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Original article

Caution is required in the implementation of 90-day mortality indicators for radiotherapy in a curative setting: A retrospective population-based analysis of over 16,000 episodes

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ABSTRACT

Background: 90-day mortality (90 DM) has been proposed as a clinical indicator in radiotherapy delivered in a curative setting. No large scale assessment has been made. Its value in allowing robust comparisons between centres and facilitating service improvement is unknown.
Methods: All radiotherapy treatments delivered in a curative setting over seven years were extracted from the local electronic health record and linked to cancer registry data. 90 DM rates were assessed and factors associated with this outcome were investigated using logistic regression. Cause of death was identified retrospectively further characterising the cause of 90 DM.
Results: Overall 90 DM was 1.25%. Levels varied widely with diagnosis (0.20–5.45%). Age (OR 1.066, 1.043–1.073), year of treatment (OR 0.900, 0.841–0.969) and diagnosis were significantly associated with 90 DM on multi-variable logistic regression. Cause of death varied with diagnosis; 50.0% post-operative in rectal cancer, 40.4% treatment-related in head and neck cancer, 59.4% disease progression in lung cancer.
Conclusion: Despite the drive to report centre level comparative outcomes, this study demonstrates that 90 DM cannot be adopted routinely as a clinical indicator due to significant population heterogeneity and low event rates. Further national investigation is needed to develop a meaningful robust indicator to deliver appropriate comparisons and drive improvements in care.

90 day mortality has been suggested in the English NHS as a clinical indicator following radiotherapy delivered in a curative setting (RDCS) [1]. It is proposed that this will deliver comparative assessments of quality of care across providers. Such assessments, aiming to inform patient choice and support service improvement [2], are now routinely used in surgery [3–6] and are increasingly seen across a range of other healthcare interventions, including chemotherapy [7–9]. It has been shown, however, that in settings where rates of early mortality are low, and where procedures are infrequent, indicators may not be adequately powered to identify outlying practice [10,11]. This may result in failure to identify poorly performing centres, complacency amongst those wrongly identified as performing in line with expectations and significant reputational damage and patient anxiety in centres falsely identified as underperforming. In addition, the ambition to transform services into learning organisations [12] depends upon the availability of indicators to quantify and understand variations in care and outcomes.

In this context it is vital to ensure the indicators used are appropriate. A number of requirements must be met to ensure this: data must be robust; the population relatively homogeneous; the indicator must reflect quality and be adequately powered to identify outlying practice. Failure to meet these objectives may render them at best unhelpful and at worst counter-productive.

Approximately 65,000 radiotherapy treatments are delivered in England each year in a curative setting [13]. Treatment courses range from short pre-operative, definitive longer course radiotherapy or chemo-radiotherapy, through to post-operative adjuvant radiotherapy. The toxicities of these complex pathways and the populations treated within them vary widely. Where significant toxicity is experienced quality supportive care is key to ensuring

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good outcomes and the avoidance of harm. Unfortunately, for some patients it is disease progression, during or very shortly after treatment that results in death. Identifying the primary cause of mortality is, however, complex and it is unclear if a single indicator has value across all treatment approaches.

To date only small scale assessments of 90 DM following RDCS have been carried out with overall rates of around 2.3% reported [14]. With this evidence it is unclear if the 90 DM indicator can meet the required standards to ensure valid, clinically meaningful outcomes in this setting.

This study aimed to investigate 90 DM in a large 7-year regional cohort in England. It assessed the factors associated with 90 DM, considered the value of this indicator in guiding service improvements and investigated its potential to provide robust comparisons between centres.

Materials and methods

All radiotherapy episodes delivered in Leeds Cancer Centre (LCC), between January 2004 and December 2010, were identified using the electronic patient record. Patient demographics (date of birth and sex) and treatment information (date of treatment, planned fractionation, dose, treatment intent and site treated) were extracted from this resource. These data were linked to the cancer registrations held by the National Cancer Registration and Analysis Service (Northern and Yorkshire), ensuring robust diagnostic, socioeconomic status (SES) and date of death information were available for all linked records. SES was derived on the basis of rank quintile of the Index of Multiple Deprivation (IMD), (ONS 2010 version) [15], for the Lower Super Output Area (population defined geographical region of approximately 1500 people [16]) of residence at diagnosis.

Diagnosis was defined using International Classification of Diseases (ICD-10) codes [17]. Clinically recognised diagnostic groups were formed by combining diagnoses; Brain tumours included all central nervous system tumours, Head and Neck (H + N) cancer encompassed all cancers arising between the hypopharynx (inferiorly) and nasopharynx (superiorly) and salivary gland tumours, excluding sarcomas. See supplementary Table 1s for ICD10 groupings. A significant number of patients had multiple malignant diagnoses and were identified as such. Small diagnostic groups were combined to form the "Other" category, this included, but was not limited to, thyroid cancer, and male and female genital tract tumours not otherwise classified.

Intent of treatment was defined using a combination of treatment dose, fractionation, intent specified by clinicians and departmental protocols. RDCS included all neo-adjuvant, adjuvant and primary radiotherapy/chemo-radiotherapy. Throughout the study period, treatment was delivered within well-defined clinical protocols with limited change over time. To ensure that patients only entered the cohort once and that fragmented courses (e.g. where 2 phases were recorded separately) were not considered twice, only the first episode was considered. Exclusions were made to limit this investigation to adult RDCS treatments, for solid organ tumours and to ensure data quality (Fig. 1). Patients under the age of 25 are treated within the paediatric and young adolescent practice and were therefore excluded.

LCC is a university affiliated centre serving a population of 2.8 million (the second largest UK radiotherapy centre). Consultant clinical oncologist numbers increased from 18 to 30 during the study period. All are site specialised to a maximum of three primary diagnostic groups. LCC is resourced through a national NHS tariff system (reflecting treatment planning complexity and separately the number of fractions and complexity of delivery).

90-day mortality

The proportion of people dying within 90-days of the start of treatment was assessed. The start of treatment was used as the reference date providing a consistent time point across all fractionation patterns delivered, ensuring capture of deaths occurring on treatment and aligning with the methodology used in other interventions [18]. The dependent variable, death within 90-days, was considered as a binary outcome. Factors potentially impacting upon 90 DM were considered using logistic regression. Explanatory variables included, age at the start of radiotherapy (a continuous variable), sex, socioeconomic status, primary diagnosis and year of treatment. Colorectal cancer was used as the baseline diagnostic group within the logistic regression model, representing the largest disease group including both male and female patients across a wide range of age and SES. Patients in whom the SES was not known (506 individuals) were omitted from regression analysis.

Cause of death (COD)

For all patients dying within 90 days of the start of radiotherapy COD was determined (malignancy, treatment, co-morbidity or post-operative) using death certificate data in combination with retrospective clinical record review. This assessment was made in order to determine what is measured by 90 DM and, hence, the quality of the indicator. Determining the underlying COD can be challenging. COD was assessed by two investigating clinicians independently to provide as accurate an assessment as possible.

Further investigation of the H + N and lung cancer populations was carried out. These two groups were considered due to their size and the moderate 90 DM rates seen, allowing more in depth analysis incorporating the impact of anatomical subsite (oropharyngeal versus other H + N sites), morphology (non-small cell versus small cell lung cancer) and year of treatment. The introduction of the cancer waiting times directive within the NHS in the early part of this cohort [19] and increased capacity within the service in 2008 resulted in a marked reduction in waiting times. Consistent information on waiting time was only available for the first four years. Time from decision to treat to first treatment (TTFT) was determined for this cohort and variation between years assessed using ANOVA.

Statistical analyses were carried out using STATA IC 14. The study was approved by the local audit department.

Results

The final study population consisted of 16,675 radiotherapy treatments. Women were the majority of the cohort (10,541 (63.2%)), reflecting the large number of patients (6597 (39.6%)) treated for breast cancer. Prostate cancer (1993 (12%)), colorectal cancer (1197 (7.2%)), H + N cancer (1165 (7.0%)) and lung cancer (871 (5.2%)) were the next most frequently treated diagnoses. The distribution of age and SES were in line with expectations. The number of treatments delivered each year rose from 2001 to 2699 between 2004 and 2010 (see Table 1).

Overall, 90 DM was 1.25%, but varied widely with diagnosis ranging from 0.2% in prostate cancer to 5.45% in oesophageal cancer. Lung (3.89%) and H + N cancers (3.86%) had moderate levels of 90 DM (see Table 1).

Factors significantly associated with increased 90 DM on univariable logistic regression included increasing age, earlier year of treatment and individual diagnostic groups (see Table 2). Age and year retained their significance on multivariable analysis. Breast (OR 0.248, $p < 0.001$) and prostate (OR 0.076, $p < 0.001$) cancer treatments were associated with significantly lower 90 DM than colorectal cancer whilst head and neck cancer (OR 1.837,

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