence of adjustment for missing data.

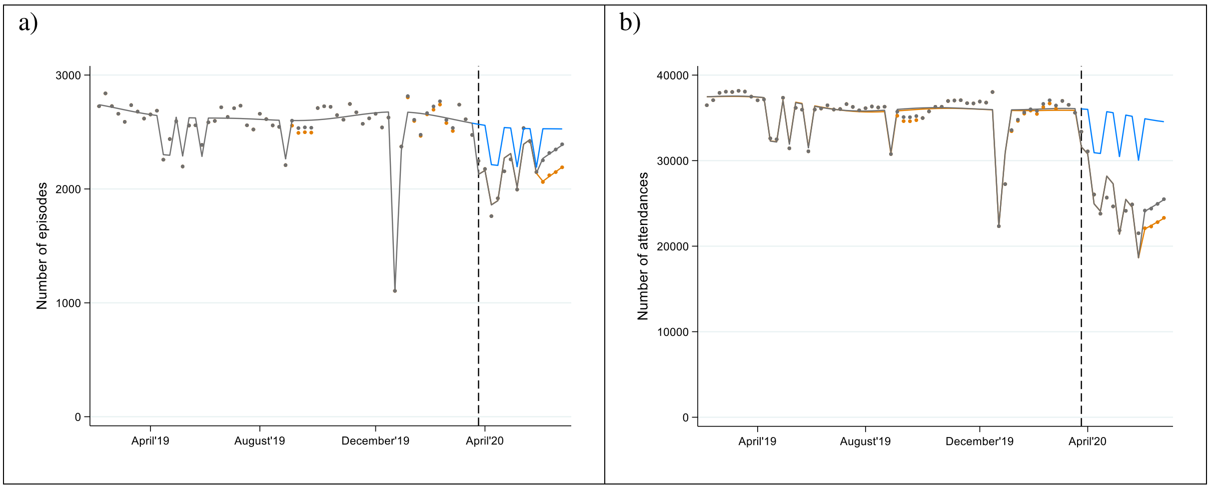


Figure 2. Bubble plot illustrating the change in fractionation patterns delivered for radical treatment to a range of individual diagnoses over time in descending order of total number of courses. The proportion of treatment delivered using a given fractionation category is displayed on the y-axis of each panel and the total number of treatment courses in the period on the x-axis. The size of the bubble reflects the number of treatments delivered using the specified fractionation category.

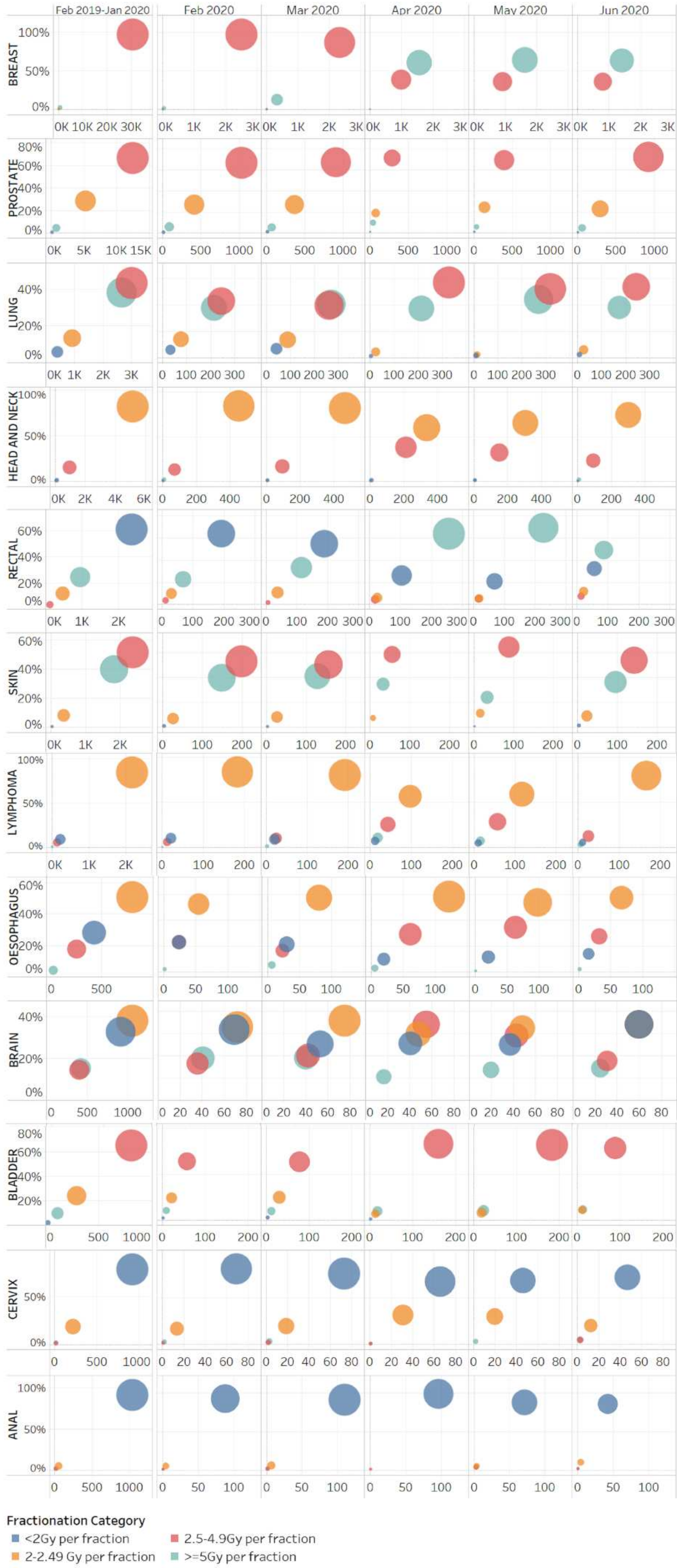
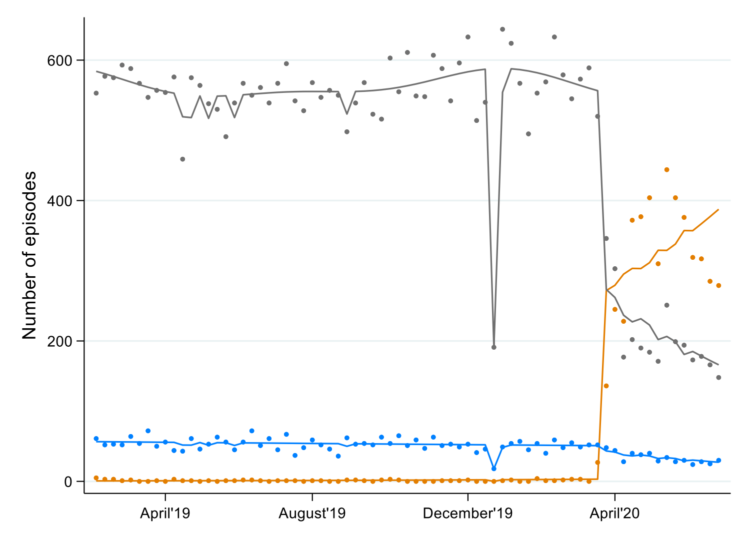

Feb 2019-Jan 2020
Feb 2020
Mar 2020
Apr 2020
May 2020
Jun 2020
BREAST
PROSTATE
LUNG
HEAD AND NECK
RECTAL
SKIN
LYMPHOMA
OESOPHAGUS
BRAIN
BLADDER
CERVIX
ANAL
Fractionation Category
<2Gy per fraction
2.5-4.9Gy per fraction
2-2.49 Gy per fraction
>=5Gy per fraction

Figure 3. Change in fractionation patterns delivered for breast cancer across the English NHS prior to and following lockdown. Model predictions (lines) of the use of differing regimens for the adjuvant treatment of breast cancer with observed weekly courses (dots). Grey = 40Gy in 15 fractions, Orange = 26Gy in five fractions and Blue = all other regimens.



References:

1. Stevens S, Pritchard A. Next steps on NHS repsonse to COVID-19 [Internet]. 2020 [cited 2020 Sep 28]. Available from: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/20200317-NHS-COVID-letter-FINAL.pdf

2. In WHO global pulse survey, 90% of countries report disruptions to essential health services since COVID-19 pandemic [Internet]. [cited 2020 Oct 19]. Available from: https://www.who.int/news/item/31-08-2020-in-who-global-pulse-survey-90-of-countries-report-disruptions-to-essential-health-services-since-covid-19-pandemic

3. Borras JM, Lievens Y, Dunscombe P, Coffey M, Malicki J, Corral J, et al. The optimal utilization proportion of external beam radiotherapy in European countries: An ESTRO-HERO analysis. Radiother Oncol. 2015 Jul 1;116(1):38–44.

4. Overview | COVID-19 rapid guideline: delivery of radiotherapy | Guidance | NICE [Internet]. NICE; [cited 2020 Jun 25]. Available from: https://www.nice.org.uk/guidance/NG162

5. Royal College of Radiologists. Coronavirus (COVID-19): Cancer treatment documents. https://www.rcr.ac.uk/college/coronavirus-covid-19-what-rcr-doing/clinical-information/coronavirus-covid-19-cancer.

6. Martinez D, Sarria GJ, Wakefield D, Flores C, Malhotra S, Li B, et al. COVID's Impact on Radiation Oncology: A Latin American Survey Study. Int J Radiat Oncol. 2020 Oct;108(2):374–8.

7. ASTRO. COVID-19's Impact on Radiation Oncology - Initial results of a Nationawide Physician Survey, 5/20/20 [Internet]. 2020 May [cited 2020 Nov 9]. Available from: https://www.astro.org/ASTRO/media/ASTRO/News%20and%20Publications/PDFs/ASTROCOVID19Survey1-ExecSummary.pdf

8. Slotman BJ, Lievens Y, Poortmans P, Cremades V, Eichler T, Wakefield DV, et al. Effect of COVID-19 pandemic on practice in European radiation oncology centers. Radiother Oncol. 2020 Sep;150:40–2.

9. National Radiotherapy Dataset (RTDS) [Internet]. [cited 2020 Sep 28]. Available from: http://www.ncin.org.uk/collecting_and_using_data/rtds

10. ICD-10 2010 [Internet]. [cited 2017 Feb 10]. Available from: http://apps.who.int/classifications/icd10/browse/2010/en#/II

11. Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, et al. Factors associated with COVID-19-related death using OpenSAFELY. Nature. 2020 Aug;584(7821):430–6.

12. Who's at higher risk from coronavirus (COVID-19) [Internet]. nhs.uk. 2020 [cited 2020 Oct 12]. Available from: https://www.nhs.uk/conditions/coronavirus-covid-19/people-at-higher-risk/whos-at-higher-risk-from-coronavirus/

13. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol. 2017 Feb;46(1):348–55.

14. Yu J, Ouyang W, Chua MLK, Xie C. SARS-CoV-2 Transmission in Patients With Cancer at a Tertiary Care Hospital in Wuhan, China. JAMA Oncol. 2020 Jul 1;6(7):1108.

15. Zaorsky NG, Yu JB, McBride SM, Dess RT, Jackson WC, Mahal BA, et al. Prostate Cancer Radiation Therapy Recommendations in Response to COVID-19. Adv Radiat Oncol [Internet]. 2020 Apr 1 [cited 2020 Jun 29]; Available from: http://www.sciencedirect.com/science/article/pii/S2452109420300610

16. Pisansky TM, Hunt D, Gomella LG, Amin MB, Balogh AG, Chinn DM, et al. Duration of Androgen Suppression Before Radiotherapy for Localized Prostate Cancer: Radiation Therapy Oncology Group Randomized Clinical Trial 9910. J Clin Oncol. 2015 Feb 1;33(4):332–9.

17. Kwan W, Wilson D, Moravan V. Radiotherapy for locally advanced basal cell and squamous cell carcinomas of the skin. Int J Radiat Oncol. 2004 Oct;60(2):406–11.

18. Kunkler IH, Williams LJ, Jack WJL, Cameron DA, Dixon JM. Breast-conserving surgery with or without irradiation in women aged 65 years or older with early breast cancer (PRIME II): a randomised controlled trial. Lancet Oncol. 2015 Mar 1;16(3):266–73.

19. Sud A, Jones ME, Broggio J, Loveday C, Torr B, Garrett A, et al. Collateral damage: the impact on outcomes from cancer surgery of the COVID-19 pandemic. Ann Oncol. 2020 Aug 1;31(8):1065–74.

20. Lai AG, Pasea L, Banerjee A, Denaxas S, Katsoulis M, Chang WH, et al. Estimating excess mortality in people with cancer and multimorbidity in the COVID-19 emergency. medRxiv. 2020 Jun 1;2020.05.27.20083287.

21. Huddart RA, Birtle A, Maynard L, Beresford M, Blazeby J, Donovan J, et al. Clinical and patient-reported outcomes of SPARE – a randomised feasibility study of selective bladder preservation versus radical cystectomy. Bju Int. 2017 Nov;120(5):639–50.

22. Crosby T, Hurt CN, Falk S, Gollins S, Staffurth J, Ray R, et al. Long-term results and recurrence patterns from SCOPE-1: a phase II/III randomised trial of definitive chemoradiotherapy +/ − cetuximab in oesophageal cancer. Br J Cancer. 2017 Mar;116(6):709–16.

23. Murray Brunt A, 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 multicentre, non-inferiority, randomised, phase 3 trial. Lancet Lond Engl. 2020 May 23;395(10237):1613–26.

24. Coles C. Guidelines on radiation therapy for breast cancer during the COVID-19 pandemic. [cited 2020 Nov 6]; Available from: https://www.rcr.ac.uk/sites/default/files/breast-cancer-treatment-covid19.pdf

25. Spencer K, Parrish R, Barton R, Henry A. Palliative radiotherapy. BMJ. 2018 Mar 23;k821.

26. NHS Providers - Government updates [Internet]. 2020 [cited 2020 Oct 19]. Available from: https://nhsproviders.org/topics/covid-19/coronavirus-member-support/national-guidance/government-updates/daily-updates

27. NHS England. Statistics » Cancer Waiting Times [Internet]. [cited 2020 Nov 9]. Available from: https://www.england.nhs.uk/statistics/statistical-work-areas/cancer-waiting-times/

28. Maringe C, Spicer J, Morris M, Purushotham A, Nolte E, Sullivan R, et al. The impact of the COVID-19 pandemic on cancer deaths due to delays in diagnosis in England, UK: a national, population-based, modelling study. Lancet Oncol. 2020 Aug;21(8):1023–34.

29. Sud A, Torr B, Jones ME, Broggio J, Scott S, Loveday C, et al. Effect of delays in the 2-week-wait cancer referral pathway during the COVID-19 pandemic on cancer survival in the UK: a modelling study. Lancet Oncol. 2020 Aug;21(8):1035–44.

30. Lewis PJ, Morris EJA, Chan CSK, Darley K, Sebag-Montefiore D, Evans M. COVID RT – Assessing the Impact of COVID-19 on Radiotherapy in the UK. A National Cancer Research Institute Clinical and Translational Radiotherapy Research Working Group Initiative in Partnership with the Royal College of Radiologists, the Society of Radiographers and the Institute of Physics and Engineering in Medicine. Clin Oncol R Coll Radiol G B [Internet]. 2020 Sep 2 [cited 2020 Oct 8]; Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7467021/