How much of the regional variation in RRT incidence rates within the UK is explained by the health needs of the general population?

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Abstract

Background. Variation in end-stage renal disease treatment rates in the UK persist after adjustment for socio-demographic factors.

Methods. UK-wide ecological study using population socio-demographic factors, health status characteristics and access to health services factor in to explain the incidence of renal replacement therapy (RRT).

Results. There was a 6% higher incidence rate of RRT per standard deviation (SD) increase in area diabetes prevalence after adjustment for area level socio-economic deprivation status and the proportion of non-white residents [incidence rate ratio adjusted (IRR adjusted) 1.06 (95% confidence interval 1.03,1.09), P < 0.001]. A 3% lower-adjusted RRT incidence rate was seen with each SD higher proportion of diabetics achieving an HbA1c of <7.5% [IRR 0.97 (0.94, 1.00), P = 0.03]. Hypertension prevalence was independently associated with an 8% higher RRT incidence rate per SD increase [IRR adjusted 1.08 (1.04, 1.11), P < 0.001] and an SD increase in life expectancy in an area was independently associated with 7% lower RRT incidence rate [IRR adjusted 0.93 (0.91, 0.96), P < 0.001]. An SD increase in premature cardiovascular (CV) mortality rate in an area was also independently associated with 7% lower RRT incidence rate [IRR adjusted 1.06 (1.03, 1.09), P < 0.001]. Rates of coronary artery bypass grafting (CABG)/angioplasty and knee replacement were positively associated with RRT incidence, but mammography uptake was not associated. In total, 31% of the regional variation in RRT incidence could be explained by these factors.

Conclusions. Diabetes prevalence, the proportion of diabetics achieving good glycaemic control, hypertension prevalence, life expectancy, premature CV mortality, CABG/angioplasty and knee replacement rates were all associated with RRT incidence. A third of the regional variation in RRT incidence between areas can be explained by these demographic, health and access to health services factors.

Keywords: access to healthcare; diabetes; hypertension; incidence; renal replacement therapy

Introduction

Variation in the incidence of treated end-stage renal disease (ESRD) between and within countries has been attributed to several interlinking factors or domains. The age structure of the population in question [1] and the prevalence of conditions such as diabetes and hypertension within the general population are two important factors [2, 3] alongside the differential growth in treatment rates for diabetic patients [4–6] within regions. The prevalence of predisposing conditions such as vascular disease, obesity and smoking levels [7–9], including as yet unrecognized factors and the access to renal replacement therapy (RRT) for older and more comorbid patients [5, 6, 10, 11], also plays a part. The incidence of RRT is also affected by differences in the quality of care for and survival from diseases that would otherwise cause death before ESRD is reached [12–15]. The timing of dialysis initiation [12, 16] has also been implicated in increasing RRT incidence rates in some countries.

Although some of the variation in ESRD treatment rates is attenuated by adjusting for the age, ethnicity and socio-economic status of the population, considerable unexplained variation persists in the UK [17].

This study examines the association between the RRT incidence in the population of each health area in the UK with measures of the socio-demographic characteristics, health status and health service access profiles of those populations. We then use this approach to determine how much of the regional variation in RRT incidence is explained by each of these potential domains. We use a population-based approach to determine the contribution of these factors to the population incidence of RRT.

Methods

Study design

An ecological (population level) study was designed using the number of patients commencing RRT in each of the 192 administrative health areas in the UK as the outcome to be explained. We have termed these 192 areas Local Health Areas (LHAs) in this paper but they are known as Primary Care Trusts/Organisations in England (n = 152), Health
Boards in Scotland (n = 14), Local Health Boards in Wales (n = 22) and Health and Social Services Boards in Northern Ireland (n = 4).

**Data sources and variables**

All patients commencing RRT between 1 January 2007 and 31 December 2008 were identified from the UK Renal Registry (UKRR) database. Patients recovering renal function within 90 days were excluded. The UKRR collects data for all patients receiving RRT in the UK, from Day 0 (data collection methods have been described in detail elsewhere [18]).

LHA RRT incidence was defined as the number of patients commencing RRT in the study period with a residential postcode within that LHA (Table 1).

General population socio-demographic data were obtained from the Office for National Statistics (ONS) (Table 1).

LHA level diabetes prevalence was obtained from the Quality Outcomes Framework (QOF) database for 2007/2008 (http://www.ic.nhs.uk/statistics-and-data-collections) (Table 1). QOF is an annual financial reward and incentive scheme for primary care doctors, which encourages registration of patients with chronic conditions and the attainment of standards in their care. The percentage of QOF registered diabetic patients achieving an HbA1c of <7.5% in the last 15 months was calculated using the total number of patients on the diabetes register as the denominator, as the published QOF results for this indicator are based on a denominator that excludes patients that primary care physicians consider non-concordant with care or in whom it is deemed inappropriate to achieve the set standard (Table 1).

The LHA level hypertension prevalence [pre-defined as blood pressure (BP) ≥160/100 or ≥150/90 if evidence of end-organ damage] was similarly obtained from the QOF database. As with the diabetes variable, the denominator for the percentage of hypertensive patients with controlled hypertension was taken as all hypertensive patients (Table 1).

**Table 1. Description of the data sources and variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td>UK Renal Registry</td>
</tr>
<tr>
<td>Number of new patients starting RRT in 2007–08</td>
<td>Office National Statistics</td>
</tr>
<tr>
<td><strong>Predictor variables</strong></td>
<td>Office National Statistics</td>
</tr>
<tr>
<td>Age: % residents ages 0–49, 50–59, 60–69, 70–79 and &gt;80</td>
<td>Office National Statistics</td>
</tr>
<tr>
<td>SES: Townsend area deprivation score</td>
<td>Office National Statistics</td>
</tr>
<tr>
<td>Ethnicity: % non-white residents</td>
<td>Quality Outcomes Framework</td>
</tr>
<tr>
<td><strong>Health status</strong></td>
<td>Adapted from Quality Outcomes Framework</td>
</tr>
<tr>
<td>Prevalence diabetes mellitus over 17 years old (types 1 and 2) in 2007–08</td>
<td>Association Public Health Organisations/Ireland and Northern Ireland</td>
</tr>
<tr>
<td>Percentage registered diabetic patients achieving HbA1c &lt; 7.5% in past 15 months 2007–08</td>
<td>Populations Health Observatory. Modelled diabetes mellitus prevalence data were not available for Scotland and Wales</td>
</tr>
<tr>
<td>Modelled prevalence diabetes mellitus (type 1 and 2 diagnosed and undiagnosed) in 2007–08</td>
<td>Quality Outcomes Framework</td>
</tr>
<tr>
<td>Prevalence hypertension (defined as sustained BP ≥ 160/100 or ≥150/90 on medication or ≥150/90 on medication with evidence of end organ damage) in 2007–08</td>
<td>Adapted from Quality Outcomes Framework</td>
</tr>
<tr>
<td>Percentage registered hypertensive patients achieving BP ≤ 150/90 in 2007–08</td>
<td>Office National Statistics</td>
</tr>
<tr>
<td>Cardiovascular mortality under 75 years (rate per 100 000 standardized European Standard Population) in 2007–08</td>
<td>Office National Statistics</td>
</tr>
<tr>
<td>Life expectancy (mean years from birth) in 2005–07 latest estimate</td>
<td>Hospital Episode Statistics (reported by Office for National Statistics), Division Scotland</td>
</tr>
<tr>
<td>Access to health services</td>
<td>Hospital Inpatient Statistics Northern Ireland and Information Services Division Scotland</td>
</tr>
<tr>
<td>CABG/angioplasty rate (mean number of procedures per million population per year based on 2005–08 data)</td>
<td>Health and Social Care Information Centre (England) Scottish Breast Screening Programme, Breast Test Wales and the Northern Ireland Public Health Agency</td>
</tr>
<tr>
<td>Mammography screening uptake (percentage of women invited who attend for screening in 2007–08)</td>
<td>Hospital Episode Statistics (reported by Office for National Statistics), Hospital Inpatient Statistics Northern Ireland and Information Services Division Scotland</td>
</tr>
<tr>
<td>Total knee replacement rate (number of procedures per million population per year based on 2005–08 data)</td>
<td>Hospital Episode Statistics (reported by Office for National Statistics), Hospital Inpatient Statistics Northern Ireland and Information Services Division Scotland</td>
</tr>
</tbody>
</table>

HbA1C, glycosylated haemoglobin; SES, socio-economic deprivation status; CABG/angioplasty, coronary artery bypass graft/coronary angioplasty.
an exposure or offset term to allow for the differing population sizes of each LHA.

Confounders were identified and adjusted for, including age (% 0–49, 50–59, 60–69, 70–79 and >80 years), gender (% male), ethnic origin (% non-white) and area deprivation. Area socio-economic deprivation was defined using the Townsend score which is based on four variables available from the National Census 2001: overcrowded housing, unemployment, non-car ownership and non-home ownership. The score obtained increased as deprivation increased. Confounders were examined using correlation coefficients and several were found to be highly collinear.

![Conceptual framework of factors influencing renal replacement therapy incidence. Socio-demographics: age, ethnicity and socio-economic status; predisposing disease prevalence: diabetes mellitus, hypertension prevalence and CV morbidity; disease management: % of patients with diabetes mellitus with HbA1c < 7.5% and % of patients with hypertension with BP < 150/90 mmHg; competing risk: life expectancy; access to health services: mammography uptake, TKR and CABG/coronary angiography rates.](https://academic.oup.com/ndt/article/27/10/3943/1827988)
Table 3. The association between population health status and access to health services factors and RRT incidence

<table>
<thead>
<tr>
<th>Model number</th>
<th>Unadjusted IRR (95% CI)</th>
<th>Adjusted IRR (95% CI) (adjusted for socio-demographic factors)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. DM (per SD increase), 1 SD = 0.5% increase in prevalence</td>
<td>1.10 (1.07–1.13), P &lt; 0.001</td>
<td>1.06 (1.03–1.09), P &lt; 0.001</td>
</tr>
<tr>
<td>2. DM control (per SD increase), 1 SD = 5%</td>
<td>0.92 (0.89–0.95), P &lt; 0.001</td>
<td>0.97 (0.94–1.00), P = 0.03</td>
</tr>
<tr>
<td>3. HTN (per SD increase), 1 SD = 1.9% increase in prevalence</td>
<td>0.95 (0.93–0.98), P = 0.001</td>
<td>1.08 (1.04–1.11), P &lt; 0.001</td>
</tr>
<tr>
<td>4. HTN control (per SD increase), 1 SD = 8%</td>
<td>0.96 (0.92–0.99), P &lt; 0.001</td>
<td>1.00 (0.95–1.09), P = 0.8</td>
</tr>
<tr>
<td>5. CV mortality (per SD increase), 1 SD = 17 deaths per 100 000</td>
<td>1.09 (1.07–1.12), P &lt; 0.001</td>
<td>1.06 (1.03–1.09), P &lt; 0.001</td>
</tr>
<tr>
<td>6. Life expectancy from birth (per SD increase), 1 SD = 1.5 years</td>
<td>0.91 (0.88–0.93), P &lt; 0.001</td>
<td>0.93 (0.91–0.96), P &lt; 0.001</td>
</tr>
<tr>
<td><strong>Access to health services</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Knee replacement rates (per SD increase), 1 SD = 40 per 100 000 population</td>
<td>0.96 (0.93–0.98), P = 0.003</td>
<td>1.04 (1.00–1.07), P = 0.04</td>
</tr>
<tr>
<td>8. CABG/angioplasty rates (per SD increase), 1 SD = 49 per 100 000 population</td>
<td>1.01 (0.99–1.04), P = 0.4</td>
<td>1.07 (1.04–1.10), P &lt; 0.001</td>
</tr>
<tr>
<td>9. Mammography uptake rates (per SD increase), 1 SD = 7%</td>
<td>0.90 (0.87–0.93), P &lt; 0.001</td>
<td>1.03 (0.98–1.07), P = 0.3</td>
</tr>
</tbody>
</table>

IRR, incidence rate ratio; CI, confidence interval; DM, diabetes mellitus (types 1 and 2); HTN, hypertension (BP ≥ 160/90); CV, cardiovascular; SD, standard deviation; CABG/angioplasty, coronary artery bypass graft/coronary angioplasty.

Table 4. The cumulative contribution of each variable in the model

<table>
<thead>
<tr>
<th>Model inclusions</th>
<th>Variation explained (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: percentage non-white residents</td>
<td>5</td>
</tr>
<tr>
<td>Step 2: above + area deprivation score</td>
<td>22</td>
</tr>
<tr>
<td>Step 3: above + diabetes prevalence</td>
<td>26</td>
</tr>
<tr>
<td>Step 4: above + CABG/angioplasty rates</td>
<td>31</td>
</tr>
</tbody>
</table>

CABG/angioplasty, coronary artery bypass graft/coronary angioplasty.

However, when added together into the models, no evidence of large effects on the IRR or standard errors was detected. Nevertheless, when two collinear variables were found not to improve the model fit compared with a single variable, one was excluded. The effect of socio-demographic factors on RRT incidence has been examined previously and so was not explicitly displayed again here. The first set of models (shown in Table 3) examined the association between the health status variables and RRT incidence followed by the access to health services variables and RRT incidence independent of the socio-demographic characteristics of each area in each case. Non-linearity was investigated first by examining scatter plots of each variable and RRT incidence and then by including a quadratic term for each variable and comparing models with and without this term with the likelihood ratio test. All relationships were found to be approximately linear. In order to compare the effects of each predictor variable, they were each converted into standard deviation (SD) changes. We checked and failed to find any evidence of overdispersion in the final models using the regression method [19].

To explore how much of the variance in RRT incidence can be explained by these socio-demographic, health and access to services domains, a further random-intercept Poisson regression model (shown in Table 4) was built containing each variable that improved the ability of the model to predict RRT incidence. Variables were placed into the model in a pre-determined order starting with the demographic domain variables, then the health status variables and then the access to services variables. Within each of these domains, variables were added with the greatest univariable association first. The likelihood ratio test was then used to compare models and if the model fitted better (significance threshold of 0.2) with the addition of the variable, it was retained. To determine the variance explained by this model, we calculated the predicted mean rate of RRT using the full model and then the predicted mean rate of RRT using the information from one predictor variable alone adding in each variable cumulatively. We then examined the correlation coefficient between the full model including centre-level effects and the restricted model containing only the predictor of interest and this can be interpreted as the proportion of variability explained by each variable in this model [20]. To examine the proportion of variability in RRT incidence seen between renal centres and that seen between LHAs in this data set, we used the exact calculation method [20].

Sensitivity analyses

To assess the reliability of the QOF diabetes data, analyses were repeated using modelled diabetes prevalence rates calculated by the Association of Public Health Organisations [21]. The analyses were also repeated for RRT incidence due to primary renal diseases that may be expected to be influenced by diabetes and vascular risk: diabetes, hypertension, reno-vascular disease and ‘uncertain aetiology’.

Results

During the study period, 13 331 patients commenced RRT in the UK, 76 (0.6%) did not have a recognizable postcode and had to be excluded from analyses leaving 6643 patients in 2007 and 6612 in 2008. The mean (SD) LHA population size was 315 000 (200 000) individuals, giving a mean (SD) incidence rate per LHA of 112 (30.5) per million population (pmp). The socio-demographic, health status and access to health service characteristics of the LHAs, stratified into quintiles of RRT incidence, are presented in Table 2. A trend across quintiles, which was unlikely to be due to chance, was observed between the Townsend area deprivation score, proportion non-white residents, diabetes prevalence, diabetes control, hypertension control, CABG/angioplasty rate, knee replacement rate and mammography uptake rate and area level RRT incidence (Table 2) so that poorer areas, those with more ethnic minorities, greater diabetes prevalence, less well-controlled diabetes and hypertension and lower access to health services, had higher RRT rates.

Population health status (adjusted for socio-demographic factors)

Diabetes prevalence and control. The QOF prevalence of diabetes was positively associated with RRT incidence in the unadjusted analysis [IRR 1.10 (95% CI 1.07–1.13), P = 0.001] (Table 3). After adjustment for area level demographics—% non-white residents and Townsend area deprivation score—each SD higher diabetes prevalence in
an LHA was associated with a 6\% higher RRT incidence rate [IRR 1.06 (1.03–1.09), P < 0.001] (Table 3). The socio-demographic variables were found to be highly correlated in this ecological data set (R = 0.74 between the \% aged 0–49 years and the area deprivation score, R = 0.73 between \% aged 0–49 years and \% non-white and R = 0.51 between \% male and \% non-white) with no improvement in model fit after including age or gender in addition to these other markers (likelihood ratio test P = 0.2 and 0.1, respectively), resulting in the exclusion of a specific age or gender adjustment in this and all subsequent models.

Similar results were obtained in the sensitivity analysis using modelled diabetes prevalence [unadjusted IRR 1.14 (1.09–1.19), P < 0.0001 and adjusted IRR 1.13 (1.09–1.18) P < 0.001]. The mean difference between modelled and QOF diabetes prevalence was +0.64\% (0.58–0.71, P < 0.001) and this difference was similar at each level of diabetes prevalence in the population. The correlation coefficient between the two measures was R = 0.54, P < 0.001.

Considering control of diabetes, LHAs with a higher proportion of diabetic patients with an HbA1c of <7.5\% were found to have 3\% lower RRT incidence in the adjusted analysis [IRR 0.97 (0.94–1.00), P = 0.03 per SD change].

**Hypertension prevalence and control.** Although the univariable analysis identified a counterintuitive, negative association between hypertension prevalence and RRT incidence [IRR 0.95 (0.93–0.98), P = 0.001 per SD change], the independent association observed following adjustment for area level socio-demographic variables was positive [IRR 1.08 (1.04–1.11), P < 0.001 per SD change] (Table 3). The association observed between the proportion of hypertensive patients achieving a moderate BP target and RRT incidence was attenuated to the null [IRR 1.00 (0.95–1.01), P = 0.8 per SD change] after adjustment (Table 3).

**Life expectancy and CV mortality.** Each SD increase in CV mortality (and therefore assumed CV morbidity) was associated with a 9\% higher incidence rate of RRT in unadjusted analyses [IRR 1.09 (1.07–1.12), P < 0.0001] (Table 3) and 6\% higher incidence rate of RRT after adjustment (Table 3). A negative association was observed between life expectancy at birth and RRT incidence: each SD higher life expectancy was associated with a 9\% lower RRT incidence rate in unadjusted analyses [IRR 0.91 (0.88–0.93), P < 0.001] and a 7\% lower RRT incidence rate in adjusted analyses [IRR 0.93 (0.91–0.96), P < 0.001] (Table 3).

**Access to health services (adjusted for socio-demographic factors)**

Each SD higher CABG/angioplasty rate was associated with a 7\% higher RRT incidence rate [IRR 1.07 (1.04–1.10), P < 0.001] (Table 3). This association remained similar even after the CV mortality rate was taken into account, suggesting that it does not merely reflect CV morbidity (results not shown). There was surprisingly little correlation between premature CV mortality rates and CABG/angioplasty rates (R = 0.07). Each SD higher TKR rate was associated with a 4\% higher rate of RRT [IRR 1.04 (1.00–1.07), P = 0.04], reversing the previous unadjusted association. No significant association was found between mammography screening rates and RRT incidence after adjustment for area deprivation score and area ethnicity was made.

**Explaining variation in RRT incidence between LHAs**

The amount of variation in RRT incidence that was seen between groups of LHAs making up a single renal centre (n = 70) and between all LHAs (n = 192) was calculated for each area using the variables in the final model shown in Table 4. The mean (SD) amount of variation seen between renal centres was 55\% (11) which leaves just 45\% of the total variation in RRT incidence due to factors specific to individual LHAs. The variables used in the final model and their stepwise contribution to the variance explained are presented in Table 4. These factors explained 31\% of the total variation in RRT incidence.

**Discussion**

This UK study used cross-sectional general population socio-demographic, health status and access to health services data to explain the regional variation in population RRT incidence. It is the first insight into the amount of within-country variation in RRT incidence that can be explained by regional variation in the health and medical care of a population. An ecological approach was taken to identify structural factors which affect the incidence of RRT in a population rather than in an individual patient [22]. LHAs with lower socio-economic status and greater percentages of non-white residents were found to have higher incidence rates of RRT. These demographic characteristics alone explained 22\% of the variation which exists between LHAs. Diabetes and hypertension prevalence, CV mortality, life expectancy and CABG/angioplasty rates were the next most strongly associated (each associated with a 6–7\% change in RRT incidence per SD change), and finally, diabetic control and knee replacement rates were more weakly associated with RRT incidence. Age was not taken into account in the final poisson models because when used together with the other socio-demographic variables did not improve the models but the contribution of the age structure of each LHA could be considered included by the other socio-demographic variables. This result is in keeping with previous work showing higher rates of RRT among non-white [6] and more socially deprived groups [17, 23]. The percentage of males in an area was not found to be associated with RRT incidence once adjustment for \% non-white was made and so adjustment was not made for gender in any of the models. This is in contrast to individual level studies where the incidence of RRT among men is 1.6 times higher than in women [24] but is likely due to the fact that in this study, there was significant
correlation between the proportion of male residents and % non-white residents. There was a wide variation in the number of residents in each health area, and a negative correlation between area population and RRT incidence rates was seen ($r = −0.14$, $P = 0.05$). This association was explained by socio-demographic factors; areas with the largest populations had fewer non-white residents and were less deprived on average. Once these factors were taken into account, there was no longer an association between area population and RRT incidence (data not shown).

Diabetes and hypertension are responsible for ESRD in 25% of the incident RRT patients in the UK [1], so it is not surprising that their prevalence in the catchment area population is associated with treatment rates. Higher rates of RRT incidence in areas with more diabetes have been demonstrated previously in Tyrol [3] and between England/Wales and Germany [2]. The percentage of diabetic patients who achieved an HbA1c of $<7.5\%$ was used as a measure of disease control. Alternatively, it may be acting as a surrogate marker for the quality of chronic disease management by primary care in each area or for disease severity. The use of HbA1c in this regard has been established elsewhere [25]. The association seen (the higher the percentage of patients achieving good glycaemic control the lower the incidence of RRT) is in keeping with patient level evidence linking better diabetic control with lower rates of microvascular complications [26] and with evidence regarding the potential importance of good pre-ESRD care in slowing the progression of CKD [26–28]. The association between diabetes prevalence and RRT incidence shown here is similar to that obtained in a recent study using an older, less complete QOF data set [29].

Markers of better general health in each area such as greater life expectancy were found to be associated with lower RRT incidence rates, with evidence of attenuation of the effect after adjustment for area deprivation score, known to be the greatest determinant of life expectancy in the UK [30]. Premature CV mortality rates, as a surrogate marker for CV morbidity, were associated with RRT incidence (6% higher RRT rate for each SD increase in premature CV mortality). CV disease has been shown to be associated with vascular/ischaemic nephropathy [31–33] as well as being a risk factor for the progression of chronic kidney disease due to other causes [31, 34, 35]. Our findings are different from patient level studies looking at the long-term effects of CV disease on outcome where it seems to act as a competing risk for RRT [15, 36]. Our study is likely to contain unmeasured confounders in this relationship which might explain this discrepancy such that at an area level, CV disease is positively associated with RRT possibly due to higher levels of smoking, obesity and low birth weight in areas with high CV disease rates.

The demographic and health characteristics of the general population accounted for 31% of the between LHA variation in RRT incidence. There is likely to be residual confounding in these relationships (e.g. from the use of the Townsend score for socioeconomic deprivation status (SES) or from non-measurement of other important health status variables, although the use of multivariable analysis hopes to reduce this), meaning that we might be underestimating the true effect of population health on RRT incidence. The variation in RRT incidence explained by renal centre factors might be due in part to renal service organizational or ‘supply’ factors which are the subject of ongoing research. Investigations into geographic variation in hysterectomy rates [37], primary care physician prescribing [38] and mortality among dialysis patients [39] all demonstrated that access to treatment factors (physician practice patterns and hospital characteristics) as well as the level of ‘need’ were important in determining outcomes or rates. Indeed, macroeconomic and renal service organizational factors have proven more important in explaining variation in RRT incidence between countries [40].

The access to health-care variables attempted to capture either the quality of the public health/preventative healthcare system (mammography rates) or access to secondary care (TKR and CABG/angioplasty rates). CABG/angioplasty rates were associated with RRT incidence (7% higher RRT rate for each SD higher CABG/angioplasty rate) even after taking into account CV mortality rates and were able to explain 5% of variation in RRT rates overall. Similarly, areas with higher rates of knee replacement were associated with higher rates of RRT incidence, even after adjustment for area deprivation score, one of the known determinants of TKR rates [41]. This is despite the fact that there is a mismatch between provision and need so that poorer areas are relatively under-provided [41]. It might be that these factors are identifying more diseased populations rather than truly measuring access to health services in each area but we hope that by adjusting the relationship between CABG/angioplasty rates for CV mortality we take this into account.

Hypertension prevalence was found to be highly correlated with the age profile of an LHA, and before adjustment, there was a counter-intuitively lower rate of RRT associated with higher hypertension prevalence. The reason for this is likely to be that while age and ethnicity are both strongly linked to RRT incidence, ethnicity is the stronger determinant in this study and areas with a high proportion of non-white residents tended to be younger than other areas [42]. This phenomenon is well recognized in the UK and the impact of the ageing non-white population on RRT incidence rates has been a matter of concern for some time [29].

The majority (>98%) of primary care practices report data to QOF; however, QOF disease rates require (1) that the patient attends their doctor, (2) the doctor makes a diagnosis and (3) the diagnosis is registered on their practice IT system—they therefore differ from population screening studies. When we compared modelled and QOF diabetes prevalence, we found lower levels of agreement ($\rho = 0.54$, $P = 0.001$) but small actual differences (mean +0.64%) and no systematic bias at any level of diabetes prevalence. Both performed similarly in the models.

There were several other limitations to this study. The Townsend score has been criticized as underestimating true deprivation in rural communities [43] but was chosen in this study as it could be applied to each country similarly, whereas other potential measures of deprivation use...
different domains in each of the four countries of the UK [43]. CV mortality was used here as a surrogate marker for the level of CV morbidity in each area as these data were not available.

In conclusion, only a third of the variation in LHA treatment rates of ESRD can be explained by variation in the ‘needs’ of their populations. The age, SES and ethnicity profile of their catchment populations as well as the prevalence of diabetes and the proportion of diabetics achieving good glycaemic control were all found to predict this ‘need’. There was also some evidence that areas with good access to other treatments (TKR and CABG/angioplasty) also had higher rates of RRT incidence. Ongoing work is examining how much of the remaining variation is explained by supply-side factors such as conservative care programmes, outreach CKD clinic provision and the quality of communication between primary and secondary care.

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Conflict of interest statement. None declared.

References
Prevalence and predictors of the sub-target Hb level in children on dialysis†

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Abstract
Background. Anaemia is a common and potentially treatable co-morbidity of end-stage renal disease. We aimed to determine the prevalence of the sub-target haemoglobin (Hb) level among European children on dialysis and to identify factors associated with a low Hb level.

Methods. From the European Society for Paediatric Nephrology (ESPN)/European Renal Association-European Dialysis Transplant Association (ERA-EDTA) registry, data were available on 2351 children between 1 month and 18 years of age, totalling 5546 measurements from 19 countries.

Results. The mean Hb level was 10.8 g/dL (5th–95th percentiles, 7.4–13.9). Among those above 2 years of age, the mean Hb level was 10.9 g/dL (11.4% below 8.5 g/dL), while it was 10.3 g/dL among those below 2 years (11.2% below 8.0 g/dL). A total of 91.2% of the patients were on an erythropoiesis-stimulating agent (ESA). Hb levels increased with age and were higher in peritoneal dialysis compared with haemodialysis patients. Patients with congenital anomalies of the kidney and urinary tract showed the highest Hb levels, and those with cystic kidney diseases or metabolic disorders the lowest ones. Ferritin levels between 25 and 50 ng/mL were associated with the highest Hb levels. We found a weak inverse association between parathyroid hormone (PTH) and Hb. Whereas standardized blood pressure (BP) was not elevated in patients with above-target Hb, elevated systolic BP z-score was noted in those with sub-target Hb levels.

Conclusions. Sub-target Hb levels remain common in children on dialysis, in spite of virtually all children being treated with ESA; although we cannot exclude under-