Equity of access to dialysis facilities in Wales

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Summary

Background: Demand for dialysis, particularly, in-centre haemodialysis (HD), is growing, and more units will be needed. Travel time to treatment is consistently a major area of concern for patients.

Aim: To analyse access to current dialysis facilities in Wales, and use the data to help plan for new dialysis units.

Methods: We analysed a combination of UK Renal Registry, Welsh population census data, the Welsh Index of Multiple Deprivation 2005 (WIMD), travel time and geographical information systems.

Results: Prevalence of HD fell significantly with increasing travel time from units. This was not influenced by the WIMD. Prior to the opening of a new HD unit in Aberystwyth, prevalence in the surrounding area was significantly lower than for Wales as whole, but within 2 years, prevalence had risen to approximate national levels. In Haverfordwest, an area >30 min drive from any current facility, prevalence is consistently and significantly lower than for Wales as a whole, and has not shown the growth seen elsewhere in the country.

Discussion: The ability to combine data has enabled modelling of the likely immediate impact of opening a new unit in Haverfordwest, and also provided an estimate of its required capacity. This multidisciplinary approach to demand analysis should help to highlight areas of under-provision, and facilitate the planning of the sites and sizes of new dialysis units in Wales.

Introduction

The provision of renal replacement therapy (RRT) to suitable patients with established renal failure (ERF) is a life-prolonging intervention. The ability to treat is, however, influenced by a number of factors that include the absolute numbers of patients, the choice of RRT modality and the location and capacity of dialysis facilities. The absolute number of patients (prevalence) is dependent upon a dynamic interaction between new (incident) patients, movement between RRT modes—Haemodialysis (HD), Peritoneal dialysis (PD) and Transplantation (Tx)—and overall mortality. The incidence, in turn, reflects the detection of underlying renal disease and subsequent referral rates. In Wales, there had been an historically high incidence of ERF when compared to England, though recent data1 show that such differences are becoming less pronounced. However, the UK as a whole still treats a relatively small proportion of its population with dialysis, compared to most developed countries.

Data from the UK Renal Registry suggest that in the next 10 years the numbers of patients on renal replacement therapy (RRT) will rise at 5% per annum.2 The greatest demand will be for haemodialysis (HD), which is currently growing at a compound rate of ~7% per year, and growth in the number and/or capacity of HD units will be needed to cope with demand. The majority of
HD patients are now elderly and dependent, and consequently many will require centralized dialysis units rather than home treatment options. In a relatively sparsely populated area such as Wales, correct planning of the site and size of dialysis units to facilitate access to treatment will be important.

We used a novel, collaborative approach to study access to current RRT facilities in Wales, which to date have focussed largely around the main renal units. Data from the Welsh Assembly Government, Statistical Directorate, Cartographic Unit; the Welsh population census of 2001; the Welsh Index of Multiple Deprivation 2005, and the UK Renal Registry (2004) were combined to assess prevalence and its relationship to travel time to units and socio-economic status. Using historical, prospectively collected, data, we were able to study the actual growth in demand following the opening of a new unit in West Wales, and have developed a simple model that might help with the planning of the site and size of future units across the Principality.

**Methods**

**General population and deprivation index**

Population data for Wales was obtained, under licence, from the Census of 2001. Data was broken down into the smallest units (census output areas, COA) each of which had a population of $\sim$500. For the purposes of analysis, the whole COA population was assumed to be living in a point defined by the population-weighted centroid. Wales has a very stable population with a relatively low ethnic mix. We assumed no significant population changes between 2001 and 2004 for the purposes of analysis. Data were also obtained to assess the socioeconomic status of the populations contained within each isochrone. The Welsh Index of Multiple Deprivation 2005 provides a measure of deprivation based on seven variables for small clusters of population ($\sim$1500) called lower-level super output areas (LSOA). The factors assessed are: income; employment; health; education skills and training; housing; physical environment, and geographic access to services by bus, train, walking, etc. Each LSOA is then scored and ranked across Wales, with the area ranked 1 being the most deprived.

**RRT data**

Data for the prevalence of patients living in Wales and receiving RRT within the Principality were obtained from the UK Renal Registry, to which all Welsh renal units contribute. This data has recently been validated across Wales by comparing key data items stored in the Registry with the data on the local databases and the case-note records. Data from December 2004 were fully anonymized, including transposing postcodes into $x,y$ coordinates. Each individual patient (categorized only by mode of treatment) could then be placed within the defined areas of a digital map of Wales. There are a small number of Welsh residents who obtain treatment across the border in Shrewsbury, Hereford, Liverpool and Chester, and a few English residents who receive treatment in Wales: these patients were not included in the analyses.

**Unit data**

Main dialysis units (Cardiff, Swansea, Wrexham, Rhyl and Bangor) were defined as centres with a permanent consultant nephrologist presence, in-patient beds, and a dialysis unit. Only one centre in Wales (Cardiff) undertakes transplants, but patients from North Wales are transplanted in Liverpool. Subsidiary units were defined as those with visiting consultant nephrologists and no in-patient renal beds. These were all located in South Wales and under the clinical direction of either Cardiff ($n = 5$) or Swansea ($n = 2$), with all but one within a hospital site. All units were identified and geocoded using Geographic Information System (GIS). Dialysis capacity, based on two daily shifts and three-times-weekly treatment at the time of the analysis, was obtained directly from each unit manager/senior nurse.

**Travel (Drivetime) data**

MapInfo Professional v7.5 and MapInfo Drivetime v 6.1 were used to assess journey times. These were then plotted as lines representing the distance that could be travelled to each centre for the selected travel times (isochrones). All analyses were undertaken by personnel from the Welsh Assembly Government Cartographic Unit, with years of expertise in the use of the software for a wide variety of applications. Clearly, the type of road, the route taken, the time of travel, the weather, the type of vehicle, the effects of urbanization and the ability to park can all influence journey time. In our modelling, we assumed an average journey time under normal driving conditions. In discussions with colleagues and patients, they were generally felt to be a reasonably accurate reflection of reality.
Results

Current dialysis numbers and capacity

Overall, the population of Wales was 2,903,085 in 2001, of whom 2,841,505 (97.9%) were White. In December 2004, the total number of patients receiving RRT was 2,173, giving an overall prevalence of 749 patients per million population (pmp). The numbers (prevalence) by mode of treatment were HD 821 (283 pmp), PD 342 (118 pmp) and Tx 1010 (348 pmp). Combined historic UK Renal Registry and All Wales audit data show sustained growth in HD within Wales, whereas PD numbers are relatively static. Using linear regression analysis on these data, we estimate that there will be ~1,400 patients on HD and ~420 on PD in Wales by 2014 (Figure 1). This in line with published models of growth in the UK Renal Association Standards and others.\textsuperscript{2,3}

Capacity

Haemodialysis capacity was calculated using the number of dialysis treatment points (stations), assuming two shifts of dialysis per day, and that each patient receives HD three times weekly. Under these circumstances each station can treat four patients per week. At the time of data collection, total capacity for Welsh main and subsidiary HD was ~180 stations (720 patients). The capacity was 132 stations (518 patients) in the South, and 48 stations (192 patients) in the North. Current capacity is 193 stations, and when a subsidiary unit is open fully, 198 stations. This enables about 800 patients to be treated three times weekly, still short of dialysis numbers over 1 year ago. The shortfall between capacity and demand is currently only addressed by using twilight shifts (operating regularly in two main units), by dialysing patients outside of official chronic dialysis capacity (e.g. in blocked beds on a ward), and by a small number of patients who receive twice-weekly treatment for medical and/or social reasons.

Travel times

Isochrones for 15, 30, 45, 60 and >60 min journey times from dialysis units under normal driving conditions are shown in Figure 2. The isochrones, combined with Renal Registry and Census data enabled us to determine the population and numbers of patients by dialysis mode contained within each of the Drivetime areas. The derived prevalences and 95%CIs are shown in Table 1. As journey time increases from units, there are significant falls in the prevalence of all modes of RRT. The prevalence of patients receiving HD was significantly higher than Wales as a whole within 15 min drivetime of current units, but thereafter the prevalence was markedly and significantly lower in all isochrones, except at extremes of time, when both very low population and patient numbers

Figure 1. Actual and extrapolated growth (using linear regression analysis) in HD and PD in Wales to 2014.
Figure 2. Digital map of Wales, showing isochrones for driving times from current dialysis facilities.
led to wide confidence intervals. Transplantation rates were again higher within 15 min and lower at between 30 and 60 min drive time. Prevalence of all RRT was higher within 15 min drive of renal units and lower in the population >30 min drive away from a unit. The WIMD 2005 scores for the isochrones <15 min; 15–30 min, and 30–45 min are shown as median and first and third quartile values (Table 1). When compared using the Mann-Whitney U test, these were not statistically different.

**Access to units**

If a drive time of 45 min is taken as a benchmark for maximum driving time for any patient, then there is considerable overlap in the populations that can reach units in that time. For example, a patient living in Swansea could live within 45 min drive of the main Swansea unit and any one of three subsidiary units. In addition, each unit will have a population that can only exclusively be reached within 45 min. Approximately 2.7 m (92%) of the population and 95% of the dialysis patients—778 HD (278 pmp), 318 PD (117 pmp), 969 Tx (363 pmp) and 2065 all RRT (759 pmp)—lived within 45 min of a unit.

We analysed the populations with exclusive access to a unit within 45 min and the populations in the overlap sections. For the sake of simplicity the two largest units with satellite units (Cardiff and Swansea) were analysed as ‘networks’ with all of their units being included under the banner of the main unit. Prevalence analysis of these showed no apparent difference between exclusive and overlap areas, or between the North and South of Wales (Table 2).

**Impact of opening a new unit: Aberystwyth**

This area has historically received clinical care from the unit at Swansea, a 76 mile, ~90 min drive away. Up until 1999, patients requiring HD had to travel to Carmarthen or Swansea. However, since 1999 a new HD facility has been open in the local hospital along with an outreach nephrology clinic. Combined isochrone, renal registry and census data show that the HD prevalence before the unit opened was 117 (±86) pmp (7 patients), significantly lower than for the rest of Wales. The unit was planned to accommodate these patients with some ‘guesstimated’ extra capacity for an expected increase in prevalence. It opened as a 4-station facility able to treat up to 16 patients. However, within 2 years of opening, numbers requiring dialysis rose rapidly and are now at 20. Based on the assumption that the immediate area around the new unit would rapidly reach levels similar to the

<table>
<thead>
<tr>
<th>Drivetime (min)</th>
<th>Population %</th>
<th>HD pmp (95%CI)</th>
<th>PD pmp (95%CI)</th>
<th>Tx pmp (95%CI)</th>
<th>All pmp (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15</td>
<td>1116404</td>
<td>38.5%</td>
<td>401 (324–456)</td>
<td>359 (312–404)</td>
<td>116 (95–138)</td>
</tr>
<tr>
<td>30–45</td>
<td>4141752</td>
<td>14.3%</td>
<td>68 (16–176)</td>
<td>146 (125–165)</td>
<td>69 (16–176)</td>
</tr>
<tr>
<td>45–60</td>
<td>175230</td>
<td>6.0%</td>
<td>16 (9–25)</td>
<td>26 (16–37)</td>
<td>15 (9–25)</td>
</tr>
<tr>
<td>&gt;60 All Wales</td>
<td>598900</td>
<td>2.1%</td>
<td>820 (274–302)</td>
<td>823 (274–302)</td>
<td>100 (100–100)</td>
</tr>
</tbody>
</table>

The median and range of Welsh Index of Multiple Deprivation (WIMD) for each isochrone is also shown. Differences in prevalence were considered significantly different from Wales as a whole if the 95% CIs for did not overlap, pmp, per million population. Significantly higher than for All Wales. Significantly lower than for All Wales.

The WIMD 2005 scores for the isochrones <15 min; 15–30 min, and 30–45 min are shown as median and first and third quartile values.
rest of Wales, our model would have predicted a near immediate demand for ~17–22 patients in the 59,974 population that live within 45 min of the unit. The latest data show 20 patients living in the area, and the confidence limits suggest that HD prevalence is now in line with the rest of Wales (333 ± 146 pmp).

Discussion

It is clear that the numbers of patients needing dialysis, and in particular in-centre haemodialysis, will continue to rise. In Wales, dialysis capacity is overwhelmed, more than 20% of the population still lives more than 30 min drive away from a dialysis unit, and there are areas of relative under-provision. There is, therefore, a need to plan the building of additional, appropriately resourced, facilities. We have combined data from four sources, the UK Renal Registry, the 2001 Census, the 2005 Welsh Index of Multiple Deprivation, and GIS data, and integrated them to provide a picture of current dialysis provision across Wales. Proximity to a dialysis unit is clearly a major factor in determining dialysis prevalence, and the opening of a new facility will, in itself, rapidly increase local prevalence. These effects appear to be independent of a comprehensive measure of deprivation. A combined approach to analysis of GIS, ease of access, and population and dialysis demographics should facilitate both the identification of areas of under-provision, and subsequent planning of the size and site of new units.

In a previous cross-sectional study in West Wales, the likelihood of being referred to the renal service for investigation and treatment of renal disease was inversely proportional to the distance from a renal unit.4 This phenomenon is particularly important for more sparsely populated areas such as Wales, where it is more likely that people will live some distance from dialysis facilities. Reducing the distance effect should iron out irregularities in referral patterns, and this can only be achieved by establishing local ‘renal presence’ in the form of new renal units or outreach clinics. In reality, in Wales, there are unlikely to be any new main renal units, and so an increase in outreach renal clinics/facilities will need to be necessary in addition to expansion of current main unit capacity.

There are a number of other possible contributing factors to referral rates to renal services that have been widely discussed in the literature.5 These include age, socio-economic status, and the proportion of ethnic groups, including Black and South Asian. The non-White population in Wales is very small (~2%) compared to some areas in the UK, where it can be a very significant factor in determining the prevalence of ERF.5,6 In some cities in the UK, the South Asian and Black subgroups (in whom the incidence of renal disease can be up to four times higher7) make up 25–30% of the population (2001 Census). In contrast, the highest prevalence of South Asian and Black ethnicity in Wales was in Cardiff (5.3% of the population), and in Swansea, Newport, Bangor and Rhyl, the prevalence was even lower at 0.4–3.1%. Even allowing for a 400% increase in prevalence within this population, the absolute numbers would be very small and have little impact on the overall picture in Wales. This is supported by our data. We found no significant difference in dialysis prevalence between North and South Wales, although the ethnic minority population in the North is only 0.4%, compared to 2.8% in the South. In a previous cross-sectional study of referral patterns to the renal service in SW Wales, ethnicity was not a significant independent risk factor.4 In addition, ethnic mix would be unable to explain the effect of the opening of the Aberystwyth dialysis unit.

Our longitudinal data show another important slant on the distance effect on referral observation. The prevalence on RRT falls significantly with travel time from a facility, even over relatively small journey times. However, at the extremes of journey time, while it may appear that prevalence once again rises, the relatively small numbers on

| Table 2 Prevalence of dialysis in North and South Wales and in areas served exclusively by one unit or more (overlap) |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Population | HD pmp | 95%CI | PD pmp | 95%CI | Tx pmp | 95%CI | All pmp | 95%CI |
| South | 2,070,915 | 566 | 273 | 251–295 | 253 | 122 | 107–137 | 769 | 371 | 345–397 | 1588 | 767 | 729–805 |
| Exclusive | 1,677,580 | 466 | 278 | 253–293 | 198 | 118 | 102–134 | 561 | 334 | 306–362 | 1225 | 730 | 689–771 |
| Overlap | 1,031,265 | 312 | 303 | 279–337 | 120 | 116 | 95–137 | 408 | 396 | 358–434 | 840 | 815 | 760–870 |
| Wales | 2,708,845 | 778 | 287 | 267–307 | 318 | 117 | 104–130 | 969 | 358 | 335–381 | 2065 | 762 | 729–795 |

Significant differences are defined as those where 95% CIs do not overlap. HD, haemodialysis; PD, peritoneal dialysis; Tx, transplantation.
treatment and the small populations concerned make reliable interpretation of the data uncertain. There are no differences between the North and South of Wales, or for areas that are adjacent to a number of facilities versus those with exclusive access to one. The prevalence on PD appears to be less affected than that for either Tx or HD. This might be expected, since PD is almost entirely home based therapy that tends to be preferred by patients who are more mobile and independent. Under these circumstances, the need for a unit nearby is not as great, and so would be less likely to influence the take-up of treatment. Haemodialysis and transplantation require specialist facilities for treatment and follow-up, which may be some distance away.

The specific influence of socioeconomic status was assessed using the WIMD 2005. We found that this comprehensive measure did not differ significantly with travel time, and was thus independent of the observation of changes in dialysis prevalence. This is also borne out by the observation of an initial low prevalence of dialysis in the Aberystwyth area and the dramatic rise in prevalence, with regression to the national mean, precipitated by the opening of the new unit, all in the same population. It is possible that patients may be more likely to opt for HD if they live in a remote area and a new facility opens, or that patients might move into an area for the same reason. We have no data to support the latter. In addition, a simple switch of modality would result in the same overall dialysis prevalence but a change in how it is delivered. Our data suggest that the opening of a new unit appears to increase prevalence in all modes of treatment, and that the increase is therefore due to the recognition of previously undiscovered patients with severe chronic kidney disease.

Haverfordwest is the major town in Pembrokeshire in South Western Wales. This is one of the immediately obvious major population centres and geographical areas in South Wales with no local dialysis facility within a 30 min drive, according to our analysis (Figure 2).

<table>
<thead>
<tr>
<th>Population</th>
<th>HD pmp</th>
<th>95% CI</th>
<th>PD pmp</th>
<th>95% CI</th>
<th>Tx pmp</th>
<th>95% CI</th>
<th>All pmp</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>121 253</td>
<td>17 140</td>
<td>73–207*</td>
<td>13 107</td>
<td>49–165</td>
<td>26 214</td>
<td>132–296*</td>
<td>56 462</td>
</tr>
<tr>
<td>2004</td>
<td>121 253</td>
<td>14 115</td>
<td>-3–233*</td>
<td>17 140</td>
<td>73–207</td>
<td>26 214</td>
<td>132–296*</td>
<td>57 470</td>
</tr>
</tbody>
</table>

*Significantly different from All Wales 2004. HD, haemodialysis; PD, peritoneal dialysis; Tx, transplantation.
with built-in capacity to accommodate future growth of 7% per annum for in-centre HD.

In Wales, all but one of the current HD units are based on hospital sites. In the rest of the UK, subsidiary units are sited in more ‘off hospital’ locations. Without exception, the major area of complaint for patients undergoing HD is transport and journey times: a journey to and from an HD unit in Wales can take longer than the treatment itself. The large and sparsely populated areas outside of the major towns have small roads that also traverse difficult terrain, making travel time even longer and less predictable. The location of future units should, therefore, take these and other factors into account. The Drivetime software described here gives a much more accurate picture of travelling difficulties than can be gleaned from a map alone, and we suggest it should be integral to the planning process. Combining the GIS, Renal Registry, Census and WIMD 2005 data makes it even more flexible.

Adopting a multidisciplinary and analytical approach to the planning of the location and capacity of future units should improve patient access to dialysis facilities and, therefore, reduce travel time and ensure that sufficient space is available for treatment. The use of the simple models outlined here should help reduce the tendency for new units to be saturated within a short period of time, and should also allow the objective comparison of the impact of several potential sites within an area.

References