Economic report : home haemodialysis

AUTHOR(S)

Jaithri Ananthapavan, J Lowin, E Bloomfield

PUBLICATION DATE

01-01-2010

HANDLE

10536/DRO/DU:30063031

Purchasing and Supply Agency

Centre for Evidence-based Purchasing

Economic report

Home haemodialysis

CEP10063

March 2010

Informing procurement - Encouraging innovation

Contents

Summary

When kidney dysfunction reaches a critical level, renal replacement therapy is required to sustain life. Haemodialysis is the most common form of dialysis and involves the cleansing of the blood via a dialysis machine. Haemodialysis can take place in a variety of settings. This cost-effectiveness analysis compares home based haemodialysis with hospital based haemodialysis for patients who are suitable for the home intervention. The cost-effectiveness of home haemodialysis is also compared with satellite unit haemodialysis, and the impact of indirect costs on the economic evaluation results is assessed.

Home haemodialysis involves undertaking haemodialysis in the home setting, either independently or with the assistance of a friend or family member. Hospital haemodialysis involves travelling to the hospital and undertaking haemodialysis with the assistance of nursing staff and under the supervision of medical staff. In a satellite unit, treatment is managed by nursing staff with little medical input.

A literature search and review was undertaken to inform the model. The aim of the literature review was to identify and review the published evidence on the clinical and cost-effectiveness of home versus hospital or satellite unit haemodialysis. A structured search based on a previous systematic review was undertaken using several databases and limited to publications after 2001. The clinical studies reviewed were largely observational studies and therefore it was difficult to exclude selection bias as an explanation for the reported results. However, the evidence suggested that home based haemodialysis was at least as clinically effective as hospital and satellite based haemodialysis in terms of renal function, safety and quality of life. The economic evaluations reviewed generally found that home based haemodialysis therapies were either the dominant strategy or a cost effective strategy compared with hospital and satellite unit haemodialysis. Data on resource use and health related utility for haemodialysis interventions are limited, especially in the home setting.

A cost-effectiveness analysis was conducted based on a state transition Markov model. The model time horizon is lifetime and a 1 month cycle length is employed. For the home haemodialysis intervention, patients start with hospital haemodialysis, where they receive training before transition to the home setting. Once patients start home based treatment, patients in the model can die, have a transplant, transfer to peritoneal dialysis or return to hospital dialysis due to home haemodialysis modality failure. Patients in the hospital haemodialysis arm are able to experience all the same transitions as those in the home based intervention but cannot transition to any of the home based haemodialysis states.

The cost categories included in the calculation of Markov state costs include the cost of access surgery, dialysis, complications, medications and other health care services. The key costing assumption for the home haemodialysis intervention is that the capital building costs for home adaptation occur at the start of the home based intervention. The cost of NHS transport has been included in the base case for the hospital haemodialysis intervention. There was little information available regarding the health related quality of life of patients undertaking home based haemodialysis. A key assumption is that health related quality of life is better in the home haemodialysis group compared with hospital haemodialysis and similar to that for patients undertaking limited care haemodialysis.

The base case results and one way sensitivity analyses indicate that home haemodialysis is cost saving (approximately £20,700) and more effective (approximately 0.38 QALYs) than hospital based haemodialysis. Home haemodialysis remained the dominant strategy in all the sensitivity analyses undertaken. When indirect costs were included in the analysis, home haemodialysis remained the dominant strategy. In the comparison with satellite unit haemodialysis, home haemodialysis was once again the dominant strategy, resulting in approximately £17,000 of cost savings and utility improvement of 0.38 QALYs.

The main drivers of the model are the variables that impact on the amount of time the cohort is exposed to the home HD intervention (*i.e.* model time horizon, transplantation rates and home HD modality failure rate).

Home haemodialysis is a cost effective treatment strategy for eligible patients producing a cost saving and improvements in health related quality of life compared with hospital based and satellite unit based haemodialysis.

Background

Kidney function is required to regulate blood pressure, excrete waste from the blood, and regulate certain hormonal functions. When kidney function reaches a critical level, renal replacement therapy (RRT) is required to support life. If renal transplantation is not an option, or while waiting to receive a donor kidney, patients are generally treated with either haemodialysis (HD) or peritoneal dialysis (PD). In the UK in 2007, 45,484 adult patients received renal replacement therapy, most commonly transplantation (46.6%), followed by HD (43.2%) and then PD (10.2%) [1].

Haemodialysis involves removing blood from the patient, cleaning it by passing it through a dialyser, and returning it to the patient. Haemodialysis can be carried out in a hospital setting, in a satellite unit or within the patient's home. The proportion of HD patients receiving therapy in the different settings in 2007 is presented in table 1.

Table 1. Setting of haemodialysis delivery in 2007*

Patient population	Home	Hospital	Satellite
Under 65 years	3.8%	57.7%	37.2%
Over 65 years	1.2%	58.1%	40.7%
Non-diabetics (all ages)	2.5%	58.8%	38.8%
Diabetics (all ages)	0.0%	62.2%	37.8%

*Figures are calculated from data reported in the UK Renal Registry annual report for 2008 [1].

Rationale and scope

This economic report evaluates the costs and consequences associated with home HD as an alternative to hospital HD. An additional analysis considers the comparison of home HD with satellite HD. An economic model is constructed based on published evidence. The scope is limited to assessment of costs in those patients requiring renal replacement therapy (RRT) who have been designated as suitable for HD. The analysis does not consider frequency of treatment or other methods of RRT.

This report summarises available literature and describes the structure and findings of the economic model. An interactive version of the model is also available, allowing users to determine the likely cost-effectiveness of the technology within their own organisations, on the basis of local data.

Product description

Home HD provides patients with an additional treatment option. Patients and carers (patient's family or friends) are trained in how to perform HD independently at home. Training can take 2 - 4 months to complete, during which time the patient will generally attend a renal unit for treatment sessions. The main advantage of home HD is the ability to tailor the dialysis regime (timing, length and frequency) to suit individual patients [2]. Other advantages include decreased travel and waiting time compared with hospital and satellite HD [2].

Hospital HD is provided in a specialist dialysis unit of a large hospital. Patients will generally receive outpatient treatment three times a week for 3 - 5 hours [2]. The advantages of hospital HD include the availability of trained physicians and nurses at all times, and their ability to deal with any emergencies that might arise [2].

Satellite HD units were developed to improve geographical accessibility of dialysis services. They are largely run by trained renal nurses with limited input from medical staff [3]. For many patients, the advantage of HD being administered in a satellite unit is the decreased travel time. However, if complications arise, patients may need to be transferred to the hospital renal unit or emergency department [2].

Literature review

Objective

The aim of the literature review was to identify and review the published evidence on the clinical and cost-effectiveness of home HD versus hospital or satellite HD.

Scope

A national systematic review and economic evaluation entitled *'Systematic review of the effectiveness and cost-effectiveness, and economic evaluation of home versus hospital or satellite unit haemodialysis for people with end-stage renal failure'* was conducted in 2003 as part of the HTA programme [2]. The scope of the current report was to present an update on the literature published thereafter. The review was structured rather than systematic. It was based on the systematic review search strategy, but the approach was less stringent than that required for a formal systematic review.

Attempts were made to include studies reporting results for any adult patient requiring chronic RRT. Studies reporting the effectiveness of different regimes of haemodialysis (*eg* short daily or nocturnal haemodialysis) have not been included unless the study included one group who were investigated in the home setting and another group in the hospital or satellite unit. Studies assessing the effectiveness of PD were excluded as the aim was to investigate the effectiveness of the different settings for the delivery of HD.

Methods

A structured search was conducted to identify relevant papers published from January 2001 through to January 2010. OvidSP was used to carry out searches using the MEDLINE, EMBASE and EBMR databases. The search updated the search strategy used in the HTA review [2]. The search strategy was modified to ensure all studies with subjects on HD were included, and not limited to those defined as having end stage renal failure. Full details of the search strategy are given in appendix 1.

Inclusion and exclusion criteria

The search strategy resulted in 5577 papers. All titles and abstracts were reviewed to identify potentially relevant papers. 46 papers were deemed potentially relevant to the clinical review and 30 papers for the economic review. The full-texts of all potentially relevant papers were acquired. Inclusion and exclusion criteria were applied to the papers in order to define the final set of papers suitable for review.

The following inclusion and exclusion criteria were applied for the clinical effectiveness review. The criteria are based on those applied by the HTA conducted by Mowatt *et al* [2].

- Participants: adult patients requiring RRT.
- Type of study: systematic reviews and all interventional and observational studies were included due to the lack of studies with high quality interventional designs.
- Interventions: home HD compared to either hospital or satellite HD. Studies investigating PD undertaken in any setting, or a mix of subjects on HD and PD were excluded.
- Outcomes: quality of life, hospitalisation rates, employment status, technique failure, adverse events / complications, mortality, dialysis adequacy, blood pressure and renal disease biochemistry.
- Reporting of methods: reviews that did not have a methodology section reporting the strategy used to include and exclude studies were excluded.
- Publication date: the date of publication was from 2001 to week 1 2010. The reference list of the systematic review [2] was reviewed and any studies from 2001 already included in the HTA review were excluded from the current review1.
- Language: studies not in the English language were excluded.

Similar inclusion criteria were applied to the retrieved cost-effectiveness papers.

- Type of study: all cost studies, partial and full economic evaluations and utility studies that met the above '*Participants*' and '*Interventions*' criteria were included in the cost-effectiveness literature review.
- Additional filters: papers that did not include primary research were excluded (unless they were structured or systematic reviews of previously published literature).

The majority of the papers identified in the clinical search investigated the effectiveness of alternative treatment regimes for HD (*eg* short daily and nocturnal HD) rather than assessing the setting of HD delivery and therefore were not included in the current review. The majority of papers identified in the economic search did not report primary research, presented a combination of treatment modalities / regimes or summarised previous studies. Those included in the utility sub-group tended to

[1] The Mowatt *et al* [2] literature review included papers that were published up until October 2001.

report quality of life measures rather than preference-based utilities or utilities derived from alternative methods, or did not report primary research.

Results

There are 7 studies included in the clinical effectiveness review, and 11 studies included in the economic review. A summary of the study design, results and limitations are presented in the following sections.

Clinical effectiveness studies

Of the 7 clinical effectiveness papers reviewed, one was a systematic review [4], and six were comparative studies (one case control [5] , two prospective [[6,7], two retrospective [8,9], and one where the methodology was not well defined [10]). The definition of the interventions in terms of location was not clear in most papers. Many studies report ‘in-centre’ HD as one of the interventions. However, whether this involved a centre as part of a major hospital or a satellite unit was difficult to ascertain. It was determined that the effectiveness comparison was home HD versus satellite HD in two studies [7,9], home HD versus hospital HD in two studies [5,6], home HD versus satellite and hospital HD in one study [10], and not clear in two studies [4,8]. In terms of the outcomes assessed in the included papers, four studies reported adverse events (including hospitalisations) [5-7,9], three reported dialysis adequacy and successful dialysis delivery [5,6,9], three reported quality of life [5,6,10], two reported mortality [5,8], one reported modality survival (also called technique failure) [4], one reported employment status [10], one reported compliance [6], and one reported health status (as assessed by a measure of nutritional status) [9]. For completeness, we also include a review of the index systematic review conducted by Mowatt *et al* [2]. Table 2 summarises the new data reviewed.

Mowatt *et al* 2003

Mowatt *et al* [2] systematically reviewed 27 studies on clinical effectiveness, comprising four systematic reviews, one randomised crossover study and 22 comparative observational studies. The overall quality of the systematic reviews was relatively low (out of a scale of 1 (extensive flaws) to 7 (minimal flaws), two studies scored 3, one scored 4, and one scored 5). Of the 23 primary studies, the mean quality score was also relatively low (12 out of a possible 27). However, this reflects the inherent risk of known and unknown confounders in observational studies. Mowatt *et al* report that in general the equipment used and the duration and frequency of dialysis was often poorly described, and in the majority of papers, patient characteristics (*eg* age, co-morbidities *etc*) were not well balanced between the intervention groups.

The authors report that the characteristics of patients dialysing at home are different from those of patients dialysing in hospital. Home HD patients were younger, more likely to be male, and had fewer co-morbidities compared with those dialysing in the hospital and satellite unit setting. Home HD was reported to be more effective than hospital HD and modestly more effective than satellite HD. For several outcomes, home HD was statistically significantly better than the other modalities, and for those outcomes that were not significantly different, the direction of effect favoured home HD. In comparison with those undergoing hospital HD, home HD patients had better blood pressure control, lower mortality rates, fewer adverse events, better quality of life, and were more likely to be in full time employment. Compared with satellite HD patients, those on home HD had moderately better quality of life, were more likely to be in full time employment, and experience better survival. However, home HD patients had more hospitalisations and experienced shorter time to modality failure (the time a patient remains on a specific type of RRT). The authors conclude that it is difficult to estimate the magnitude of effectiveness of home HD versus hospital or satellite HD.

Ageborg *et al* 2005

Ageborg *et al* [10] report on the results of a comparative study which investigated the quality of life of patients undertaking home HD, self-care HD in a satellite centre, or conventional nurse led HD in a satellite centre. A total of 19 patients across the three groups completed the *Short Form 36* (SF-36) and other questionnaires. The results of the SF-36 for the three groups and the normal Swedish population are presented graphically in the article for eight different health domains, however significance testing was not performed. The home HD group had consistently higher SF-36 scores compared to the other two groups for all aspects of health, and for the social functioning domain, the home HD group had the same score as the normal Swedish population. There are many limitations of this study. Firstly, there were baseline differences between the groups in age, work situation, family situation and years of education. Secondly, the study sample size was very small, with only five subjects in the home HD group. Thirdly, there was lack of detail on study methodology. Therefore, definitive comparisons between the groups cannot be made.

Piccoli *et al* 2004

In 2004 Piccoli *et al* [7] conducted a comparative study of 77 HD patients (42 treated at home and 35 treated in the centre with limited care) followed up at a renal satellite unit of a large university centre. A trial of daily HD was offered to all subjects, of whom 28 subjects experienced at least one trial of daily HD. Several univariate and multivariate models were used to test the determinants of vascular access failure endpoints (*eg* surgery for new vascular access, angioplasty *etc*) individually, and the determinants of a composite index of all adverse events related to vascular access. Baseline characteristics showed that patients who dialysed at home were younger, had a shorter history of renal replacement therapy, and less co-morbidity than patients treated in the limited care unit. However, testing was not carried out to assess the significance of the difference between subjects dialysing in the different settings. The results show that, in the univariate and logistic regression models, there were no significant differences in vascular access failure and all adverse events between subjects who dialyse at home and those who dialyse in a limited care facility. In the Cox proportional hazards model, treatment in the limited care setting was a significant factor protective of vascular access failure (p=0.005). The authors report that the study is limited by the small sample size and the possibility that the differences between the groups might be attributable to selection bias.

Suri *et al* 2006

Suri and colleagues [4] in 2006 completed a systematic review of primary research to assess the published evidence for daily HD, including the quality of studies, the magnitude of benefits and the risks associated with daily HD. Although this study didn't specifically investigate the difference between home HD and HD in other settings, there were some synthesised data on modality survival for the cohorts reviewed who had daily HD in-centre (hospital or satellite setting not specified) versus at home. It is reported that of the studies reviewed, modality survival was reported for nine of the 14 cohorts, and the median modality survival was 59% for in-centre patients, versus 93% for home patients. However, there is no assessment of whether this difference is significant. The authors report that generally the studies that were evaluated were limited by small sample size, non ideal control groups and selection bias, therefore these results should be used with caution in any economic modelling. Furthermore, it is unknown if the median modality survival in the different treatment settings for daily HD can be generalised to other more conventional HD regimes.

Sands *et al* 2009

In 2009, Sands *et al* [9] conducted a retrospective review of 29 patients who were undertaking home HD and had transitioned from in-centre (private outpatient dialysis clinic) HD. The aim of the study was to assess the efficacy and safety of home HD using a specific HD machine (2008K@home). Subjects were included if they had at least 3 months of medical records and three sets of specific laboratory tests for both the in-centre and home HD phases. Evidence of completion of patient and lay helper training was also a specified inclusion criterion. Subjects were excluded if they required health care professional assisted HD while at home.

The outcomes that were assessed included the adequacy dialysis, measured by the standard weekly Kt/V (fractional urea clearance), safety, determined by the rate of adverse events, and overall health, assessed by nutritional status. In addition, the adequacy of home HD was also assessed by comparing the prescribed dialysis with the delivered dialysis. The results showed that dialysis adequacy remained stable during both periods, but increased from 2.30 ± 0.5 to 2.42 ± 0.56 (p<0.05) from the end of the in-centre phase to the start of the home HD phase. To assess the relative safety of the two treatments, the rate of adverse events per 100 treatments was reported. During the in-centre phase, there were 5.84 adverse events per 100 treatments compared with 3.34 in the home HD phase. Mean serum albumin levels increased from 3.87 ± 0.50 g/dL in-centre to 3.99 ± 0.43 g/dL ($p < 0.001$) during the home period, indicating improved nutrition during the home period. For the home HD phase, the delivered treatment time, blood flow and dialysate flow were all over 95% of those prescribed.

There are several limitations of this study that are acknowledged by the authors. Firstly, the study is retrospective, which could result in the introduction of several biases. Furthermore, the sample size is very small and limited to subjects who were adequately trained and were successful for at least a period of 6 months on home HD. Therefore, it is likely that this sample does not represent the entire cohort of subjects who commence home HD, but a select sample of well trained subjects and partners who have been successful for at least 3 months of home HD. The authors conclude that despite the limitations, the study shows that the selected cohort was successful with home HD with few adverse events.

Kraus *et al* 2007

In 2007, Kraus *et al* [6] conducted a comparative cross-over study of in-centre versus home HD in 32 patients treated across six renal centres in the US. Patients with end stage renal failure with a life expectancy of at least 1 year, who were dialysing at least three times a week and who were determined to be appropriate[2] for home HD were recruited. Patients with specific co-morbidities and specific dialysis-related adverse effects were excluded. The intervention consisted of using a specific HD system (NxStage System One) for 8 weeks in-centre, followed by a 2 week transition period, and then 8 weeks at home. The primary outcome was the successful delivery of the prescribed fluid volume and a composite measure of all adverse events. Secondary endpoints included treatment compliance adequacy and a quality of life measure. The patient population consisted of relatively young subjects (mean age 51 years), with only a relatively small proportion with diabetes induced end stage renal failure (16%). The results indicate that compliance was comparable between the two treatment settings. Successful delivery of at least 90% of the prescribed fluid volume was achieved in 98.5% of treatments in the in-centre phase and 97.3% in the home phase of the study. Adverse events were defined as any unfavourable or unintended sign, symptom or disease temporally associated with the use of the dialysis device. The adverse event rate per 100 treatments was significantly higher for the in-centre phase (5.30) compared with the home phase (2.10, $p=0.007$) of the trial. Treatment adequacy (Kt/V) measures were similar across treatment settings. There were no significant differences between treatment settings in any item of the *Kidney Disease Quality of Life Short Form*. There were three hospitalisations during the in-centre phase compared with one during the home phase. There are several limitations of the study that are acknowledged by the authors. There is potential for bias due to the

---

[2] The determinants of appropriateness for home HD were defined independently by each centre in this multi-centre study.

study not being a randomised controlled study and the low patient numbers. Since the in-centre phase was the first phase for all participants, a systematic increase in adverse events at the start of daily HD cannot be ruled out as an explanation for the reported increase in adverse events. Reporting of adverse events may be higher during in-centre dialysis due to the presence of dialysis staff. The authors report that despite these potential sources of bias, it can be concluded that the use of the NxStage System One in the home setting is no worse than in-centre.

Kjellstand *et al* 2008

In 2008 Kjellstand *et al* [8] conducted a retrospective chart review of all the authors' patient records to calculate the survival statistics of patients undergoing short daily HD. The pooled experience of the authors (from Italy, France, UK and USA) provided information on 415 patients treated with short daily HD, 265 of who were treated in the home setting. Survival of the daily HD patient group was compared with data from the US Renal Data System 2005 annual data report. An analysis using the Cox proportional hazards model identified in-centre dialysis as an independent factor associated with mortality. Survival analysis showed that daily home dialysis patients had better survival than in-centre daily dialysis patients, with a relative risk of death for patients dialysing daily at home to be 0.44 compared with in-centre daily dialysis patients after correction for differences in age and diagnosis. Survival curves for patients on home HD were found to be very similar to those for patients who had received cadaveric kidney transplants.

Several study limitations are highlighted by the authors. Firstly, due to the study design, the results are subject to selection bias. The dialysis units, and therefore the patients that were included in this study, were determined by the location in which the authors worked, and therefore it is unclear how well these patients represent the average HD patient in each of the country settings. The authors acknowledge that selection of patients will impact survival outcome, but report that the patients selected for daily HD were those with serious co-morbidities and poor prognosis and are a representative group of chronic dialysis patients. They also report that the results were consistent across the different countries and the different methods used to normalise survival. The authors conclude that the improved survival seen as a result of daily HD was unlikely to be related to patient selection. The applicability of the survival results of home versus in-centre short daily HD to more conventional regimes is unknown.

Saner *et al* 2005

Saner *et al* [5] conducted a case cohort study including all 103 patients treated with home HD in the Berne district in Switzerland between 1970 and 1995. The cases were matched with patients undertaking in-centre home HD (at the University hospital of Berne) and were identified by retrospective chart review. The controls were matched for gender, time and age at onset of dialysis and primary renal disease. The aim of the study was to assess whether the improved survival previously observed in the home HD group was due to the location of dialysis. Only 58 controls were found for the 103 cases, and therefore only the matched 58 pairs were used in the analysis. The baseline characteristics indicate that a higher proportion of the home HD group were married (84%) compared with the in-centre controls (70%). Both the cases and controls appeared to be similar in terms of age, year of dialysis onset and the main co-morbidities related to survival. However, no significance testing was reported for any of the baseline characteristics.

The treatment duration and the number of treatments per week appeared to be similar between the cases and controls. However, there was no significance testing. The analysis showed that the cases had significantly fewer hospitalisations (6.3 per patient) over the observation period than the controls (10.5 per patient). The total number of operations was higher in the controls compared with the cases (8.8 versus 6.4 per patient). However, the difference was not significant. Survival time was significantly longer for the home HD group than for the in-centre group. The 5, 10 and 20 year survival was 93%, 72% and 34% for the cases, and 64%, 48% and 23% for the matched controls dialysing in-centre. Age at onset of dialysis, year of onset, a co-morbidity index, and location of treatment were found to be significant predictors of mortality. However, even after controlling for age, year, and co-morbidity, the survival advantage of home HD persisted.

The authors report that the home HD group were more likely to be married compared to the in-centre group and this could impact the mortality difference seen between the groups given that married people have been reported to have longer survival time. Another observation was that the additional number of deaths in the controls occurred mainly during the first month of treatment, and therefore a sustained survival benefit of home HD cannot be concluded. However, the authors report that even if the apparent benefit of home HD is due to selection bias, the analysis found no negative effect of home HD.

Table 2. Summary of clinical effectiveness literature

Author	Type	Summary	Outcomes of interest	Comments
Suri *et al* 2006 [4]	Systematic review	Systematic review of daily haemodialysis	Modality survival Home HD: 85-100% (median 93%) IC (unclear whether hospital HD or satellite HD): 43-100% (median 59%)	Limitations: Quality of the studies reviewed Applicability of outcome from daily HD to other more conventional regimes is unknown.
Piccoli *et al* 2004 [7]	Comparative study - prospective	77 subjects followed up for 2160 patient-months (42 home HD, 35 limited care IC). All subjects were offered daily HD. 28 subjects completed ≥1 daily HD trial.	All adverse events related to vascular access: Home HD: 30 events; 2.8/100 patient-months Limited care IC: 27; 2.5/100 patient-months Differences between settings were NS. Vascular access failure: Home HD: 1.5/100 patient-months Limited care IC: 1.01/100 patient-months	Limitations: Potential for selection bias and low patient numbers
Sands *et al* 2009[9]	Comparative study - retrospective	29 patients receiving home HD and who had transitioned from IC HD (at a private renal care centre). Subjects must have received HD in both settings for at least 3 months.	Dialysis adequacy/efficacy (Kt/V): IC: 2.3 ± 0.7 at start; 2.3 ± 0.7 at end (p=NS) Home HD: 2.4 ± 0.6 at start; 2.5 ± 0.7 at end (p=NS) IC vs. home HD: increased from 2.30 ± 0.51 to 2.42 ± 0.56 (p<0.05) Safety rate of AE per 100 treatments: IC: 5.84 Home HD: 3.34 Health status - mean serum albumin (g/dL): IC: 3.87 ± 0.50 Home HD: 3.99 ± 0.43 (p<0.001) Delivered/prescribed treatment parameters for home HD: Treatment time 98% ± 10% Blood flow 95% ± 7% Dialysate flow 99% ± 8%	Limitations: Study design can lead to bias Small sample size Select sample who have been successful on home HD.

Author	Type	Summary	Outcomes of interest	Comments
Ageborg *et al* 2005 [10]	Comparative study	19 subjects receiving home HD (n=5), self care IC (n=6) or conventional IC (n=8).	<u>QoL</u> No numerical vales for the quality of life outcome. Home HD group has better SF-36 scores than the other 2 groups for all health domains (physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional & mental health. home HD group had the same score for the social functioning domain as the normal Swedish population <u>Work situation</u> Home HD: Working 4/5 Student 1/5 Self care IC: Working 4/6 Sick leave 1/6 Disability pension 1/6 Conventional IC: Sick leave 1/8 Disability pension 7/8	Limitations: Study design can lead to bias. Baseline differences between groups can be reason for differences in outcome measures. Small sample size Little information on recruitment and reasons for non participation.
Kjellstrand *et al* 2008 [8]	Comparative study - retrospective	415 subjects undertaking daily haemodialysis IC (unknown if in hospital or satellite unit) (n=150) and home HD (n=265) from USA, Italy, France and UK. Compared with data from the USRDS 2005 data (conventional HD and recipients of kidney transplants)	<u>Factors influencing survival:</u> 1. Secondary renal disease HR 2.72 (CI 1.76-4.20, p<0.0001) 2. IC HD 2.42 (CI 1.54-3.79). 3. Age >52 years HR 2.39 (CI 1.49-3.83) <u>Survival of daily home HD versus daily IC HD</u> RR=0.44 after correcting for differences in age and diagnosis. Survival curve for daily home haemodialysis versus USRDS 2005 data for cadaver kidney recipients presented	Limitations: Study design can lead to bias. Applicability of survival data from daily HD to other more conventional regimes is unknown.

Author	Type	Summary	Outcomes of interest	Comments
Saner *et al* 2005 [5]	Case control study	103 home HD patients 58 IC (hospital) patients matched for age and time of dialysis onset, sex, and kidney disease category. Age at dialysis onset: Home HD: 50.1 (SD13.5) IC: 50.6 (SD 13.1) Married: Home HD: 84% IC: 70% Work: Technical/Farming Home HD: 37.9% IC: 20.7% Office Home HD: 29.3% IC: 46.6%	Hospitalisations: Home HD: 6.3 IC: 10.5 ($p<0.001$) Operations: Home HD: 6.4 IC: 8.8 Difference NS Survival: 5 years Home HD: 93% IC: 64% 10 years Home HD: 72% IC: 48% 20 years Home HD: 34% IC: 23%	Limitations: Study design and findings don't preclude the conclusion that the difference in outcomes is due to differences between the home HD and IC groups.

Author	Type	Summary	Outcomes of interest	Comments
Kraus *et al* 2007 [6]	Comparative study - prospective	32 ESRD patients, mean age 51 years. Treated with 8 weeks IC (hospital) HD, 2 weeks transition, and 8 weeks home HD using NxStage System One.	Compliance: Completion of 43-48 treatments IC: 88% Home HD: 89% (significance test not reported) Successful delivery: ≥ 90% prescribed fluid delivered IC: 98.5% Home HD: 97.3% (significance test not reported) Adverse Events: Rates per 100 treatments IC: 5.3 Home HD: 2.10 (p=0.007) Difference: 3.16 (CI: 0.79,5.54) Number of subjects reporting ≥ 1 adverse event IC: 24 (75%) Home HD: 13 (48.1%) (significance test not reported) Number of adverse events generally associated with HD and reported in >5% of subjects IC: 23 Home HD: 10 (significance test not reported) Treatment adequacy: spKt/V IC: 0.53 ± 0.09 Home HD: 0.54 ± 0.11 (significance test not reported) Standard Kt/V IC: 2.26 ± 0.04 Home HD: 2.27 ± 0.03 (significance test not reported) Quality of Life: Kidney Disease Quality of Life Short Form No difference between treatment phases in any domain	Limitations: Study design can lead to bias Potential for systematically increased reports of adverse events in IC group Little significance testing as study aimed to show using device for home HD is no worse than IC

*IC – In-centre

Economic studies

The search strategy identified 11 relevant studies, five of which were economic evaluations, one a systematic review of economic evaluations, three costing studies and two utility studies (one of which comprised a structured review of the utility literature). One economic study was included in the index systematic review and so is not reported separately here. The results from the index systematic review and economic model are included in our review. Data extraction tables for the two key economic evaluations are presented in appendix 2.

Economic evaluations

Five economic evaluations and two systematic reviews of previous evaluations were identified as relevant to the current review. Other more general reviews of costing studies were excluded from this review. Two of the five economic evaluations were conducted from a UK perspective. (One of these reported an adjusted analysis of the first model.)

Mowatt *et al* 2003

The authors developed an economic model to assess the cost-effectiveness of home HD relative to hospital HD or satellite HD. The base case patient population comprised patients under 50 years of age. A Markov model was developed consisting of three health states which included the three interventions of home HD, hospital HD and satellite HD. The absorbing states[3] in the analysis were death, transplantation, and continuous ambulatory peritoneal dialysis (CAPD). Data on direct health service costs, probability of transitioning to the various health states, probabilities of specific adverse events and health utility in the different health states were required to populate the model. These data were based on the systematic review conducted by the same authors (see below). The time horizon for the model was 5 and 10 years and the cycle length was 1 year. The primary outcome considered was incremental cost per quality adjusted life year (QALY) gained.

Findings suggest that for patients who were younger and with fewer co-morbidities who receive home HD for 4-5 hours three times per week (conventional regime), home HD was less costly than satellite HD which in turn was less costly than hospital HD. These differences in costs were driven by the differences in the staffing resource use across the different interventions.

---

[3] A state from which a subject cannot transition and in which no further costs or benefits attributable to home HD are accrued.

Home HD was found to be the dominant strategy compared with hospital HD for all time horizons analysed, *ie* home HD was found to be both less costly and result in higher QALY gains than hospital HD. In the first year, home HD was the dominant strategy compared with satellite HD. However, over the 5 and 10 year time horizons, the cost of home HD was greater. Utility weight for both home and satellite HD was assumed to be the same. However, the survival benefit that was applied for the home strategy resulted in an incremental cost-effectiveness ratio (ICER) of £2215 per QALY for the 5 year time horizon and £3914 for 10 years of follow up. In sub-group analyses of diabetic patients (< 50 years or > 65 years), home HD tended to dominate both hospital and satellite HD when considering a 5 year analysis time horizon (10 year results not reported).

Several sensitivity analyses were conducted to assess the impact of various variables on the cost-effectiveness estimates. The two factors that had the largest impact were the inclusion of travel costs for hospital and satellite unit HD, and carer allowance for the home HD cohort. The resultant ICER for home versus hospital HD was approximately £12,000 per QALY and was £45,000 to £50,000 when home HD was compared with satellite HD. Home-based short daily and nocturnal HD gave an ICER of approximately £8500 per QALY over 5 years when compared with conventional hospital HD, and approximately £30,000 per QALY over 5 years when compared with satellite HD. However, in this analysis it was assumed that home short daily and nocturnal dialysis does not result in any increase in QALYs compared with home HD using the conventional regime.

The authors report that limitations of the cost-effectiveness model include the use of data from non-randomised studies, and the possibility that newly developed home HD devices may change the results of the analysis. The model assumes improvements in survival for home HD over hospital HD based on results of a paper by Hellerstedt *et al* 1984 [11]. The utility benefits are based on a small but matched sample and collected using general population valuations based on a UK tariff [12].

Mowatt *et al* present a relatively simple model where the majority of data inputs are clearly explained. However resource use was not always clear for all cost categories, and the methodology used to calculate the annual dialysis machine costs for the home HD cohort also lacked detail.

McFarlane *et al* 2006

The McFarlane *et al* [13] study reports on a Markov state transition cost-effectiveness model comparing two interventions. In the first, the cohort starts the model with hospital HD and then transfers to home nocturnal haemodialysis (HNHD). The other intervention consists of the cohort staying on hospital HD. The study was conducted in two hospitals in Toronto, Canada from the health payer perspective with a lifetime time horizon. The Markov model is fairly comprehensive in allowing change in HD modalities, transplantation and death. This model incorporated one Markov state representing HNHD during the first year, and another state represented HNHD in subsequent years in order to capture the high initial costs of HNHD.

The cost and utility data in the analysis used estimates from previous publications form the same authors [14,15]. Other transition probabilities were based on published studies, experience from the hospitals the authors work in and author estimates/assumptions. The study found that for the base case, HNHD was less costly and more effective than hospital HD. HNHD was the dominant strategy in the majority of scenarios and sensitivity analyses except when hospital HD was less costly or associated with higher utility or when transplantation or death occurred in less than 108 weeks after home HD initiation. The authors report limitations including the lack of rigorous randomised controlled trial data for key inputs, the possibility that the model simplifies the lives of patients undergoing HD, and the possibility of selection bias due to the simulated model cohort being systematically different from the average HD subject. They also report the possibility of survival bias as the data sources for the model were studies that used prevalent HD patients.

Gonzalez-Perez *et al* 2005

Gonzalez-Perez *et al* report additional results of the cost-effectiveness analysis comparing home, hospital and satellite HD conducted by Mowatt *et al* [2] for the purpose of the HTA analysis (described above). The base case analysis considered patients less than 50 years of age with no co-morbidities. The model was that described by Mowatt *et al* [2] however the costing approach taken was slightly different in that the costs of home conversion necessary for home HD were included in the analysis and applied at the start of home HD treatment. The transition probabilities reported suggest that there may also be a difference in the mortality benefit assumed for home HD but it is not clear if these data differ from those reported in Mowatt *et al* [2] or are just presented in a different way.

The annual cost of home HD was found to be higher than satellite and hospital HD. However, marginal benefits in survival meant that a QALY benefit was accrued. The incremental cost per QALY for home HD compared against satellite HD was estimated at £57,600 at 1 year, but reduced significantly thereafter; incremental cost per QALY at 5 and 10 years was reported at £6,665 and £3,493. In the comparison of home HD with hospital HD, the incremental cost per QALY was estimated at £14,600 at 1 year; at time periods of 5 years and beyond, home HD dominated hospital HD.

Similar sensitivity analyses were conducted as for Mowatt *et al* [2] - different estimates of utility for home HD, requirement for an assistant for home HD (no requirement assumed in the base case), different levels of clinical cover for satellite HD and different mortality rates (setting home HD mortality equal to hospital and satellite HD rates and vice versa). In the comparison with hospital HD, the model was not sensitive to these parameters and home HD remained dominant. The authors highlight key issues that need consideration when interpreting the results of the study: while patients who remain on home HD longer result in more attractive ICERs, in practice these patients may be more likely to receive transplantation. In addition, roll-out of home HD may require an additional infrastructure of specialist nurses who are in limited supply in the UK.

Kroeker *et al* 2003

Kroeker *et al* [16] constructed a simple mathematical model to estimate the cost per QALY for conventional HD (three times weekly in hospital) versus daily and nocturnal home HD. The authors report that annual costs for daily HD were substantially lower than both nocturnal and conventional HD costs ($67k versus $74k and $73k respectively). The authors also estimate annualized QALYs for each patient group based on *Health Utilities Index* (HUI) scores taken over the study period. Daily HD resulted in a 0.04 QALY gain versus a 0.01 gain for nocturnal HD and a 0.09 reduction for conventional HD. Costs per QALY are reported on a treatment basis and range from $85,400 for daily HD through $120,900 and $116,800 for nocturnal and conventional HD respectively. Incremental cost-effectiveness ratios were not estimated.

Cost and utility data for the analysis were taken from the London Daily/Nocturnal Haemodialysis study (conducted in London, Ontario). This study collected cost and quality of life data for a period of 18 months. A total of 44 patients were included in the study. Retrospective cost data were collected for 12 months prior to study initiation in order that patients could serve as their own controls. The study was designed to assess operating costs and therefore one time start-up costs were excluded from the analysis. Treatment costs were approximately doubled in the daily and nocturnal treatment arms but cost savings were a function of reduced numbers of consults, hospitalizations, emergency room visits and lab tests. The authors conclude that there are substantial benefits for home daily HD and that expansion of this treatment modality is clearly justified.

Limitations of the study include the small sample size and non-inclusion of training costs for home HD patients. The retrospective cost collection also suggested a difference in morbidity between the patients selected for the three study groups (*ie* retrospective costs when all patients were on conventional HD differed between groups) so comparisons between groups may not be robust and focus should be on the before and after analyses which used the patients as their own controls. Kroeker *et al* report resource differences according to both frequency and setting of therapy.

McFarlane *et al* 2003

McFarlane *et al* [13] conducted a study to assess the cost-utility associated with home nocturnal HD (HNHD) (n = 24) and conventional in-centre (hospital) dialysis (n = 19) in demographically similar groups of patients who had been part of a previous costing study conducted by the authors [14]. The authors found that total health care costs for the home nocturnal group was significantly lower than those of the in-centre (hospital) HD group ($55,139 vs. $66,367 p = 0.03). The authors found that lower staffing and overhead costs for nocturnal HD (p < 0.01) contributed to this while HNHD materials, and depreciation were all significantly more expensive (p < 0.01) but did not impact the overall cost differential.

Utilities were estimated through use of a computer program which elicited standard gamble (SG) based utility scores for the two intervention groups. In the hospital HD group, the utility score was 0.527 (SD 0.347). In the HNHD group, the utility score was 0.772 (0.230). The utility difference between the groups was reported to be significant (p=0.028). The authors found that quality of life was significantly higher in the HNHD patients and that costs were lower and that HNHD dominated in-centre HD across a range of sensitivity analyses. The authors report that a strength of the analysis was the similarity in both the demographics and mindset of the two groups – the patients in the in centre HD group were interested in HNHD and were capable of undergoing the regimen but did not have the facilities available at their centres. However, they note that the two groups were both dissimilar to the 'average' HD patient cohort in terms of age and co morbidities and duration of dialysis.

Mowatt *et al* 2003 (systematic review)

The systematic review of economic literature covered all papers published up to and including 2001. The review covered 18 studies that report the costs and outcome of the interventions of interest. Of the 18 studies, the majority (13 studies) were cost-effectiveness studies, or studies that reported costs and effectiveness separately. There were three cost-minimisation studies (including one systematic review of cost studies) one cost-utility study and one cost-benefit study.

The authors report that available evidence suggests that health outcomes as a result of home or satellite unit HD are as good as or better than hospital HD. However, these results are likely to be limited by selection bias. It is clear that the annual treatment costs for home HD are lower than for hospital dialysis. However, the exact cost advantage is difficult to quantify as costs are also affected by patient selection. It was found that the initial start-up costs of home HD are high, but the pay back period for these higher costs was estimated at approximately 14 months. The economic studies used a similar health benefit for home and satellite HD. The costs of satellite HD varied significantly depending on the staffing intensity and the ability of the unit to make optimal use of the dialysis machines. Haemodialysis of increased frequency (short daily or nocturnal) at home compared with conventional hospital HD resulted in better outcomes and lower costs if reductions in hospitalisation rates were incorporated.

Winkelmeyer *et al* 2002 (systematic review)

Winkelmeyer *et al* [17] conducted a systematic review of economic literature relating to renal replacement therapy up to and including the year 2000. Papers were selected for review if they contained data related to costs and quality of life. The key objective of the review was to estimate cost-effectiveness ratios for RRT to evaluate trends over the past decades. Of the 13 papers reviewed, only two reported cost-utility analyses. Cost-effectiveness ratios were estimated and converted into year 2000 prices by the authors. They did not estimate relative effectiveness.

The authors found that cost-effectiveness ratios for in-centre HD and home HD remained relatively stable over time (between $55,000 and $80,000 per life year gained (LYG) for in-centre HD and between $33,000 and $50,000 for home HD). However, they found that the cost-effectiveness ratios for renal transplantation reduced over time from over $40,000 per LYG in the 1970s to around $10,000 in the 1990s. They suggest that these trends are likely to reflect changing methodologies in both economic analysis and clinical practice (*ie* more patients treated and / or sicker cohorts eligible for treatment). The authors speculate that home HD costs are likely to have been underestimated in these cohorts as care-giver costs were not included in any of the reported studies. They suggest that it could be expected that these would form a significant proportion of the total costs given the requirement for carer aid expected for home HD patients.

Cost studies

Three cost studies were identified as relevant to the current literature review. Only one of the three studies was conducted from a UK perspective.

Baboola *et al* 2008

In 2008 Baboola *et al* [18] conducted a multi-centre costing study of the various renal dialysis modalities across six hospitals in Wales and across the UK. The renal modalities included in the costing included hospital HD, satellite HD, home HD, automated PD and CAPD. The authors conducted interviews with health service providers to identify the specific clinical pathway followed in delivering the different dialysis modalities. The study used a mixed costing approach consisting of micro-costing and a top down approach. The results are presented as summary costs for the different cost components for all modalities except for home HD which is reported only as a summary annual cost per patient. Costs are also presented for the six different centres in the study. The variability between centres was fairly substantial. However, when overhead costs were removed, the range decreased.

The authors report that the costs may be slightly overestimated for ambulatory PD and home HD and that there was variability between hospitals in the methods used to estimate overheads. Further limitations of the study include the lack of detail in terms of data collection period and the reference cost year. It is reported that there was only one unit which provided home HD and that the delivery of home HD was outsourced to a commercial organisation. Therefore, the authors assumed similar costs for consumables and machine costs to hospital HD, and staffing support, overheads and transport were assumed to be similar to automated PD. The validity of these assumptions was not reported. There is also little detail on resource use, for example nursing time per patient *etc*. This limits the generalisability of the model and the usefulness of the data for subsequent analyses.

Agar *et al* 2005

Agar *et al* [19] report the findings of an Australian study assessing the costs of satellite HD versus nocturnal home HD in a cohort of patients who had completed an uninterrupted 12 month regimen of one or other treatment modalities at the same renal centre. Patient groups were adjusted in order that the calculation compared two 'notional' 30-patient cohorts. The authors found that HNHD resulted in 10% lower costs than satellite HD ($AUS 33,392 per year versus $AUS 36,284). The paper concludes that nocturnal dialysis may be a useful stepping stone from the regimented 3 treatments per week of conventional therapy toward funding for increased frequency regimens. The paper focused on the different types of local funding mechanisms in operation and the potential savings at the parent renal unit versus the point of service (*eg* the satellite unit).

McFarlane *et al* 2002

McFarlane *et al* [14] conducted a prospective costing study comparing the costs of HNHD compared to conventional hospital HD across two renal units in Toronto, Canada. Patients from the HNHD program were matched for controls from a different hospital that did not offer a home HD programme. The controls were selected on their eligibility and interest in home HD. The reported results include weekly and annual cost for various cost categories for in-centre and home HD, costs for different costing perspectives, and some resource use information.

The authors report a limitation of this study is the limited generalisability of the results to centres of different sizes and those newly setting up a HNHD unit. The authors note that although the HNHD group and the control group were similar, neither group was representative of the typical HD patient.

Utility studies

Only two papers were identified as relevant to the current review, one a report on original research, and the other a structured review of previous literature. Additional studies which reported quality of life but did not encompass a measure of utility were excluded from the review. The research was not conducted in a UK population but utilities were estimated based on a UK tariff.

Manns *et al* 2003

Manns *et al* [20] conducted a study to determine the important determinants of health related quality of life (HR-QOL) in a sample of 192 RRT patients enrolled in an ESRD programme in Alberta, Canada. Although the study was undertaken in Canada, the tariffs used in the study were anchored to the UK general population. The sample included HD patients (n = 151) and PD patients (n=51). Patients entering the study represented the prevalent population and had been stabilised on treatment for a minimum of 6 months. Of the HD patients a small proportion (n = 16) comprised home HD or self-care patients. HR-QOL was assessed at study start and 6 months using the SF-36, the EQ5D and a disease-specific quality of life scale. Regression analysis was conducted to see which of seven core characteristics (modality of HD, living arrangements, education, gender, race, co-morbidity index and co-morbidity sex interaction) best determined HR-QOL. Only the results of the EQ5D are reported here. Living arrangements, race and co-morbidity were found to be determinants of HR-QOL. Results confirmed that RRT patients experience significant disutility with an overall EQ5D rating of 0.609 (including HD and PD patients). The paper also reports HR-QOL by subgroups: home HD and self-care HD grouped together 0.698 (95% CI 0.451-0.943); satellite HD 0.637 (95% CI 0.532-0.742); hospital HD 0.609 (95% CI 0.553-0.665). However, sub-groups were small and the robustness of these data is questionable.

The authors highlight two key limitations of the study - patients who agreed to be enrolled in the study tended toward lower co-morbidity ratings than those who chose not to participate, and patients voluntarily chose the modality of RRT, meaning that results may not be applicable to those patients for whom no choice is possible.

Dale *et al* 2008(structured review)

The authors report results of a structured review of utility papers published between January 1990 and January 2006 [21]. A total of 35 relevant papers were reviewed and assigned quality scores according to a simple algorithm developed by the authors for the purpose of the review. The authors report a high degree of variability in research in this area from the method of utility elicitation used through to the quality of the papers. However, the majority of papers (70%) scored low on the quality assessment scale (between 2 and 3 on a scale of 6). Full results and descriptions of the utilities estimated are provided in the paper but are not summarised here. Very broadly, estimates for home HD varied between 0.49 and 0.77 and for HD between 0.42 and 0.87. The type of valuation method used (*eg* standard gamble, time trade-off, EQ5D *etc*) had a significant impact on derived utilities, and reported patient groups ranged from standard renal replacement patients to those with significant co-morbidities. The importance of standardising methodologies for utility estimation, particularly when data are intended to be used to estimate outcomes such as an incremental cost per QALY is stressed.

The authors suggest that only two studies of those reviewed have direct relevance to future UK evaluations, namely those conducted by Manns *et al* [22] and de Wit [12] (used in the base case in the Mowatt economic analysis [2]). This reflects NICE's requirement for a standardised measure of utility (the EQ5D) estimated using valuation from the UK general population. Interestingly, the paper by de Wit is highlighted as one of those where the preference scores derived are relatively high in comparison with other studies. Although this is not categorised as a quality issue, the use of the more up-to-date paper by Manns may be indicated for subsequent analyses.

National guidance

The National Institute for Health and Clinical Excellence (NICE) published a technology appraisal on this topic in 2002 [23], based on the HTA conducted by Mowatt *et al* [2] and consultations with renal patient groups and clinical experts. The guidance is limited to consideration of the location of HD and does not consider different frequencies of HD or other methods of RRT. The recommendations apply only to those patients who have been defined as suitable for HD.

The Guidance reports that due to the selection bias of studies and the difficulty in conducting randomised controlled trials to compare the efficacy of the location of HD, there is no robust evidence to support the superior effectiveness of home HD. However, the evidence suggests that home HD is at least as effective as hospital HD. It was also reported that increased frequency of dialysis can improve markers of cardiovascular disease and decrease cost of some healthcare resources. NICE concluded that the difference in costs between home and hospital HD is likely to be even greater in favour of home HD than reported by Mowatt *et al* [2], and made the following recommendations.

- All suitable patients should be offered the choice between the different HD treatment settings.
- An assessment of clinical needs, social circumstances, and home environment is required to determine suitability for home HD.
- Patients and carers should be fully informed regarding the different options for HD, and impact of the different options on their life and household.
- Patients undertaking HD in the hospital who are potentially suitable for home HD should be informed about all their dialysis options.
- Home HD patients and their carers require training and access to a support service which offers respite hospital or satellite HD as required.
- Home HD patients should have the option to change HD locations if their circumstances change.

Discussion

Despite a high number of original hits when running the literature search strategy, the final number of papers eligible for inclusion in this review was limited. Those data that were identified suggested a high degree of variability in both cost and utility. However, home HD was consistently found to be more attractive, in economic terms, than hospital HD. Key limitations of the included studies related to generalisability of the data and robustness of the conclusions.

Limitations in the application of the Mowatt *et al* [2] model to the current UK setting is that it is a relatively simple model which doesn't incorporate states that are likely to have some impact on the results. For example, the model assumed that once patients commence home HD, they don't revert back to hospital based HD. However it is likely that for an intervention that is required long term, patients' circumstances may change resulting in them reverting to hospital based therapies (NICE guidance recommends that patients should be given the opportunity to change HD locations). McFarlane *et al* [13] present a more complicated disease model with many states relating to the costs and outcomes of transplantations. Our current model aims to answers the question specifically related to the location of HD and therefore the outcome of transplantation has less relevance.

The current model will investigate whether a Markov model structure that incorporates features of both the Mowatt [2] and McFarlane [13] models and updates treatment costs to reflect current UK clinical practice may alter the results of a cost-effectiveness analysis. The de novo model will also change some key assumptions based on the latest available evidence.

In terms of utility data, we would suggest that we limit consideration to the two papers heralded by Dale *et al* (ref) as relevant to subsequent UK economic analyses. Both of these papers utilise the EQ5D as the method for eliciting preferences and both are anchored to the UK general population. No papers were retrieved in this search beyond 2006 which is the date at which the Dale structured review terminated.

It is more difficult to find appropriate sources for transition to transplant or death amongst the papers reviewed and it is anticipated that these data are likely to come from national data such as the UK renal registry [1] and the NHS Blood and Transplant publications [1,24]. One paper reported convincing ratios suggesting survival benefits for home HD patients over hospital HD patient but care needs to be taken in using this ratio in our model (RR death 0.44) as it is not clear for how long this benefit would be sustained. One of the key criticisms applied to all the papers reviewed was the comparability of patient groups, it is therefore important that the patient group included in the economic analysis is clearly defined and that data, where possible, relate specifically to this group.

Objectives

The objectives of the current analysis are to:

- evaluate the cost-effectiveness of home HD compared with hospital based HD for patients requiring RRT as a result of kidney failure in the UK setting.
- assess the indirect costs associated with home haemodialysis.

Scope

An analysis has been conducted to assess the cost-effectiveness of home HD relative to conventional hospital HD and HD conducted at a satellite unit.

The scope is limited to assessment of costs in those patients requiring chronic RRT who have been defined as suitable for home HD. The analysis does not consider frequency of treatment or other methods of RRT.

Methods

There have been two key economic evaluations assessing the cost-effectiveness of home based HD, however neither of the models met the objectives for the current model. The Mowatt *et al* [2] study provides a credible basis for further UK based analyses, however the cost estimates need to be updated and improvements to the model structure could also be made. The McFarlane *et al* [13] Markov model, although comprehensive in structure, requires data inputs for which there is little UK-specific evidence available. Furthermore, the treatment pathways reflect Canadian treatment practices for HNHD, and therefore applicability to conventional home HD in the UK setting is limited.

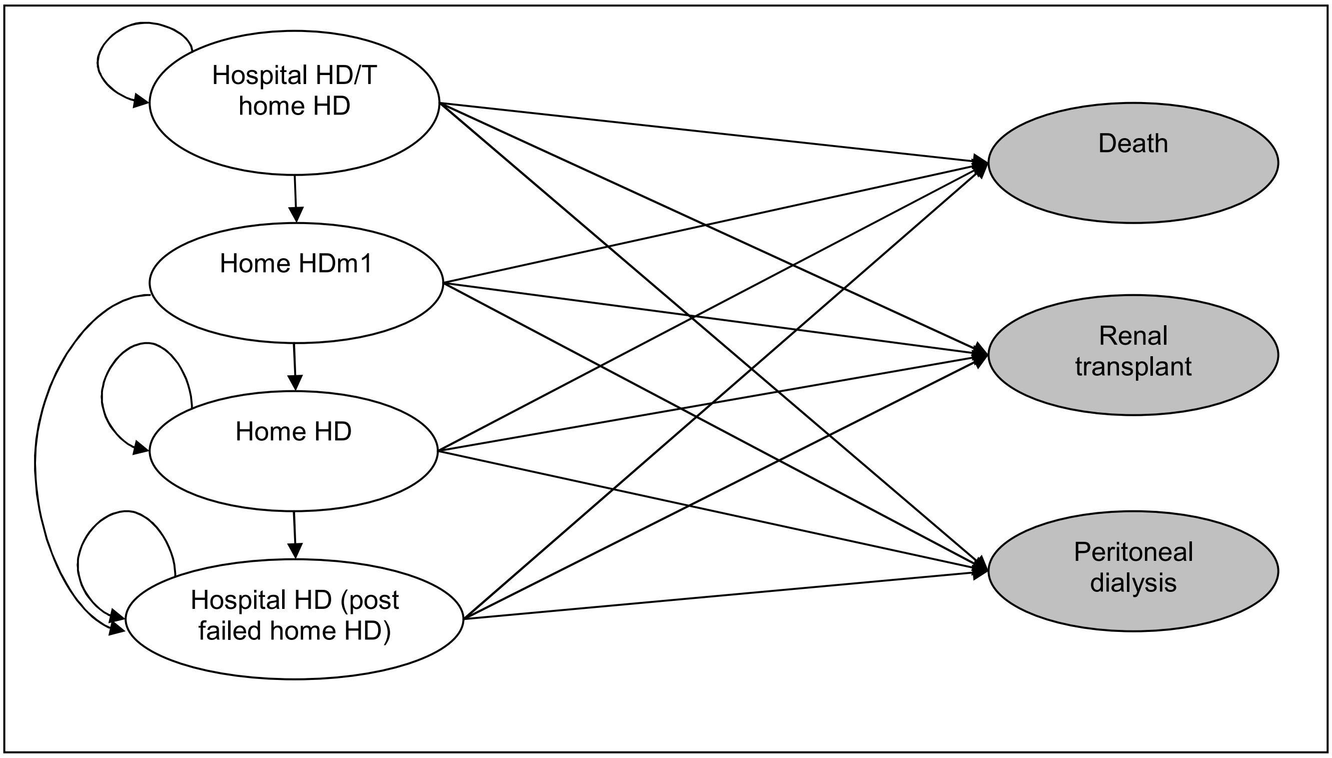
The current model comprises a simple Markov state transition model, with a structure that incorporates features from the Mowatt *et al* HTA model [2] and the more sophisticated model developed by McFarlane *et al* [13] (Figure 1). The most current data inputs will be incorporated into the current model.

The perspective of the model is that of the National Health Service (NHS) and Personal Social Services (PSS). Indirect costs (limited to transport costs and informal care) are included as a sensitivity analysis.

The time horizon of the model is the lifetime of the patient (up to age 90 years). The time horizon for the base case analysis is 10 years. Outcomes for 1 and 5 year time horizons are investigated in sensitivity analyses.

The patients included in the model base case are patients requiring HD without additional complications. The starting age for the patient cohort is 48 years. This age reflects the mean age in published trials in this area.

Figure 1. Model outline



For the home HD treatment strategy, all patients start the model in a state undertaking hospital-based HD during which they receive training for home HD (hospital HD/T home HD). Patients can then transfer to the state representing the first month of home haemodialysis (home HDm1). From here, the subject can either transfer to the state representing costs and outcomes on subsequent months of home based treatment (home HD), or experience home HD modality failure and return to hospital HD. The hospital HD state has the same transition probabilities as hospital HD/T home HD, except that patients cannot transfer to any of the home-based HD states.

From the four key states described, patients can also transfer to three absorbing states (shaded in grey), representing that patients can die, have a kidney transplant, or transfer to PD. Once patients move to an absorbing state they remain in this state and do not accrue additional costs or benefits[4]. In each of the non absorbing states, patients can experience complications which are captured in each of the state costs. Only complications resulting in hospitalisations have been incorporated into the model state costs. According to expert clinical opinion, the majority of healthcare resource use associated with HD related complications will be captured as hospital admissions. The exception is the use of antibiotics which are likely to be delivered during the HD session. Health outcomes of complications are not incorporated in the model.

The current model uses a 1 month cycle length. The McFarlane [13] Markov model uses a 1 week cycle length, whereas the Mowatt *et al* [2] model uses a 1 year cycle length. The chosen cycle length allows us to manipulate the time spent in training for home HD.

For the hospital HD treatment strategy, patients start in the hospital HD state which excludes training costs and patients cannot transfer to any of the home-based HD states. In the sensitivity analysis, the home based HD intervention is compared to satellite unit based HD where all home related HD states are substituted for satellite unit HD states and the cohort will be able to experience the same transitions as patients in the home-based HD strategy. The primary outcome of the analysis is the incremental cost per QALY gained through use of home HD relative to hospital HD. Secondary outcomes include total cost stratified by type of cost (capital, staff or other) and total QALYs.

Data

Due to the lack of published RCTs comparing the efficacy of the various locations for HD, the data used to populate this model is limited and various assumptions based on expert clinical opinion have been made. Extensive sensitivity analyses are performed to assess the impact of alternative data and assumptions on the results.

Transition rates

Data from the UK Renal Registry [1], NHS Blood and Transplant Activity Report 2009 [24] and other published data [13] are used to ascertain the transition probabilities. Basic transitions reflecting the published annual rates are detailed in the table below (table 3). In the model, these data are adjusted to reflect the 1 month cycle length (see appendix 3).

---

[4] Although patients in the PD and renal transplant absorbing states are likely to accrue costs and benefits in real life, these have not been included in the current model. The transition to these states are identical for all treatment arms, and therefore the costs and benefits accrued in these states are assumed to be independent of the location of HD.

The probability of transplantation was calculated assuming that the model cohort consists of patients who are on the renal transplant list. In 2008-09, of the 12,067 patients on the kidney transplant list, 2172 patients where transplanted [24]. The patients on the transplantation list represent a select group of patients; in 2007 the total number of subjects having dialysis (PD and HD) was approximately 24,352 [1] and this number would have increased by 2008-09. The cohort in the model consists of relatively young subjects with little co-morbidity, and it was clinically confirmed that this cohort is likely to be representative of patients on the transplantation list. Rates from the list were therefore assumed applicable to our model cohort. In the sensitivity analysis, the impact of this assumption is tested by changing the transplantation rate.

Table 3. Model annual transition probabilities

Transitions within model	Year 1	Subsequent years	Source
home HD modality failure*	0.05	0.05	McFarlane *et al* 2006 [13]
Rate of transplantation	0.18	0.18	NHS Blood and Transplant 2009 [24]
Rate of switch to PD	0.03	0.003	UK renal registry 2008 [1]

* Only applicable for the home-based HD intervention

Mortality

The literature review suggested that mortality of RRT patients is age dependant. For this reason, death is not included as a transition within the model transition matrix but is estimated according to patient age. The UK Renal Registry Annual Report 2008 [1] states the expected age-dependent increase in mortality for RRT patients compared to the general UK population (table 4 These mortality rates for RRT are applied to the latest UK life-tables [25] to estimate a basic survival rate within the model. These data are assumed to approximate survival for hospital-based HD patients given that these patients make up the majority of patients included in the UK Renal Registry.

Published data suggest a mortality benefit for home HD patients over hospital-based HD [2,8] and the HTA model [2] incorporated a survival benefit in the base case. However data on mortality come from observational studies with the potential for selection bias. Clinical opinion suggests that if the regime of HD is the same across the different settings, then physiologically there is limited clinical explanation for a survival benefit with home HD[5]. In the base case, no mortality benefit for home HD is

[5] Clinical opinion indicates that there could be a survival benefit associated with home HD related to lower depression levels and lower incidence of multi-resistant virus infections.

assumed, however in a sensitivity analysis, data from Kjellstrand [8][6] are used to weight the basic survival estimates to incorporate the mortality benefit into the model.

Table 4. Death rate by age for RRT patients [1]

Age	Mortality rate
20-24	21.5
25-29	31.1
30-34	20.4
35-39	19.3
40-44	18.3
45-49	16
50-54	14.2
55-59	10.8
60-64	10.5
65-69	8.7
70-74	7.1
75-79	5.9
80-84	4.6
85+	2.9

Cost data

The cost of Markov states have been estimated from several sources. The aim was to source resource use for the different states in the model, however when this was not possible, the cost reported in previous publications have been inflated to 2008/09 prices using the *Hospital and Community Health Services* (HCHS) pay and price inflation index [26]. UK specific unit costs have been sourced from the National Schedule of Reference Costs 2008/09 [27], the Personal Social Services Research Unit (PSSRU) 2009 [26], the British National Formulary 2009 [28], and the Office of National Statistics 2009 [29] . All costs have been adjusted to reflect the expected cost in 1 month (one cycle) in each of the states.

---

[6] The Kjellstrand [8] study reports a mortality RR of 0.44 for daily HD in the home setting compared to daily HD in the hospital setting. It is assumed that because both reported interventions have the same frequency of dialysis (daily), the differential mortality is a result of the location of the HD and therefore can be applied to the current model although the HD frequency in the current model (conventional 3 times per week) is different to the Kjellstrand study (daily HD).

The aim was to use UK specific resource use data to reflect clinical practice in the UK. However, detailed data on home HD related resource are limited. When the required data were not available for the home HD intervention, the proportion of resource use between hospital HD and home HD reported in overseas studies has been used to adjust the UK data on hospital HD resource use to estimate home HD resources. Four key cost categories are included in the analysis: dialysis, medications, complications and other healthcare services. Dialysis costs include consumables, capital costs, home renovations (for home HD), equipment costs, staff costs, medications, transport costs and outpatient visits. The methods used for estimating these costs are described below.

Vascular access surgery

Although there are several HD access mechanisms, it is assumed that all patients use fistulas for vascular access. According to clinical opinion, when fistulas are used for vascular access, they will need to be replaced between 1.8 and 2 times every 10 years. At the start of the model (first cycle), the cost of access surgery is added to all patients on HD. Due to this cost not being repeated each cycle of the Markov state, it is not captured as a state related cost. In the same way, the cost of vascular access surgery is built into the model every 5 years and applied to all patients in states related to any form of HD. The elective in-patient unit cost for '*Vascular access surgery for renal replacement therapy'* was used and a weighted average of the cost for patients with and without complications was calculated [27].

Dialysis costs

The cost per session of dialysis consumables reported in Mowatt *et al* 2003 [2] was adjusted to exclude the cost of erythropoietin (which has been costed separately), and inflated to 2008/09 prices.

For the states in which HD is delivered in the hospital setting, the capital cost of the hospital building as reported in Mowatt *et al* 2003 [2] has been inflated to 2008/09 prices. For the home HD intervention, Mowatt *et al* 2003 [2] reports an annuitised cost for home renovations. The current model assumes that the capital outlay occurs in the first month of starting home HD, and therefore the inflated capital outlay for home conversion was calculated and applied to the first cycle in the home HDm1 state. It was assumed that the home conversion would last the patient's lifetime and therefore no further building conversion costs have been applied to the home HD intervention.

Roderick *et al* 2005 [3] completed a HTA evaluation of the costs and effectiveness of the provision of RRT in hospitals and satellite units in the UK[7]. A cross sectional comparison of patients receiving satellite HD and those receiving hospital HD who were eligible for satellite HD was undertaken. This study reports that the annual cost of the HD machine per patient treated in the hospital. This value has been inflated and used in the model for states associated with hospital HD. For the home based HD states, the annuitised cost of the dialysis machine as reported in Mowatt *et al* [2] is used. An option would be to apply the entire cost for a new dialysis machine when home based HD commences in the model, however according to clinical opinion, it is most likely that patients on home HD receive older machines, and that if a patient no longer required the machine, it would be used immediately for another patient. In a sensitivity analysis the cost of a new dialysis machine as reported in Roderick *et al* [3] is inflated and applied as a once off cost in the home-based HD intervention in the home HDm1 state. For the home HD intervention, the monthly cost of water treatment and parts was reported by Mowatt *et al* [2] and has been inflated and included in the model.

Mowatt *et al* [2] reports the calculated medical staff cost per patient per HD session. For the hospital HD related states, this cost has been inflated and applied. For the home HD related states, no hospital medical staff costs related to dialysis sessions has been included. The hospital nursing staff time per patient per session is reported in the Roderick [3] HTA and has been inflated and used in the hospital-based HD states. McFarlane *et al* 2002 [14] report the amount of nursing time required for HNHD compared to HD in a hospital unit. The ratio of nursing time in the 2 settings has been applied to the time required for hospital HD states and applied to home HD states. This assumes that that conventional home HD requires the same nursing input at HNHD. This assumption is likely to be conservative (the costs for home HD are likely to be less that HNHD). Time requirements for a dialysis technician for hospital HD and HNHD was reported in McFarlane *et al* [14]. The wage of a dialysis technician was assumed to be the same as a Band 5 nurse and the time requirement for HNHD was assumed to be the same as convention home HD. The travel costs for a dialysis technician was estimated using figures from Mowatt *et al* [2] and applied to the home HD related states.

Roderick *et al* [3] report that 48% of patients attending hospital HD require NHS transport. The cost reported in the National Schedule of Reference Costs [27] is applied in the model. No NHS transport costs have been applied to the home HD related states.

---

[7] Note this paper did not fulfil our criteria for inclusion in the literature review as it does not include a home HD component but it plays an important role in subsequent costing of the hospital HD regimen.

Roderick *et al* [3] reports the average number of visits to the outpatient renal clinic for those having hospital-based HD. It was assumed that home HD patients would have the same number of visits. The cost for a consultant led face to face follow up appointment at a nephrology clinic was sourced from the National Schedule of Reference Costs [27].

Training for home HD is assumed to take place in the hospital, and training costs have been included in the Hosp/T_HDD state for the home HD intervention. It is costed by inflating the cost of training reported by Mowatt *et al* [2].

Medications

Erythropoietin (EPO) is an expensive drug and frequently used in HD. This is the only medication cost that is included in the model. Roderick *et al* [3] reports the mean dose of EPO per patient per week on hospital HD. The mean dose per patient prescribed EPO has been calculated and used for hospital HD related states. For home HD related states, the proportion of EPO use in HNHD and hospital HD as reported in McFarlane *et al* [14] is used to adjust the proportion of patients on home HD prescribed EPO[8].

Complications

Although there are several adverse events that can occur in patients undertaking HD, the only events that have been costed in this analysis are hospitalisations. Roderick *et al* [3] reports the number of hospitalisations for those undertaking hospital HD. This was costed by calculating the weighted average of all the non elective admissions described as 'Chronic renal failure' using the National Schedule of Reference Costs [27]. The number of hospitalisations reported in Roderick *et al* [3] has been adjusted by the proportion of hospitalisations reported in the home HD and hospital HD groups in the Saner *et al* [5] publication which reports lower rates of hospitalisations for the home HD group. Possible reasons for fewer hospitalisations in the home HD group maybe related to the fact that in the hospital setting, monitoring by medical and nursing staff may increase the likelihood of reporting adverse events and the convenience of a hospital admission whilst the patient is at the hospital dialysis unit might increase the number of hospitalisations. Patients dialysing in the centre may also have fewer social supports and therefore may need hospitalisation for more minor events compared to those patients who may have carers to nurse them through minor complications.

[8] The price differential between HNHD and hospital HD as reported in McFarlane *et al* [14] 2002 was used to ascertain the relative use of EPO in the 2 groups.

Other healthcare services

The number of GP, district nurse and social worker visits was reported in Roderick *et al* [3] for patients undertaking hospital HD. It is assumed that the resource use for GP services is the same for both the home HD and hospital HD interventions. According to McFarlane *et al* [14] the amount of social worker time for both the HNHD and the hospital HD groups are the same, and therefore the home HD and the hospital HD groups are assumed to require the same amount of time and visits. It is assumed that patients in the home HD states have double the amount of visits by a district nurse compared to the hospital HD states. All the 'Other healthcare services' are costed using the PSSRU [26].

Indirect costs

In a sensitivity analysis, the impact of including patient travel/wait time costs, travel costs and carer time costs is assessed. The median adult hourly rate as reported by the Office of National Statistics [29] is used to cost patient and carer time. For private transport costs, the cost of travel for a community health worker is used as it is assumed that the travel costs for patients and health care workers are the same.

Table 5 summarises the unit costs used in the model. Where source data have been adjusted, a comment is included in the table. Table 6 shows the resource use for each of the non absorbing Markov states, and table 7 provides a summary of the state costs. The total costs represent the monthly per cycle costs assigned within the base case model.

Table 5. Unit costs

Cost		Unit costs (£)	Source	Comment
Access	Vascular access surgery	1687.53 per surgery	National Schedule of Reference costs [27]	Weighted average of codes QZ13A and QZ13B for elective inpatient stayQ
Dialysis	Consumables	37.62 per session	Mowatt *et al* [2]	Cost of EPO removed from Mowatt reported costs and inflated
	Capital costs - building	8.95 per session	Mowatt *et al* [2]	Inflated
	Capital costs - dialysis machine	971.53 per year	Roderick *et al* [3]	Inflated
	Capital costs - water treatment systems	624.52 per year	Mowatt *et al* [2]	Applied to home HD intervention only
	Medical staff	7.785 per session	Mowatt *et al* [2]	Inflated
	Nursing staff	6679.76 per year	Roderick *et al* [3]	Inflated

	Renal Technician	27,100 assumed annual salary	Assumption; PSSRU [26]	Assumed same salary as a Band 5 nurse
	Renal Technician - travel costs	133 per year	Mowatt *et al* [2]	Inflated and applied to home HD intervention only
	NHS Travel costs	29 one way	National Schedule of Reference costs [27]	Outpatient patient transport service
	Patient/Carer time costs	10.99 per hour	Office of National Statistics [29]	2009 Annual Survey of Hours and Earnings. Median adult hourly rate
	Patient travel cost	1.4 per visit	PSSRU [26]	Assume travel costs for community health worker comparable to patient travel costs
	Scheduled outpatient hospital visits	136 per visit	National Schedule of Reference costs [27]	Nephrology clinic
	Training cost	2.77 per session	Mowatt *et al* [2]	Inflated
Medications	EPO	40.83 per 8,000 units	BNF [28]	
Complications	Hospitalisations	2130.33per admission	National Schedule of Reference costs [27]	Weighted average non elective admissions with chronic renal failure
Other Healthcare services	GP	52 per visit	PSSRU [26]	Assume 17.2 minute consultation
	District nurse (home visit)	26 per visit	PSSRU [26]	Home visit
	Social worker	138 per visit	PSSRU [26]	1 hour visit

Table 6. Resource use per month in each Markov state

Cost		Hospital HD/T_home HD	Hospital HD	Home HDm1	Home HD	Source/ Notes
Dialysis	Consumables	13	13	13	13	Per session cost converted to monthly cost
	Capital costs - building	13	13	1	-	
	Capital costs - dialysis machine	0.08	0.08	0.08	0.08	

	Capital costs - water treatment systems	-	-	0.08	0.08	
	Medical staff	13	13	-	-	
	Nursing staff	0.08	0.08	-	-	
	Renal technician	0.0033	0.0033	0.01	0.01	McFarlane *et al* [13]
	Renal technician - travel costs	-	-	0.08	0.08	
	NHS travel costs	26*0.48	26*0.48	-	-	Roderick *et al* [3], 48% of patients use NHS transport
	Patient / carer time costs	21.45	21.45	13	13	Roderick *et al* [3], assumption that 1 hour carer time required for each home HD session
	Patient travel cost	13*0.52	13*0.52	-	-	Roderick *et al* [3], 52% of patients use private transport
	Scheduled outpatient hospital visits	0.29	0.29	0.29	0.29	Roderick *et al* [3]
	Training for home HD	13	-	-	-	
Medications	EPO	4.33*0.91	4.33*0.91	4.33*0.91	4.33*0.91	Roderick *et al* [3] reports 91% of patients are prescribed EPO
CCs	Hospitalisations	0.059	0.059	0.035	0.035	Roderick *et al* [3]; Saner *et al* [5]
Other healthcare services	GP	0.375	0.375	0.375	0.375	Roderick *et al* [3]
	District nurse (home visit)	0.158	0.158	0.158*2	0.158*2	Roderick *et al* [3], assumed double the amount of visits for home HD/home HDm1
	Social worker	0.158	0.158	0.158	0.158	Assumption based on Roderick *et al* [3] and McFarlane *et al* [14]

Table 7. Summary of Markov state costs (£)

	Cost	Hospital HD/T_home HD	Hospital HD	Home HDm1	Home HD
Dialysis	Consumables	489.10	489.10	489.10	489.10
	Capital costs - building	116.30	116.30	5784.08	-
	Capital costs - dialysis machine	80.96	80.96	270.99	270.99
	Capital costs - water treatment systems	-	-	52.04	52.04
	Medical staff	101.21	101.21	-	-
	Nursing staff	556.65	556.65	151.81	151.81
	Renal technician	90.33	90.33	135.50	135.50
	Renal technician - travel costs	-	-	11.08	11.08
	NHS travel costs	359.73	359.73	-	-
	Patient / carer time costs	116.01	116.01	142.87	142.87
	Patient travel cost	9.46	9.46	-	-
	Scheduled outpatient hospital visits	39.56	39.56	39.56	39.56
	Training for home HD	35.97	-	-	-
Medications	EPO	160.75	160.75	96.98	96.98
CCs	Hospitalisations	125.87	125.87	75.52	75.52
Other healthcare services	GP	19.50	19.50	19.50	19.50
	District nurse (home visit)	4.12	4.12	8.23	8.23
	Social worker	21.85	21.85	21.85	21.85
Total costs for base case		**2,201.88**	**2,165.91**	**7,156.24**	**1,372.16**

Utility data

Utility values for the health states are based on those reported by Manns *et al* 2003 [20]. The literature suggests that home HD patients have improved quality of life and utility relative to hospital HD patients. In the model we apply the preference-based utility from Manns *et al* to hospital HD. However there was difficultly in ascertaining utilities for the home HD group due to small patient numbers and applicability of literature to the UK setting. Therefore the value reported in Manns *et al* for hospital

HD is adjusted using the relative weight for limited care HD and hospital HD reported in deWitt *et al* 1999:

Hospital HD utility = 0.609; home HD utility = 0.609 * (0.81/0.66) = 0.747

It is assumed that the utility of patients undergoing HD in a limited care setting is comparable to patients undertaking home HD. The state utility is applied for the duration for which the subject remains in each state.

As there is no convincing evidence to support the increased efficacy of home HD compared with hospital HD, it is interesting that health related quality of life appears to be better in home HD patients. This could be related to the increased complications and hospitalisations in the hospital HD group compared with home HD and the impact of more control over their HD on patient psychosocial wellbeing could also be a possible explanation.

Please note that this utility benefit can be 'switched off' within the model. In the analysis against satellite HD we assume that the utility for satellite HD patients is the same as hospital HD patients. This is supported by the evidence from Roderick *et al* [3] which reports that the EQ5D in hospital HD and satellite HD is very similar (0.60) and not significantly different to each other. Clinical opinion confirms that the quality of life in subjects on home HD is likely to be higher than those dialysing in the hospital and satellite unit setting.

Sensitivity analyses

A series of one-way sensitivity analyses were performed in order to address the issue of uncertainty around key model parameters. Analysis parameters are described in table 8.

Table 8. Variables used in one way sensitivity analyses

No	Sensitivity analysis	Base case values	Values used in the sensitivity analysis
1	Discount rate	3.5%	0%
2	Discount rate	3.5%	6%
3	Time horizon	10 years	1 years
4	Time horizon	10 years	5 years
5	Time horizon	10 years	20 years
6	Age at start	48 years	65 years
7	Age at start	48 years	40 years

8	Cost and utilities	Costs: See table 7 Utilities: Hospital HD; Hospital HD/T_home HD: 0.609 Home HD; home HDm1: 0.747	Costs & utilities from Mowatt *et al* 2003 [2] converted to monthly costs: Hospital HD: £2396.97; 0.66 Home HD: £2097.86; 0.81
9	Cost	Costs: See table 7	Costs from Baboola *et al* 2008 [18] converted to monthly costs Hospital HD: £2918.58 Home HD: £1730.33
10	Costs	Home HD –annuitised cost of dialysis machine	Home HD – non annuitised cost of dialysis machine applied in home HDm1 state
11	Costs	Include NHS transport	Exclude NHS transport
12	Utilities	Utilities: Hospital HD; hospital HD/T_home HD: 0.609 Home HD; home HDm1: 0.747	Utilities from McFarlane *et al* 2006 [13] Hospital HD: 0.53 Home HD: 0.77
13	Utilities	Utilities: Hospital HD; hospital HD/T_home HD: 0.609 Home HD; home HDm1: 0.747	Utilities: Hospital HD; hospital HD/T_home HD: 0.609 Home HD; home HDm1: 0.609
14	Transition to home HDm1 from Hospital HD/T_home HD	Mean training time is 2 months	Mean training time is 4 months
15	Transition to home HDm1 from hospital HD/T_home HD	Mean training time is 2 months	Mean training time is 1 month
16	Transition to hospital HD from home HD/home HDm1	5%	20%
17	Transition to hospital HD from home HD/home HDm1	5%	0%
18	Transplantation rate	18% annually	30% annually
19	Transplantation rate	18% annually	0% annually
20	Mortality	Mortality RR = 1 for home HD	Kjellstrand [8] reported mortality RR = 0.44 for home HD

Scenario analyses were also conducted. Scenario 1 compared home HD against satellite HD. To assess the cost-effectiveness of home HD compared to satellite HD, the same model structure was used, where all home based HD states were replaced with satellite unit based HD. Although there is no training costs involved in preparation for satellite HD, it is assumed that patients start with HD in the hospital setting (for 1 month) before transitioning to a satellite HD unit. It is assumed that the cost of consumables, capital building costs and the cost of dialysis technicians are assumed to be the same as hospital HD. Medical staff time for satellite HD is based on the estimates reported in Mowatt *et al* [2], and the rest of the costs are based on the Roderick *et al* HTA [3].

The utility for the satellite HD intervention was assumed to be the same as the hospital HD intervention. Transition to the kidney transplant and PD absorbing states is assumed to be the same as for the home HD intervention. It is assumed however that the annual probability of satellite HD modality failure is half that of home HD (*i.e.* 2.5% a year), this was confirmed as being a reasonable assumption by the clinical expert. It is also assumed that the age related probability of death for satellite HD is the same as home HD.

Scenario 2 assessed the impact of including patient costs for travel and assigning a cost to informal care. Patient travel and wait time for hospital HD was included however the actual time for undertaking HD was not included. Clinical opinion suggests that 1 hour of carer time is required for each home HD session for set up, monitoring and disconnection. Although some patients dialysing at home will be able to complete the whole procedure independently, 1 hour carer time is assigned to the entire home HD cohort. Private transport travel costs were also included in this analysis.

Base case analysis

The base case results comparing home HD to hospital HD are shown in table 9. home HD is the dominant strategy over hospital HD, producing better outcomes at a lower cost.

The total costs over the 10 year time horizon are substantial for both interventions, however home HD produces cost savings in the region of £20,700 compared to hospital HD. hospital HD staff costs are approximately £15,000 greater than home HD. As expected, the home HD intervention involves higher capital costs compared to hospital HD.

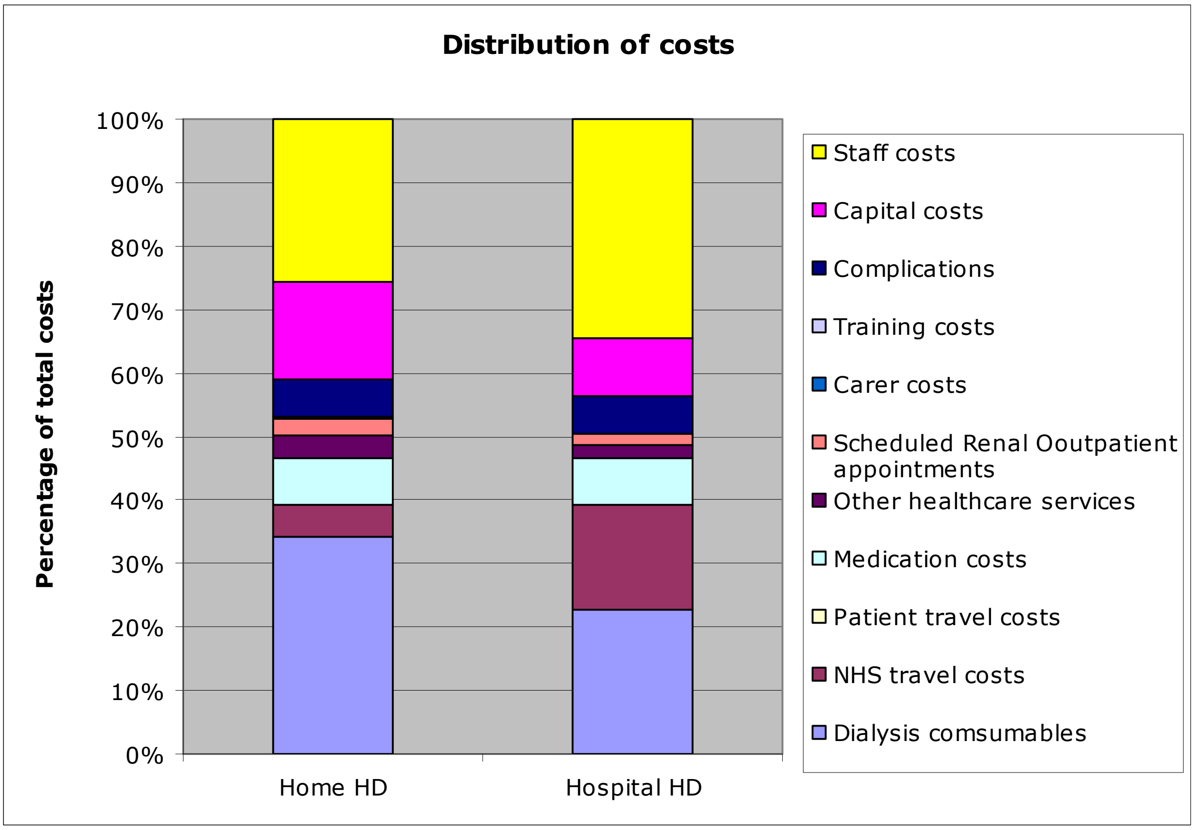
Over the 10 year period is it expected that the home HD patients will accrue approximately 0.38 more QALYs compared to hospital HD patients.

Table 9. Base case - home HD versus hospital HD

	Home haemodialysis	Hospital haemodialysis	Incremental
Total cost (£)	68,284	89,029	-20,745
Capital costs (£)	8,886	7,918	969
Staff costs (£)	14,736	30,033	-15,297
Total QALY	2.42	2.04	0.38
Cost per QALY			Home HD dominates

The distribution of costs across the two treatment modalities is provided in Figure 2. Consumables and capital costs comprise the largest percentage of costs for the home HD patients, while travel costs and staff costs comprise the largest percentage of hospital HD costs.

Figure 2. Distribution of total costs by treatment modality



Sensitivity analyses

For the base case scenario, a set of one way sensitivity analyses have been completed and are reported below (table 10). The results of the one way sensitivity analysis show that in all scenarios home HD is the dominant strategy.

There were three different time horizons that were investigated (analysis 3-5). When the time horizon was decreased to 1 or 5 years, there was a substantial decrease in the cost savings and the incremental QALYs for the home HD intervention. When the time horizon was increased to 20 years, as expected home HD had slightly higher cost savings. Therefore the longer a patient remains in the home HD intervention, the longer the subject has to benefit from the treatment.

Changing the age of the cohort at the start of the model has a significant impact on the incremental cost results (analysis 6&7). When the age at start of the model was 70 years, the cost savings dramatically reduced. This is due to patients in the older age group not living long enough to benefit fully from home HD. When the age at start was decreased, cost savings increased.

The impact of changing the cost and utility values was assessed in analyses 8 to 13. Estimates of costs and utilities from various sources were used to assess the impact on the resultant incremental costs and QALYs. In analysis 8, the state costs and utilities reported in the Mowatt *et al* [2] HTA was tested in the current model. This results in the estimated savings produced by the home HD intervention being much less than in the base case model. When the Baboolal *et al* [18] cost estimates for the Markov states were used, the cost savings for home HD improved considerably (analysis 9). In analysis 10, the impact of applying the entire cost for the dialysis machine at the start of the home based therapy was assessed. Analysis 11 assessed the impact of excluding NHS transport costs. Both these analyses result in significantly reduced cost savings for the home HD intervention.

When using the utilities reported by McFarlane and colleagues [13], the incremental QALY gain for the home HD intervention was greater than in the base case analysis (analysis 12). When no utility benefit was assumed, home HD remained a cost saving strategy (analysis 13).

Analysis 14 and 15 assessed the impact of changing the time required to train patients for home HD. This parameter has limited impact on the results.

Increasing transitions out of the home HD state either into the transplantation state or back to the hospital HD state due to home HD modality failure resulted in reduced cost savings and benefits for the home HD strategy. Conversely, decreasing the probability of transitions out of the home HD state, improves cost savings and benefits for the home HD intervention (analysis 16-19).

Analysis 20 assessed the impact of different assumptions regarding risk of death in the model. A crude mortality assumption based on the RR value reported by Kjellstrand *et al* [8] is used (RR = 0.44) and is applied for the entire time horizon. This resulted in the incremental QALYs increasing as expected, however the cost savings for the home HD intervention decreased. This is because if patients die quicker as a result of an intervention, they no longer require expensive dialysis treatment and therefore the total cost decreases for the hospital HD intervention.

Results

Table 10. Results of the one way sensitivity analyses - home HD versus HospHD

No	Sensitivity analyses	Costs						Results
		Home HD	Hospital HD	Incremental	Home HD	Hospital HD	Incremental	ICER
	Base case	**68,284**	**89,029**	**-20,745**	**2.42**	**2.04**	**0.38**	**home HD dominates**
1	Discount rate – 0%	73,958	96,909	-22,951	2.63	2.22	0.41	home HD dominates
2	Discount rate – 6%	64,873	84,275	-19,402	2.29	1.93	0.36	home HD dominates
3	Time horizon – 1 year	23,576	24,718	-1,143	0.64	0.54	0.10	home HD dominates
4	Time horizon – 5 years	55,597	72,047	-16,451	1.97	1.65	0.32	home HD dominates
5	Time horizon – 20 years	71,950	93,543	-21,593	2.54	2.14	0.40	home HD dominates
6	Age at start – 70 years	52,000	66,272	-14,272	1.80	1.51	0.29	home HD dominates
7	Age at start – 40 years	71,790	93,903	-22,112	2.55	2.15	0.40	home HD dominates
8	Cost and utilities – Mowatt *et al* [2]	88,376	98,304	-9,928	2.62	2.21	0.41	home HD dominates
9	Cost - Baboolal *et al* [18]	79,803	119,242	-39,439	2.42	2.04	0.38	home HD dominates
10	Costs – non annuitised HD machine costs	81,567	89,029	-7,462	2.42	2.04	0.38	home HD dominates

Results

No	Sensitivity analyses		Costs					Results
		Home HD	Hospital HD	Incremental	Home HD	Hospital HD	Incremental	ICER
	Base case	**68,284**	**89,029**	**-20,745**	**2.42**	**2.04**	**0.38**	**home HD dominates**
11	Costs – exclude NHS travel costs	65,784	74,590	-8,805	2.42	2.04	0.38	home HD dominates
12	Utilities – McFarlane *et al* [13]	68,284	89,029	-20,745	2.44	1.77	0.66	home HD dominates
13	Utilities – no utility benefit for home HD	68,284	89,029	-20,745	2.04	2.04	0.00	home HD dominates
14	Transition – 4 months training	69,389	89,029	-19,641	2.40	2.04	0.36	home HD dominates
15	Transition – 1 month training	67,714	89,029	-21,315	2.43	2.04	0.39	home HD dominates
16	Transition – home HD modality failure 20%	76,587	89,029	-12,442	2.30	2.04	0.26	home HD dominates
17	Transition – home HD modality failure 0%	64,338	89,029	-24,691	2.48	2.04	0.44	home HD dominates
18	Transplantation rate – 30%	48,331	60,974	-12,643	1.65	1.38	0.26	home HD dominates
19	Transplantation rate – 0%	131,655	176,552	-44,897	4.81	4.07	0.74	home HD dominates
20	Mortality – home HD RR = 0.44	72,180	89,029	-16,849	2.58	2.04	0.54	home HD dominates

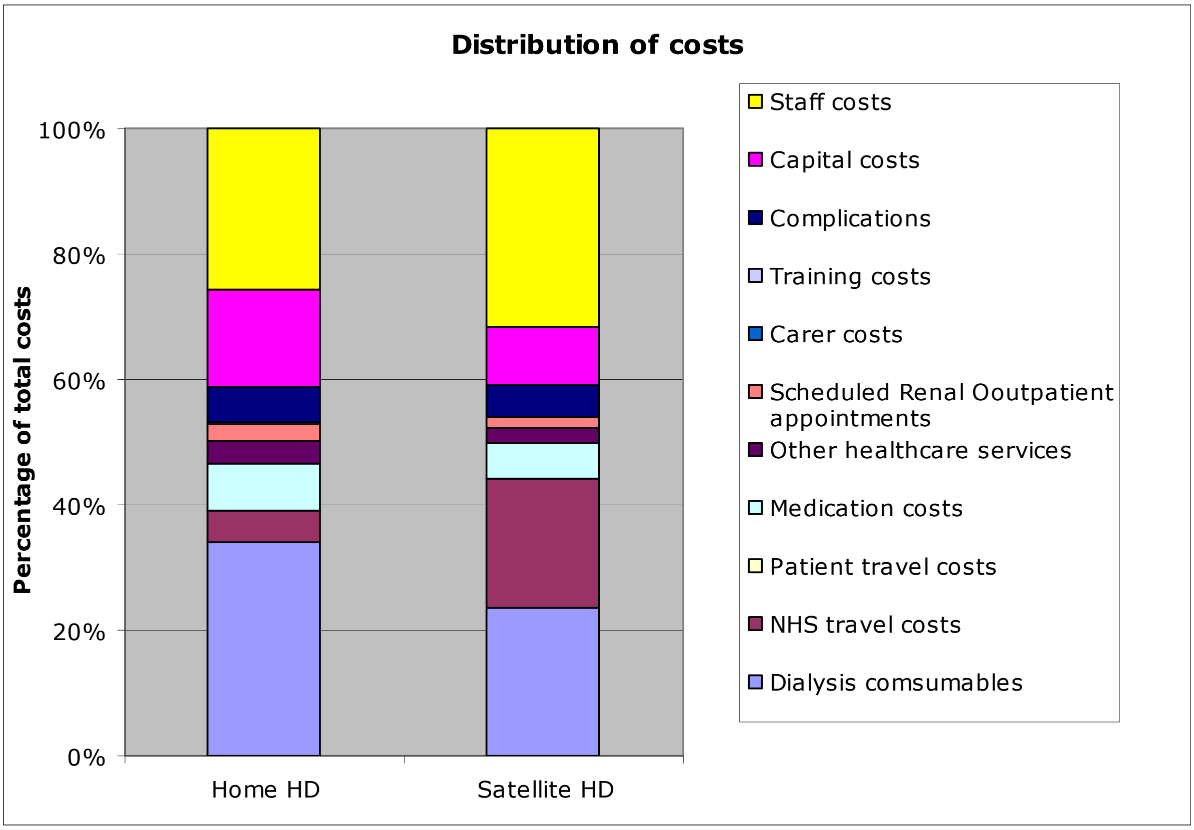
Scenario 1: home HD versus satellite HD

In the comparison against satellite HD, home HD dominated with cost savings in the region of £17,000 and a QALY gain of approximately 0.38 QALY over the 10 year time horizon (table 11). Figure 3 shows the distribution of costs for the home HD and satellite HD interventions. The distribution of costs for the satellite HD intervention is similar to the hospital HD intervention with staff and NHS travel costs being significant contributors to the total costs.

Table 11. Scenario 1: home HD versus satellite HD

	Home HD	Satellite HD	Incremental
Total cost (£)	68,284	85,445	-17,160
Capital costs (£)	8,886	7,625	1,262
Staff costs (£)	14,736	26,404	-11,668
Total QALY	2.42	2.04	0.38
Cost per QALY			home HD dominates

Figure 3: Distribution of costs for scenario 1



Scenario 2: inclusion of informal care and patient travel time (home HD versus hospital HD)

In the comparison of home HD against hospital HD where costs of informal care were included, home HD dominated with cost savings in the region of £15,000 (table 12). A breakdown of the costs incurred indicates that in this analysis around 12% of total costs are accounted for by the informal care costs (

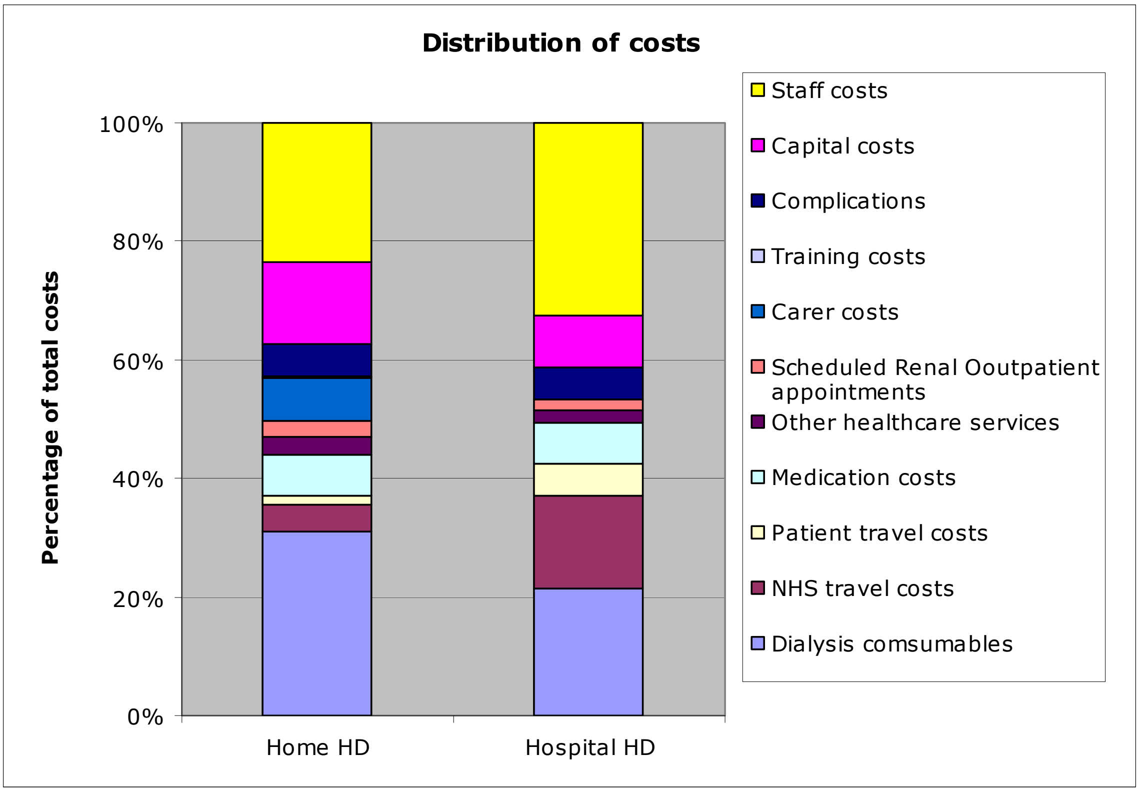
Figure 4).

Table 12. Scenario 2: inclusion of informal care and patient travel time

	Home HD	Hospital HD	Incremental
Total cost (£)	73,898	94,066	-20,167
Capital costs (£)	8,886	7,918	969
Staff costs (£)	14,736	30,033	-15,297
Total QALY	2.42	2.04	0.38

Cost per QALY	home HD dominates

Figure 4. Distribution of costs for scenario 2



Discussion

Kidney function is required to sustain life, and when kidney dysfunction reaches a critical level, RRT is required. After renal transplant, HD is the most common method of RRT used in the UK [1]. The current analysis explored the cost-effectiveness of home-based versus hospital-based HD in a cohort of young and relatively healthy cohort of patients on HD and suitable for home HD.

The literature review revealed relatively few studies specifically reporting the outcome of HD in different treatment settings. Due to the nature of the intervention, the majority of the papers where observational studies which are prone to selection bias, limiting their applicability to the cost-effectiveness model. Due to the lack of robust clinical data to populate the current model, many assumptions have been made. Expert clinical opinion was used to ascertain the most appropriate assumptions for the UK base case and these assumptions have been tested in one way sensitivity analyses. Although the assumptions were based on the most likely UK scenario, some assumptions that could have a large impact on the results were intentionally biased against home HD in order for the cost-effectiveness estimates to be conservative (*e.g.* no mortality benefit was used in the base case despite observational studies reporting this benefit [8,11]).

The current model incorporates features of the two most relevant modelling papers [2,13] and attempts to use the most current UK specific data to populate the analyses. Extensive sensitivity analyses have been completed to test the robustness of the model assumptions. The results indicate that home HD is less costly and more effective than hospital HD for the base case. The cost savings are in the order of £20,700 over the 10 year time frame. The utility benefit was in the order of 0.38 QALYs over the 10 year period for the base case assumptions. The direction of results are consistent with the outcome of the Mowatt *et al* [2] and the McFarlane *et al* [13] papers. This is not unexpected given the reliance of the current model on the data from these two papers. However, the current model's updated model structure, the use of more current data when available, and changes in key assumptions, ensure that the current model results adds to the literature available and reinforces that in the current UK setting, home HD remains a cost-effective strategy when compared with hospital and satellite HD.

As seen in the one-way sensitivity analyses, the model results were most sensitive to parameters that resulted in transitions from the home HD state. The largest cost savings occurred when the transplantation rate was assumed to be 0%, and the lowest cost savings occurred when the time horizon was limited to 1 year. This is predictable as the start-up costs would have been incurred, but there is a limited period in which the cohort could benefit from the home HD intervention. Using the Baboolal *et al* [18] state cost estimates also significantly increases the cost savings for the home HD intervention, whereas applying non-annuitised dialysis machine costs and excluding the NHS transport costs significantly decreased the cost savings.

The sensitivity analyses that resulted in the highest incremental QALY estimates for the home HD intervention was the analysis which set the transplantation rate to 0%, the analysis which used the utility measures from the McFarlane [13] paper and when a survival benefit for the home HD intervention was applied. There was no QALY gain in the home HD intervention when state utilities were assumed to be equal and the QALY gain was significantly reduced when the probability of modality failure and transplantation was high.

There are several limitations to the current economic model. The first relates to the data used to populate the model; there are inherent sources of bias when using data from observational studies. There was a lack of resource use data available to accurately estimate the current costs especially for the home HD intervention and there were limited data on the utility associated with home HD. Therefore several assumptions have been made. Secondly, the model applies a relatively crude method for estimating utility and assumes that the utility of the Markov states do not change as patients age in the model. This is also a limitation of the current model but data did not exist to inform a more sophisticated approach. Thirdly, when there was a lack of current data, it was often necessary to use data from previous models, limiting the relevance of a de novo model. A final limitation involves the model's approach to the inclusion of indirect costs. Although some indirect costs are included, this scenario does not represent a true societal perspective and results should be interpreted with caution.

There is adequate evidence that the conventional regime of home HD is a more cost effective RRT modality compared to the conventional regime of hospital HD and satellite HD. Due to the recent increased interest in daily HD, and the logistical advantage of the home setting to deliver the daily regime of HD, it will be useful in conduct cost-effectiveness analyses for the UK setting comparing the impact of daily HD regimes in the home compared to conventional HD in the hospital or satellite unit setting. Although the current model structure is largely appropriate to undertake this analysis, further literature review will be required to assess the efficacy and cost inputs for the new interventions.

Conclusions

As reported in previous cost-effectiveness studies, the current analysis found that home HD is a cost-effective RRT modality compared to hospital based HD and satellite HD in a select group of patients who are suitable for home HD. This analysis found that home HD was both cost saving and produced greater QALYs compared to hospital HD and satellite HD. Although there is limited high quality evidence to support the superiority of home HD, the model analyses found that home HD was cost-effective in the majority of analyses and scenarios tested.

Acknowledgements

We should like to thank the following for their contribution to this report.

Stephen Morris, Professor of Health Economics, Research Department of Epidemiology and Public Health

Albert Power, Imperial College Kidney & Transplant Institute

References

(1) UK Renal Registry. The Eleventh Annual Report. 2008.

(2) Mowatt G, Vale L, Perez J, Wyness L, Fraser C, Macleod A, et al. Systematic review of the effectiveness and cost-effectiveness, and economic evaluation, of home versus hospital or satellite unit haemodialysis for people with end-stage renal failure. [Review] [64 refs]. Health Technology Assessment (Winchester, England) 2003;7(2):1-174.

(3) Roderick P, Nicholson T, Armitage A, Mehta R, Mullee M, Gerard K, et al. An evaluation of the costs, effectiveness and quality of renal replacement therapy provision in renal satellite units in England and Wales. Health Technology Assessment 9(24)()(pp iii-92), 2005 Date of Publication: Jul 2005 2005;(24):iii-92.

(4) Suri RS, Nesrallah GE, Mainra R, Garg AX, Lindsay RM, Greene T, et al. Daily hemodialysis: a systematic review. [Review] [78 refs]. Clinical Journal of The American Society of Nephrology: CJASN 2006 Jan;1(1):33-42.

(5) Saner E, Nitsch D, Descoeudres C, Frey FJ, Uehlinger DE. Outcome of home haemodialysis patients: a case-cohort study. Nephrology Dialysis Transplantation 2005 Mar;20(3):604-10.

(6) Kraus M, Burkart J, Hegeman R, Solomon R, Coplon N, Moran J. A comparison of center-based vs. home-based daily hemodialysis for patients with end-stage renal disease. Hemodialysis International 2007 Oct;11(4):468-77.

(7) Piccoli GB, Bermond F, Mezza E, Burdese M, Fop F, Mangiarotti G, et al. Vascular access survival and morbidity on daily dialysis: A comparative analysis of home and limited care haemodialysis. Nephrology Dialysis Transplantation 19(8)()(pp 2084-2094), 2004 Date of Publication: Aug 2004 2004;(8):2084-94.

(8) Kjellstrand CM, Buoncristiani U, Ting G, Traeger J, Piccoli GB, Sibai-Galland R, et al. Short daily haemodialysis: Survival in 415 patients treated for 1006 patient-years. Nephrology Dialysis Transplantation 23(10)()(pp 3283-3289), 2008 Date of Publication: October 2008 2008;(10):3283-9.

(9) Sands JJ, Lacson J, Ofsthun NJ, Kay JC, az-Buxo JA. Home hemodialysis: A comparison of in-center and home hemodialysis therapy in a cohort of successful home hemodialysis patients. ASAIO Journal 55(4)()(pp 361-368), 2009 Date of Publication: July-August 2009 2009;(4):361-8.

(10) Ageborg M, Allenius BL, Cederfjall C. Quality of life, self-care ability, and sense of coherence in hemodialysis patients: a comparative study. Hemodialysis International 2005 Oct;9:Suppl-14.

(11) Hellerstedt WL, Johnson WJ, Ascher N, Kjellstrand CM, Knutson R, Shapiro FL, et al. Survival rates of 2,728 patients with end-stage renal disease. Mayo Clin Proc 1984 Nov;59(11):776-83.

(12) de Wit GA, Ramsteijn PG, de Charro FT. Economic evaluation of end stage renal disease treatment. Health Policy 1998 Jun;44(3):215-32.

(13) McFarlane PA, Bayoumi AM, Pierratos A, Redelmeier DA. The impact of home nocturnal hemodialysis on end-stage renal disease therapies: a decision analysis. [Review] [67 refs]. Kidney International 2006 Mar;69(5):798-805.

(14) McFarlane PA, Pierratos A, Redelmeier DA. Cost savings of home nocturnal versus conventional in-center hemodialysis. Kidney International 62(6)()(pp 2216-2222), 2002 Date of Publication: 2002 2002;(6):2216-22.

(15) McFarlane PA, Bayoumi AM, Pierratos A, Redelmeier DA. The quality of life and cost utility of home nocturnal and conventional in-center hemodialysis. Kidney International 64(3)()(pp 1004-1011), 2003 Date of Publication: 01 Sep 2003 2003;(3):1004-11.

(16) Kroeker A, Clark WF, Heidenheim AP, Kuenzig L, Leitch R, Meyette M, et al. An operating cost comparison between conventional and home quotidian hemodialysis. American Journal of Kidney Diseases 2003 Jul;42(1:Suppl):Suppl-55.

(17) Winkelmayer WC, Weinstein MC, Mittleman MA, Glynn RJ, Pliskin JS. Health economic evaluations: the special case of end-stage renal disease treatment. Medical Decision Making 2002 Sep;22(5):417-30.

(18) Baboolal K, McEwan P, Sondhi S, Spiewanowski P, Wechowski J, Wilson K. The cost of renal dialysis in a UK setting - A multicentre study. Nephrology Dialysis Transplantation 23(6)()(pp 1982-1989), 2008 Date of Publication: Jun 2008 2008;(6):1982-9.

(19) Agar JWM, Knight RJ, Simmonds RE, Boddington JM, Waldron CM, Somerville CA. Nocturnal haemodialysis: An Australian cost comparison with conventional satellite haemodialysis. Nephrology 10(6)()(pp 557-570), 2005 Date of Publication: Dec 2005 2005;(6):557-70.

(20) Manns B, Johnson JA, Taub K, Mortis G, Ghali WA, Donaldson C. Quality of life in patients treated with hemodialysis or peritoneal dialysis: What are the

important determinants? Clinical Nephrology 60(5)()(pp 341-351), 2003 Date of Publication: Nov 2003 2003;(5):341-51.

(21) Dale PL, Hutton J, Elgazzar H. Utility of health states in chronic kidney disease: a structured review of the literature. [Review] [60 refs]. Current Medical Research & Opinion 2008 Jan;24(1):193-206.

(22) Manns BJ, Walsh MW, Culleton BF, Hemmelgarn B, Tonelli M, Schorr M, et al. Nocturnal hemodialysis does not improve overall measures of quality of life compared to conventional hemodialysis. Kidney International 2009 Mar;75(5):542-9.

(23) NICE. Guidance on home compared with hospital haemodialysis for patients with end-stage renal failure. Technology Appraisal Guidance - No. 48. 2002.

(24) NHS Blood and Transpplant. Transplant Activity Report 2008-2009. 2009.

(25) Office of National Statistics. Interim Life Tables, United Kingdom 2006-08. 2009.

(26) Personal Social Services Research Unit (PSSRU). Unit Costs of Health and Social Care 2009. 2009.

(27) Department of Health. NHS Reference Costs 2008-09. 2010.

(28) BMJ Group and RPS Publishing. British National Formulary 58. 2009.

(29) Office of National Statistics. 2009 Annual Survey of Hours and Earnings. 2009.

Table 13. Search strategy (adapted and updated search by Mowatt *et al* 2003 (2)

Search	Strategy
1	hemodialysis,home/
2	home dialysis/
3	hemodialysis/ or exp continuous hemodialysis/
4	exp renal replacement therapy/
5	Hemodiafiltration/
6	exp chronic kidney failure/
7	kidney,artificial/
8	hemodialysis units,hospital/
9	dialysis centers/
10	dialysis patients/
11	(hemodia$ or haemodia$ or dialy$).tw.
12	((kidney? or renal) adj2 (replac$ or artificial or extracorporeal or disease? or failure? or sufficien$ or insufficien$)).tw.
13	ur?emi$.tw.
14	or/3-13
15	home care services/
16	home care services,hospital-based/
17	community health services/
18	home nursing/
19	home nursing,professional/
20	(home or domicilliary or community).tw.
21	night care/
22	(nocturnal or night).tw.
23	((slow or daily or regimen?) adj2 (hemodia$ or haemodia$ or daily$)).tw.

24	or/15-23
25	1 or 2 or (14 and 24)
26	randomized controlled trial/
27	controlled clinical trial/
28	clinical trial/
29	non randomized trials/
30	intervention studies/
31	exp randomization/
32	random assignment/
33	case-control studies/
34	non equivalent control group/
35	evaluation studies/
36	comparative studies/
37	comparative study/
38	experiment$.tw.
39	impact.tw.
40	intervention?.tw.
41	chang$.tw.
42	evaluat$.tw.
43	effect?.tw.
44	(randomised or randomized).tw.
45	case control.tw.
46	controls.tw.
47	compar$.tw.
48	(control adj (group? or subject? or patient?)).tw.

49	animal/
50	human/
51	50 not 49
52	or/26-48
53	52 not 51
54	25 and 53
55	(home adj1 (hemodia$ or haemodia$ or dialy$)).ti.
56	54 or 55
57	meta-analysis/
58	review/
59	systematic review/
60	(meta or synthesis or literature or published).ab.
61	(extraction or medline or selection or sources).ab.
62	(trials or review or reviewed).ab.
63	(articles or english or landguage).ab.
64	(randomised or trial? or controlled).hw.
65	or/57-63
66	(comment or letter or editorial).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
67	65 not (51 or 66)
68	25 and 67
69	65 or 68

Table 14. Data extraction table for economic models: McFarlane *et al* 2006 [13]

Reference: McFarlane *et al* 2006 [13]
Country: Canada

Population:
Simulated cohort have characteristics of a previous study by authors [14,15]. The typical patient in the simulated cohort is male, relatively young has better education and has fewer co-morbidities compared to a typical patient on haemodialysis.

Setting and perspective:
Haemodialysis unit with home nocturnal haemodialysis (HNHD) program; Health care payer

Time horizon:
Lifetime

Study design:
Cost-effectiveness analysis.

Comparators:
Only in-centre HD (ICH) (in hospital)
ICH followed by transfer to HNHD

Study endpoints:
Cost, QALYs, NMB

Cost derivation:
Taken from previously published study by authors [14,15] and presented in 2003 Canadian dollars

Analytic framework:
Decision analytic Markov model developed in TreeAge®. Several Markov states to incorporate the differential costs in the 1st year of HNHD compared to subsequent years, complications and post kidney transplant states. Cycle length 1 week.

Differential timing:
3% annual discount rate for costs and outcomes.

Sponsorship/Research Support*:*
Canadian Society for Nephrology & Kidney Foundation of Canada

Health outcomes:
QALY weights, complication rates - previously published study by authors [15] and other published papers
Mortality – Published paper by Wolfe *et al* 1999
Post transplant variables taken from various published sources.

Costs:
Summary costs for states (annual), and weekly costs for complications - previously published study by authors [14] and other published papers.
Post transplant costs taken from various published sources.

Incremental analysis:
Cost per QALY – HNHD found to be more effective and cost saving.
NMB positive for various willingness to pay thresholds between $0-$100,000 per QALY.
HNHD was dominant strategy for all scenarios tested.

Sensitivity analysis:
HNHD was dominant strategy for all scenarios tested.
HNHD was not cost effective in the following SA:

- ICH less costly than HNHD
- ICH utility better than HNHD
- Time to death or transplantation < 108 weeks

Study limitations:
The authors report limitations including the lack of rigorous RCT data for key inputs; the possibility that the model simplifies the lives of patients undergoing HD; selection bias – cohort systematically different to the average haemodialysis subject; data on prevalent dialysis patients used in the model introducing survivorship bias.

Table 15. Data extraction table for economic models: Mowatt *et al* [2]

Reference: Mowatt *et al* [2]
Country: UK

Population:
Patients with end stage renal disease
Subgroups: Low (base case), medium and high risk patients

Setting and perspective:
Haemodialysis provision in the different settings in the UK; Health care payer

Time horizon:
Lifetime

Study design:
Cost-effectiveness analysis

Comparators:
Home HD versus Hospital HD - 3 times a week
Home HD versus satellite unit HD – 3 times a week

Study endpoints:
Cost, QALYs

Cost derivation:
Majority of costs taken from the European Dialysis and Cost effectiveness study. Costs presented in 2001/02 pounds sterling

Analytic framework:
Decision analytic Markov model developed in TreeAge®. Starting Markov states included Hospital HD, Satellite HD and Home HD. Absorbing states included death, transplantation and peritoneal dialysis
Cycle length - 1 year

Differential timing:
6% annual discount rate for costs
1.5% annual discount rate for outcomes

Sponsorship/Research Support*:*
Commissioned to inform the appraisal and guidance development processes managed by NICE

Health outcomes:
QALY weights – Published paper by de Wit *et al* 1998
Mortality – Published paper by Hellerstedt *et al* 1984
Transition to other absorbing states – UK Renal Registry data

Costs:
Direct costs – access surgery; training; dialysis and complications cost. Majority of costs taken from the European Dialysis and Cost effectiveness study.
Indirect costs – time, travel and productivity costs reported separately.

Incremental analysis:
Cost per QALY – Home HD was the dominant strategy compared to hospital HD for all time horizons.
Home haemodialysis was the dominant strategy compared to satellite unit HD for the 1st year, and then resulted in a cost per QALY of <£4000 for other timeframes.

Sensitivity analysis:
Various OWSA were performed and the factors with the most influence on the results was travel costs and cost of carer allowances.

Study limitations:
The authors report limitations including the lack of rigorous RCT data for key inputs; the possibility that the newer home dialysis units that were in development could change the result of this analysis.

Table 16. Monthly transition matrix for the training period for the home HD intervention

	Home HD haemodialysis transition matrix year 1							
		Transition from states						
		Hospital HD/T_home HD	Hospital HD	Home HD	Home HDm1	Transp	PD	Death
Transition to states	Hospital HD/T_home HD	0.981	0.000	0.000	0.000	0.000	0.000	0.000
	Hospital HD	0.000	0.981	0.004	0.004	0.000	0.000	0.000
	Home HD	0.000	0.000	0.977	0.977	0.000	0.000	0.000
	Home HDm1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Transp	0.016	0.016	0.016	0.016	1.000	0.000	0.000
	PD	0.003	0.003	0.003	0.003	0.000	1.000	0.000
	Death	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Table 17. Monthly transition matrix for the first year of the home HD intervention

	Home HD haemodialysis transition matrix year 1							
		Transition from states						
		Hospital HD/T_home HD	Hospital HD	Home HD	Home HDm1	Transp	PD	Death
Transition to states	Hospital HD/T_home HD	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Hospital HD	0.000	0.981	0.004	0.004	0.000	0.000	0.000
	Home HD	0.000	0.000	0.977	0.977	0.000	0.000	0.000
	Home HDm1	0.981	0.000	0.000	0.000	0.000	0.000	0.000
	Transp	0.016	0.016	0.016	0.016	1.000	0.000	0.000
	PD	0.003	0.003	0.003	0.003	0.000	1.000	0.000
	Death	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Table 18. Monthly transition matrix after the first year of the home HD intervention

Home HD haemodialysis transition matrix after year 1								
		Transition from states						
		Hospita lHD/T_home HD	Hospital HD	Home HD	Home HDm1	Transp	PD	Death
Transition to states	Hospital HD/T_home HD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
	Hospital HD	0.0000	0.9833	0.0043	0.0043	0.0000	0.0000	0.000
	Home HD	0.0000	0.0000	0.9791	0.9791	0.0000	0.0000	0.000
	Home HDm1	0.9833	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
	Transp	0.0164	0.0164	0.0164	0.0164	1.0000	0.0000	0.000
	PD	0.0003	0.0003	0.0003	0.0003	0.0000	1.0000	0.000
	Death	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Table 19. Monthly transition matrix for the first year of the hospital HD intervention

Hospital HD haemodialysis transition matrix year 1								
		Transition from states						
		Hospital HD/T_home HD	HospitalHD	Home HD	Home HDm1	Transp	PD	Death
Transition to states	Hospital HD/T_home HD	0.981	0.000	0.000	0.000	0.000	0.000	0.000
	HospitalHD	0.000	0.981	0.004	0.004	0.000	0.000	0.000
	Home HD	0.000	0.000	0.977	0.000	0.000	0.000	0.000
	Home HDm1	0.000	0.000	0.000	0.977	0.000	0.000	0.000
	Transp	0.016	0.016	0.016	0.016	1.000	0.000	0.000
	PD	0.003	0.003	0.003	0.003	0.000	1.000	0.000
	Death	0.000	0.000	0.000	0.000	0.000	0.000	1.000

Table 20. Monthly transition matrix after the first year of the hospitalHD intervention

Hospital HD haemodialysis transition matrix after year 1								
		Transition from states						
		Hospital HD/T_home HD	Hospital HD	Home HD	Home HDm1	Transp	PD	Death
Transition to states	Hospital HD/T_home HD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
	Hospital HD	0.0000	0.9833	0.0043	0.0043	0.0000	0.0000	0.000
	Home HD	0.0000	0.0000	0.9791	0.0000	0.0000	0.0000	0.000
	Home HDm1	0.9833	0.0000	0.0000	0.9791	0.0000	0.0000	0.000
	Transp	0.0164	0.0164	0.0164	0.0164	1.0000	0.0000	0.000
	PD	0.0003	0.0003	0.0003	0.0003	0.0000	1.0000	0.000
	Death	0.000	0.000	0.000	0.000	0.000	0.000	1.000

*Note that the transition to death is dependent on age and therefore has not been included in the transition matrix (see Mortality section)

Author and report information

Economic report: Home haemodialysis

Jaithri Ananthapavan, Julia Lowin, Emma Bloomfield

IMS Health
7 Harewood Avenue
London NW1 6JB

Tel: 020 3075 5000
Email: jlowin@uk.imshealth.com
www.imshealth.com

About CEP

The Centre for Evidence-based Purchasing (CEP) is part of the NHS Purchasing and Supply Agency. We underpin purchasing decisions by providing objective evidence to support the uptake of useful, safe, and innovative products and related procedures in health and social care.

CEP publications since 2002 are available from our website.

www.dh.gov.uk/cep