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Original Article

Estimating the financial cost of chronic kidney disease to the NHS in England

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Abstract

Background. Chronic kidney disease (CKD) is a major challenge for health care systems around the world, and the prevalence rates appear to be increasing. We estimate the costs of CKD in a universal health care system.

Methods. Economic modelling was used to estimate the annual cost of Stages 3–5 CKD to the National Health Service (NHS) in England, including CKD-related prescribing and care, renal replacement therapy (RRT), and excess strokes, myocardial infarctions (MIs) and Methicillin-Resistant Staphylococcus Aureus (MRSA) infections in people with CKD.

Results. The cost of CKD to the English NHS in 2009–10 is estimated at £1.44 to £1.45 billion, which is ~1.3% of all NHS spending in that year. More than half this sum was spent on RRT, which was provided for 2% of the CKD population. The economic model estimates that ~7000 excess strokes and 12 000 excess MIs occurred in the CKD population in 2009–10, relative to an age- and gender-matched population without CKD. The cost of excess strokes and MIs is estimated at £174–£178 million.

Conclusions. The financial impact of CKD is large, with particularly high costs relating to RRT and cardiovascular complications. It is hoped that these detailed cost estimates will be useful in analysing the cost-effectiveness of treatments for CKD.

Keywords: chronic kidney disease; English NHS; expenditure; health economics

Introduction

Chronic kidney disease (CKD) is a major and growing challenge for health care systems. The prevalence rates of CKD appear to be increasing globally [1, 2] and are likely to increase further as a consequence of ageing populations and increased prevalence of Type II diabetes mellitus. Recent studies indicate that 6–8.5% of adults in England have Stages 3–5 CKD [3–5]. The prevalence of renal replacement therapy (RRT) in England has grown by almost 50% over the past decade [6, 7].

In the National Health Service (NHS) in England, annual spending on kidney care was estimated at £445 million in 2002 (~£566 million in 2009–10 prices) [8]. Programme budgeting analysis by the Department of Health estimated the total NHS expenditure on kidney care, including CKD, at £1.64 billion in 2009–10 [9].

Over the past decade, there have been significant changes in the management of CKD in England. The Quality and Outcomes Framework for General Practice (QOF) provides financial incentives for the identification and management of CKD and hypertension in primary care. National Institute for Health and Clinical Excellence (NICE) guidelines set out recommended diagnostic and treatment pathways for CKD, with a particular emphasis on blood pressure control and the use of angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin-II receptor blockers (ARBs) to manage proteinuria [10].

The objective has been to identify people with CKD earlier in their illness in order to reduce the risk of end-stage renal disease (ESRD) and of cardiovascular events for which people with CKD have elevated risk [11, 12].

The NICE recommendations were explicitly based on criteria relating to high clinical impact and to more efficient use of NHS resources [10]. However, the financial consequences for the NHS of CKD have not been well described so far.

The financial impact of excess cardiovascular events in the CKD population is generally not recognized in the estimates of the cost of CKD.

Materials and methods

The annual cost to the NHS in England of Stages 3–5 CKD, including ESRD, was estimated. All costs are expressed in 2009–10 British pounds. Activity figures for 2009–10 were used where available. In some instances, activity data for 2008–09 or for calendar year 2009 were used.

Both direct and indirect costs were estimated. Direct costs are defined as those arising from health care provided explicitly for or because of CKD. Indirect costs are defined as those arising from non-renal conditions for which CKD carries increased risk. For non-renal conditions, costs were estimated only for 'excess' events, above the level expected for a matched population without CKD.

The NHS in England provides annual data on primary care activity through the QOF [13] and annual activity and cost data for all NHS hospitals through NHS Reference Costs [14]. Hospital Episode Statistics (HES) provide details of diagnoses, procedures and length of stay for all hospital admissions. The NHS Information Centre collects data on prescribing and associated expenditure in primary and secondary care.

The UK Renal Registry [7] and NHS Blood and Transplant [15] provide data on RRT incidence and prevalence.

Where possible, data on patient numbers, activity levels and costs were taken from these national data sets. Evidence from published studies and local data sets were also used (Table 1). Staff costs were taken from the Personal Social Services Research Unit (PSSRU) [16].

Direct costs were estimated for primary care, outpatient attendances, admitted patient care and RRT. There is some overlap between these areas. Decisions about the classification of costs were taken in a pragmatic way, according to the data availability. Care was taken not to double-count costs.

Indirect costs were estimated for an excess length of hospital stay, and for excess Methicillin-Resistant Staphylococcus Aureus (MRSA) infections, strokes and myocardial infarctions (MIs).

Generalized linear model regression (gamma family, log link) was conducted, using HES data, to estimate the impact of CKD diagnosis on the length of stay, keeping patients' age, gender, index of multiple deprivation decile, admission method (elective or emergency) and specialty type (surgical or non-surgical) constant. Admissions in adults with CKD were identified by International Classification of Diseases (ICD) 10 Code N18. Activity in CKD-specific Healthcare Resource Groups (HRGs) was excluded, as costs for activity in these HRGs are counted under admitted care. Maternity admissions and non-emergency hospital transfers were excluded.

Data on the incidence of MRSA infection in RRT patients in 2008–09 were provided by the UK Health Protection Agency (HPA).

An economic model was constructed to estimate excess strokes and MIs in people with CKD. The model estimated the expected incidence of strokes and MIs in the CKD population and in a non-CKD population with the age and gender distribution of the CKD population. Costs were estimated for strokes and MIs in excess of the number expected in the absence of CKD (Table 2).

Further details of methodology are given in the Supplementary Appendix.

Results

Direct costs

Primary care. In 2009–10, 1.81 million people were recorded by general practitioners (GPs) as having CKD Stages 3–5 [13]. It was assumed that all these patients had two GP consultations a year in addition to care they would receive if they did not have CKD.

Based on QOF activity data, it is estimated that 1.76 million people with CKD had a blood pressure test, and that 1.35 million had an albumin:creatinine ratio (ACR) or protein:creatinine ratio (PCR) test in the 15 months preceding the 2009–10 QOF data collection. It was assumed that these tests took place during a single visit to a practice nurse.

The QOF register recorded that CKD prevalence increased by 78 428 in 2009–10. Adjustments for mortality suggest that ∼119 000 new cases were diagnosed in 2009–10. (Mortality was estimated using age distribution in CKD from an English study and mortality rates by age from a US study [3, 11].)

It was assumed that patients had two additional GP visits and two additional ACR or PCR tests in the year of diagnosis.

The total expenditure on primary care tests and consultations for CKD is estimated at £143 million (Table 3).

A longitudinal population cohort study at an English university hospital found that 89.4% of patients with Stages 3–5 CKD were hypertensive in 2008–10. The average annual cost of anti-hypertensive medications per hypertensive patient was estimated at £132 [17].

A model was constructed to estimate the expected prevalence of hypertension in a non-CKD population with the age and gender distribution of the CKD population. Age and gender distributions in the CKD population were estimated from a primary care study [3]. Hypertension prevalence for the general population, by age and gender, was derived from Health Survey for England data [18].

The model suggests that the expected prevalence of hypertension in an age- and gender-matched non-CKD population is ∼26%. If national prevalence of hypertension in CKD is similar to the level in the cohort study, it is estimated that 1.2 million people in the diagnosed CKD population are prescribed anti-hypertensive medications, over and above the number one would expect in a matched non-CKD population.

If anti-hypertensive medications are prescribed at national level in the same quantities and proportions as for the study cohort, the annual cost of this excess prescribing is estimated at £152 million (Table 4).

The level of anti-hypertensive prescribing estimated here is very much higher than that recorded in the QOF. In 2009–10, only 4.6% of patients on CKD registers were recorded in the QOF as being treated with an ACEI or ARB. However, the QOF indicator covers only patients with proteinuria and does not include anti-hypertensive medications other than ACEIs and ARBs.

Data supplied by the NHS Information Centre indicate that the expenditure on primary care prescribing of vitamin D supplements, erythropoietin (EPO), erythropoiesis-stimulating agents (ESAs) and phosphate binders was £27 million in 2009–10 (Table 5).

Outpatient care. There were 679 538 nephrology outpatient consultations in England in 2009–10, at a total cost of £106 million [14]. Figures supplied by two English

Table 1. Summary of data sources and assumptions for estimation of direct costs

Category of care		Patient numbers	Costs	Assumptions	Notes
Primary care	Activity				
	Blood pressure (BP) monitoring and control, ACR/PCR tests	QOF	PSSRU [16] for staff inputs, NICE [10] for lab. tests	Patients with diagnosed CKD have two GP consultations a year in addition to those they would have without CKD. BP tests and urine tests take place at a single 20-minute consultation with a practice nurse every 15 months.	
	Prescribing anti-hypertensive medications	Farmer *et al.* [17]	Farmer *et al.* [17]	National prevalence of hypertension in CKD is similar to East Kent levels and anti-hypertensive medications in CKD are prescribed in the same quantities and proportions as for the East Kent cohort.	Costs are estimated only for excess prescribing in the CKD population.
	Prescribing vitamin D, EPOs/ESAs, Phosphate binders	Not estimated	NHS Information Centre ePACT	All primary care prescribing of these medications is for people with CKD	Estimates are of price paid, not list price
Outpatient care (OP)	Nephrology OP attendances	NHS Reference Costs 2009–10 [14]	NHS Reference Costs 2009–10 [14]	50% of nephrology outpatient attendances are for CKD Stages 3–5 (excluding RRT)	
Admitted patient care	Admissions in CKD-specific HRGs (LA05Z, LA08A-C, LA08E-F and QZ13A-B)	NHS Reference Costs 2009–10 [14]	NHS Reference Costs 2009–10 [14]		
RRT	Transplants—initial assessment	NHS West Midlands Specialised Commissioning Team 2010 [19]	NHS Kidney Care 2010 [20]		Costs adjusted upwards by 15% to allow for overheads
	Transplants—waiting list clinic attendances	NHS Blood and Transplant [15]	NHS Kidney Care 2010 [20]		
	Transplant acute episode and post-transplant care to the end of Year 1	NHS Blood and Transplant [15]	NHS Kidney Care 2010 [20]		
	Immunosuppression Year 1	NHS Blood and Transplant [15]	NHS West Midlands Specialised Commissioning Team 2010 [19]		
	Care after Year 1	UK Renal Registry [7]	NHS West Midlands Specialised Commissioning Team 2010 [19]		
	Live donor costs		NHS Reference Costs 2009–10 [14]		Live donor cost estimates are likely to be a substantial underestimate
	Dialysis care	UK Renal Registry [7]	NHS Reference Costs 2009–10 [14]		
	Dialysis transport	The Information Centre for Health and Social Care 2011 [21]	NHS Reference Costs 2009–10 [14]		

hospital trusts indicate that ~50% of nephrology outpatient consultations are for Stages 3–5 CKD (excluding consultations for RRT patients, which are counted separately below). If these proportions are representative of the country as a whole, the cost of outpatient consultations for Stages 3–5 CKD, excluding RRT patients, is estimated at £53 million.

Admitted patient care. Admitted patient care in NHS Reference Costs is classified by HRGs. An HRG is a

Table 2. Summary of data sources and assumptions for estimation of indirect costs

	General Population risk	Excess risk, Stages 3–4 CKD	Excess risk, dialysis	Cost
Stroke	Truelsen *et al.* [35]	Weiner *et al.* [36]	Iseki *et al.* [37]	National Audit Office [38]
MI	Oxford Record Linkage Study (data supplied to British Heart Foundation) [39]	Meisinger *et al.* [40]	No robust source identified. Stages 3–4 excess risk used.	NICE [41]

Table 3. Expenditure on primary care tests and consultations for CKD, as specified in the QOF, 2009–10

Intervention	Number of patients	Unit cost	Frequency	Annual cost
GP consultation	1 817 871	£32	6 months	£116 343 744
Additional GP consultations for newly diagnosed cases	119 359	£32	2 in first year	£7 639 004
Consultation with a practice nurse	1 760 581	£10.00	15 months	£14 084 647
ACR/PCR laboratory test	1 347 584	£3.46	15 months	£3 730 112
Additional ACR/PCR tests for newly diagnosed cases	119 000	£3.46	2 in first year	£823 480
				£142 620 986

grouping of clinically similar treatments that are also similar in cost. Admitted patient HRGs which are specific to CKD, or likely to contain almost exclusively CKD activity, accounted for 63 504 hospital admissions in 2009–10 and costs of £75 million [14]. Costs by HRG are supplied in the Supplementary Appendix.

Renal replacement therapy

In 2009, 40 962 people in England were receiving RRT [7]. About 47.4% were transplant recipients, 44.4% were on haemodialysis (HD), and 8.2% were on peritoneal dialysis (PD).

In 2009–10, 2329 people received kidney transplants and there were 6178 people on the waiting list for transplant [15]. Transplant prevalence at the end of 2009 was 19 418 [7]. Approximately 2,500 people a year attend initial transplant assessment clinics (2008–09 figures) [19].

The number of patients receiving ongoing post-transplant care after 1 year in 2009–10 was estimated by deducting the 2009–10 incident population from the December 2009 prevalent population. No costs are counted for patients who died or experienced graft failure during the year.

Table 4. Estimated numbers of people with CKD and hypertension, and costs of anti-hypertensive medications, 2009–10

Hypertension in CKD	Prevalence (%)	Number of patients	Annual cost of anti-hypertensive medications
All hypertension	89.4	1 625 260	£214 566 790
Expected hypertension	26.0	472 369	
Excess hypertension	63.4	1 152 891	£152 204 595

Table 5. Primary care prescribing of vitamin D, EPO/ESAs, and phosphate binders, 2009–10

Product	Items	Primary care expenditure
Vitamin D	662 006	£7 420 039
EPO/ESA	45 797	£9 723 189
Phosphate binders	59 225	£9 413 957
Total		£26 557 185

Table 6. Estimated expenditure on kidney transplants, 2009–10

	Annual cost per patient	Patients	Annual expenditure
Initial Assessment clinic	£2537	2531	£6 421 018
Waiting list clinic attendances (4 × year)	£2971	6178	£18 356 775
Acute transplant episode	£14 731	2329	£34 307 984
Post-transplant OP visits year 1	£12 884	2329	£30 007 668
Immunosuppression after Week 12 (Year 1)	£4810	2329	£11 201 675
Ongoing care (after Year 1)	£7318	17 089	£125 050 287
Live donor costs			£59 112
Total			£225 404 520

It is not possible to derive robust estimates of the total cost of transplant from routine data sets. Two recent studies have estimated unit costs for kidney transplants in England [19, 20]. Based on these figures, and Reference Cost estimates of donor-related expenditure, the annual cost of transplant is estimated at £225 million (Table 6). This is likely to be an underestimate; donor-related activity is substantially under-recorded, and no cost estimates were available for cadaveric organ retrieval or transport. The average annual cost per patient over the first 5 years of transplant (including pre-transplant costs) is estimated at £14 618.

The unit costs used relate to adult transplant recipients. In the absence of detailed cost estimates for children, the estimates for adult care have been applied to all transplants.

There were 21 544 people on dialysis in England at the end of 2009; 18 191 were on HD and 3353 were on PD [7]. 2009–10 NHS Reference Costs show dialysis activity valued at £505 million [14]. Of this sum, ~£56 million was recorded for outpatient activity.

Table 7. Estimated expenditure on dialysis, 2009–10

	HD	PD	All dialysis
Patients	18 191	3353	21 544
Implied unit cost	£24 043	£20 078	£23 426
Total cost	£437 359 152	£67 321 076	£504 680 228

Implied annual per patient costs are ∼£24 043 for HD and £20 078 for PD (Table 7).

In principle, NHS Reference Costs are calculated on a full cost absorption basis. Therefore, no further costs are counted here for drugs provided to dialysis patients by acute providers.

Hospital admissions for complications arising from RRT are not included in these tables. At least some of these costs are captured in the estimates of inpatient activity set out above. Of the £75 million of inpatient expenditure identified, £24 million is in HRGs specifically identified as associated with RRT. It is likely that some of the remaining activity is also related to RRT, but it is not possible to quantify this.

A 2010 audit found that NHS-funded transport was provided for 61% of patient journeys in England for hospital and satellite HD [21]. If these results are representative, they suggest that ∼3.3 million NHS-funded journeys are taken each year for dialysis. This estimate is based on the assumption that, on average, patients travel to the dialysis centre three times a week, 52 weeks a year.

Costs of £50 million have been estimated for these journeys, using the average transport cost for a patient attendance from NHS Reference Costs 2009–10. This is equivalent to £2792 for each HD patient, bringing the estimated annual mean cost of HD to £26 835 per patient. No transport costs are estimated for transplant or PD patients.

Length of stay

Hospital Episodes Statistics show that in 2009–10, there were 86 488 hospital admissions with at least one overnight stay for patients with a recorded CKD diagnosis (excluding admissions in CKD-specific HRGs). A multivariate regression analysis indicates that the expected length of stay was 35% (95% CI 33–36%) longer for a patient with CKD than for a patient without CKD. Using the mean length of stay for patients without a recorded CKD diagnosis (6.78 days) as a baseline, the number of excess bed days in CKD was estimated at 203 625. The NHS Institute has estimated the cost of an inpatient bed day at £225 [22]. The expenditure on excess bed days for people with CKD is estimated at £46 million.

MRSA infection

HPA data indicate that in 2008–09, there were 153 reported and verified cases of MRSA in HD patients in England [23].

The total number of MRSA infections reported in England (among renal and non-renal patients) was 2935 in 2008–09, or ∼0.006 per 100 people. Given these figures, the expected number of infections in 17 349 people (the number of people receiving HD at the end of 2008 [23]) was 0.98, so ∼152 infections can be attributed to CKD. This figure is not adjusted for age or co-morbidity as MRSA data are not available for population subgroups. Sensitivity analysis is shown in the Supplementary Appendix.

The hospital costs for the treatment of a bloodstream infection were estimated at £5397 in 1994–95 [24] (£9316 in 2009–10 prices). Using this unit cost, the hospital cost for the treatment of 152 infections is estimated at £1.4 million.

Table 8. Estimated excess strokes and MIs in CKD population and associated expenditure, 2009–10

	Unit cost	QICKD		HSE	
		No. of events	Expenditure	No. of events	Expenditure
Stroke	£12 200	6734	£82 155 382	6533	£79 703 607
MI	£7734	12 334	£95 391 470	12 189	£94 269 590

Strokes

The economic model estimates the incidence of stroke in a non-CKD population, with the age and gender profile of the CKD population, at 9.6 per 1000 patient-years. The incidence of stroke in the CKD population is estimated at 12.0 per 1000 patient-years. Using prevalence estimates for CKD derived from a recent study [4], the number of excess strokes in the CKD population, relative to an age- and gender-matched population without the condition, is estimated at 6734 in 2009–10. Excess strokes are estimated for the population aged 25 and above. No excess strokes have been estimated for the transplant population.

Sensitivity analysis was conducted, using Health Survey for England (HSE) CKD prevalence estimates [5]. This produced an excess stroke estimate of 6533 in 2009–10.

The cost to the NHS of care for excess strokes in people with CKD is estimated at £80 to £82 million in 2009–10 (Table 8).

Myocardial infarction

The economic model estimates the incidence of MI in a non-CKD population of the age and gender profile of the CKD population at 7.4 per 1000 patient-years. The incidence for the CKD population is estimated at 11.9.

Using prevalence estimates for CKD from a recent study [4], the model suggests that 12 334 excess MIs occurred in people with CKD in 2009–10. Sensitivity analysis was conducted using HSE prevalence estimates [5]. This produced an excess MI estimate of 12189 in 2009–10.

The cost of excess MIs in CKD is estimated at £94 million to £95 million in 2009–10 (Table 8).

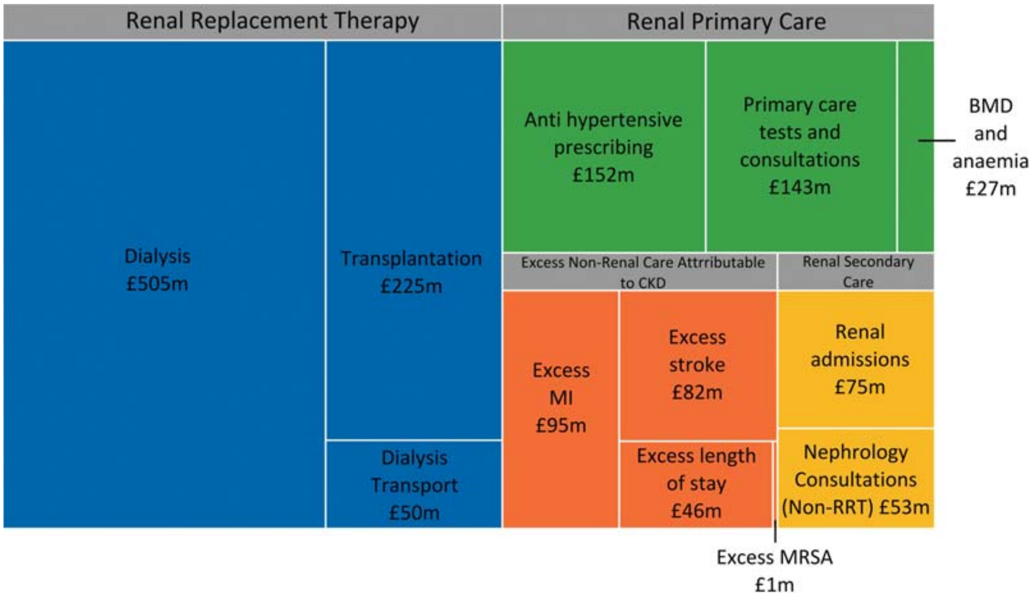

Fig. 1 Distribution of costs attributable to CKD (to the nearest £million), 2009–10. Where estimates have been calculated as a range, the higher figure is shown.

Total expenditure

The overall annual cost of CKD is estimated at £1.44 to £1.45 billion. This is equivalent to ~£795 for every person recorded with a diagnosis of CKD in the QOF. Direct costs account for ~85% and dialysis alone for 35% of the total expenditure (Figure 1).

Discussion

The accuracy of cost estimates is inevitably dependent on the quality of the underlying data sources and the appropriateness of the assumptions made in the economic modelling. For this reason, we have attempted to be as transparent as possible in setting out data sources and key assumptions. Much of the estimation is based on coded activity within the NHS; not all CKD-related activity may be coded as such.

The lack of appropriate data sources or epidemiological studies meant that the costs of a number of CKD-related activities could not be estimated. No costs have been included for conservative care, or for prescribing in areas where it was not possible discretely to identify costs for the CKD population.

It is known that CKD entails excess risk of conditions such as heart failure and fragility fractures, which are not considered here [25]. There is also evidence that people with CKD are at increased risk of infections other than MRSA, and that this effect holds for the general CKD population (Stages 3–5), not just for those on HD [26–28].

The focus of this paper is on NHS costs. However, CKD also imposes costs on patients and their carers through lost working days and morbidity. There are also additional costs to the public through tax and benefit effects and the use of social care services.

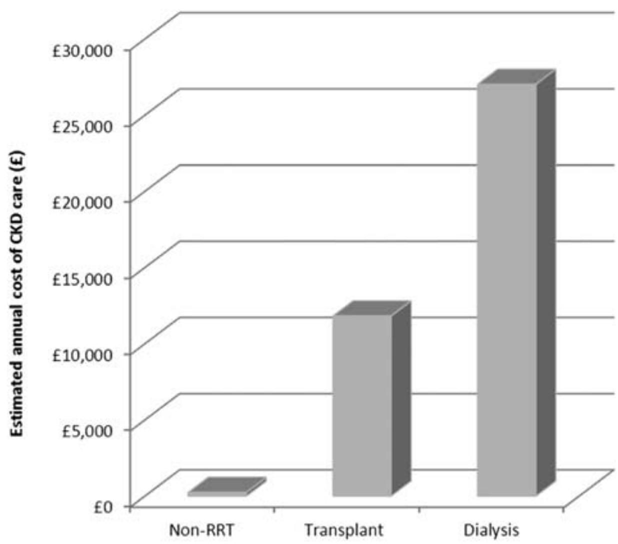

Fig. 2 Estimated annual cost of direct CKD care, RRT and non-RRT patients.

All estimates are based on current practice rather than on optimal care.

The estimate of expenditure on CKD presented here may be compared with NHS Programme Budgeting data, which showed spending on renal problems at £1.64 billion in 2009–10. However, the Programme Budgeting renal category is broader than CKD, and does not include indirect costs. The total direct costs estimated here are £1.23 billion. More than half of the total estimated expenditure is for RRT, although the RRT population comprises only 2% of the diagnosed CKD population. The mean annual cost of direct CKD care per patient on dialysis can be crudely estimated at £27 000, the cost per transplant recipient at £12 000 and the cost per patient not on RRT at £235 (Figure 2).

Given the impact of ESRD on patients' quality of life, and the high level of expenditure on RRT, there is a need for further analysis on the potential for improved outcomes and cost savings through enhanced strategies to reduce progression rates to ESRD. For example, modelling based on the figures in this paper suggests that ACEI/ARB prescribing for patients with hypertension and proteinuria produces a mean annual net saving to the NHS of ~£470 per treated patient over a 5-year perspective. This saving arises through reduced ESRD, stroke and MI risk [29, 30]. QOF data indicate that, in 2009–10, 82 834 people with hypertension and proteinuria (6.1% of those who had an ACR or PCR test) were treated with ACEIs/ARBs. The net annual saving for this group, over a 5-year perspective, is estimated at £39 million.

However, ~468 000 people on CKD registers did not undergo an ACR or PCR test in the 15 months before the 2009–10 QOF data collection. If hypertension and proteinuria joint prevalence were at the same level in the untested group as in the tested CKD population, there could be an additional 29 000 patients who would benefit from ACEI/ARB prescribing. The net annual saving from ACEI/ARB prescribing for a group of this size is estimated at £13 million over a 5-year perspective. There may also be undiagnosed hypertension and proteinuria in the 900 000 to 1.8 million people who are believed to have undiagnosed CKD [3–5].

There is also a need for further work on the relative costs and benefits of RRT modalities. The implied annual per patient cost for PD presented in this paper is lower than that for HD. However, these figures are derived from Reference Costs, and do not include the full impact of infections and complications. Most recent UK studies have found that mean costs are lower for PD than for HD [31–33], though one study reported that it may be more cost-effective to manage patients starting RRT with hospital HD than Continuous Ambulatory Peritoneal Dialysis, given the existence of HD infrastructure [34]. Home HD may be less expensive than PD [33]. There is also uncertainty regarding the relative clinical effectiveness of different modalities [32].

Because of the paucity of data on resource use by people with CKD in the English NHS, cost-effectiveness and cost–benefit studies have often been based on international data. However, it is known that care delivery and associated expenditure vary substantially across countries. It is hoped that this paper will provide a robust foundation for cost analysis in future studies and for tackling questions such as the cost-effectiveness of screening for CKD and strategies for early detection and intervention.

Supplementary data

Supplementary data are available online at http://ndt.oxfordjournals.org.

Conflict of interest statement. None declared. The contents of this paper have not been published previously in whole or part.

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