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Economic Evaluation

Value of an Integrated Home Dialysis Model in the United Kingdom: A Cost-Effectiveness Analysis

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ABSTRACT

Objectives: This study aimed to determine the lifetime cost-effectiveness of increasing home hemodialysis as a treatment option for patients experiencing peritoneal dialysis technique failure compared with the current standard of care.

Methods: A Markov model was developed to assess the lifetime costs, quality-adjusted life-years, and cost-effectiveness of increasing the usage an integrated home dialysis model compared with the current patient pathways in the United Kingdom. A secondary analysis was conducted including only the cost difference in treatments, minimizing the impact of the high cost of dialysis during life-years gained. Sensitivity and scenario analyses were performed, including analyses from a societal rather than a National Health Service perspective.

Results: The base-case probabilistic analysis was associated with incremental costs of £3413 and a quality-adjusted life-year of 0.09, resulting in an incremental cost-effectiveness ratio of £36 341. The secondary analysis found the integrated home dialysis model to be dominant. Conclusions on cost-effectiveness did not change under the societal perspective in either analysis.

Conclusions: The base-case analysis found that an integrated home dialysis model compared with current patient pathways is likely not cost-effective. These results were primarily driven by the high baseline costs of dialysis during life-years gained by patients receiving home hemodialysis. When excluding baseline dialysis-related treatment costs, the integrated home dialysis model was dominant. New strategies in kidney care patient pathway management should be explored because, under the assumption that dialysis should be funded, the results provide cost-effectiveness evidence for an integrated home dialysis model.

Keywords: economic evaluation, home hemodialysis, home-to-home transition, patient pathway management, peritoneal dialysis, renal replacement therapy.

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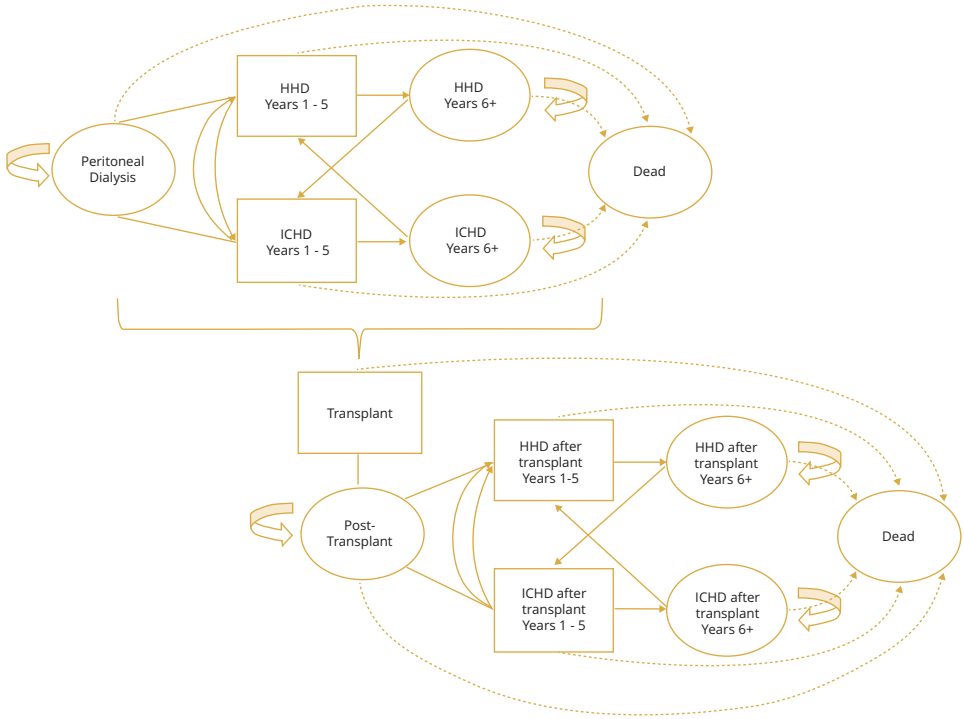
Introduction

End-stage renal disease (ESRD) is the fifth and final stage of chronic kidney disease. In patients with ESRD, kidney function would have decreased to a point where renal replacement therapy (RRT) must be initiated to stay alive. In the United Kingdom, 68 111 adult patients received RRT in 2019, accounting for a prevalence of 1293 people per million of the population.[1] Patients requiring RRT must either receive a kidney transplant or stay on dialysis for the remainder of their lives. Of those on dialysis, 82.9% are on in-center hemodialysis (ICHD), 12.5% on peritoneal dialysis (PD), and 4.6% on home hemodialysis (HHD).[1] The financial impact of RRT on the health system is large, totaling over 2% of the entire National Health Service (NHS) budget.[2]

A policy initiative was recently enacted in the United Kingdom to promote home therapies (PD and HHD) to achieve a minimum prevalent rate of 20% in every renal center by 2024.[3] Both the COVID-19 pandemic and recent studies reporting home dialysis as less costly than ICHD have spurred interest in increasing the usage of home dialysis modalities.[4-6] One avenue to increasing home dialysis usage is through keeping patients receiving PD at home by transitioning them to HHD after technique failure. Compared with patients receiving hemodialysis (HD), patients receiving PD transfer to other modalities earlier on, that is, they have shorter technique survival, because of dialysis-associated peritonitis and other complications.[7-9] Patients receiving PD who are experiencing failure will need to switch to either ICHD or HHD to stay alive, with the majority of patients utilizing ICHD as a second-line modality.[10-12]

Because patients receiving PD are already accustomed to a home modality, the choice of ICHD as a second-line modality rather than HHD may seem unexpected. High use of ICHD after PD is associated with the fact that the majority of transitions away

Figure 1. Markov model structure. All patients enter the model with ESRD and initiate RRT with PD. Patients then move through health states based on the transition probabilities described in Table 1.[1,10,17,21,23-27] Squares represent tunnel states where patients may only remain for 1 cycle. Dashed lines represent transitions to a death state whereas solid lines represent transitions between living states.



ESRD indicates end-stage renal disease; HHD, home hemodialysis; ICHD, in-center hemodialysis; PD, peritoneal dialysis.

from PD are unplanned.[12,13] Reasons for unplanned transitions include peritonitis, abdominal complications, catheter-related problems, and other infections.[14] Unplanned transfers from PD are associated with high hospitalization rates and an increased risk of mortality during the transition period.[10,13,15,16] Transitioning patients to HHD from PD requires planning in advance. For the renal centers that are able to successfully plan transitions from PD to HHD, the results are positive. A 2018 study identified patients in the United States Renal Data System who transitioned to HD from PD and found a lower risk of death for matched patients transitioning to HHD versus ICHD.[10] A 2015 study analyzing data from the Australia and New Zealand Dialysis and Transplant registry found the risk of death for patients receiving PD who transferred to HHD to be better than the outcomes of patients receiving PD who do not transfer modalities.[17]

The PD to HHD patient pathway has been referred to as the "integrated home dialysis" model.[17,18] Although there is evidence of the clinical benefits of this patient pathway, no studies have determined the cost-effectiveness of HHD compared with ICHD as a second-line modality to PD. With increasing health system interest in home dialysis, and PD being the primary home modality, transitions from PD to HD will consequently rise in future years. A solid understanding of the associated costs and health benefits of these patient pathways is needed.

This study aims to determine the lifetime cost-effectiveness of increasing use of HHD as a second-line modality for patients with ESRD in the United Kingdom experiencing PD technique failure compared with the current standard of care. The HHD treatment schedule assumed in the analysis is short daily treatment, which is defined as treatments performed 2 to 3 hours per day 5 to 7 days per week.

Methods

Model Overview

A Markov cohort model (Fig. 1) was developed to assess the cost-effectiveness of increasing the percent of the PD patient population utilizing HHD as a second-line modality compared with current use. ESRD is a chronic disease; therefore, a lifetime time-horizon was utilized. The population considered is patients 60 years and older with ESRD who require dialysis in the United Kingdom.[19] The intervention is an increase in the percent of the population using short daily HHD as a second-line dialysis modality after PD technique failure. For the base-case analysis, a PD to HHD yearly transition probability of 30% was applied for all patients receiving PD transferring to a new dialysis modality. This value was verified in local (UK) expert interviews as a viable target. The comparator is the current standard of care in which use of HHD as a second-line modality to PD is low. The current rates of transition to HHD after PD technique failure are unknown in the United Kingdom. Therefore, a rate of 1.5% was applied based on an analysis of available data from other countries and verification by local experts.[10,20,21]

A cycle length of 1 year was used with 12 possible health states, 5 of which are tunnel states (indicated in squares, Fig. 1). The cohort model design allowed for age-dependent mortality. Tunnel states allowed for the incorporation of time-dependent transition probabilities and the inclusion of treatment initiation costs for a new dialysis modality or transplant.

Patient input was included in the design of the model, following the Consolidated Health Economic Evaluation Reporting Standards guidelines.[22] A group interview was organized in a UK patient

Table 1. Clinical input parameters for the model.

Model Parameter	Mean	95% CI	Distribution	Reference
PD probability of death				
Year 1	0.1091	0.09-0.13	beta	23-25
Year 2	0.1320	0.11-0.16	beta	23-25
Year 3	0.1555	0.13-0.19	beta	23-25
Year 4	0.1679	0.13-0.20	beta	23-25
Year 5	0.1841	0.15-0.22	beta	23-25
Year 6+	0.2234	0.18-0.27	beta	23-25
ICHD probability of death				
Year 1	0.1478	0.12-0.18	beta	17,23,24
Year 2	0.1407	0.11-0.17	beta	17,23,24
Year 3	0.1501	0.12-0.18	beta	17,23,24
Year 4	0.1663	0.13-0.20	beta	17,23,24
Year 5	0.1828	0.15-0.22	beta	17,23,24
Year 6+	0.2353	0.19-0.28	beta	17,23,24
HHD probability of death under 65				
Year 1	0.0709	0.06-0.08	beta	17,23-25
Year 2	0.0674	0.05-0.08	beta	17,23-25
Year 3	0.0721	0.06-0.09	beta	17,23-25
Year 4	0.0803	0.06-0.10	beta	17,23-25
HHD probability of death over 65				
Year 1	0.0915	0.07-0.11	beta	17,23-25
Year 2	0.0870	0.07-0.10	beta	17,23-25
Year 3	0.0930	0.07-0.11	beta	17,23-25
Year 4	0.1034	0.08-0.12	beta	17,23-25
Year 5	0.1141	0.09-0.14	beta	17,23-25
Year 6+	0.1487	0.12-0.18	beta	17,23-25
Transplant probability of death				
Year 1	0.0276	0.02-0.03	beta	1
Year 2+	0.0251	0.02-0.03	beta	1
Yearly survival hazard ratios				
HHD relative to ICHD, under 65	0.4600	0.33-0.65	lognormal	25
HHD relative to ICHD, over 65	0.6000	0.35-1.06	lognormal	25
PD over 65	1.1500	1.07-1.25	lognormal	25
Previous PD exposure	1.1500	0.51-2.59	lognormal	17
PD to PD transition				
Year 1	0.7694		Dirichlet	1
Year 2	0.7828		Dirichlet	1
Year 3	0.7828		Dirichlet	1
Year 4	0.8322		Dirichlet	1
PD to HD, % to HHD (comparator)	0.0156		Dirichlet	10
PD to HD, % to HHD (intervention)	0.3000			Assumption
Other modality transitions				
HHD to ICHD	0.0500	0.04-0.06	beta	27
ICHD to HHD	0.0600	0.05-0.07	beta	21
Transplant probabilities				
Year 1	0.1327	0.11-0.16	beta	1
Year 2	0.1096	0.09-0.13	beta	1

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Table 1. Continued

Model Parameter	Mean	95% CI	Distribution	Reference
Year 3	0.1096	0.09-0.13	beta	1
Year 4	0.0472	0.04-0.06	beta	1
Year 5	0.0472	0.04-0.06	beta	1
Year 6	0.0377	0.03-0.05	beta	1
Year 7	0.0283	0.02-0.03	beta	1
Year 8	0.0188	0.02-0.02	beta	1
Year 9	0.0094	0.01-0.01	beta	1
Year 10+	0.0000		beta	1
Graft survival				
Year 1	0.9448	0.76-1.13	beta	1
Year 2+	0.9813	0.79-1.17	beta	1
Dialysis modality after transplant failure				
Year 1 on transplant, ICHD	1.0000			Assumption
Year 2+ on transplant, ICHD	0.9500	0.90-1.00		Assumption
Baseline utility values for patients in all health states				
ICHD	0.5600	0.49-0.62	normal	26
HHD	0.5800	0.50-0.67	normal	26, Assumption
PD	0.5800	0.50-0.67	normal	26
Transplant and post-transplant	0.8100	0.72-0.90	normal	26

Probabilities were assigned a beta distribution for binomial data and a Dirichlet distribution for multinomial data. If the standard error of the probabilities was not given, it was estimated to be 10% of the mean. Relative risks were assigned a lognormal distribution. All cost and utilization parameters were assigned a gamma distribution with the standard error (SE) estimated at 20% and 10%, respectively, if not given. A 20% SE was assigned to cost parameters as they were expected to have larger uncertainty around the mean value. Utility values were assigned a normal distribution.
CI indicates confidence interval; HHD, home hemodialysis; ICHD, in-center hemodialysis; PD, peritoneal dialysis.

advisory board for Fresenius Medical Care (United Kingdom). The findings from the patient advisory board informed the design of the model and guided the interpretation of model results.

Model Inputs

Literature searches were conducted on PubMed and EMBASE for parameters that could not be found in the UK Renal Registry (UKRR), European Renal Association – European Dialysis and Transplant Association (ERA-EDTA) Registry, or in NHS reference costs. All input parameters are summarized in Tables 1[1,10,17,21,23-27] and 2.[1,23,24,28-44]

Survival and transition probabilities

Recent survival data from the United Kingdom were available for patients on ICHD but not PD; therefore, data from the ERA-EDTA registry annual report, providing data from 34 European countries, including the United Kingdom, were deemed the most appropriate option.[23,24] A 5-year graph from the ERA-EDTA registry comparing PD and HD survival was digitized and unadjusted survival probabilities derived from the data. These data were calibrated to reach a 10-year survival probability based on data published by National Institute for Health and Care Excellence.[23] These survival probabilities were converted into cumulative hazard rates with hazard ratios applied to adjust for relevant factors. Because the ERA-EDTA does not distinguish between ICHD and HHD, a hazard ratio was applied for short daily HHD to reflect the survival gains patients experience compared with ICHD.[25] These rates were then converted into 1-year survival probabilities, summarized in Table 1[1,10,17,21,23-27] with the derivation described in Appendix A in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.02.009. Annual survival data in the general UK population were collected and included in the model to ensure that underestimation of mortality did not occur as the cohort aged.[45] Transition probabilities between dialysis modalities were primarily taken from an analysis of observational data published in the UKRR.[1] Because the UKRR does not distinguish between ICHD and HHD in transition data, other sources were used as described in Table 1.[1,10,17,21,23-27] All transition probabilities were verified in local expert interviews.

Health-related quality of life

Utility values associated with the 3 dialysis modalities and kidney transplantation were obtained from published literature. The EQ-5D instrument is the preferred utility elicitation method in the United Kingdom; therefore, the 2008 meta-analysis by Liem et al[26] was chosen for inclusion.[26,46] Utility values are reported in Table 1.[1,10,17,21,23-27] Utilities were half-cycle corrected and discounted by 3.5%.[46]

Cost and healthcare resource use

The healthcare payer (NHS) perspective was adopted for the base-case analysis.[46] A societal perspective was used for additional analyses to assess the effect of patient and informal caregiver productivity losses on the results. All costs were converted to 2020 British pounds sterling using the NHS Cost Inflation Pay & Prices Index.[47] Similar to utilities, a half-cycle correction was implemented and a discount rate of 3.5% was applied.

Table 2. Cost and resource utilization input parameters for the model.

Model parameter	Mean	Standard error	Distribution	Reference
Costs PD				
CAPD consumables per day	£48.00	9.60	gamma	28
APD consumables per day	£57.00	11.40	gamma	28
Proportion APD	0.63	0.063	gamma	1
Establish access via PD catheter	£887.64	177.53	gamma	29
PD cost of catheter removal	£887.64	177.53	gamma	29
Average weight UK adult, kg	78.60	0.300	gamma	29
Peritonitis rate	0.30	0.030	gamma	32
Catheter removal rate for peritonitis	0.25	0.025	gamma	33
Proportion treated for peritonitis in hospital	0.65	0.065	gamma	7
Average outpatient visits per year	16.00	1.600	gamma	34
Costs HD				
HD proportion with graft/fistula access	0.66	0.066	gamma	1
HD removal of Central Venous Catheter	£421.91	84.38	gamma	29
Fistula/shunt removal costs	£2632.21	526.44	gamma	29
HHD Establish access via Catheter	£1011.04	202.21	gamma	29
HHD Establish access vis Fistula or graft	£2632.21	526.44	gamma	29
Costs HHD				
HHD consumables per week (catheter access)	£466.00	93.20	gamma	28
HHD consumables per week (fistula/graft access)	£466.00	93.20	gamma	28
HHD Establish access vis Fistula or graft	£2632.21	526.44	gamma	29
Costs ICHD				
ICHD consumables per session (catheter access)	£123.00	24.60	gamma	28
ICHD consumables per session (fistula/graft access)	£154.00	30.80	gamma	28
Hospitalization				
PD outpatient hospitalization	£175.43	35.09	gamma	29
Inpatient hospitalization	£2457.86	491.57	gamma	29
PD hospitalization rate	2.30	0.230	gamma	35
Hazard Hosp HHD vs ICHD	0.92	0.038	lognormal	36
Hazard Hosp HHD vs PD	0.73	0.031	lognormal	36
Medication costs				
ESA (cost per pack) 1000 units/0.5 mL	£33.18	6.64	gamma	37
PD proportion on ESAs	0.77	0.077	gamma	1
HHD proportion on ESAs	0.90	0.090	gamma	1
ICHD proportion on ESAs	0.91	0.091	gamma	1
PD average dose of ESAs, IU/week	4800.00	480.00	gamma	1
HHD average dose of ESAs, IU/week	8000.00	800.00	gamma	1
ICHD average dose of ESAs, IU/week	8000.00	800.00	gamma	1
PD iron	£43.52	8.70	gamma	37
PD average dose of iron (mean monthly dose in mg)	183.00	18.30	gamma	38
PD proportion on iron	0.39	0.039	gamma	38
Vancomycin for peritonitis	£23.54	0.222	gamma	39
Ciprofloxacin for peritonitis	£1.16	0.003	gamma	39
Vancomycin dosage, g	2.00	0.200	gamma	40
Ciprofloxacin dosage, mg	500.00	50.00	gamma	40
Transportation				
Yearly HHD transportation costs	£400.02	80.00	gamma	41

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Table 2. Continued

Model parameter	Mean	Standard error	Distribution	Reference
Yearly PD transportation costs	£138.98	27.80	gamma	42
Yearly ICHD transportation costs	£5673.03	1134.61	gamma	23
Transplantation				
Transplant	£14 304.75	2860.95	gamma	24,29
Annual cost post-transplant	£8921.58	1784.31	gamma	30
Transplant failure	£3838.74	767.75	gamma	29
Societal costs				
Mean hourly earnings	£17.66	3.53	gamma	43
% 60+ working on RRT	0.21	0.021	gamma	44
ICHD patient lost working hours	844.80	84.48	gamma	31
HHD patient lost working hours	703.00	70.30	gamma	31
PD patient lost working hours	651.60	65.16	gamma	31
ICHD caregiver lost working hours	82.49	8.249	gamma	31
HHD caregiver lost working hours	506.24	50.62	gamma	31
PD caregiver lost working hours	22.91	2.29	gamma	31
ICHD caregiver proportion assisting	0.10	0.010	gamma	31
HHD caregiver proportion assisting	0.70	0.070	gamma	Assumption
PD caregiver proportion assisting	0.31	0.031	gamma	31

All costs are reported in 2020 British pounds sterling. Reimbursement for PD is based on a daily rate, annual costs were calculated by multiplying this rate by 7*52. HHD is reimbursed on a weekly rate, annual costs were calculated by multiplying this rate by 52. ICHD is reimbursed on a per session basis, assuming a treatment schedule of 3 times a week, annual costs were calculated by multiplying the per session rate by 3*52. Transportation costs under NHS perspective were 78% of cost listed.[48] All cost and utilization data is reported yearly unless otherwise noted. All cost and utilization parameters were assigned a gamma distribution with the standard error estimated at 20% and 10%, respectively, if not given. Hazard ratios were assigned a lognormal distribution. Detailed costing analysis reported in Appendix B in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.02.009.

APD indicates automated peritoneal dialysis, CAPD, continuous ambulatory peritoneal dialysis; ESA, erythropoiesis-stimulating agent; HD, hemodialysis; HHD, home hemodialysis; ICHD, in-center hemodialysis; IU, international unit; PD, peritoneal dialysis; RRT, renal replacement therapy; UK, United Kingdom.

The cost of dialysis was calculated following a 2-step approach. First, the reimbursement tariff prices were taken from the NHS Best Practice Tariffs for 2020/2021.[28] Next, the cost components not included in the tariff price were sourced from outside databases and literature, described in Table 2.[1,23,24,28-44]

Outside the cost components comprising the tariff prices, the costs included in the analysis under the NHS perspective were dialysis access costs, medication costs, all-cause hospitalizations, transportation costs, and costs associated with transplantation. All outpatient visits for patients receiving HD are covered in the tariff price. Only the cost of outpatient visits for patients receiving PD was separately included. Owing to a lack of data, the differences in hospitalization costs between the treatment and comparator groups are only because of the overall differences in hospitalization rates between PD, ICHD, and short daily HHD; this is explored further in a scenario analysis. Certain medications (phosphate binders, vitamin D, and antihypertensive drugs) were excluded from the costing analysis because of a scarcity of modality specific utilization data. Transportation costs paid by the NHS were included in the model for the base-case NHS perspective.[48] Transplant and transplant failure costs were based on NHS reference costs and costs incurred post-transplant were sourced from Kerr et al.[29,30]

In addition to a healthcare perspective, a societal perspective was undertaken in which productivity losses were calculated for both the patient and informal caregiver. Information on the time spent assisting with dialysis (or time spent on dialysis for patients) and time spent on outpatient care was sourced from Tang et al.[31] An assumption was made that there would be no productivity losses for patients or caregivers after age 70. The time spent by patients and informal caregivers was multiplied by the mean hourly earnings for UK adults. Under the societal perspective, both out-of-pocket and NHS financed transportation costs were included.

Model Analyses

Total costs, quality-adjusted life-years (QALYs), and life-years (LYs) accrued were estimated for each treatment strategy. The base-case calculation was carried out using the mean value for each parameter. The incremental cost-effectiveness ratio (ICER) was assessed using the recommended willingness-to-pay (WTP) threshold in the United Kingdom of £20 000 to 30 000 per QALY gained.[49]

Secondary analysis

Dialysis is an expensive chronic healthcare intervention, which is inherently not cost-effective under the UK threshold of £20 000 to £30 000 per QALY gained.[23] It is important to note that, although not cost-effective, there is no alternative for this life-saving treatment for patients who are medically unfit for a kidney transplant or unable to receive one because of a shortage of kidney donors.[2] This study examines the effect of transitioning more patients receiving PD to HHD rather than to ICHD. Patients on HHD experience survival gains compared with patients on ICHD, meaning that the patients in the intervention group will need dialysis longer, incurring the high costs of dialysis for every LY gained. This results in the continued utilization of an already non–cost-effective treatment. For this reason, a secondary

Table 3. Deterministic costs, health outcomes (QALYs and LY) and cost-effectiveness analysis for base case both healthcare and societal perspective, and scenario analysis.

Analysis results	Intervention	Comparator	Difference
Base case			
Hospitalization	£20 156	£19 740	£416
Transportation	£6399	£7620	−£1222
EPO	£6672	£6417	£255
Tariff	£96 299	£92 447	£3852
Transplant and transplant failure	£33 154	£32 950	£204
Initial access costs	£1868	£1867	£1
NHS costs	£164 548	£161 041	£3507
QALY	4.63	4.53	0.09
LY	6.9	6.76	0.14
Incremental cost per QALY			£37 263
Incremental cost per LY			£24 220
Base case, societal perspective			
Hospitalization	£20 156	£19 740	£416
Transportation	£8203	£9769	−£1566
EPO	£6672	£6417	£255
Tariff	£96 299	£92 447	£3852
Transplant and transplant failure	£33 154	£32 950	£204
Initial access costs	£1868	£1867	£1
Productivity loss	£12 026	£10 773	£1254
NHS costs	£164 548	£161 041	£3507
Societal costs	£13 831	£12 922	£909
QALY	4.63	4.53	0.09
LY	6.9	6.76	0.14
Incremental cost per QALY			£46 920
Incremental cost per LY			£30 497
Secondary analysis: Intervention cost difference only			
Healthcare system costs	£33 004	£33 604	−£600
QALY	4.63	4.53	0.09
LY	6.9	6.76	0.14
Incremental cost per QALY			−£6375
Incremental cost per LY			−£4144
Secondary analysis: Intervention cost difference only, societal perspective			
Healthcare system costs	£33 004	£33 604	−£600
Societal costs	−£10 052	−£10 565	£513
QALY	4.63	4.53	0.9
LY	6.9	6.76	0.14
Incremental cost per QALY			−£931
Incremental cost per LY			−£605

EPO indicates erythropoietin; LY, life-year; NHS, National Health Service; QALY, quality-adjusted life-year.

analysis was conducted including only the difference in dialysis treatment costs between modalities. Each year a patient was on dialysis in the model, the cost incurred was the cost difference between modalities in each cost category, for example, (ICHD transportation cost − HHD transportation cost) + (ICHD erythropoietin cost − HHD erythropoietin cost). This muted the impact of the baseline dialysis costs common among all patients, allowing for an analysis, which looked at the incremental cost differences between modalities. The logic behind this is that because the NHS has already ruled that the underlying costs of dialysis are worth it, these general dialysis-related costs may be inappropriate to include in new analyses, because they have the potential to discriminate against life-extending interventions in renal care.

Sensitivity analyses

To assess the robustness of the results, deterministic and probabilistic sensitivity analyses (PSAs) were conducted. A cost-effectiveness acceptability curve was plotted by using PSA results to calculate the probability that the intervention was cost-effective at different WTP thresholds. Deterministic sensitivity analyses were conducted to test the sensitivity of individual parameters on model results.

Scenario analyses

In the first scenario analysis, hypothetical HHD tariff prices were examined because the current reimbursement structure incentivizes a treatment schedule of 3 times per week. To increase utilization of more frequent treatment schedules, greater reimbursement is required. An increased utility value for HHD was examined in the second scenario analysis because some cost-effectiveness analyses have reported higher values for HHD than PD. Treharne et al[50] reported a utility value for HHD of 0.69, taking the ratio of limited care HD to conventional HD utility scores from De Wit and applying it to the HD value from Liem et al.[26,50,51] Hospitalization rates from a recent publication by Weinhandl et al[19] were used in a third scenario analysis of the base case. Weinhandl et al[19] reports the rate of hospital admissions for the 12 months pre- and postconversion to HD from PD. These data were applied in the model as a first-year rate of hospitalizations for patients receiving ICHD transitioning from PD. An assumption was made that the HHD group would not experience high rate of hospitalizations because of the fact that these transitions should be planned.

Results

The objective of this analysis was to assess ICER of PD with an increased use of HHD as a second-line modality compared with current use for patients with ESRD in the United Kingdom. Costs, QALYs, LYs, incremental costs per QALY gained, and incremental costs per LY gained of the analysis are reported in Table 3.

Base-Case Analysis

With an increase in PD to HHD transitions to 30%, the deterministic QALYs gained were 0.09 per patient at an increased cost of £3507, resulting in an ICER of £37 263 per QALY gained. Based on the incremental cost breakdown, the reimbursement tariff and transportation costs are the biggest drivers in the difference in incremental costs. The annual reimbursement tariff cost for HHD is greater than the annual tariff cost for ICHD; therefore, it is logical that the group with more patients utilizing HHD have a greater average lifetime reimbursement tariff cost. With this being said, the total annual cost of care, including all relevant cost components, is lower for patients receiving HHD than ICHD. This means that the increased incremental costs for the intervention group must be driven by the costs in LYs gained. This hypothesis was validated by conducting an analysis with no mortality difference.

Base-Case Sensitivity Analysis

In the PSA of the base-case analysis, the average ICER was £36 341 with 86% of the 1000 simulations allocated in the northeast quadrant of the cost-effectiveness plane indicating that the intervention is more effective but also costlier than the comparator. With a WTP of £20 000, 28% of iterations fall below the cost-effectiveness line and with a WTP of £30 000, 43%. It can be concluded that, when including life-extension costs, increased usage of HHD as a second-line modality to PD is most likely not cost-effective under UK decision criteria. In addition to the PSA, a one-way sensitivity analysis was conducted, which showed the ICER as sensitive to assumptions on the utility value for patients receiving HHD (see Appendix D in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.02.009). Consequently, a scenario analysis was conducted using HHD utility data from a different source.

Secondary Analysis

In the secondary analysis, with only the difference in intervention costs included, the intervention becomes cost-saving with deterministic incremental costs of −£600 (Table 3). This resulted in an ICER of −£6375, indicating that the intervention is dominant, that is, it is cost-saving and more effective.

Secondary Analysis Sensitivity Analysis

As seen in Figure 2, the results of the secondary analysis were robust, with 90% of the simulations below the WTP threshold of £20 000 and 95% at £30 000. The results of the univariate sensitivity analysis are reported in Appendix D in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.02.009.

Societal Perspective Analyses

For both the base-case and secondary analysis, the societal perspective resulted in increased costs for the intervention group because of the high productivity costs for HHD informal caregivers. This increase did not change the conclusions made about cost-effectiveness in either the base-case or secondary analysis.

Scenario Analyses

Increased reimbursement

When increasing the weekly reimbursement tariff for HHD in the secondary analysis (Fig. 3), the intervention remained cost-effective at a £30 000 WTP threshold with up to a 40% increase in the reimbursement (up to £652 per week). With a £20 000 WTP threshold, the intervention remains cost-effective with up to a 30% increase in reimbursement (£605 per week).

Increased utility value for HHD

Using a utility value of 0.69 for HHD rather than 0.58 resulted in an incremental cost of £3507 and an incremental QALY of 0.14, leading to an ICER of £24 722 in the base-case analysis.

High hospitalization rates during transition

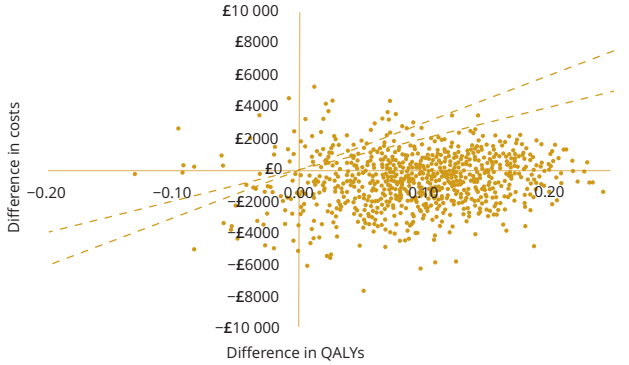
Averaging Weinhandl's monthly rates of hospital admissions during the conversion period resulted in a first-year ICHD hospitalization rate of 2.85. This increased hospitalization rate for the ICHD group resulted in an ICER of £34 503 per QALY gained in the base-case analysis.

Discussion

Main Findings

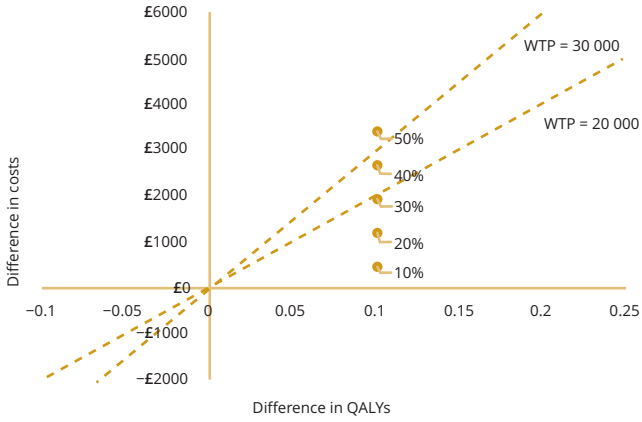
To the best of our knowledge, this is the first study evaluating the potential cost-effectiveness of an integrated home dialysis model. When including life-extension costs, the analysis found that an integrated home dialysis model was associated with higher costs and higher QALYs than the current treatment pathways for patients receiving dialysis in the United Kingdom. The estimated ICER was not considered cost-effective under the National Institute for Health and Care Excellence decision-making criteria. In the secondary analysis, it was acknowledged that,

Figure 2. Cost-effectiveness plane for the secondary analysis. Cost-effectiveness plane displaying the incremental costs and effects of increased transition from PD to HHD versus current transition probabilities.



HHD indicates home hemodialysis; PD, peritoneal dialysis; QALY, quality-adjusted life-years.

Figure 3. Cost-effectiveness plane for the secondary analysis with increased HHD reimbursement. Incremental costs and effectiveness of increased transition from PD to HHD with 10% up to 50% increase in HHD reimbursement versus the current scenario. Dashed lines indicate a WTP threshold of £20 000 and £30 000.



HHD indicates home hemodialysis; PD, peritoneal dialysis; QALY, quality-adjusted life-year; WTP, willingness-to-pay.

although dialysis is not cost-effective considering the WTP thresholds in the United Kingdom, it remains widely accepted as the standard of care. Therefore, it can be reasoned that new dialysis-related interventions should not be penalized for these underlying baseline costs. When including only dialysis treatment cost differences, thereby minimizing the negative cost implications of improved survival, the secondary analysis found the intervention to be dominant, with lower costs and higher QALY gains. Under a societal perspective, the costs for the intervention group remained lower in the secondary analysis, although the difference was reduced because of a shift in the burden of care responsibilities from the nurse to the informal caregiver for patients receiving HHD. Despite uncertainty in input parameters, the overall conclusions did not change in the PSA of the base-case and secondary analysis.

Patient Choice

This study models the cost-effectiveness of keeping patients at home but, because choice of treatment is highly personalized, it is important to recognize and report patient preference. The interview with the patient group highlighted the importance of personal choice in dialysis treatment. Patients were asked for their thoughts on health systems recommending and incentivizing certain ratios or shares of patients on specific dialysis modalities. One patient receiving dialysis responded,

"Whilst I understand why companies may be given incentives and why healthcare providers may have targets to get to, nobody chooses to go on dialysis. We don't choose to be in renal failure. So therefore, it's important that we maintain what choice we can have, and if that choice is an informed choice about our type of dialysis that suits us best, then that's what should be given, that choice." (Patient A, Patient Advisory Board organized by Fresenius Medical Care on March 31, 2022).

This sentiment is important to consider when applying the findings of the analysis. The results of this cost-effectiveness analysis support the idea that health systems should build up the structural mechanism in PD patient pathway management that allows for patients to have the option to transfer to HHD after PD, if they so desire. It is important to note that the intervention in the analysis is a hypothetical scenario. To achieve increased use of HHD as a second-line modality, patients receiving PD and their care providers will need to consider the next step in the care continuum from day 1 of treatment.

Additionally, to give patients full flexibility in treatment options, reimbursement for HHD will need to be restructured to allow for increased use of short daily HHD. The current reimbursement structure in the United Kingdom incentivizes a treatment schedule of 3 times per week. In order to minimize the financial disadvantages of offering more frequent treatment schedules, greater reimbursement will be required. With this being said, increased reimbursement will not overcome all of the barriers that prevent an uptake in short daily HHD utilization. The results of the secondary analysis provide evidence that increasing the proportion of patients transferring to short daily HHD remains cost-effective at a WTP threshold of £30 000 with up to a 40% increase in the weekly HHD reimbursement tariff.

Limitations

Pushes for increased usage of home modalities in the United Kingdom, and across countries worldwide, will result in a steady rise in the proportion of patients with ESRD experiencing the PD to HD transition. Understanding the cost-effectiveness of these patient pathways, therefore, becomes increasingly important. This article analyzed these pathways with the best data currently available. Nevertheless, limitations remain in this model that are worth considering.

A general challenge in finding appropriate data to use is the scarcity of randomized controlled trials in the field because of patients valuing choice in treatment.[16,52] Consequently, all data included in the model are from observational studies, which are subject to selection bias because younger and healthier patients typically choose home therapies. Although adjusted for age and comorbidities, it is possible that certain confounding factors remain in the data, which could lead to biased estimate on health-related quality of life (HRQoL) and mortality data. This analysis focuses on the RRT population in the United Kingdom over the age of 60. The literature finds a greater reduction in mortality for younger patients on HHD compared with ICHD, than for older patients.[25] The results of this analysis should therefore be considered within the context of the defined age group.

Certain input parameters could not be found in the United Kingdom and therefore had to be obtained from outside sources. Ideally, UK data would be available on observed differences in survival for patients receiving HHD and ICHD after transfer from PD. Using data from the ERA-EDTA with hazards applied runs the risk of not accurately reflecting the true mortality differences in the United Kingdom. Additionally, to improve the accuracy of the cost estimations, the availability of utilization rates for all relevant dialysis medications and utility consumption data for patients receiving HHD in the United Kingdom are needed. Finally, it is widely accepted that there are large indirect costs related to dialysis, but there is minimal quantitative research conducted in this area in the United Kingdom, limiting the inclusion of relevant societal costs. This research identified key gaps in the national UK renal data that should be filled to allow for more precise estimations of country-specific clinical effects and costs.

Another limitation is that the model cannot accurately reflect all of the complexities that come with transition periods. More research is needed to account for clinical differences in the patient pathways. Although there is information on the rate of hospitalizations during the transition from PD to HD, there are no data breaking this down by HD modality. The hypothesized decrease in hospitalization rates because of planned transition from PD to HHD was therefore not accounted for in the main analyses. This likely results in an underestimation of the difference in hospitalization costs between the intervention and comparator. Information is also scarce on the QoL impact of the transition periods. These periods of transition are marked by both physical and mental challenges, especially when patients experience technique failure because of medical reasons.[53,54] Further research is needed to elicit quantitative data on the effect of these transitions on HRQoL.

As for the HRQoL data, a 2008 meta-analysis of EQ-5D data was used.[26] Although these estimates may, indeed, reflect the reality of treatment today, more recent EQ-5D data for the UK population would be preferred for inclusion in the model. An additional limitation in these data is that utility values for HHD are not given. Therefore, an assumption was made that patients receiving HHD have the same utility values as patients receiving PD.[51,55] Specific utility data on HHD, elicited from the EQ-5D, would increase the robustness of the results.

The limitations of this analysis highlight the need for further research to close key evidence gaps. Although these limitations represent important caveats to the results, they do not diminish the overall contribution of this research. Key strengths of this analysis include the extensive mapping of the PD to HD patient pathway, the inclusion of a societal perspective in addition to an NHS perspective, engagement with patients in the design of the study, and the inclusion of multiple sensitivity and scenario analyses.

Conclusions

This study assessed the cost-effectiveness of PD with an increased use of HHD as a second-line modality compared with current use for patients with ESRD in the United Kingdom. This study found that increasing transition to HHD was not cost-effective under an NHS and societal perspective because of the high cost during LYs gained. When excluding general dialysis-related treatment costs, thus decreasing life-extension costs for patients receiving HHD, increasing PD to HHD transfer rates results in less costs with higher QALY gains under both an NHS and a societal perspective, making this patient pathway a dominant strategy. Management of kidney patient pathways should be reevaluated, because, under the assumption that the NHS should fund dialysis treatment, these results suggest potential cost-effectiveness evidence for increasing the proportion of patients transferring to HHD after PD technique failure.

Supplemental Material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jval.2023.02.009.

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