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Original Article

Radiotherapy waiting times, resources and protocols for breast carcinoma: a survey of UK radiotherapy centres

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Abstract

Purpose: Radiation techniques employed for breast cancer must be efficient as well as effective in order to minimise waiting lists. Protocol restrictions, or the technical application of treatment, may influence planning and treatment times as radiographers follow departmental policies. A national survey of UK radiotherapy centres was undertaken to establish trends in waiting times for breast cancer irradiation; and to investigate relationships of waiting times with the deployment of equipment and personnel and technical procedures adopted.

Method: A questionnaire was posted to the Head of Radiotherapy Services and a Clinical Oncologist with an interest in breast cancer in the radiotherapy centres in the UK. Survey questions investigated a number of issues, including the number of breast patients planned per week; protocols chosen; average treatment and planning times; levels of personnel and equipment; and the population served.

Results: A total of 53 centres were contacted, of which 51 centres responded to some aspect of the survey (96%). Average waiting times for treatment fluctuated from 1 to 7 weeks and maximum waiting times of 11 weeks were reported. Variation in clinical practice was found, including procedure times and the number of radiographers employed per linear accelerator. A multiple regression analysis indicated that a combination of equipment levels, simulation times, and the number of breast contours taken best predicted the average waiting time for breast treatment.

Conclusion: Waiting times reported were influenced by a combination of levels of equipment available and protocols adopted.

Keywords

Radiotherapy; breast cancer; waiting times; protocols; resources

INTRODUCTION

In the UK, radiotherapy doses for breast cancer are known to vary substantially.[1,2] Delays before the start of treatment are also known to vary.

In 1993 in an effort to ensure good practice throughout the UK, the Joint Council for Clinical Oncology (JCCO) published targets for acceptable delays in radiotherapy.[3] For adjuvant breast cancer these guidelines recommended that patients should not wait more than four weeks between surgery and the start of radiotherapy. In 1998, the Royal College of Radiologists performed a national audit of waiting times for radiotherapy. The results showed that for patients with operable breast cancer 39% of patients fell outside the maximum acceptable delay of 4 weeks, with 15% of patients waiting more than six weeks.[4]

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The audit also tabulated waiting times according to 11 UK regions in an effort to establish trends, correlating equipment availability with the average waiting time for each region. This demonstrated a negative correlation between megavoltage equipment availability and waiting time ($p < 0.05$), with patients from those regions with the higher levels of equipment per million head of population waiting less for treatment. The authors attributed delay in treatment with shortfalls in equipment availability, although other factors that may have contributed to delays were not considered. For example, these may include the number of exposures achieved per linear accelerator, the design of treatment protocols, and the number of new patients planned per week. This audit served to highlight the national variability in waiting times for adjuvant radiotherapy treatment, but gave limited insight into the probable causes.

Regional variations in radiotherapy for breast cancer may not be confined to the issue of delay before commencement of treatment. A study of radiotherapy centres in Northern Italy identified differences in treatment planning for early breast cancer.[5] The depth of lung incorporated in the treatment fields and the number of contours taken during planning are just two of the areas where variations were observed between centres. Similarly, the Patterns of Care study in the US sampled 449 breast cases from 72 establishments documenting treatment planning processes and prescriptions.[6] This study found that compliance with existing guidelines varied for different aspects of treatment and across treatment facilities.

Differences in the design of treatment protocols mean the risk of side effects may vary dependent on the treatment centre. Furthermore, differences in technical approaches may result in differences in the use of resources for breast carcinoma across centres. This may have an impact on each individual centre's ability to meet demand, hence influencing the waiting time before a patient can start treatment. To establish the extent of treatment variations in this country a survey of all UK radiotherapy centres was initiated in 1997. Within the time that has elapsed since this survey was conducted changes in equipment protocols and staffing levels may have occurred. However, the findings concerning the potential impact of treatment protocols on waiting time should prove of value in informing policy.

METHOD

Contact with the Head of each radiotherapy department in the UK was attempted by telephone and details of the study were explained followed by a request for permission to send a questionnaire. Simultaneously, a Clinician with an interest in breast cancer was also contacted by telephone and a similar request was made. Contact was established with a total of 53 centres, and 51 centres responded to at least one aspect of the survey (96% response rate).

The questionnaire was divided into three sections to be completed, respectively, by the Clinical Oncologist; the Head of Radiotherapy Services; and the Radiographer in charge of simulation and planning. This approach was adopted to maximise the reliability of the data, with the questions for each section relevant to the individual concerned.

The questionnaire for the Head of the radiotherapy department covered aspects of radiography staffing, the number of new cancers treated with radiotherapy in 1996, the size of the catchment area served and details of equipment and annual exposures for 1996. The Superintendent in charge of Planning or simulation was requested to give details of the dose fractionation schedules used for breast cancer, details of average procedure times, specific protocol designs for breast irradiation, average waiting times for breast irradiation as well as simulator equipment in use. The Clinical Oncologist was asked to give details on policies and guidelines related to breast cancer irradiation.

The questionnaires were piloted in five centres. As no changes were required following the pilot the results of these questionnaires have been included in the main results.

Statistical analysis

The majority of questionnaire responses have been reported in frequencies to demonstrate similarities or differences across departments. To investigate the relationship between resource variables (such as staffing and equipment levels) and waiting times for breast irradiation a Spearman Rank correlation coefficient was used. A linear regression analysis was undertaken using an SPSS statistical analysis package (version 11), to investigate the strength of relationships between waiting times for breast radiotherapy and resources and protocol variables. Using the information from a univariate analysis a subset of variables were investigated using all combinations.

The results of the survey have been divided into four main sections: guidelines and dose prescription, personnel and equipment levels, treatment protocol design and factors influencing waiting times.

RESULTS

The response rates for the questionnaires can be found in Figure 1.

GUIDELINES AND DOSE PRESCRIPTION

Each centre was asked to give their standard dose fractionation schedule for early stage breast carcinoma. A total of 14 different dose fractionation schedules were reported across responding centres for chest wall fields. The most common dose used was 50 Gy in 25 fractions, with 78% of responding centres reporting using one of the three common dose fractionation schedules (i.e. 50 Gy in 25 fractions, 45 Gy in 20 fractions, or 40 Gy in 15 fractions).

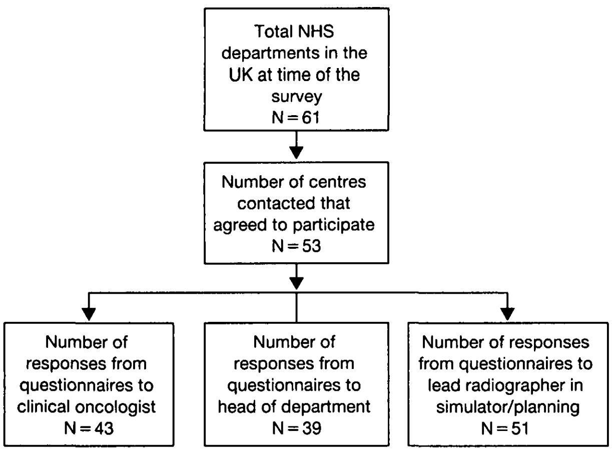

Figure 1. A flow diagram of the survey respondents.

To establish whether centres formalised their strategy for treating breast cancer they were asked to state if they had policies covering a range of activities (Table 1).

For the majority of cases centres chose to formalise their practice through guidelines. In the case of new radiotherapy developments the reverse is apparent. For a number of procedures, particularly gaps in treatment and surgical approach, the percentage of missing data is high.

Equipment and personnel levels

The number of treatment machines and the complement of staff to operate them are important factors that may influence the ability to meet the demands of breast cancer treatment. The number of linear accelerators in each department would be expected to vary according to the population served. As Figure 2 indicates capital resources varied widely from centre to centre.

Figure 3 identifies the number of radiographic staff for each of the responding centres, expressed as whole time equivalent radiographers per 100,000 population (served).

Differences in the staff complement are not just due to the size of the population served. Across the 37 centres that reported staff complement, this varied from less than 1.5 to more than 3 radiographers per 100,000 of population served. The majority of centres (51%) reported using four radiographers per linac, with 32% using less than four WTE radiographers.

Table 1. *Policies that influence radiation practice*

Procedure/ Policy	Policy %(n)	No policy %(n)	Missing data %(n)
Surgical approach	47.1(24)	17.6(9)	35.3(18)
Radiotherapy technique	64.7(33)	11.8(6)	23.5(12)
Radiotherapy borders of breast fields	49(25)	25.5(13)	25.5(13)
Use of a breast boost	49(25)	29.4(15)	21.6(11)
Use of nodal irradiation	60.8(31)	17.6(9)	21.6(11)
New radiotherapy developments	27.5(14)	54.9(28)	17.6(9)
Fractionation schedules for palliative techniques	56.9(29)	25.5(13)	17.6(9)
Gaps in treatment	51(26)	5.9(3)	43.1(22)
Standard treatments	60.8(31)	19.6(10)	19.6(10)

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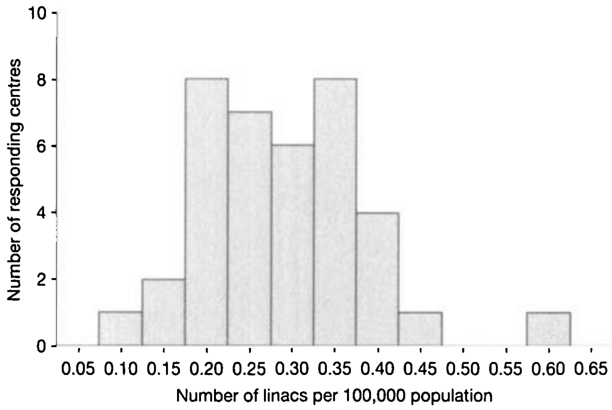

Figure 2. Number of linear accelerators/100,000 population for each responding centre (n = 38).

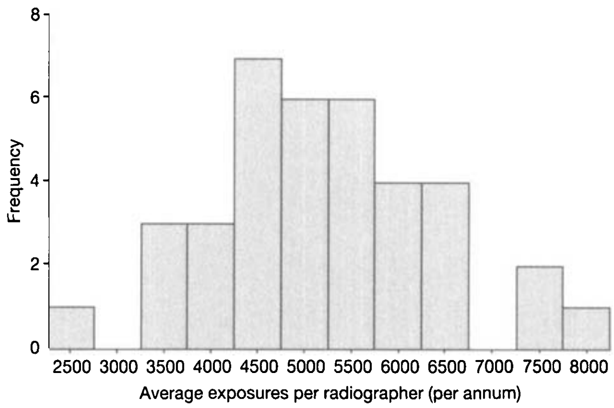

Figure 4. Average exposures per radiographer per annum.

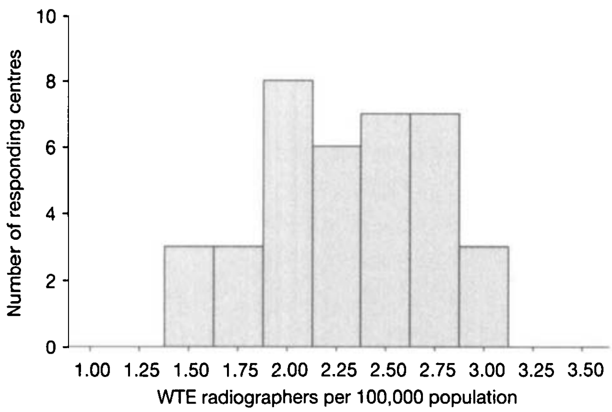

Figure 3. Whole time equivalent radiographers/100,000 population for each of the responding centre (n = 37).

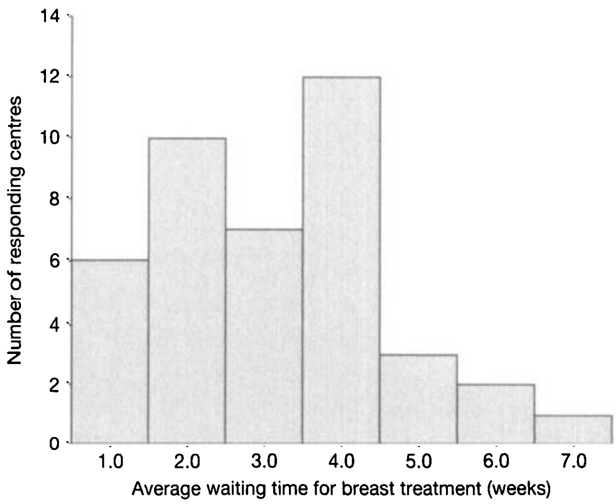

Figure 5. Average waiting times for adjuvant breast irradiation. (Time from date seen by a Clinical Oncologist to start of radiotherapy n = 41.)

Figure 4 demonstrates the level of productivity achieved by each radiographer assigned to the linac for each of the responding centres. Some centres appear to be more efficient than others achieving more exposures from each member of their radiography staff. However, consideration should also be given to the quality and complexity of the treatment employed. Nevertheless, Figure 4 demonstrates a three fold difference between the most and least productive centres.

Even with clear differences in levels of resources such as equipment and personnel, many centres were able to keep their waiting times for breast irradiation within four weeks. The majority of centres (87%) reported average waiting times within acceptable limits as defined by the RCR guidelines. Unfortunately centres also reported that on occasions their waiting times for breast treatments could rise.

A third of responding centres reported that their waiting times could rise to a maximum of 6 weeks. Only 50% of centres were able to keep their maximum waiting times within the RCR guidelines. From this survey 15% reported average waiting times greater than 4 weeks (Fig. 5). An inverse relationship between megavoltage units per 100,000 head of population and waiting time for breast radiotherapy was evident from the responding centres ($r = -0.47$, $p = 0.013$ Spearmans rank coefficient). Similarly, waiting times and WTE radiographers per 100,000 population was inversely related (r = −0.37, p = 0.02 Spearmans rank coefficient).

Other factors may influence each centre's ability to meet demand. It is possible that diversity in the design of treatment protocols may account for differences across centres in the time taken to simulate a breast treatment.

The majority of centres reported planning two field breast techniques within 15–20 minutes although 25% of centres took on average over 30 minutes for each patient (Fig. 6). Similar differences could be seen in the time taken to simulate three and four field treatments. Most centres could plan three fields within 30 minutes, yet 27% of respondents reported 40 minutes or longer.

Simulation is a fundamental part of the radiotherapy process. Long simulation times mean a smaller number of patients can be planned during the working day and this can reduce overall patient throughput, increasing the risk of pre-treatment delays. This variation was also seen in the average treatment times recorded for breast treatments by participating centres. The majority of centres (62%) were able to treat a standard (2 field) breast treatment in less than 10 minutes.

Treatment protocol design

Within the questionnaire the issue of protocol design focused on the skin marking options employed; the policies on maximum lung volumes incorporated in the treatment portals; the number and method used for obtaining patient contours; and treatment verification techniques.

Specific protocol issues relating to how the treatment may be applied on a day-to-day basis may be illustrated by the skin marking methods adopted. Permanent tattoos are often considered the most accurate way of delineating field borders. However, with such a large area to cover in the chest wall, the questions for adjuvant breast irradiation are where is the best place to position tattoos, and how many are necessary to ensure precision?

While the number of tattoos used may be dependent on the number of fields being irradiated, the use of tattoos in the application of breast irradiation varied from zero to ten across responding centres. The median number of tattoos used was 3 (26% of responding centres, SD = 1.9), with 19% of centres using 5 or more.

Radiotherapy protocols for breast cancer are constrained by the need to protect underlying or adjacent normal tissue. This is reflected in the limits placed on the amount of lung considered safe to include in the chest wall fields. As Figure 7 demonstrates, across the responding centres the depth of lung incorporated in the chest wall varied from 2 cm to 4 cm, although only 5% exceeded 3 cm. Similarly, quality assurance limits for acceptable deviations in the depth of lung included in treatment portal checks varied from 2 mm up to 10 mm, and over a quarter of responding centres had no formal tolerance guidelines.

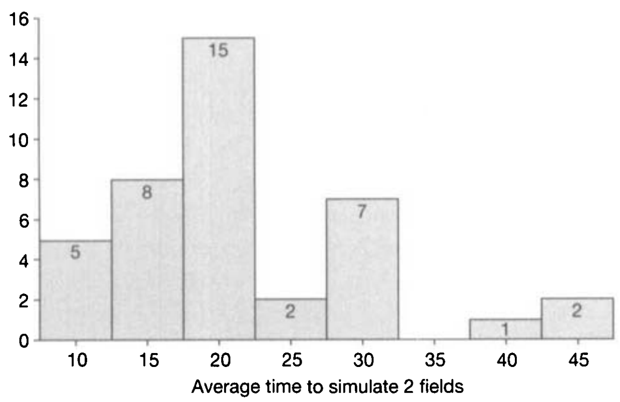

Figure 6. Average time to simulate a two field breast technique (n = 40).

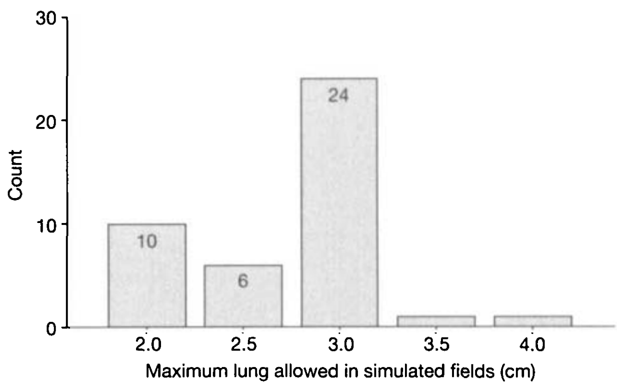

Figure 7. Maximum lung depth allowed at simulation (n = 42).

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Table 2. Correlation coefficients of survey variables with average waiting time (Spearman rank coefficient)

Variable	Correlation	N
Number of linacs/1000 cases	−0.5	37
No. of linacs/100,000 population	−0.4	37
Average number of breast pts planned/week	0.4	38
Average time to treat 2 fields	0.3	41
Average time to treat 3 fields	0.2	38
Average time to treat 4 fields	0.2	31
Number of outlines taken	0.2	41
Number of simulator units	0.4	40
Average time to sim 2 fields	0.3	40
Average time to sim 3 fields	0.3	37
Average time to sim 4 fields	0.3	29

Table 3. Regression summary

	Unstandardised coefficients Beta	95% CI	Sig.
Constant	3.3		
No. of linacs per 1000 new cases	−1.72	−2.6 to −0.9	<0.001
No. of outlines taken	0.54	0.06 to 1.02	0.04
Av time to simulate 3 fields (minutes)	0.057	0.02 to 0.1	0.006

As lung tissue does not attenuate the radiation beam to the same extent as normal tissue, a lung correction factor may be employed. The calculation of transmission factors can be complicated by the loss of electronic equilibrium close to the lung boundary or interface. If a correction factor is not applied there is a risk that calculated estimates of dose in the exit part of the beam are underestimated by approximately 6%.[7]

Half of the responding centres reported using either data from CT images or calculation estimates from simulation to determine lung positions (52%, n = 22), although a number (40%, n = 17) did not employ lung correction factors.

For the contouring method, CT or Sim CT along with laser systems were used to obtain outline information in a minority of centres (38%, n = 16). At the time of the survey the majority of centres reported using manual methods (57%, n = 24). A single central outline was employed by 79% of responding centres.

Factors influencing waiting times

A linear regression was used to assess the impact of resource levels and protocol design on reported waiting times. This analysis involved a univariate analysis of the variables thought to influence average waiting time (Table 2). Using this information a subset of variables were investigated using all combinations.

Using linacs per 100,000 population on its own produced a model with an R value of 0.45, accounting for approximately 20% of the variability seen in the average waiting times reported. Linacs per 1000 new cases appeared to account for more of the variability seen in reported waiting times than linacs per 100,000 population and was therefore used in the final model. Only linacs per 1000 new cases, the number of outlines taken and the average time to simulate 3 fields were significant variables in the multivariate analysis ($R^2 = 0.473$). Table 3 provides details of this regression summary.

DISCUSSION

The disparity in dose fractionation schedules reported was not unexpected. The majority of centres reported using one of three dose fractionation schedules, as also defined by the recent START survey.[8] However, 22% of responding centres used other fractionations.

On the issue of formalised policy many centres at the time of the survey did not have formal policies to define practice. This was particularly noticeable for new developments. As new technology is emerging and the pace of change increases, the implementation of new developments could lead to poorer predictability in the use of resources if guidelines fail to keep pace with these changes.

Missing data may be attributable to policies in the process of being drafted, or uncertainty over the existence of policies for the aspect being surveyed.

The survey demonstrated a variation in the deployment of capital and human resources across

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the UK, with inequalities apparent in equipment and staff complement (WTE) per 100,000 population. Equipment availability may have improved since this survey following government initiatives aimed at reducing the disparity between UK and European levels. However, staff shortages, particularly therapy radiographers, may mean that reports from this survey are unrepresentative of the current situation.

The wide variation in linac output (Fig. 4), a three fold difference between the most and least productive centres, supports the view that the ability of some centres to meet demand may be partly a function of staff efficiency. Alternatively, shortfalls in staffing levels may mean that in some centres radiographers are required to work harder to achieve the same output as that achievable under full staffing conditions. It is also important to note that at the time of the survey staffing levels were higher, and the current picture may reflect significant decreases in productivity. In addition, the use of exposures as an instrument of productivity is far from ideal. Differences in protocol design, patient groups and quality assurance policies will influence the levels of exposures achieved per WTE radiographer. However, these data serve to demonstrate variations in practice and the impact this may have on output. This is further demonstrated in the differences reported in procedure times for simulation.

Obviously simulation and treatment times take no account of the accuracy with which treatment is applied, and this is paramount to treatment efficacy and patient safety. They do however serve to demonstrate that variations in treatment application exist which in turn may influence the ability of each centre to meet demand. The accuracy of the reported procedure times will vary across departments depending on the audit tools available.

One other area of variability is in the amount of lung allowed in the treated chest wall fields. Within the range of lung depths reported it is possible that some patients may experience unwanted respiratory symptoms.

Many centres did not utilise lung correction factors, with the possibility that safe tissue tolerance may be exceeded in small volumes and a potential long-term risk of radiation induced bone damage to the ribs on the ipsilateral side.[9] Patients treated at centres where a lung correction factor is not employed are at a greater theoretical risk of long-term rib damage than those patients where a lung correction factor has been used.

At the time of the survey the majority of centres employed manual outline methods. These can be difficult to implement accurately and have the potential to be time consuming. In addition, a single central outline was the most common option adopted by respondents for planning. The problem with using only one central outline is that differences occur caudo-cephalically in breast or chest wall shape, and the shape and position of the lung volume also changes which greatly affects the contribution of scatter and ultimately the distribution of dose.[10] Two dimensional planning is considered to be sub-optimal compared with 3D planning.[11] The wide variation in the use of permanent tattoos indicates the need for further evidence based practice in this area. If some centres can achieve adequate treatment accuracy utilising three tattoos, why is it necessary within other protocol designs to use up to ten tattoos?

The variations in the protocol designs that were reported may not only influence patient outcome but also have the potential to influence the use of resources. The complexity of radiographer efficiency and staffing levels has shown that the influence of all these factors on the waiting time for treatment is not simple. The regression analysis supported the view that it is not sufficient to equate waiting list problems with a lack of equipment availability.

While there is clearly a negative correlation between waiting times and equipment availability the role of treatment efficiency (related to simulation times and protocol design) cannot be ignored. It is therefore imperative that while maintaining treatment quality, treatment techniques should be used that allow the most appropriate use of resources.

The regression analysis identified three variables, the number of linacs per 1000 new cases, the number of patient contours taken, and the time taken to simulate three fields, that were significantly

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associated with reported waiting times. Indicating that higher levels of equipment per 1000 new cases, fewer contours and a shorter time to simulate three fields may allow shorter waiting times. This neither demonstrates that these variables, in isolation or combination, directly influence waiting times, nor that other variables investigated do not. Firstly, the analysis is based on reports that may not be entirely reliable. Secondly, it is possible that with better response rates, particularly from Heads of Department, other variables may prove to be significantly associated with waiting times. The regression analysis gives an insight into the factors that may influence the delays before treatment, but further study in this field is probably warranted. The design and subsequently the implementation of the breast protocol chosen by each centre will determine the accuracy and reproducibility of treatments, as well as the ability of the centre to meet demand. Using exposures or number of fields treated as a measure of radiotherapy workload does not fully represent the issues of technique complexity, accuracy or patient status. A model proposed by Delaney et al.[12] "The Basic Treatment Equivalent" (BTE) incorporates some but not all of these factors. Studies of the BTE model have been undertaken both in Canada and the UK.[13,14] These models encompass a complexity factor for treatment difficulty but have also shown that treatment times are correlated with the BTE.[14] The model derived from our survey of UK radiotherapy centres indicated that simulation times played an important role in the ability of centres to meet workload demands.

The treatment approaches that are adopted have the potential to influence patient outcomes and the severity of side effects experienced. The national variations in breast protocols that have been demonstrated may result in differences in patient experience as well as differences in practice across the UK. Nevertheless, available international comparisons reflect well on UK practice. In a survey of 39 radiotherapy centres in Northern Italy[5] the mean delay before the start of radiotherapy for early breast cancer was 6.5 weeks, substantially greater than the UK average. Within the Italian survey 88% of centres reported the use of tattoos for field positioning compared with 95% of UK centres. For lung depths allowed in treatment portals 78% of Italian centres surveyed used <3 cm compared with 95% of UK departments. Guidelines from a consensus meeting of the EORTC Radiotherapy and Breast Cancer co-operative groups, and the EUSOMA, stated central lung depths should usually be 1–2 cm, but not exceed 3 cm.[15] On the whole UK practice outlined within this survey demonstrated good compliance with this European consensus report.[15] However these guidelines recommend the use of lung density corrections within the computed calculations of dose and the use of formal procedures for cases where field light positions deviate from those planned. In many of the responding centres in the UK lung correction was not employed and protocols for positional differences did not exist.

The differences demonstrated in the application of breast irradiation across the UK highlight potentially significant variations in practice. These highlight the uncertainty that still exists over what is considered a safe lung depth, and the effect of permanent tattoos on treatment accuracy. Variations in procedure times reflect differences in efficiency and protocol design, with implications for resource commitments.

This report scopes the variation in UK practice during the survey period, and analyses the relationship between specific variables and delays in the commencement of radiotherapy for breast cancer. The time taken to simulate breast techniques has been shown to be a factor in this equation. The relevance of these results to current practice where there may be substantially greater linear accelerator capacity (although reduced staffing capacity) lies in the factors found to influence waiting times. An appreciation of these factors indicates that enhancement in linac capacity may on its own have limited impact on waiting times if there is a change in the complexity factor for treatment. With the greater use of 3D planning an extra pre-treatment commitment may counter any improved equipment availability in terms of reduced waiting times.

This survey supports the view that protocols influence breast radiotherapeutic throughput, evidence relating to the trade-off between efficiency and efficacy of radiotherapy remains to be addressed. This survey provided preliminary background data for a prospective clinical trial to assess the impact of two different breast protocol designs on the use of resources and the experience of the patient. This later study investigated the use of two different lung depth limits and the use of 3 tattoos versus skin marks alone.

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