UK Renal Registry 14th Annual Report: Chapter 4 Comorbidities and Current Smoking Status amongst Patients starting Renal Replacement Therapy in England, Wales and Northern Ireland from 2009 to 2010

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Key Words
Comorbidity · Diabetes · Dialysis · eGFR · Ethnicity · Haemoglobin · Mortality · Renal replacement therapy · Smoking · Survival analysis

Summary

- Data on comorbidity at the time of start of RRT were submitted for only 6,130 (49.3%) of the incident adult ($\geqslant$18 years) RRT patients reported to the UKRR between 2009 and 2010. In 2010, four centres provided data on 100% of new patients and 15 centres provided data for less than 5% of new patients.
- In patients with comorbidity data, more than half had one or more comorbidities (55.4%). In the subgroup of patients aged $\geqslant$65 years, 67.6% had one or more comorbidities.
- Diabetes mellitus and ischaemic heart disease were the most common conditions, observed in 33.3% and 21.1% of patients respectively. Ischaemic heart disease, cerebrovascular disease, COPD, claudication and malignancy were more prevalent in patients aged >65 years.
- In 2009–2010, 13.2% of incident RRT patients were recorded as being smokers at the initiation of dialysis.
- There was a higher prevalence of ischaemic heart disease ($p < 0.01$) and cerebrovascular disease ($p < 0.0001$) in patients referred early to a nephrologist than amongst those referred late. Malignancy ($p < 0.0001$) was more common in patients who were referred late.
- In multivariable survival analysis, malignancy and the presence of ischaemic/neuropathic ulcers remained the strongest independent predictors of poor survival at 1 year in individuals who survived more than 90 days from the start of RRT in patients <65 years.

Introduction

The importance of adjusting for comorbidity when undertaking centre [1–3] and international survival comparisons [4] is well recognised. As with all observational data, registry analyses exploring epidemiological issues, including access to treatments or survival analyses, are subject to a number of potential selection biases and confounding factors. Such registry analyses can be significantly strengthened by adjustment for case-mix as differences in patient populations that exist across centres may influence both process and outcome measures. However an important consideration in applying case-mix adjustment to analyses is data completeness. If individuals with comorbidity data differ systematically from those without data, entering variables into statistical models can further bias outcome measures and provide invalid associations [5, 6].

The aim of this work is to describe the completeness of comorbidity data submitted to the UK Renal Registry (UKRR), the prevalence of comorbid conditions and current smoking status in incident renal replacement therapy (RRT) patients reported to the UKRR and to examine the association between these comorbidities and early mortality.

Methods

Study population

Incident adult ($\geqslant$18 years) RRT patients during 2009 and 2010 in the centres submitting data to the UKRR were considered. Of these, patients who had data recorded on comorbid conditions were included in statistical analyses. Data on completeness of comorbidity returns from each centre and overall may differ from those in previous UKRR reports due to some centres retrospectively entering previously missing comorbidity data.

Centre exclusions

The nine centres in Scotland do not provide comorbidity data to the UKRR and are not included in these analyses. There was concern that data extraction in two centres (Stoke and Colchester) was inaccurate and these centres were excluded from this year's comorbidity analyses.

Definition of comorbidity and method of data collection

Clinical staff in each centre are responsible for recording in yes/no format the presence or absence of 13 comorbid conditions and information on current tobacco smoking (table 4.1) for each patient at the time of starting RRT on their renal information technology (IT) system. Definitions of each of these conditions are given in appendix B (www.renalreg.com/report-area/report 2011/appendix-B.pdf).

Table 4.1. Comorbid conditions listed in the UKRR dataset

Comorbidity
• Angina • Previous myocardial infarction (MI) within 3 months prior to start of RRT • Previous MI more than 3 months prior to start of RRT • Previous coronary artery bypass graft (CABG) or coronary angioplasty (in some analyses the above four variables are combined under the term 'ischaemic heart disease')
• Cerebrovascular disease • Diabetes (when not listed as the primary renal disease) • Chronic obstructive pulmonary disease (COPD) • Liver disease
• Claudication • Ischaemic or neuropathic ulcers • Non-coronary angioplasty, vascular graft, or aneurysm • Amputation for peripheral vascular disease (in some analyses these four variables are combined under the term 'peripheral vascular disease')
• Smoking • Malignancy

Patients were classified as having complete comorbidity data if there was at least one entry (yes/no) for any one or more of the comorbid conditions. Comorbidities were grouped into broader categories for some analyses:

- 'Ischaemic heart disease' was defined as the presence of one or more of the following conditions: angina, myocardial infarction (MI) in the three months prior to starting RRT, MI more than three months prior to starting RRT or coronary artery bypass grafting (CABG)/angioplasty.
- 'Peripheral vascular disease' was defined as the presence of one or more of the following conditions: claudication, ischaemic or neuropathic ulcers, non-coronary angioplasty, vascular graft, aneurysm or amputation for peripheral vascular disease.
- 'Non-coronary vascular disease' was defined as the presence of cerebrovascular disease or any of the data items that comprise 'peripheral vascular disease'.

Specific consideration needs to be made regarding diabetes coding. The UKRR also collect data on Primary Renal Diagnosis (PRD), and have used these data alongside the comorbidity data to determine which people had diabetes mellitus. The comorbidity screen is intended to capture those patients who have diabetes only when it is not the PRD, however some clinicians do enter 'yes' in the comorbidity field in such cases. Prior to statistical analyses, we examine these fields together to identify these cases and ensure diabetes is only counted as either the PRD or a comorbid condition for a certain individual.

Ethnicity data reporting

Some centres electronically upload ethnicity coding to their renal IT system from the hospital Patient Administration Systems (PAS) [7]. Ethnicity coding in PAS is based on self-reported

ethnicity and uses a different system [8] to the remaining centres where coding of ethnicity is performed by clinical staff and recorded directly into the renal IT system (using a variety of coding systems). For all these analyses, data on ethnic origin were grouped into Whites, South Asians, Blacks and Others. Appendix H details the regrouping of the PAS codes into the above ethnic categories.

Statistical methods

The statistical methods for the three individual sections of this chapter are described separately.

1) Patient demographics

The proportion of patients starting RRT with various comorbidities was examined by age group (18–34, 35–44, 45–54, 55–64, 65–74 and $\geqslant$75 years), primary renal disease, ethnic origin and first modality of RRT. Chi-squared, Fischer's exact and Kruskal-Wallis tests were used as appropriate to test for statistically significant differences between groups.

2) Late presentation (referral) and start of RRT

Referral time was defined as the number of days between the date first seen by a nephrologist and the date of starting RRT. Referral times of more than 90 days and less than 90 days define early and late presentation, respectively. Data on referral time were incomplete and therefore only patients with data on comorbidity and referral time from centres with >75% data completeness for referral time were included in this analysis. Many UKRR analyses, including those presented here, rely on the accuracy of the date of start of RRT. A discussion of the issues around definition of the start date is included in chapter 13 of the 2009 Report [9].

3) Patient survival

The Registry collected data with a 'timeline' entry on all patients who had started RRT for Established Renal Failure (ERF). Patients presenting acutely and initially classified as acute renal failure requiring dialysis who continue to require long-term dialysis, can subsequently be re-classified by clinicians as having had ERF from the date of their first RRT. The death rate is high in the first 90 days of commencing RRT with variability observed between centres. This between centre variation may in part be due to clinician variation in the classification of patients who present acutely requiring RRT and who may be deemed from the start to be unlikely to recover renal function. As mortality rate varies with time on RRT and to remove the influence of between centre variation in the classification of patients, the survival analysis was stratified into two time frames. This also enables comparison with results from other national registries. The association of comorbid conditions and survival within the first 90 days was analysed and subsequently the association of comorbid conditions and 1 year survival in the cohort who survived after 90 days from the start of RRT was also analysed.

For each of the follow up periods, the association of baseline comorbidity with survival was analysed using univariable and multivariable Cox regression models. For analyses of survival within the first 90 days, the cohort included patients starting RRT between 1st January 2005 and 30th September 2010 to allow a minimum of three months follow-up from the start of RRT. For the 1 year survival analyses in individuals who survived at least 90 days after the start of RRT, the cohort data on individuals who started RRT between 1st January 2005 and 30th September 2009.

For each variable, the models were used to estimate the hazard ratio of death, comparing the survival experience of patients with a particular comorbidity with those who did not have the comorbidity (reference group). For both the univariable and multivariable Cox models, patients were first stratified by age group (<65 years and $\geqslant$65 years) to account for the increasing incidence of certain comorbidities with age, which may otherwise confound the analyses. The multivariable models used an automatic selection procedure to identify the variables most strongly related to survival. The potential variables to be included were: age (per 10 year increase), smoking status, diabetes (listed as PRD or not listed as PRD) and the other 12 comorbidities listed in table 4.1. The automatic procedure starts by including only the variable most strongly related to survival. Then, with that variable included, it fits models adding each of the remaining variables in turn (singly) and chooses the variable that adds most to the model (in addition to the contribution made by the first variable included). The process continues in this way, adding variables that make a further significant contribution to the model, and removing any whose contribution becomes non-significant once other variables have been added. The final model only includes those variables selected by the process. These automatic methods have been used to give an indication of the variables most strongly related to survival but caution is needed in interpreting them because, amongst other things, when using correlated variables, a slight difference in the data (or in the algorithm chosen) could result in different variables being included in the final models. A more robust analysis would make a considered judgement of which variables should be included (rather than an automatic one) and may require additional interaction terms.

For each model, a R^2 value was calculated using the Royston and Sauerbrei method [10]. The R^2 value is the percentage of the variation in mortality which is explained by the variables included in the final model.

All statistical analyses were performed using SAS version 9.2.

Results

Completeness of comorbidity returns from each participating centre

The number of patients with data on comorbidity and other variables included in the analyses are summarised in figure 4.1.

Of 12,434 incident RRT patients in 2009 and 2010, 6,130 individuals (49.3%) had data on comorbidity reported. In 2010, 6,154 patients commenced RRT in centres in England, Wales and Northern Ireland. Comorbidity data were provided for 3,024 (49.1%) of those patients (tables 4.2, 4.3). Table 4.2 highlights the continued wide variation in the completeness of data returns with 4 centres providing data on 100% of

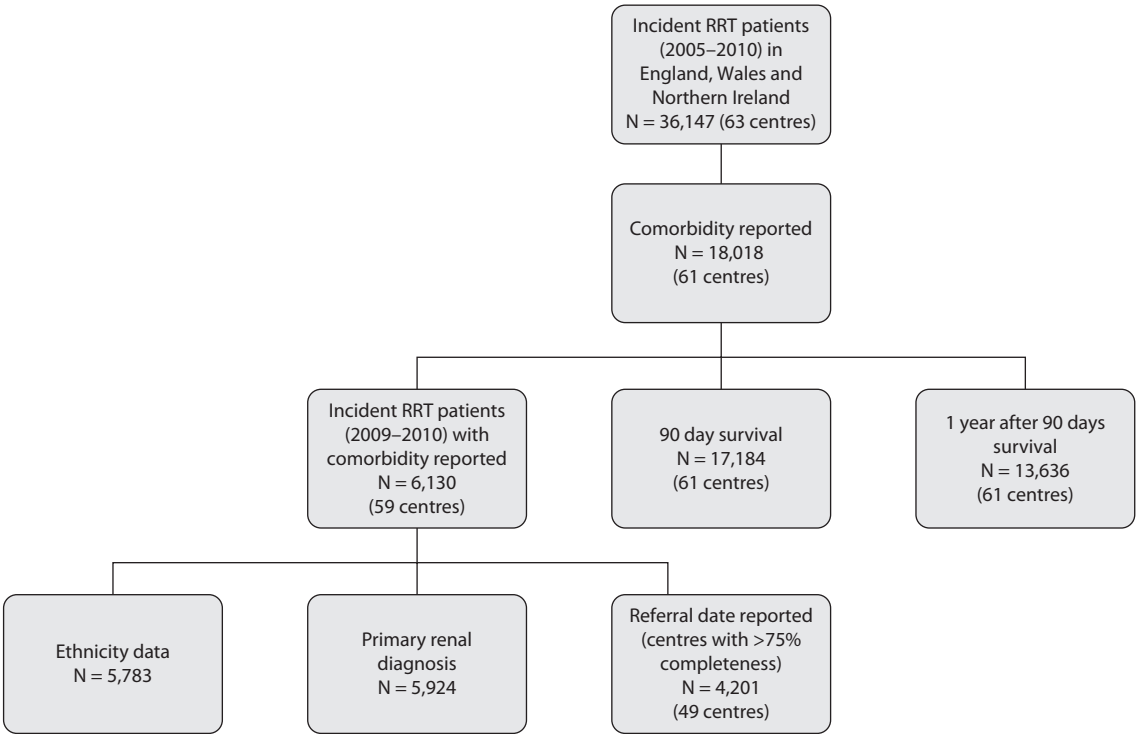

Fig. 4.1. Flow chart showing number of patients included in the various analyses

patients, but 15 centres providing data for less than 5% of new patients in 2010.

Limiting the comparison to the centres that reported in 2005, data completeness for comorbidity has remained roughly the same. Completeness was 48.9% in 2005 and 49.1% in 2010 (table 4.3). When centres with 0% completeness for comorbidity were excluded, the median percentage of comorbidity returns in 2010 was 72.0%. For centres returning comorbidity data there has been an annual improvement since 2005 (table 4.3). This could suggest that once renal information systems are set up to return comorbidity information, it is possible to improve data completeness.

Prevalence of multiple comorbidity

Including all incident patients from the years 2009–2010 (n = 12,434), comorbidity data were available for 6,130 (49.3%). More than half of these patients had one or more comorbidities (55.4%) (table 4.4), but in the subgroup of patients aged ⩾65 years, 67.6% had one or more comorbidities (table 4.5).

Frequency of each comorbid condition

Table 4.5 lists the prevalence of specific comorbidities and the percentage of the total number of incident patients for whom data was available for that item. Diabetes mellitus (either listed as the cause of PRD or as a comorbidity) was present in 32.7% of all patients. This is different to the sum of diabetes (not listed as PRD) and diabetes listed as PRD in Table 4.5 and reflects some patients having both an entry in the comorbidity field for diabetes and having it recorded as their PRD as described in the methods section.

Prevalence of comorbidity by age band

Ischaemic heart disease, cerebrovascular disease, COPD, claudication and malignancy were more prevalent in patients 65 years and over. Liver disease, ischaemic/neuropathic ulcers and prior amputation were more frequently observed in younger patients; actual percentages, nevertheless, were quite small (table 4.5). Smoking was also more common amongst patients under 65 years. With age categorised in 10 year age groups, prevalence of most comorbidities is seen to increase markedly from 18–65 years and appeared to plateau beyond this (figures 4.2, 4.3). In those patients aged >75 years there was a slight reduction of most reported comorbidities.

Prevalence of comorbidity by ethnic origin

Figures 4.4 and 4.5 illustrate the presence of comorbidity by ethnic origin and age group. Figure 4.4 shows a

Table 4.2. Completeness of comorbidity data returns on incident patients from individual renal centres 2005–2010

	2005		2006		2007		2008		2009		2010	
Centre	N	% return	N	% return	N	% return	N	% return	N	% return	N	% return
Antrim	42	12	33	9	37	14	41	32	21	38	41	95
B Heart	119	5	116	3	101	6	105	10	99	49	95	74
B QEH	199	1	186	1	225	2	268	1	255	3	197	0
Bangor	40	50	42	60	36	69	41	68	30	83	26	96
Basldn	32	53	45	76	39	77	40	88	26	88	32	91
Belfast	130	25	121	26	90	33	70	33	61	44	71	46
Bradfd	67	96	50	98	88	100	63	90	61	90	64	92
Brightn	112	14	131	24	120	37	121	34	120	12	107	6
Bristol	175	81	176	98	156	83	176	77	158	85	169	92
Camb	111	3	156	3	128	2	109	0	136	3	108	1
Cardff	184	22	206	7	221	5	150	5	179	9	188	16
Carlis	31	94	27	93	26	92	30	97	24	88	21	62
Carsh	183	54	186	59	194	76	216	82	208	77	221	68
Chelms	40	48	50	84	52	54	36	36	52	37	42	29
Clwyd	26	19	18	22	22	36	15	40	17	53	13	0
Colchr							58	0	17	0	32	0
Covnt	84	0	104	2	113	0	116	0	118	0	118	1
Derby	71	76	70	71	63	86	96	92	78	94	80	85
Derry			4	75	8	63	6	50	17	71	18	72
Donc					20	90	26	27	40	43	44	61
Dorset	49	88	53	92	65	89	85	85	76	78	72	65
Dudley	38	0	45	2	40	0	46	0	69	0	41	0
Exeter	111	29	105	30	126	8	135	4	145	1	136	4
Glouc	61	97	74	89	58	97	47	87	79	67	58	43
Hull	125	98	105	91	99	98	113	91	101	76	88	84
Ipswi	59	29	42	62	40	50	38	34	38	8	34	9
Kent					172	75	140	79	131	89	134	100
L Barts	187	90	190	83	214	84	206	80	239	86	207	72
L Guys	148	11	152	12	168	8	164	2	176	3	144	2
L Kings	131	99	110	100	121	100	151	99	128	98	148	99
L Rfree	132	1	194	1	185	0	173	1	170	0	203	0
L St.G					93	69	100	70	109	60	83	54
L West	302	52	313	51	278	53	318	45	357	2	367	1
Leeds	172	74	178	78	127	83	159	79	154	90	130	89
Leic	226	66	241	68	244	77	243	77	228	69	250	64
Liv Ain	29	41	35	54	36	44	42	67	38	71	49	4
Liv RI	139	63	141	52	112	56	102	42	110	45	102	21
M Hope	110	33	132	12	121	12	142	1	125	0	146	0
M RI					160	33	133	41	147	64	163	40
Middlbr	84	90	108	77	99	79	93	92	95	92	98	96
Newc	112	17	106	16	106	22	97	21	100	23	95	52
Newry	28	14	13	23	15	27	21	90	20	100	21	95
Norwch	119	10	113	12	110	18	90	20	73	23	85	39
Nottm	145	99	137	97	130	93	115	89	134	97	113	96
Oxford	153	51	157	24	144	87	150	81	177	91	167	95
Plymth	60	45	92	66	76	79	69	70	56	82	55	73
Ports	149	64	175	64	157	69	170	58	149	62	150	45
Prestn	121	29	121	33	132	43	112	42	147	50	122	46
Redng	90	3	88	3	94	6	105	3	99	3	89	0
Sheff	158	43	168	58	165	57	180	52	150	53	144	78
Shrew	41	59	55	65	58	66	61	87	47	87	58	100
Stevng	89	48	122	53	89	73	103	77	98	95	110	98
Sthend	34	71	48	83	34	88	36	81	23	96	30	70
Stoke					87	0	81	0	110	0	93	0
Sund	60	93	57	93	62	100	45	98	64	98	55	78

Table 4.2. Continued

	2005		2006		2007		2008		2009		2010	
Centre	N	% return	N	% return	N	% return	N	% return	N	% return	N	% return
Swanse	101	97	116	97	127	97	124	96	116	97	135	79
Truro	32	84	52	77	45	91	41	37	58	64	43	67
Tyrone	24	42	29	59	21	81	25	72	19	89	10	100
Ulster	9	56	8	63	16	100	14	100	13	100	20	95
Wirral	60	7	52	0	53	0	39	3	63	2	52	0
Wolve	95	84	85	88	68	93	88	95	65	100	107	93
Wrexm	42	38	26	58	27	63	21	76	20	90	24	100
York	46	89	48	90	38	84	38	79	47	68	36	92
Totals	**5,517**		**5,807**		**6,151**		**6,238**		**6,280**		**6,154**	

Blank cells – no data returned to the UKRR for that year

Table 4.3. Summary of completeness of incident patient comorbidity returns (2005–2010)

	Years						Combined years
	2005	2006	2007	2008	2009	2010	
Number of renal centres included	56	57	62	63	63	63	
Total number of new patients	5,517	5,807	6,151	6,238	6,280	6,154	36,147
Number of patients with comorbidity data entries	2,699	2,838	3,195	3,156	3,106	3,024	18,018
Percentage of patients with comorbidity data entries	48.9	48.9	51.9	50.6	49.5	49.1	49.8
Percentage restricted to centres in since 2005	48.9	48.9	52.2	51.1	49.1	49.1	49.9
Median percentage amongst only centres returning >0% comorbidity	50.5	59.3	69.4	69.8	70.6	72.0	65.5

higher prevalence of having at least one comorbidity recorded amongst patients of White origin compared to incident patients from an ethnic minority. Figure 4.5 shows that this pattern is observed across all age groups. However, diabetes mellitus specifically is much more frequently reported in South Asian patients (48.1%) than in White individuals (30.0%) (table 4.6). The reported prevalence of smoking was highest in individuals of White ethnicity (14.8%).

Prevalence of comorbidity amongst patients with diabetes mellitus

Table 4.7 describes comorbidity amongst patients with and without diabetes (as either primary renal disease or comorbidity). As would be expected, patients with diabetes mellitus had higher prevalence of peripheral vascular disease (20.3% compared to 7.5% in non-diabetics). Similarly, ischaemic heart disease and cerebrovascular disease were more common in diabetics. Similar proportions of diabetic and non-diabetic patients were smokers at the time of initiation of RRT (13.3% and 13.0% respectively). Malignancy was more common in non-diabetic patients ($p < 0.0001$) and may reflect "competing risks", with diabetics tending to die at a younger age with cardiovascular disease, rather than developing malignancy in older age.

Table 4.4. Number of reported comorbidities in patients starting RRT, as a percentage of those for whom comorbidity data were available 2009–2010

Number of comorbidities	0	1	2	3	4	5+
Percentage	44.6	28.6	13.6	7.7	3.2	2.4

Late presentation and comorbidity

Table 4.8 shows the referral time for patients with various comorbidities. In total, 4,201 individuals contributed data to this analysis. Patients referred to a nephrologist early had a higher prevalence of peripheral vascular disease, cerebrovascular disease and ischaemic heart disease. There were a higher proportion of patients with malignancy in the late referral group.

Table 4.5. Frequency with which each condition was reported in incident RRT patients 2009–2010

Comorbidity	Age <65 years		Age ⩾65 years		p value*	% overall prevalence
	N	(%)	N	(%)		
Any comorbidity present	1,338	(43.4)	2,058	(67.6)	<0.0001	55.4
Angina	207	(6.8)	538	(18.0)	<0.0001	12.3
MI in past 3 months	49	(1.6)	91	(3.0)	0.0002	2.3
MI >3 months ago	170	(5.6)	453	(15.1)	<0.0001	10.3
CABG/angioplasty	178	(5.8)	327	(10.9)	<0.0001	8.4
Cerebrovascular disease	200	(6.6)	454	(15.1)	<0.0001	10.8
Diabetes (not listed as PRD)	183	(6.0)	385	(12.8)	<0.0001	9.4
Diabetes listed as PRD	824	(27.4)	612	(20.5)	<0.0001	23.9
COPD	148	(4.9)	302	(10.1)	<0.0001	7.4
Liver disease	114	(3.7)	53	(1.8)	<0.0001	2.8
Claudication	129	(4.2)	256	(8.6)	<0.0001	6.4
Ischaemic/neuropathic ulcers	120	(3.9)	94	(3.1)	0.0917	3.5
Angioplasty/vascular graft	76	(2.5)	172	(5.7)	<0.0001	4.1
Amputation	81	(2.7)	66	(2.2)	0.24	2.4
Smoking	453	(15.4)	313	(10.9)	<0.0001	13.2
Malignancy	204	(6.7)	596	(19.8)	<0.0001	13.2

*p values from Chi-squared tests for differences between age groups in the percentage with the comorbidity

Age and comorbidity in patients by treatment modality at start of RRT

All comorbidities were more prevalent in patients receiving haemodialysis as their initial modality of treatment than in those starting on peritoneal dialysis (table 4.9). The median age for all patients starting dialysis in England, Wales and N. Ireland in 2009–2010 67.9 years (IQR 55.1–76.6 years) for haemodialysis and 58.4 years (IQR 45.1–69.3 years) for peritoneal dialysis. In comparison, the median age of patients with comorbidity data starting RRT on HD was 67 years compared with 59 years for those starting on PD (Kruskal Wallis test, $p < 0.0001$).

For each of the comorbid conditions, the median age of patients on HD was higher than for patients on PD (table 4.9).

Comorbidity and survival within 90 days of starting RRT

On univariable analysis stratified by age, most comorbidity was associated with an increased risk of death in the first 90 days after starting RRT when

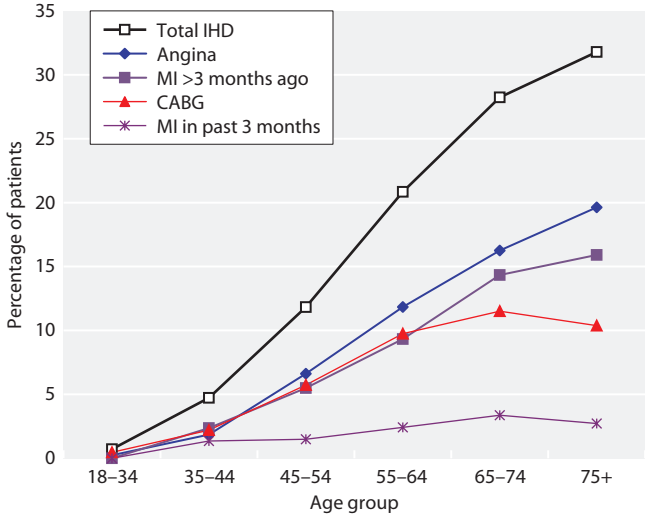

Fig. 4.2. Prevalence of ischaemic heart disease amongst incident patients 2009–2010 by age at start of RRT

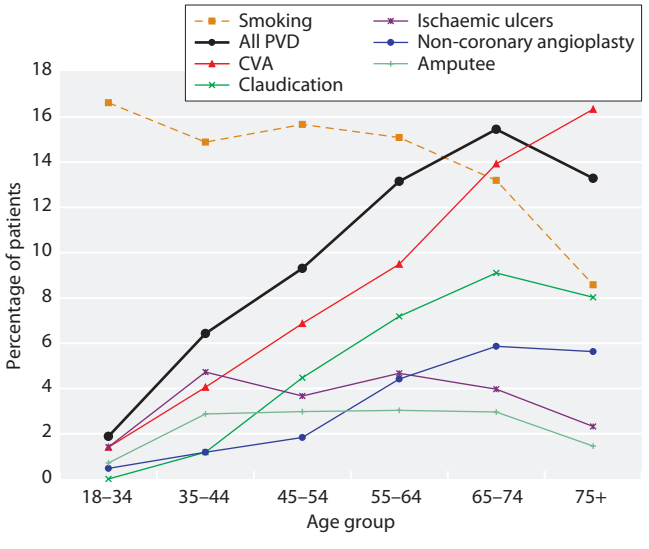

Fig. 4.3. Prevalence of non-coronary vascular disease amongst incident patients 2009–2010 by age at start of RRT

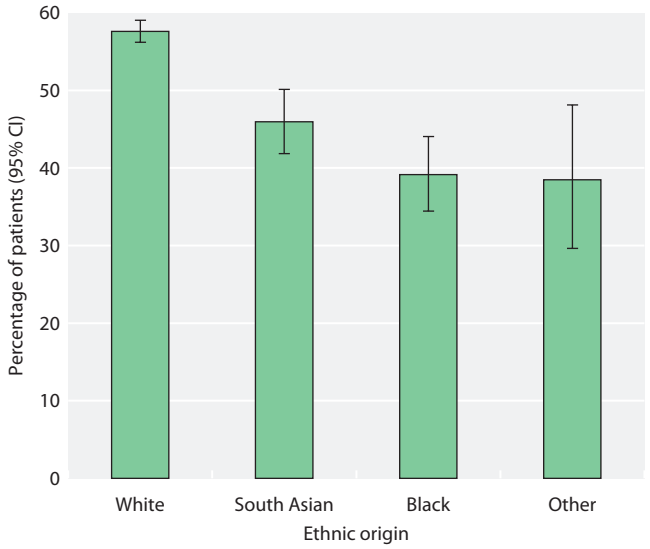

Fig. 4.4. Presence of comorbid conditions at the start of RRT by ethnic origin amongst patients starting RRT 2009–2010

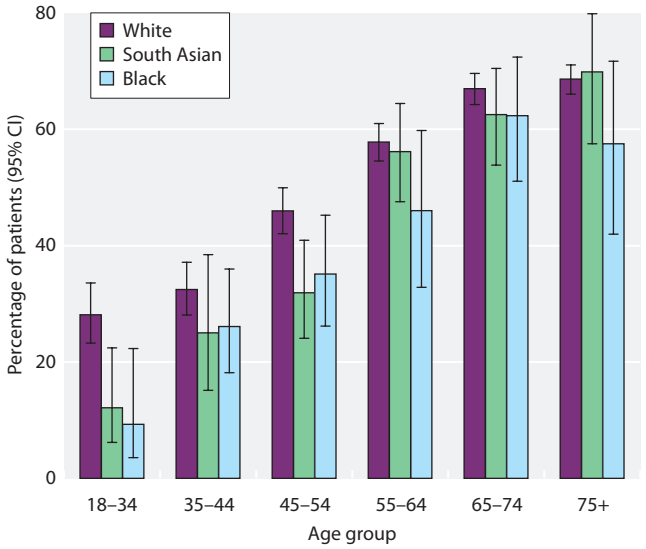

Fig. 4.5. Percentage of patients with comorbidity by ethnic origin in each age group at the start of RRT 2009–2010

Table 4.6. Prevalence of comorbidities amongst incident patients starting RRT 2009–2010 by ethnic group, as percentages of the total number of patients in that ethnic group for whom comorbidity data was available

	Number of patients (%) with comorbidity								
	White		South Asian		Black		Other		p value*
Ischaemic heart disease	1,002	(21.5)	146	(26.7)	34	(8.7)	9	(8.7)	<0.0001
Cerebrovascular disease	516	(11.0)	52	(9.6)	48	(12.3)	7	(6.7)	0.30
Diabetes (not listed as PRD)	426	(9.1)	54	(9.9)	27	(6.9)	6	(5.8)	0.26
Diabetes listed as PRD	1,000	(21.6)	209	(38.2)	119	(30.2)	22	(21.4)	<0.0001
COPD	394	(8.4)	19	(3.5)	12	(3.1)	2	(1.9)	<0.0001
Liver disease	119	(2.5)	16	(2.9)	20	(5.1)	3	(2.9)	0.030
Peripheral vascular disease	584	(12.5)	46	(8.6)	31	(8.1)	5	(4.8)	0.001
Smoking	639	(14.2)	42	(7.9)	31	(8.2)	12	(11.8)	<0.0001
Malignancy	692	(14.8)	21	(3.9)	24	(6.2)	7	(6.7)	<0.0001

*p values from Chi-squared tests for differences between ethnic groups in the percentage with the comorbidities

Table 4.7. Number and percentage of patients with and without diabetes (either as primary diagnosis or comorbidity) who have other comorbid conditions

	Non-diabetic patients		Diabetic patients		
Comorbidity	N	(%)	N	(%)	p value*
Ischaemic heart disease	653	(16.8)	581	(29.8)	<0.0001
Cerebrovascular disease	342	(8.8)	282	(14.5)	<0.0001
COPD	291	(7.5)	150	(7.7)	0.77
Liver disease	101	(2.6)	52	(2.7)	0.87
Peripheral vascular disease	292	(7.5)	393	(20.3)	<0.0001
Smoking	487	(13.0)	249	(13.3)	0.74
Malignancy	584	(15.0)	184	(9.5)	<0.0001

*p values from Chi-squared tests for differences in the percentage with the comorbidities between diabetic patients and non-diabetic patients

Table 4.8. Percentage prevalence of specific comorbidities amongst patients presenting late (0–89 days) compared with those presenting early (>89 days)

	Late referral		Early referral		
Comorbidity	N	(%)	N	(%)	p value*
Ischaemic heart disease	136	(16.9)	769	(23.0)	0.0002
Cerebrovascular disease	51	(6.3)	384	(11.5)	<0.0001
Diabetes (not listed as PRD)	57	(7.0)	315	(9.4)	0.031
COPD	61	(7.5)	273	(8.1)	0.6
Liver disease	29	(3.6)	86	(2.6)	0.12
Peripheral vascular disease	81	(10.0)	414	(12.4)	0.065
Malignancy	161	(19.9)	398	(11.9)	<0.0001
Smoking	118	(15.2)	415	(12.7)	0.07

*p values from Chi-squared tests for differences between referral groups in the percentage with the comorbidities

compared with a patient in the same age group without that comorbidity. This was true amongst patients aged <65 years and those aged ⩾65 years, the associations being more profound for those aged <65 years (data not shown). Results of the multivariable stepwise Cox regression analyses stratified by age group (<65 and ⩾65) are shown in tables 4.10 and 4.11. As identified in the univariable models, the relative magnitude of the hazard ratios associated with comorbidity in younger patients tended to be greater than in the older patient group. Diabetes did not emerge as an independent predictor of death, perhaps explained by its close association with, and mediation in the causal pathway by, cardiovascular diseases. Some comorbidities may appear not to be associated with an increased risk of death in this analysis because of the low number of patients in these groups or because of selection within the cohort. For example individuals with severe comorbid disease, and whose prognosis on RRT was considered very poor, may not have been started on RRT (for instance, liver disease in those aged ⩾65 years).

The final five variables in the model examining death within the first 90 days of starting RRT in patients aged <65 (table 4.10) explain 47% of the variation in survival. For patients aged ⩾65, the final eight variables in the model explain 15% of the variation in survival (table 4.11).

Comorbidity and survival 1 year after 90 days of commencing RRT

Age, smoking and five comorbidities were independently associated with an increased hazard of death within the first year after 90 days of commencing RRT for patients aged <65 years and four of these (age,

Table 4.9. Number (and percentage) of incident patients with comorbid conditions starting PD and HD 2009–2010

	HD			PD			
Comorbidity	N	(%)	Median age	N	(%)	Median age	p value*
Angina	635	(13.9)	72.5	108	(8.5)	70.2	<0.0001
MI in past 3 months	131	(2.9)	69.8	8	(0.6)	61.3	<0.0001
MI > 3 months ago	511	(11.2)	72.5	105	(8.3)	69.8	0.0026
CABG/angioplasty	408	(9.0)	70.6	90	(7.1)	67.0	0.037
Cerebrovascular disease	558	(12.2)	71.9	91	(7.2)	68.2	<0.0001
Diabetes (not listed as PRD)	478	(10.5)	71.6	83	(6.5)	69.1	<0.0001
COPD	393	(8.6)	71.6	56	(4.4)	67.4	<0.0001
Liver disease	138	(3.0)	61.0	23	(1.8)	58.4	0.019
Claudication	326	(7.2)	70.9	57	(4.5)	65.0	0.0007
Ischaemic/neuropathic ulcers	181	(4.0)	64.2	33	(2.6)	55.9	0.022
Angioplasty/vascular graft	223	(4.9)	72.0	22	(1.7)	61.8	<0.0001
Amputation	121	(2.7)	64.8	24	(1.9)	56.8	0.13
Smoking	610	(13.9)	63.4	135	(11.1)	53.1	0.01
Malignancy	697	(15.3)	73.2	99	(7.8)	67.6	<0.0001

*p values from Chi-squared tests for differences between modalities in the percentage with the comorbidities

Table 4.10. Multivariate Cox proportional hazards model* for predictors of death within the first 90 days of starting RRT during 01/01/2005–30/09/2010: patients aged <65 years

Comorbidity	Hazard ratio	95% CI	p value
Malignancy	3.9	2.6–6.0	<0.0001
Claudication	2.6	1.5–4.4	0.001
Liver disease	2.1	1.1–4.0	0.026
Angina	1.8	1.1–2.9	0.013
Age (per 10 yrs)	1.7	1.4–2.1	<0.0001

*This is the result of a stepwise procedure. The variables considered in the model were: age (in 10 year units) and the 14 comorbidity variables except that 'diabetes (not listed as PRD)' was replaced by 'diabetes of either category' which included 'diabetes listed as PRD'

Table 4.11. Multivariate Cox proportional hazards model* for predictors of death within the first 90 days of starting RRT during 01/01/2005–30/09/2010: patients aged ⩾65 years

Comorbidity	Hazard ratio	95% CI	p value
Ischaemic/neuropathic ulcers	2.2	1.5–3.3	0.0001
MI in past 3 months	2.0	1.4–2.9	0.0003
Malignancy	1.7	1.4–2.1	<0.0001
MI > 3 months ago	1.6	1.2–2.0	0.0002
COPD	1.6	1.2–2.1	0.0006
Age (per 10 yrs)	1.5	1.3–1.7	<0.0001
Angina	1.4	1.1–1.8	0.003
CABG/angioplasty	0.7	0.5–1.0	0.04

*This is the result of a stepwise procedure. The variables considered in the model were: age (in 10 year units), smoking and the 14 comorbidity variables except that 'diabetes (not listed as PRD)' was replaced by 'diabetes of either category' which included 'diabetes listed as PRD'

malignancy, liver disease and COPD) were among the eight variables independently associated with mortality beyond day 90 in patients ⩾65 years (tables 4.12, 4.13). Diabetes mellitus was independently associated

Table 4.12. Multivariate Cox proportional hazards model* for predictors of death in the year after the first 90 days of starting RRT during 01/01/2005–30/09/2009: patients aged <65 years

Comorbidity	Hazard ratio	95% CI	p value
Malignancy	3.1	2.3–4.2	<0.0001
Ischaemic/neuropathic ulcers	2.3	1.6–3.4	<0.0001
Diabetes of either category	1.7	1.4–2.2	<0.0001
Liver disease	1.6	1.1–2.5	0.021
COPD	1.6	1.1–2.3	0.024
Age (per 10 yrs)	1.4	1.2–1.5	<0.0001
Smoking	1.3	1.0–1.7	0.047

*This is the result of a stepwise procedure. The variables considered in the model were: age (in 10 year units) and the 14 comorbidity variables except that 'diabetes (not listed as PRD)' was replaced by 'diabetes of either category' which included 'diabetes listed as PRD'.

Table 4.13. Multivariate Cox proportional hazards model* for predictors of death in the year after the first 90 days of starting RRT during 01/01/2005–30/09/2009: patients aged ⩾65 years

Comorbidity	Hazard ratio	95% CI	p value
Amputation	2.0	1.3–3.1	0.002
Liver disease	2.0	1.3–2.9	0.001
Malignancy	1.8	1.6–2.1	<0.0001
Age (per 10 yrs)	1.7	1.6–1.9	<0.0001
COPD	1.5	1.2–1.8	<0.0001
Cerebrovascular disease	1.4	1.2–1.6	0.0002
Angina	1.3	1.1–1.5	0.005
Claudication	1.3	1.0–1.5	0.04

*This is the result of a stepwise procedure. The variables considered in the model were: age (in 10 year units) and the 14 comorbidity variables except that 'diabetes (not listed as PRD)' was replaced by 'diabetes of either category' which included 'diabetes listed as PRD'

with increased mortality in patients <65 years but not in those aged ⩾65 years. Overall the final seven variables in the model exploring death in the year after the first 90 days of starting RRT in patients <65 years explain 30% of the variation in survival. For patients' ⩾65 years, only 14% of the variation in survival was explained by the eight variables included in the final model.

Discussion

Comorbidity data completeness has been a cause for concern since comorbidities were first reported by the UKRR in 1999 [11]. Overall the completeness of comorbidity reporting to the UKRR is fairly static. The current prevalence of comorbidity reporting of 49.3% in the UK compares with 85% in Canada, 95–100% in Australia and New Zealand and 100% in the US. Some work has recently been undertaken to learn from experience in these countries [12]. Missing data may hamper case-mix adjustment but also introduce the risk of selection bias, so caution must be used in interpreting the influence of comorbidity on patient outcomes. A recent study based on UKRR data suggested that patients with comorbidity recorded have significantly better health outcomes than those with missing comorbidity [6], so the findings from the selected group of patients reported in this chapter cannot be assumed to be representative of the whole dialysis population. Comorbidity information should improve in the future through a combination of linkage with other secondary

data sources (e.g. Hospital Episode Statistics Dataset), statistical imputation techniques and local governance pressures, given that comorbidity items form part of the mandatory National Renal Dataset. In addition, ongoing efforts to understand the barriers to data capture and to optimise the processes utilised, involving all relevant stakeholders from individual clinicians, data managers, system suppliers and the UKRR team, are required to help improve the quality and completeness of this important information.

An interesting recurrent finding in several of the survival analyses is the lack of independent association of smoking or diabetes with mortality. This highlights the need for caution when interpreting the results of multivariable analyses in which co-variables are included in the model that may lie on the causal pathway. For example smoking and diabetes both contribute to vascular disease which may result in death. Therefore by including ischaemic heart disease or peripheral vascular disease in the model, the association between diabetes and smoking and mortality will be attenuated. The absence of an independent association should not however be interpreted as meaning smoking (for example) does not increase a dialysis patient's risk of death [13]. The observation that 13% of new RRT patients are recorded as current smokers remains a concern given the recognised substantial excess in cardiovascular risk that dialysis patients have compared with those with CKD or normal renal function [14, 15].

A further consideration is that even in analyses (both inside and outside the UK) with 100% comorbidity completeness, the proportion of variance in survival that can be explained by these major medical disorders generally remains below 50% when age, primary renal disease, ethnicity and comorbidities are included in the statistical model. The UKRR is currently undertaking work exploring the associations between comorbidity and survival in greater detail. Future studies of survival should consider other factors such as nutrition, mobility, cognition and socio-economic status in addition to centre level factors at the start of dialysis to better assess the risk factors and outcomes for RRT patients.

Conflicts of interest: none

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