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Variation in centre-specific survival in patients starting renal replacement therapy in England is explained by enhanced comorbidity information from hospitalisation data

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Abstract

Background: Unadjusted survival on Renal Replacement Therapy (RRT) varies widely from centre to centre in England. Until now, missing data on case-mix has made it impossible to determine whether this variation reflects genuine differences in the quality of care. Data linkage has the capacity to reduce missing data.

Methods: Modelling of survival using Cox proportional hazards of data returned to the UK Renal Registry on patients starting RRT for established renal failure in England. Data on ethnicity, socioeconomic status and comorbidity were obtained by linkage to the Hospital Episode Statistics database, using data from hospitalisations prior to starting RRT.

Results: Patients with missing data were reduced from 61% to 4%. Prevalence of co-morbid conditions was remarkably similar across centres. When centre-specific survival was compared after adjustment solely for age, survival was below the 95% limit for 6/46 centres. Addition of variables into the multivariable model altered the number of centres that appeared to be 'outliers' with worse than expected survival as follows: ethnic origin 4 outliers, socioeconomic status 8 outliers and year of start of RRT 4 outliers. The addition of a combination of 16 comorbid conditions present at the start of RRT reduced the number of centres with worse than expected survival to one.

Conclusions: Linked data between a national registry and hospital admission data dramatically reduced missing data, and allowed us to show that nearly all the variation between English renal centres in three-year survival on RRT was explained by demographic factors and by co-morbidity.

Short Summary

Centre specific outcomes which are affected by case mix should be adjusted for comparison, but variable data completeness prevents this. Data completeness for important demographic variables was improved from 39% to 96% by linking UK Renal Registry and hospitalisation data, enabling comprehensively adjusted centre specific survival reporting and reducing the number of centres with worse than expected survival from six to one.

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Keywords

Renal Replacement Therapy, Survival, Performance Measures, Open data, Data linkage

Introduction

Renal replacement therapy (RRT) for established renal failure (ERF) is currently administered to approximately 40,000 patients in England, at a cost of three quarters of a billion pounds per year(1). Recognising the potential association between the attainment of clinical and laboratory targets and improvements in hard endpoints (2), the UK Renal Registry (UKRR) regularly benchmark the 67 centres providing RRT in the UK against standards recommended by national and international governing bodies and guidelines(3). Identification of poor centre performance has prompted investigation and improvement. The UK stands apart from other countries in the reporting of centre or healthcare provider specific outcomes in such detail (4).

However, the cornerstone of centre specific reporting is uniform data quality and completeness, and variation in these has prevented the UKRR from generating comprehensively adjusted and inclusive centre specific performance indicators. Reporting of outcomes without adequate adjustment for case mix may increase or decrease the apparent variation in performance between centres, and result in inappropriate labelling of providers as delivering poor care.

Barriers in data quality and completeness are not unique to renal services or UK data collections and registries (5-7). However, other demographic patient information exists within the healthcare system, either routinely collected or as part of other disease registers. This study uses a disease registry, the UKRR, of patients receiving RRT between 2002 and 2006 linked to routine data on hospitalisation from 1998 to 2011 extracted from the Hospital Episode Statistics (HES) database. The goal is to report comprehensively adjusted centre specific incident survival on RRT, with a view to understanding the variation in survival in English renal centres.

Materials and Methods

Participants and Linkage

This is a cohort study of all RRT patients over the age of 18 and comprises all patients who started RRT for ERF in English renal centres between 1st of January 2002 and the 31st of December 2006. It gained ethical approval from the South East Research Ethics Committee in October 2010. The cohort was identified from the UKRR database, derived from data extracts from renal centres throughout the UK, and is subject to extensive data validation and cleaning prior to analysis (8). Patients who started RRT and did not have a recovery of renal function lasting more than 90 days within 90 days of starting were identified and their demographic data extracted including data on changes in treatment modality and death collected until 31st of December 2009. This export was encrypted and transferred to a third party agency responsible for the process of linkage, the Research Capability Programme (RCP) Pilot Health Research Support Service.

The RCP had already taken receipt of the HES dataset from April 1996 to February 2011, and Office of National Statistics death registrations over a similar period. Data sources were linked by validating National Health Service (NHS) numbers where possible using the NHS Personal Demographics Service (PDS), then linked on NHS number and date of birth. In situations where the NHS number existed in the datasets but could not be traced additional checks against patient details were performed.

As HES only covers hospitalisation in England, patients receiving care in English units with postcodes outside England were excluded. As the goal of the analysis was adjusted survival reporting, patients were excluded from analysis if adjustment variables were missing: where ethnicity or socioeconomic status could not be derived from either source or there were no admissions prior to start of RRT. The

absence of hospitalisation prior to the start of RRT is rare, may represent data linkage issues, or would necessitate the patient to be labelled as having no comorbidity which may be inaccurate.

Demographic Variables including Comorbidity

The ethnicity scheme employed by UKRR was mapped into that used by HES when collection began in 1998, and further simplified into White, Black, South Asian and Other. HES was used as the primary source with the UKRR dataset queried in situations when ethnicity was coded missing. Socioeconomic status was determined from both datasets using geographical data from 6 months before to 6 months after the start of RRT, in the form of the index of multiple deprivation (IMD) version 2004 (9), which ranks 32,482 geographical areas in England by deprivation. This was grouped by quintiles. When sources differed the most deprived value was used.

Comorbidity at starting RRT was determined from comorbid conditions as coded by International Classification of Disease version 10 (ICD10) from all diagnosis fields in all hospitalisation admissions prior to starting RRT. Comorbid conditions were identified from the Charlson comorbidity index(10) and the Elixhauser measure(11) using ICD10 codes from existing literature(12). Conditions collected by UKRR that did not exist in the Charlson or Elixhauser schemes were identified from the NHS Information Centre HRG grouping document which includes all ICD10 and Office of Population Censuses & Surveys (OPCS) procedural codes currently employed. Duplicate or overlapping conditions were excluded and only conditions with a prevalence of two per cent or more were explored.

Information on primary renal disease (PRD) returned by centres was enhanced with hospitalisation data from six months before to six months after date of start of RRT. The ICD10 codes of 48 causes of PRD were mapped to the seven UKRR PRD groups and patients with missing or “unknown” PRD were filled in if relevant codes were identified.

Statistical Methods

Only patients surviving beyond 90 days from the date of first RRT were analysed due to issues with variable centre reporting of patients dying within 90 days and recognition that episodes of acute kidney injury which may have recovered function will have been censored(13). Patients were assigned to the first centre they received treatment for the duration of the study. Survival was modelled using Cox proportional hazards in R(14). To facilitate comparison between centres and as per existing UKRR practice, censoring at the time of transplantation was not performed and patients transplanted before starting dialysis were included in the analysis. Centres with a high proportion of South Asian or Black origin are likely to have a healthier dialysis population, because South Asian and Black patients are less likely to undergo early transplantation(15).

Manual addition of age, gender, ethnicity, socioeconomic status and comorbid conditions of greater than two percent prevalence was employed to determine an appropriate model, with statistically significant variables being retained. To determine renal centre specific survival at three years a cox model including the variables of interest and the centre as a variable was generated. With this model, survival of a patient in each centre was predicted by varying the centre variable. The patient was coded as white, aged 65, male, of the most deprived socioeconomic group, having started RRT in 2002, and with individual comorbid conditions defined as absent. The proportion alive at three years of patients of this demography and comorbidity was reported as the centre-specific survival. Interactions between age and diabetes(16), diabetes and cardiovascular disease and ethnicity and diabetes was explored with interaction terms. Testing for the constant risk fallacy (17) was performed by fitting an interaction between centre and the candidate comorbid conditions, in addition to age, ethnicity, socioeconomic status and year of start. If the interaction term was significant, it suggested the mortality risk of a comorbid condition was not constant across all renal centres. Mean comorbid scores were compared with the independent t-test.

As renal centres vary in the number of incident patients they take on across England, a funnel plot was used to determine whether a centre was deemed to have better or worse survival than the average. Firstly the proportion of patients alive at three years derived from the Cox proportional hazards model for a centre was plotted against the size of the centre. The outlier limits of 95% and 99.8% were derived using the binomial distribution, with centre outlier status explored on the funnel plot with the addition of individual variables (18).

To index the overall comorbid burden per patient to allow a simple comparison between centres, weights for the presence of individual conditions were determined from a Cox proportional hazards model factoring age, sex and the presence or absence of statistically significant candidate comorbidities. Multivariate hazard ratios for comorbid conditions were converted into scores as per previously reported methods(19). They were summed to create an overall score using the following bandings and weights: hazard 1.2 - <1.5 : 1, ≥1.5 - <2.5 : 2, 2.5 - <3.5 : 3, ≥3.5 - <4.5 : 4. Conditions with a hazard of less than 1.2 were not assigned a score.

Results

Participants

21,633 ERF patients were identified in 46 renal centres in England, of which 19,525 patients survived to 90 days. 18,798 (96.2%) had admission HES data prior to the start of RRT and no missing data for ethnicity and socioeconomic status following dataset combination. The final analysis cohort including hospitalisation data is detailed in figure 1. Mean follow-up time was 30.5 months. Patients with complete data from the UKRR alone accounted for 39% of the cohort. At three years, 11.1% of the total cohort had changed centres, but only 4.4% of those not transplanted.

Patient demography including the overall prevalence of individual comorbid conditions, and number of centres with higher and lower than average prevalence for individual comorbidities are detailed in table 1. As illustrated in figure 2 there was wide variation in the ethnic mix of the renal centres. Of note, the comorbid conditions with the greatest range of prevalence between centres were diabetes (23.9 – 45.2%), stroke (3.2 – 16.1%), and heart failure (7.8 – 25.0%), but the overall mean comorbid score was similar across centres (figure 3). The presence of diabetes was associated with greater hazard for death in patients under 55 than other age groups (<55 years hazard for diabetes 3.307, CI 2.89 – 3.79; 55 - 65 years hazard 1.71, CI 1.52 – 1.92; > 65 years hazard 1.09, CI 1.02 – 1.16)). Interactions between diabetes with CVD and with ethnicity were not statistically significant. The proportion surviving at 3 years adjusted to age 65 was 74.5% (95% CI 73.7 – 75.4%) in those with UKRR comorbidity completed and 64.3% (95% CI 63.2 – 65.3%) in those with UKRR comorbidity missing. Lymphoma and depression (derived by HES) were the only conditions more common in patients with UKRR comorbidities missing (lymphoma: 3.8% in comorbidity missing vs 3.0% in comorbidity completed, P=0.001, depression: 2.7% in comorbidity missing vs 2.1% in comorbidity completed, P=0.006). These were sufficient to separate the groups when comparing comorbid score. The mean comorbid score was 1.10 in those with UKRR comorbid data vs 1.22 in those without (CI on the difference 0.08 – 0.15, P<0.001).

The univariate and multivariate hazard ratio of death relative to the absence of the individual comorbid conditions and their associated comorbid score is detailed in table 2. The prevalence of comorbid conditions and mean comorbid score demonstrated small variation across ethnic groups illustrated in table 3. Black patients had a significantly lower comorbid score overall, but the burden of comorbidity across White, South Asian and Other ethnic groups was similar, despite the worse survival in the White ethnic group.

The Impact of Demography on Centre-Specific Survival

Centre specific survival adjusted to age 65 years but with no adjustment for other demography or comorbidity is plotted in figure 4a, identifying six centres with worse than expected survival. The addition of ethnicity to the age only model reduced the dispersion of centre survival, with four centres remaining outliers. Socioeconomic status identified four additional outliers, bringing the total to eight, with these new outliers returning to within the 95% control lines once year of start was included. Funnel plots detailing outlying centres with adjustment for age, ethnicity, socioeconomic status and year of start of RRT are shown in figure 4b. The addition of 16 comorbid conditions with a statistically significant influence on comorbidity in addition to the above variables were added reducing the number of outlying centres with low survival to one (figure 4c). Centre reported primary renal disease enhanced by hospitalisations in the twelve months around the start of RRT (20) improved model fit but failed to explain the one remaining outlying centre.

Given the limited effect of the addition of certain comorbid conditions to the number of outliers, combinations of individual conditions were explored to determine the minimum necessary comorbid conditions required to achieve similar adjustment to a comprehensive model. The inclusion of COPD, previous myocardial infarction, congestive cardiac failure and the Diabetes-Age interaction in addition to age, ethnicity, socioeconomic status and year of start of RRT were sufficient to result in no outlying centres, masking the worse than expected survival in one centre identified with the comprehensive model including all comorbid conditions.

Non-constant risk across centres

The constant risk hypothesis was explored by examining the interaction of risk factors with centres. The comorbidities of previous myocardial infarction, valvular heart disease and claudication showed statistically significantly different hazard ratios for different centres when modelled with age, ethnicity, socioeconomic status and year of start. However following the addition of the conditions

of stroke, congestive cardiac failure, COPD and the diabetes-age interaction term non-constant risk persisted in valvular heart disease only.

Modelling survival to three years using demography and comorbidity with exclusion of conditions identified as having non-constant risk resulted in the identification of the same one outlying centre with worse than expected survival.

Information on agreement between data sources, extended linkage methodology, model performance measures and the effect of censoring for transplantation the inclusion are available in supplementary materials.

Discussion

In an effort to adjust renal unit centre survival figures for case-mix we linked all incident patients starting RRT between 2002 and 2006 to the HES database covering England, reducing patients with missing data from 61% to 3.8%. We have been able to report the most comprehensively adjusted centre specific survival for English renal centres to date and reduce apparent variation in survival between centres.

When considering centre specific adjusted reporting, one could argue if a demographic characteristic or comorbid condition has an impact on survival, is outside the control of a centre, and it varies across centre, it should be adjusted for. The ability to report a composite measure of comorbidity has allowed us for the first time to compare the case-mix of patients accepted onto RRT across England. The similar centre specific mean comorbid score across centres argues against variation in the type of patient taken on by an individual centre, for instance due to resource constraints and subsequent rationing of dialysis services(21). The variation in ethnicity and its established impact on survival (22) (23) mirrored in this study highlights the importance of ethnicity as an adjustment variable, however variation in risk across age groups tested for by interactions was not identified (24). The impact of ethnicity on centres mandates a high level of data completeness to enable adjustment.

Although other studies have highlighted the small impact comorbidity has in explaining variation in survival (25), the impact of case-mix adjustment for the individual should not be understated. Using the proposed model 70% of white patients with diabetes aged 65 survive to three years whereas 76% (difference 6%, 95% CI of difference 2-9%) of South Asians with the same case-mix survive to the same timepoint. If the patients had previous myocardial infarction and cardiac failure three year survival drops to 55% in the white and 63% in in the South Asians (difference 8%, CI of difference 2-13%) at three years. In addition, a degree of model precision is required to identify or explain

outlying centres. Although the variables used for adjustment differ, our model prediction performance (C-statistic excluding centre 0.775, CI 0.769 – 0.782, available in supplementary data) is superior to that reported at three years using US data (0.669) (26), and one year using Canadian data (0.765).

Reassurance is gained from the fact that survival in English renal centres is largely similar when all variables are taken into consideration, highlighting importance of comprehensive data collection. The residual variation in risk associated with some cardiovascular diseases such as myocardial infarction, valvular heart disease and claudication may imply a difference in how these conditions are managed in these renal centres or surrounding NHS trusts. Such non-constant risk may be explained by genuine differences in the hazard for mortality in the geographical areas that these renal centres serve (17). A more likely explanation is the variation in the coding quality across NHS trusts in England. HES data quality has been the subject of discussion for some years, with a body of work highlighting reasonable accuracy (27) and predictive ability (28). An increase in coding "quality" manifested by the number of coding fields used per admission was observed in this study over time (20), and some of the improvements seen in the hazard for death for year of start of RRT is likely to reflect this over and above improvements in clinical care. This study has been able to recommend a minimum adjustment specification to adequately explain or highlight outliers, should future linkage not be possible or concerns over the validity of HES preclude its use.

Limitations beyond the quality of HES data in this study include at this time our inability to report adjusted survival in Scotland, Wales and Northern Ireland. The lack of adjustment for late presentation or unplanned starts on RRT (29) was necessary as even in combination these datasets fail to robustly capture this in all centres. Other registry reports show a greater burden of comorbidity in those arriving late or in an unplanned start (30), and adjustment for comorbidity may represent a surrogate for this. Our inclusion of primary renal disease is purely experimental as

prevalence of unknown PRD across centres varied significantly. Our decision not to censor for transplantation may be contentious, but pre-emptive transplantation, timely deceased donor transplantation and living donor transplantation are all within a centres control. Also lacking from our analysis is the influence of quality of care after initiation of RRT on outcomes; however, these models and the data informing them give us the opportunity to study these processes.

This study highlights that routine linked data can be used to overcome missing data in disease registries, enabling performance measurement and initiating investigation and driving improvement when significant unexplained variation is identified. Some centres which have previously been identified as having unadjusted inferior survival may have been targeted inappropriately.

Disclosures

None of the authors have relationships with companies that may have a financial interest in the information contained in this manuscript.

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Transparency declarations

The authors of this manuscript have nothing to declare. The results presented in this paper have not been published previously in whole or part, except in abstract format.

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Tables

Table 1 – Demographics, comorbidity prevalence and number centres outlying for comorbidity prevalence. n=18,798

	Prevalence (%)	Centre Specific Prevalence Range (%)	Outliers (centres high/centres low, out of 46)
Age (mean, range)	60.1 (18 - 94)	-	-
Sex (female)	37.2	-	-
Race		-	-
White	81.4	-	-
Black	5.6	-	-
South Asian	6.5	-	-
Other	6.5	-	-
Comorbid Conditions			
No Comorbid Conditions			
COPD	5.2	1.6 – 12.9	5 / 7
Arrhythmia	3.6	1.3 – 8.1	3 / 2
Heart Failure	14.9	7.8 – 25.0	4 / 5
CABG	4.9	0.9 – 9.8	5 / 4
Depression	2.4	0 – 4.8	1 / 1
Stroke	7.7	3.2 – 16.1	5 / 6
Myocardial Infarction	11.9	6.8 – 19.4	5 / 4
Lymphoma	3.4	1.0 – 6.8	2 / 1
Neurological Disease	3.8	1.2 – 11.3	3 / 3
Vascular Procedure	3.5	1.2 – 7.1	3 / 4
Valvular Heart Disease	3.7	1.1 – 10.0	5 / 5

Cancer	6.8	4.5 – 14.5	2 / 2
Connective Tissue Disease	3.4	0 – 6.1	3 / 1
Peptic Ulcer Disease	4.7	1.7 – 8.5	6 / 2
Claudication	7.1	2.5 – 14.5	7 / 6
Diabetes	31.6	23.9 – 45.2	7 / 5

Note: Summary statistics reported as proportions unless stated otherwise

Centre outliers are defined as those centres with a prevalence of the comorbidity that falls outside the 95% limits for a funnel plot derived from the binomial distribution, centred around the national mean.

Table 2 –Hazard ratio of death associated with patient characteristics and comorbid score.

	Hazard Ratio for Death (Univarate) (95% CI)	Hazard Ratio for Death (Adjusted) (95% CI)	Comorbidity Score
Age (per decade)	1.27 (1.25 - 1.28)	1.23 (1.22 - 1.24)	
Sex (female)	0.98 (0.93 - 1.03)	1.05 (1.00 - 1.11)	
Race			
White	1 (ref)	1 (ref)	
Black	0.44 (0.38 - 0.51)	0.55 (0.47 - 0.64)	
South Asian	0.67 (0.59 - 0.75)	0.78 (0.69 - 0.88)	
Other	0.52 (0.46 - 0.59)	0.65 (0.57 - 0.74)	
Socioeconomic Status			
1 - Most Deprived	1 (ref)	1 (ref)	
2	1 (0.92 - 1.08)	0.95 (0.88 - 1.03)	
3	1 (0.92 - 1.09)	0.88 (0.81 - 0.95)	
4	1.12 (1.03 - 1.21)	0.92 (0.85 - 1)	
5 - Least Deprived	1.03 (0.95 - 1.12)	0.85 (0.78 - 0.93)	
Year			
2002	1 (ref)	1 (ref)	
2003	0.96 (0.88 - 1.05)	0.98 (0.90 - 1.07)	
2004	0.92 (0.85 - 1)	0.89 (0.82 - 0.97)	
2005	0.87 (0.8 - 0.94)	0.8 (0.74 - 0.88)	
2006	0.83 (0.76 - 0.9)	0.78 (0.71 - 0.84)	
Comorbid Conditions			
COPD	2.19 (2.01 - 2.39)	1.34 (1.23 - 1.47)	1
Arrhythmia	1.87 (1.67 - 2.08)	1.16 (1.04 - 1.3)	0
Heart Failure	2.27 (2.14 - 2.41)	1.39 (1.3 - 1.48)	1
CABG	1.23 (1.11 - 1.37)	0.81 (0.72 - 0.91)	0

Depression	1.54 (1.34 - 1.77)	1.55 (1.34 - 1.79)	2
Stroke	1.77 (1.64 - 1.92)	1.26 (1.16 - 1.36)	1
Myocardial Infarction	1.95 (1.83 - 2.08)	1.2 (1.11 - 1.29)	1
Lymphoma	3.85 (3.51 - 4.23)	3.48 (3.16 - 3.83)	3
Neurological Disease	1.43 (1.27 - 1.6)	1.52 (1.35 - 1.71)	2
Vascular Procedure	2.1 (1.89 - 2.34)	1.27 (1.13 - 1.42)	1
Valvular Heart Disease	1.9 (1.71 - 2.12)	1.3 (1.16 - 1.45)	1
Cancer	1.95 (1.8 - 2.11)	1.39 (1.28 - 1.51)	1
Connective Tissue Disease	1.25 (1.1 - 1.43)	1.34 (1.18 - 1.53)	1
Peptic Ulcer Disease	1.7 (1.54 - 1.87)	1.17 (1.06 - 1.29)	0
Claudication	2.03 (1.88 - 2.2)	1.19 (1.09 - 1.29)	0
Diabetes	1.47 (1.4 - 1.55)	1.44 (1.36 - 1.52)	1

Comorbid Score derived from multivariate hazard ratio (see methods), hazards of less than 1.2 are not assigned scores for centre comorbid burden comparison but all significant variables are included in the model.

Variables included in adjusted hazard ratio: Age, sex, ethnicity, socioeconomic status, year of start of renal replacement therapy.

Table 3 – Prevalence of comorbidities according to ethnicity and overall comorbid score

	All Patients (18,798)	White (81.4%, 15,309)	Black (5.6%, 1,054)	South Asian (6.5%, 1,214)	Other (6.5%, 1,221)	Chi-Squared P value
Comorbidities						
Diabetes	31.6 (5,944)	28.6	39.5	49.7	45.2	<0.001
Myocardial infarction	11.9 (2,229)	12.1	5.8	13.6	12.3	<0.001
CABG	4.9 (919)	4.7	1.8	8.2	7.3	<0.001
Heart Failure	14.9 (2,803)	14.7	14.5	16.8	15.4	0.25
Claudication	7.1 (1,344)	7.9	3.3	3.8	5	<0.001
Valvular Heart Disease	3.7 (697)	3.9	2.3	2.8	3.1	0.007
Stroke	7.7 (1,446)	7.7	7.5	7.9	7.2	0.90
COPD	5.2 (978)	5.8	0.9	3.3	3.8	<0.001
Comorbid Score (mean, 95% CI)	1.11 (1.09 - 1.13)	1.12 (1.1 - 1.14)	0.99 (0.91 - 1.07)	1.11 (1.05 - 1.17)	1.15 (1.07 - 1.23)	

CABG: Coronary artery bypass graft

Comorbid Score derived from multivariate hazard ratio (see methods)

Figures

Figure 1. Data linkage and inclusion of patients in analysis

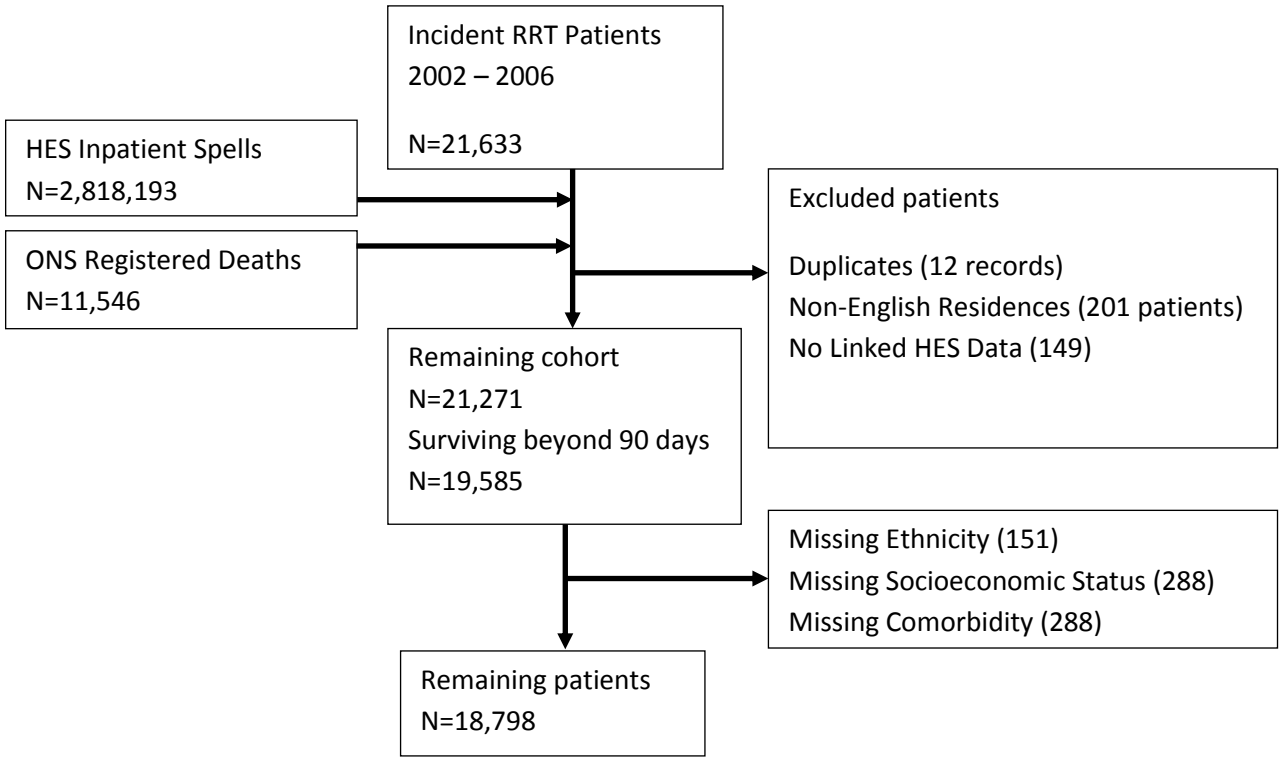
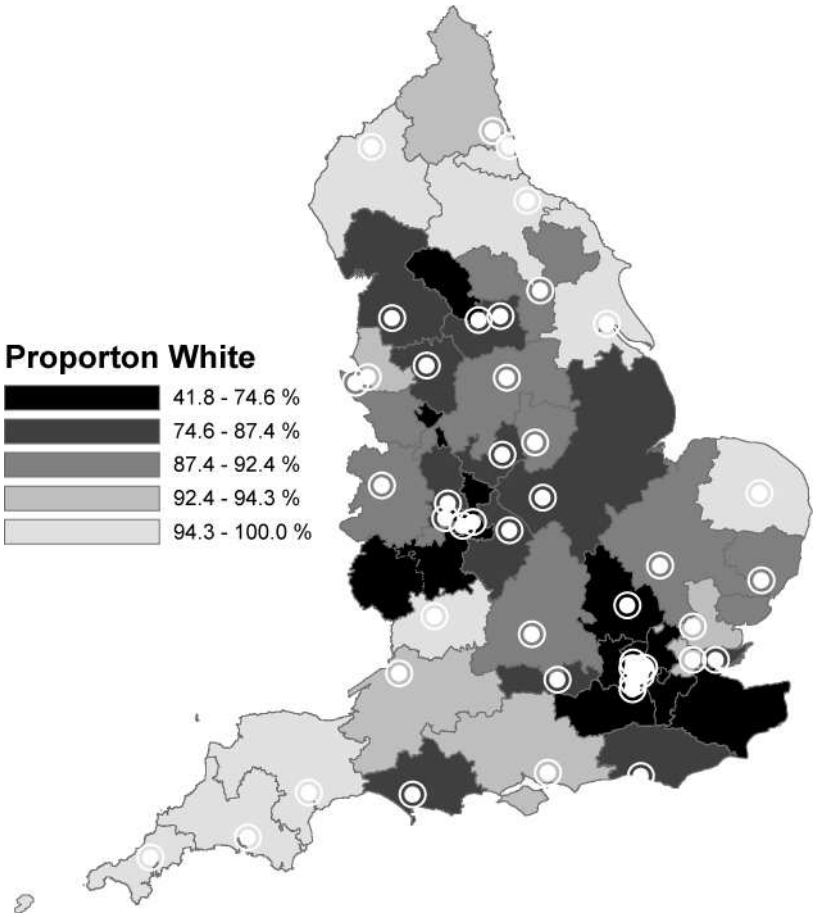


Figure 2. English renal units, catchment areas and variation of ethnicity in renal replacement therapy patients between 2002 – 2006 by Local Authority



Catchment area methodology: The renal centre receiving the greatest number of incident patients from an individual local authority is assigned the local authority as part of its catchment area. Colour represents the proportion white in the centre serving the catchment area.

Figure 3. Mean comorbid score using weighted comorbid conditions for 46 renal centres in England.

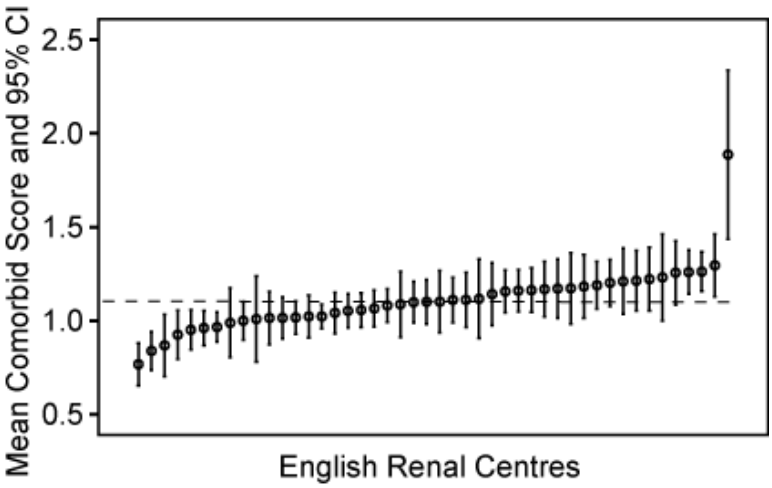
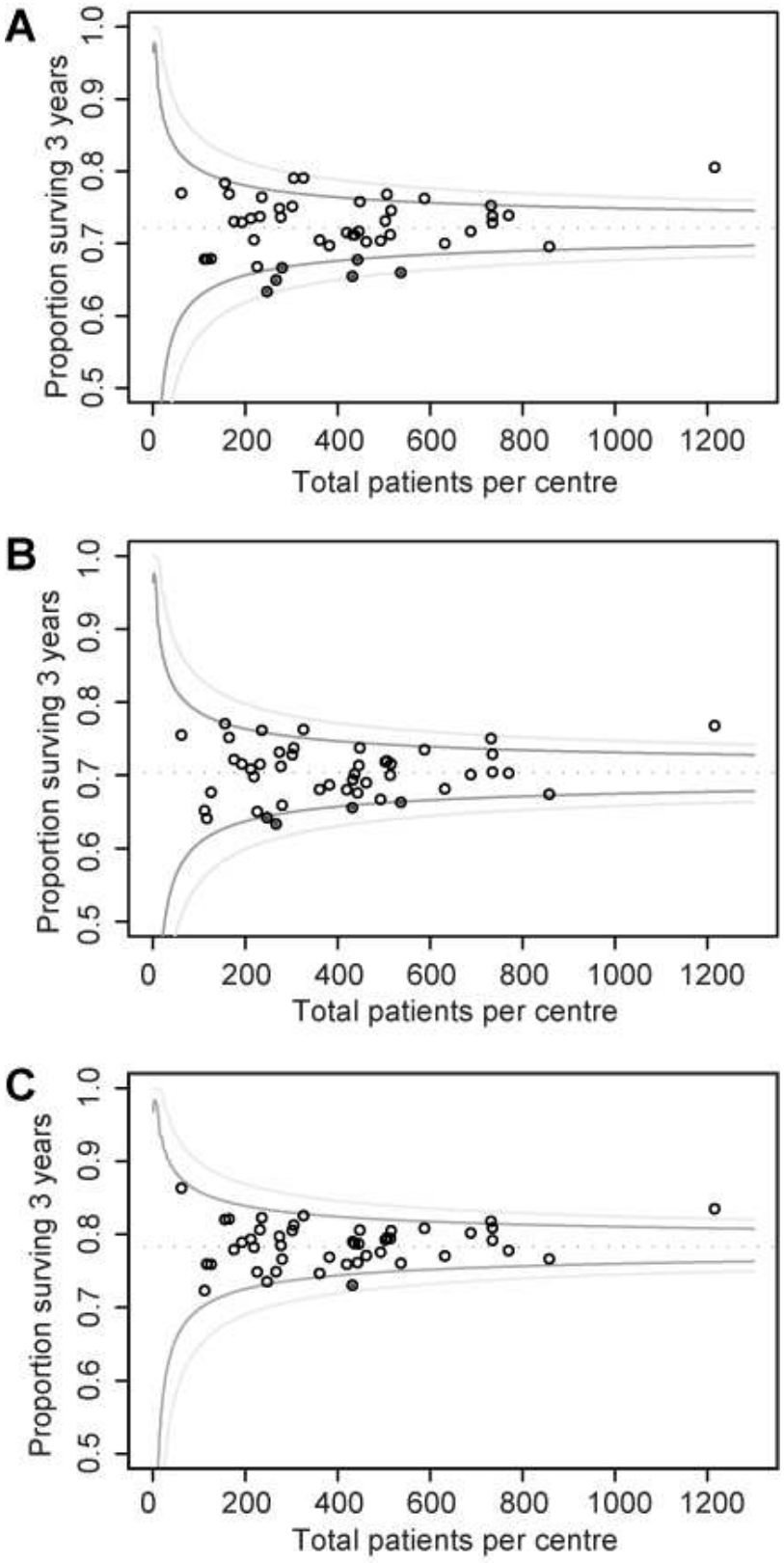


Figure 4.

Funnel plots detailing centre specific three year survival following adjustment



A) **Centre specific predicted survival at three years adjusted for age and sex.**

Mean Centre-Specific Survival at three years adjusted to age 65 and male: 69.7%, range 60.2 – 78.7%. Six centres with worse than expected survival highlighted.

B) Centre specific survival adjusted for age, sex, ethnicity, socioeconomic status and year of start of renal replacement therapy.

Mean Centre-Specific Survival at three years adjusted to white 65 year old male in most deprived group starting renal replacement therapy in 2002: 67.9%, range 60.5 – 75.02%. Four centres with worse than expected survival highlighted.

C) **Centre specific survival adjusted for age, sex, ethnicity, socioeconomic status, year of start of renal replacement therapy and 16 comorbid conditions**

Mean Centre-Specific Survival at three years adjusted to all characteristics including demography and comorbidity: 78.8%, range 72.9 – 86.3%. One centre with worse than expected survival highlighted.