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ORIGINAL RESEARCH ARTICLE

The Cost-Effectiveness of Initiating Patients on Home Dialysis Compared with In-Centre Haemodialysis

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Abstract

Objectives Kidney failure can be treated at home with peritoneal dialysis or home haemodialysis. The combination of reduced staffing, transport and overhead costs and improved quality of life through treatment at home could make initiating dialysis at home highly cost-effective. The primary objective is to estimate the cost-effectiveness of initiating patients on home dialysis therapy (HDT) compared with in-centre haemodialysis (ICHD). The secondary objective is to determine the upper limit of net benefit from removing potential service barriers within dialysis centres that hinder the adoption of HDT.

Method A multistate model using UK Renal Registry data combined with national survey data was developed to estimate patient and dialysis centre influences on dialysis treatment modality changes and the duration in each modality. These are used as inputs to a microsimulation estimating the lifetime quality-adjusted life years (QALYs) and UK National Health Service (NHS) costs incurred for patients, the cost-effectiveness of HDT compared with ICHD and the differences in costs and health outcomes associated with removing specific barriers to HDT uptake.

Results Commencing HDT compared with ICHD resulted in 0.30 additional QALYs and saved Great British (GB) £15,272. HDT has an 82% probability of being cost-effective. Implementing quality-improvement initiatives and alleviating stresses on staff capacity are identified as influential in the multistate model. Addressing these led to QALY gains of 0.22 and 0.08 and cost increases of GB £10,059 and GB £5127 from an increase of life years lived of 0.54 and 0.22, respectively.

Conclusions Initiating patients on HDT is cost-effective compared with ICHD. Alleviating stresses on staff capacity and implementing quality improvement initiatives in dialysis centres leads to health improvements, although these changes are not cost-effective owing to the associated increase in healthcare costs.

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Key Points for Decision Makers

Previous research underscores the significance of adapting dialysis modalities to the specific stage of a patient's renal replacement journey. We evaluate if it is better to start patients on home or in-centre dialysis.

Home dialysis therapy (HDT) has an 82% probability of being cost-effective. Alleviating staff capacity stresses and implementing quality improvement initiatives improves the adoption of HDT.

Starting patients on HDT is cost-effective, although the high cost of dialysis means that removing barriers to HDT adoption is not cost-effective.

1 Introduction

Chronic kidney disease (CKD) is a serious, progressive condition that affects an estimated 700–840 million people globally [1]. It is the third fastest-growing cause of death worldwide, driven by aging populations and an increase in common risk factors such as type 2 diabetes mellitus and hypertension. It is predicted to be the fifth leading cause of global life years lost by 2040 [2].

Renal replacement therapy can be treated with dialysis at home, with peritoneal dialysis or home haemodialysis, or at a hospital using in-centre haemodialysis (ICHD). The advantages of dialysis at home from both economic and patient viewpoints are well-recognised [3]. Home dialysis therapy (HDT) allows patients to spend more time at home, giving them control over their treatment schedule and location, eliminating the need to travel to dialysis centres and reducing infection risks. It also enhances their ability to travel and avoids the abnormal or unstable blood pressure (haemodynamic instability) associated with ICHD three times a week [3]. For healthcare providers, HDT reduces the need for transport to and from dialysis centres, lowers costs related to building and equipping new centres, requires fewer nurses and decreases hospitalization rates for infections [3].

Despite the apparent benefits of HDT, in Europe, only 11% of individuals beginning dialysis use peritoneal dialysis, with some countries (such as Greece, Romania and the Czech Republic) having rates of peritoneal dialysis as low as 5% or less [3]. Fewer than 1% of people in Europe start on home haemodialysis, and half of the countries in Europe do not provide this option. One approach to increasing the uptake of HDT is to address the known barriers to adoption, which include inadequate physician engagement, a low proportion of patients undergoing predialysis education, insufficient peritoneal dialysis training, small peritoneal dialysis unit sizes, limited personnel in these units and clinical and socioeconomic deprivation among the patient population [4, 5]. Several of these barriers could be addressed through financial investment in HDT capacity. To guide this investment, an analysis of the economic impact of removing specific barriers to HDT adoption is needed to establish the potential long-term cost benefits from overcoming the barriers.

Two systematic reviews on the cost-effectiveness of dialysis modalities have shown that HDT generally appears less expensive and may offer similar or better health outcomes compared with ICHD [6, 7]. However, the reviews note that the evidence is inconclusive. This is because the models contain uncertainties that pose challenges for determining which modality provides the best outcomes. Inputs into the models such as the probabilities of switching between modalities, mortality rates and utility values were based on small datasets. Most studies report average cost-effectiveness ratios, comparing the cost-effectiveness to no treatment [7], rather than incremental cost-effectiveness ratios (comparing HDT with ICHD). Additionally, many studies assumed no switches between treatment modalities, and those that did typically assumed the probabilities of switching did not change over time or with patient characteristics, which is unlikely to be true. Both reviews emphasized the need for future studies to detail the cost-effectiveness of more realistic kidney replacement treatment paths that include multiple switches between modalities.

As part of the broader Inter-CEPt project [8], which aims to identify and address barriers to HDT adoption, this health economic analysis explores a previously unexamined question in research literature: what is the cost-effectiveness of initiating HDT compared with ICHD? This study addresses the limitations of previous renal replacement therapy evaluations by using a large dataset, the UK Renal Registry [9], to estimate rates of transitions and time in modalities. In addition, it employs ICHD data from five UK dialysis centres to estimate utility values and micro-costing evidence for UK National Health Service (NHS) costs related to renal replacement therapy patients. It accounts for individual characteristics influencing patient pathways and include multiple modality switches.

Building on the primary research question, the second question asks: what is the maximum potential net benefit of removing two key barriers to HDT initiation in the UK? These barriers, identified through the broader Inter-CEPt project, are stresses on staff capacity and implementing quality improvement initiatives in centres [10]. We simulate in an economic model the impact of removing these barriers

on the patient's renal replacement therapy pathway. To our knowledge, no interventions designed to address these barriers have been proposed in literature on dialysis modalities. The relevance for decision-making in demonstrating the maximum potential net benefit is to determine the maximum amount that should be spent on any intervention designed to remove these barriers. This information can be used to support the development and formal evaluation of interventions addressing these barriers in clinical practice on the basis of their costs and effectiveness.

2 Methods

A health economic analysis plan was developed and is available in the protocol [8]. This cost–utility analysis was conducted from a health and social care perspective to appraise starting dialysis on HDT compared with starting on ICHD and the economic impact of eliminating centre service barriers that limit the use of delivery of HDT. It is reported in accordance with the Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) statement [11].

Health benefits are expressed in terms of quality-adjusted life years (QALYs). Costs focus on those incurred by the UK healthcare system. The cost-effectiveness outcome is incremental net monetary benefit (INMB). A discount rate of 3.5% is applied to UK NHS cost and health effects.

The simulation model of the renal replacement therapy pathway after initialisation on dialysis is an individual-based microsimulation [12] with a lifetime time horizon, which is appropriate because the life expectancy of patients on dialysis is short. The model relies on patient data and is therefore not publicly accessible. The impact of starting dialysis modality on an individual patient is established in the simulation through a sequence of competing events (HDT, ICHD and kidney transplant) that modify the patient's health status (health related quality of life, treatment costs and life expectancy). The model is an individual-level discrete event simulation rather than a cohort simulation because patient level characteristics (several of which vary over time) determine the pathway of renal replacement therapy modalities experienced up to death and the amount of time patients spend in each health state. The economic outcomes (costs and QALYs) are determined by this pathway, specifically by the time spent in each renal replacement therapy modality (HDT, ICHD and transplant) and demographic characteristics (e.g. age, sex and ethnicity).

A patient cohort of 2000 real patients with incident kidney failure patients in the UK Renal Registry were simulated having their initiating dialysis be HDT and again as ICHD. A cohort size of 2000 was chosen on the basis of the standard error of the INMB, which is small enough to provide confidence that the true INMB is positive. Further details of this testing and a summary of how the estimated INMB changes with varying patient numbers are provided in in Supplementary Text S1 and Supplementary Table S1.

The microsimulation model was underpinned by a multistate regression model [13] which uses data from 32,400 patients who began renal replacement therapy in England between 2015 and 2019 [9]. The regression models that determine the patient transitions between treatment modalities are described in Supplementary Text S4 and Supplementary Tables S6–S15. The defined health states are HDT, ICHD, transplantation and death. The selection of these states is affected by convergence failures from low numbers of transitions to and from the home haemodialysis state in the UK Renal Registry. After engagement with patients and consultant nephrologists, and with consideration of other modelling approaches taken in literature [6, 7], we combined peritoneal dialysis and home haemodialysis into home therapies to ensure that all transitions were accounted for. The health states are HDT, ICHD, transplantation and death, with permitted transitions shown in Fig. 1.

The costs and health-related quality of life (HRQoL) incurred for a patient in the HDT state is a weighted average

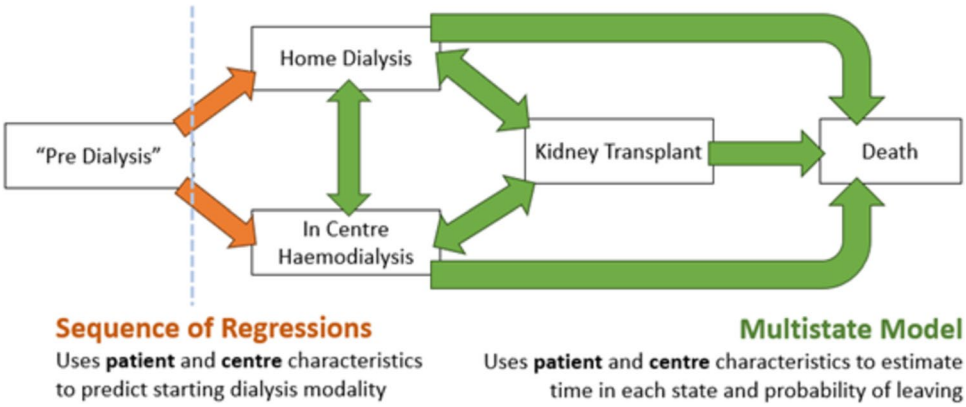

Fig. 1 Diagram of simulation model and multistate model transitions

Table 1 Summary of patient attributes sampled from the UK Renal Registry

Attribute	Patients initiated on ICHD	Patients initiated on HDT
Mean age, years (standard deviation)	62.7 (16.27), $n = 11,533$	58.1 (16.37), $n = 5073$
Percentage male	65.11%, $n = 7509$	64.42%, $n = 3170$
Percentage in deprivation group		
Index of multiple deprivation (IMD) 1	14.72%, $n = 1697$	17.53%, $n = 857$
IMD 2	16.92%, $n = 1950$	18.96%, $n = 927$
IMD 3	20.19%, $n = 2328$	19.46%, $n = 951$
IMD 4	23.56%, n =2716	21.71%, $n = 1061$
IMD 5	24.61%, n =2837	22.34%, $n = 1092$
Percentage in ethnicity group		
Asian	13.00%, $n = 1499$	13.40%, $n = 655$
Black	6.54%, $n = 754$	7.59%, $n = 371$
Mixed	1.29%, $n = 149$	1.82%, $n = 89$
White	73.78%, $n = 8509$	72.96%, $n = 3567$
Other	1.34%, n =155	1.70%, $n = 83$
Percentage with diabetes	28.12%, $n = 2997$	28.08%, $n = 1324$
Percentage on transplant waiting list	12.08%, n =1393	27.47%, $n = 1343$
High priority for a kidney transplant	89.01%, $n = 9500$	86.41%, $n = 4178$
Centre attributes		
Percentage delivering transplants	46.71%, $n = 5725$	50.36%, $n = 2605$
Percentage with research opportunities	84.33%, $n = 9726$	83.68%, $n = 4091$
Percentage with stresses on staff capacity	79.96%, $n = 9557$	82.87%, $n = 3909$
Percentage with quality improvement initiatives	91.27%, $n = 10,160$	93.71%, $n = 4425$

based on the prevalence of the modalities in the UK [14], the cost of dialysis [15–17] and of transplant [18] and the HRQoL of peritoneal dialysis [19], transplant [19] and ICHD [20]. Patients who begin dialysis at home are almost always on peritoneal dialysis [14], as starting home haemodialysis typically requires several months of in-centre training. Therefore, for patients entering the model in the HDT state, the costs and HRQoL are initially based on peritoneal dialysis.

The UK Renal Registry collects data from kidney centres and hospital laboratories on the care delivered to all patients with kidney disease in the UK [9]. Patient attributes (e.g. age, sex, ethnicity, socioeconomic deprivation (index of multiple deprivation) and diabetes status) for the simulated population are sampled at random without replacement from incident patients in the UK Renal Registry in the years 2015–2019. Table 1 provides a summary of these attributes, which are drawn from incident HDT and ICHD UK Renal Registry patients when simulating patients beginning home and centre dialysis respectively. These attributes impact the patient's probabilities of transitioning to different treatment modalities through their renal replacement therapy journey until death on the basis of the multistate regression model described in Supplementary Text S4. After the next state is sampled on the basis of these probabilities, the time until this next state occurs is determined by the mean time to state, as predicted by the multistate model, using the same patient and centre characteristics that are used to establish the transition probabilities. This multistate model has the same health states and transitions as Fig. 1 and has patient- and centre-level variables shown in Table 1.

2.1 Analysis of Barriers to HDT Initiation

To assess the impact of removing service barriers, prominent barriers to HDT initiation were first identified in the broader Inter-CEPt study [8, 10]. An ethnographic study was conducted with patients, carers and clinical staff in centre services to explore how centres could better meet patient needs. Based on this ethnographic study, a tailored survey was conducted across England between June and September 2022 to determine which aspects of a centre's service are linked to higher rates of HDT uptake [10]; 51 out of 52 centres responded, with an average of three clinical staff responses per centre [10]. We combined the centre-level responses with individual-level data from the UK Renal Registry. A logit regression established the influence of individual and centre-level barriers to HDT initiation, with centre engagement with quality-improvement initiatives and no stresses on staff capacity revealed as key centre influences (Supplementary Material Table S6).

To evaluate the health economic effect of eliminating service barriers, the model was run twice: once with the barrier present in all UK centres and once without it in any centre.

Assuming that dialysis is cost-effective compared with no treatment, and that HDT is proven to be more cost-effective than ICHD, removing these service barriers would lead to health or economic benefits. The comparative results from the two runs reveal the maximum net benefit that could be achieved by eliminating a barrier and therefore the highest amount that a policy maker should be willing to pay for any intervention aimed at removing that barrier. The impact of a specific service barrier in the model is to raise the likelihood of a patient starting dialysis on ICHD rather than HDT, as well as to affect potential modality switches. Removing these barriers increases the chance a patient will start on HDT and remain on HDT once established and increases the chance of transitioning back onto HDT from other treatment modalities. These probabilities are estimated from the parametric multistate regression model, factoring in whether the patient being modelled initiated dialysis from a centre where the barriers are present. Regression analyses and economic modelling was performed in R and the microsimulation model was built in the Simmer R package.

2.2 Health-Related Quality of Life (Utilities)

Table 2 provides a summary of health utility values and their respective sources. In our model, we employ EQ-5D-3L utility values for all health states.

ICHD patient-level utilities are based on age, sex and the duration of dialysis established in a large dataset comprising EQ-5D-5L responses from 478 patients with kidney failure undergoing ICHD. They are mapped to 5L to 3L utility scores on the basis of the UK EQ-5D-3L tariff value, using the 'EEPRU dataset' mapping approach [20]. To establish health utility in HDT in comparison with ICHD, sex-specific estimates of health utility differences between patients on ICHD and other modalities were applied [19]. These estimates of utility were identified as high-quality in a systematic review [21].

2.3 NHS Resource Use

Healthcare costs for people receiving dialysis can be stratified into those relating to the delivery of renal replacement therapy modalities and those related to hospitalisations. The latter can be related to kidney failure, dialysis complications such as catheter failure and hospitalisations from the high prevalence of co-morbid medical conditions, particularly coronary artery disease, congestive heart failure and hypertension [22]. These costs are obtained from literature and adjusted to 2023–2024 prices using the UK NHS Cost Inflation Index for Pay and Prices [23].

The routine annual costs for various dialysis modalities are derived from a comprehensive micro-costing study conducted by the UK NHS in 2022 and are presented in Table 3. The costs encompassed staffing, consumables and equipment, drugs essential for the dialysis process, outpatient clinic costs and additional expenses for installing dialysis equipment, access procedure costs, monitoring expenses and ambulance transport.

Hospitalisation costs were based on a UK study [15] that estimated the costs related to hospitalisations, emergency room visits, general practitioner visits and critical care treatment for serious illnesses from comorbidities and treatment complications in patients with CKD. These costs are adjusted to reflect the higher costs for patients on dialysis,

Table 2 Summary of health utility values

Renal replacement therapy modality	Health utility	Source
Health utility on ICHD depends on age, sex and months on dialysis. Examples below:		
Male, age 30 years, 12 months of dialysis	0.6222	EQ5D-3L utility values based on 523 patients on haemodialysis across five UK sites, collected in 2020 and 2021 [20]
Female, age 30 years, 12 months of dialysis	0.5813	
Male, age 55 years, 24 months of dialysis	0.6164	
Female, age 55 years, 24 months of dialysis	0.5753	
Male, age 80 years, 36 months of dialysis	0.6107	
Female, age 80 years, 36 months of dialysis	0.5694	
Health utility gain over ICHD for patients on HDT and for patients after transplant		
Women on peritoneal dialysis	0.179	EQ5D-3L utility values based on 416 patients with kidney failure (74 on peritoneal dialysis) from a UK centre, collected in 2002 [19]
Men on peritoneal dialysis	0.005	
Women on home haemodialysis	0.179	Assumed to be the same as for peritoneal dialysis
Men on home haemodialysis	0.005	Assumed to be the same as for peritoneal dialysis
Women with a transplant (not on dialysis)	0.332	EQ5D-3L utility values based on 416 patients with kidney failure (209 transplant recipients) from a UK centre, collected in 2002 [19]
Men with a transplant (not on dialysis)	0.159	

Table 3 Summary of costs applied to kidney disease treatment and sources

Cost component of treatments	Annual cost	Source and main costing assumptions
Routine dialysis costs		
Continuous ambulatory peritoneal dialysis	GB £17,721	Costs for UK routine dialysis [15] do not include inpatient hospital admissions and do not include medication use for commodities
Automated peritoneal dialysis	GB £22,355	[15]
Home haemodialysis	GB £24,543	[15]
ICHD	GB £37,759	[15]
Dialysis inpatient and general practitioner (GP) visit costs		
Continuous ambulatory peritoneal dialysis	GB £23,904	UK annual GP and inpatient hospital cost for patients with CKD 3 and 4 [16] (GB £9194) multiplied by 3.6, which is the ratio of patients on haemodialysis to patients with CKD stage 3 and 4 is 2.6 [17]
Automated peritoneal dialysis	GB £23,904	As above [16, 17]
Home haemodialysis	GB £33,098	UK annual GP and inpatient hospital cost for patients with CKD 3 and 4 [16] (GB £9194) multiplied by patients on haemodialysis to patients with CKD stage 3 and 4 is 3.6 [17]
Hospital haemodialysis	GB £33,098	As above [16, 17]
Transplant costs		
Transplant cost in first year	GB £32,833	Cost includes all hospital related costs to transplant and excludes medication usage [18]
Transplant cost in subsequent years	GB £1532	Cost includes all hospital related costs to transplant and excludes medication usage [18]
Immuno-suppression drug costs	GB £6968	[25]
Total annual cost of treatment		
Peritoneal dialysis	GB £44,414	Weighted average of the total annual cost incurred with continuous ambulatory peritoneal dialysis (GB £41,626) and automated peritoneal dialysis (GB £46,259). Weights are the prevalence rates of continuous ambulatory peritoneal dialysis (39.8%) and automated peritoneal dialysis (60.2%) among peritoneal dialysis patients, taken from the 2022 UK Renal Registry annual report [14]. Continuous ambulatory peritoneal dialysis and automated peritoneal dialysis total costs are established from the addition of routine dialysis costs [15] with GP and inpatient costs [16, 17]
Home haemodialysis	GB £57,641	The addition of routine dialysis costs [14] with GP and inpatient costs [16, 17]
HDT (either peritoneal dialysis or home haemodialysis)	GB £47,894	Weighted average of the total annual cost incurred with peritoneal dialysis (GB £44,414) and home haemodialysis (GB £57,641). Weights based on the prevalence rates of peritoneal dialysis (73.7%) and HD (26.2%) among patients undergoing HDT, as reported in the 2022 UK Renal Registry annual report [14]
ICHD	GB £70,856	The addition of routine dialysis costs [14] with GP and inpatient costs [16, 17]
Transplant in first year	GB £39,801	The addition of first year NHS hospital costs [18] and drug costs [25]
Transplant in subsequent years	GB £8,499	The addition of NHS hospital costs after first year [18] and drug costs [25]

which is late-stage CKD. The hospitalisation costs for UK patients with CKD are multiplied by the ratio of inpatient hospital admissions for patients on dialysis to those with CKD stages 3 and 4, as observed in a large population-based cohort study in Sweden [16]. Annual hospital costs for kidney transplants, including inpatient admissions, day cases and outpatient attendances, were taken from a multinational study of 9000 patients with chronic kidney disease [17]. Further detail on costings is reported in Supplementary Text S2.

2.4 Sensitivity Analyses and Uncertainty

Uncertainty in the model is explored using deterministic and probabilistic sensitivity analysis (PSA). A cost-effectiveness plane is used to depict a visual representation of 500 PSA samples, illustrating the incremental QALY and incremental costs for each PSA run. The positive confidence intervals of the mean incremental net monetary benefit (INMB) for home dialysis versus in-centre dialysis

confirmed additional PSA runs is unnecessary to be confident that the true INMB is positive. Further details of this testing are provided in Supplementary Text S1. Results are also presented on a cost-effectiveness acceptability curve (CEAC), showing the probability that the intervention is cost-effective for a range of threshold values. We also illustrate the incremental net monetary benefit for different costs per QALY thresholds.

In addition to the probabilistic sensitivity analysis, four deterministic analyses are applied to assess key parameter estimates. The first analysis sets the HRQoL on HDT to the level of HRQoL on ICHD because a meta-analyses of HRQoL on dialysis showed heterogenous results [21], indicting uncertainty. The second analysis sets NHS treatment costs on HDT to the cost on ICHD. The third analysis assigns patients starting on HDT a similar treatment pathway as those beginning on ICHD. Specifically, the annual transition probabilities and time-to-event values from dialysis to transplant and mortality are the same on HDT as ICHD.

The fourth sensitivity analysis adjusts the modelling methods to reflect patients on dialysis being a priority population. In this analysis, extending life due to differences in the initial dialysis modality incurs no additional costs throughout the extended life period. The purpose of this analysis is to ensure that the cost-effectiveness of dialysis is not diminished in circumstances where it improves life expectancy. Additional details on the rationale for this sensitivity analysis are provided in Supplementary Text S3.

3 Results

The probabilistic sensitivity analysis (Table 4) shows that starting dialysis on HDT dominates (i.e. is both cost-saving and QALY gaining) compared with starting on ICHD. There is an average gain of 0.30 QALYs over a lifetime, lower mean lifetime costs by GB £15,272 and life extension of 0.32 years (Table 5). The sensitivity analysis results are further detailed in the Supplementary Materials (Supplementary Table S2–S3 and Supplementary Figs S1–S3). When the maximum willingness-to-pay for a QALY is GB £20,000, the probability of HDT being cost-effective is 82%. This means that 82 out of every 100 patients initiating dialysis on HDT are expected to be cost-effective compared with if they had started on ICHD. The net monetary gain to the UK NHS is GB £21,284 per dialysis patient. The five one-way sensitivity analyses (Supplementary Table S3) made no impact on the cost effectiveness estimates and starting dialysis on HDT remained cost-effective at a cost per QALY threshold of GB £20,000.

The cost-effectiveness results of eliminating two barriers to HDT adoption are presented in Tables 4 and 5 and in the Supplementary Materials (Supplementary Tables S4–S5, Supplementary Figs. S4–S6). The probabilistic sensitivity analysis shows that no stresses on staff capacity increases QALYs by 0.078 and costs by GB £5127, with a 30% probability of being cost-effective and a net monetary loss to the UK NHS of GB £3558 per dialysis patient. Centres with quality improvement initiatives increase patient QALYs by 0.219 and costs by GB £10,059 compared with those without initiatives, with a 25.8% probability of being cost-effective and a net monetary loss to the NHS of GB £5672 per dialysis patient. Table 5 provides context for these findings. In the analysis of HDT versus ICHD, the percentage of

Table 4 Probabilistic economic results

Simulation scenario	Discounted outcomes		Difference		INMB per dialysis patient		
	QALY	Costs (GB £)	QALY	Costs (GB £)	At GB £10,000 cost per QALY (GB £)	At GB £20,000 cost per QALY (GB £)	At GB £30,000 cost per QALY (GB £)
Initiation dialysis							
Starting on ICHD	5.700	439,828	–	–	–	–	–
Starting on HDT	6.001	424,555	0.301	−15,272	18,278	21,284	24,290
Removing barriers to HDT initiation							
No quality improvement initiatives	5.874	431,503	–	–	–	–	–
With quality-improvement initiatives	6.094	441,562	0.219	10,059	−7864	−5672	−3479
Stresses on staff capacity	6.096	441,206	–	–	–	–	–
No stresses on staff capacity	6.174	446,334	0.078	5127	− 4343	− 3558	− 2774

Table 5 Years on each treatment modality observed in the probabilistic analysis

Simulation scenario	The average number of years patients spent in each treatment modality over their lifetime				The proportion of simulated patients who were treated with each modality at any point during the simulation			The proportion of life years that patients spent in each modality		
	HDT	ICHD	Transplant	All	HDT	ICHD	Transplant	HDT	ICHD	Transplant
Primary analysis: impact of type of initiation dialysis										
Starting on ICHD	1.507	6.140	3.671	11.318	36.60%	100.0%	38.7%	13.31%	54.25%	32.43%
Starting on HDT	3.141	4.820	3.673	11.634	100.00%	76.50%	40.10%	27.00%	41.43%	31.57%
Secondary analysis: impact of QI initiatives within centres										
No QI initiatives	1.407	5.963	4.148	11.518	44.20%	95.0%	42.40%	12.21%	51.77%	36.01%
QI initiatives	2.108	5.766	4.180	12.053	58.10%	92.7%	42.60%	17.49%	47.84%	34.68%
Secondary analysis: impact of stresses on staff capacity within centres										
Stresses on staff capacity	1.999	5.811	4.236	12.046	56.35%	93.06%	43.11%	16.59%	48.24%	35.17%
No stresses on staff capacity	2.393	5.706	4.167	12.266	62.54%	91.97%	42.71%	19.51%	46.52%	33.97%

life years lived with a transplant decreases by 0.86 percentage points. However, this decline is more significant with the elimination of stresses on staff capacity or centres with quality improvement initiatives, where it decreases by 1.2 and 1.34 percentage points, respectively. Since transplants incur substantially lower costs (Table 3) and higher health-related quality of life (Table 2) than dialysis, this drives the economic loss found from removing this barrier to HDT. In sensitivity analyses of this cost-effectiveness result (Supplementary Table S5), where we assume that the life extension from the improved dialysis pathway incurs no NHS treatment costs (see Supplementary Text S3 for further explanation), we find that removing these barriers is cost-saving and improves health outcomes.

4 Discussion

We find that initiating patients on HDT is cost-effective at a threshold of GB £20,000 for the cost per QALY and in all sensitivity analyses. In contrast, the elimination of centre barriers to delivering HDT is not cost-effective at a GB £20,000-per-QALY threshold. This is because removing service barriers to HDT increases the total time spent on dialysis compared with transplant as well as life years. However, it is evident even before running the simulation that dialysis is not cost-effective compared with transplant, nor is it cost-effective compared with early death. The table of input parameters for this model summarises the best-available evidence to date on costs and HRQoL of renal replacement therapy modalities, showing that dialysis patients have higher costs and lower HRQoL compared with transplant patients. In addition, the input table shows the annual cost of dialysis for both patients on HDT and patients on ICHD in the study exceeds GB £20,000, the typical cost per QALY threshold used in the UK, and the utility values show that a year on dialysis yields significantly less than one QALY. Therefore, on the basis of average UK NHS costs and the health utility of dialysis, it cannot be considered cost-effective compared with no treatment.

Removing barriers is cost-effective only in the sensitivity analyses that assumed no UK NHS costs are incurred for a life extension that has resulted from an improved dialysis treatment pathway. This sensitivity analysis reflects the likely perspective of UK decision-makers that dialysis care should continue to be provided, even though it appears at face value to not be cost-effective at typical cost-per-QALY thresholds compared with no treatment and compared with receiving a transplant. Therefore, we believe that this discovery should prompt researchers and policymakers within the UK NHS to develop interventions aimed at overcoming the two obstacles to HDT examined in our study: the lack of quality-improvement initiatives and the stresses on staff

capacity. However, such interventions are not likely to fully eliminate these barriers or be without cost, and prospective evaluations are necessary to determine their cost-effectiveness. We are not proposing that all patients should undergo HDT, nor are we advocating for it to be recommended as the first dialysis modality in clinical guidelines. Instead, we believe these results offer evidence for increasing the number of patients starting on HDT where feasible, given current capacity limitations present in most UK dialysis centres, and, in the long-term, exploring new opportunities for delivering HDT that are cost-effective.

This study demonstrated the cost-effectiveness of HDT as compared with ICHD using a model with multiple advantages compared with prior studies. A strength of the model is that the parameters informing the patient's survival and pathway through modalities are based on an analysis of UK Renal Registry data from over 30,000 patients in England [14]. This means its estimates are likely to be nationally representative. Previous modelling studies are not as generalisable to a national setting because they depend on data sourced from small study cohorts, local datasets rather than a single national dataset [7] and indirect evidence from other studies or systematic reviews [6, 7]. For instance, the most recently published UK model relies on data from outside the UK to inform a change in modalities from ICHD [24]. As highlighted in two recent systematic review of dialysis models [6, 7], these data constraints have also resulted in models relying on assumptions that lack realism and complexity regarding renal replacement therapy journeys, for instance, not allowing multiple 'switches' between modalities [7]. This limitation is not present in this study. A further benefit is that the cost estimates for dialysis modalities were based on a micro-costing study [15], enhancing the accuracy of the cost predictions.

The model has several limitations impacting the economic estimates. The two barriers are defined by the phrasing used on the survey [10], which had to be concise and therefore lacked further elaboration. Given the brevity of the description of the two barriers, they were perhaps subject to interpretation by the survey respondents. Our cost perspective is only the costs borne to the health system. Therefore, factors such as expenses for patients and their families (such as transportation and caregiving), as well as economic impacts (such as employment and productivity), are not considered in the model. The economic benefits of initiating on HDT assume that the necessary infrastructure and resources for HDT are readily available. However, increased HDT provision may require expanding capacity through the training and recruitment of specialised HDT nursing staff. These investment costs are not considered in the analysis. The health economic model simplifies clinical practice by combining peritoneal dialysis and home haemodialysis, considering them both as home-based treatments. We recognise that transitions to other treatment modalities will vary between these two methods of HDT; however, due to the limited number of patients on home haemodialysis in the renal registry, the accurate estimation of separate transition rates is not possible.

Another limitation is that, in our analysis, we assume patients are willing and able to use HDT. To the extent that they are not, this will lower the cost-effectiveness. The model focused on eliminating barriers for centres already with them, rather than for average centres. It is also unlikely that all centres could eliminate the barriers. The generalisability of our findings to different geographical contexts may be constrained by the UK sources used in the model. For instance, the findings might not hold true for low-income nations where factors such as limited access to dialysis supplies, expenses related to manufacturing of HDT consumables and transportation costs could lead to increased expenses for HDT.

Future research should evaluate the effectiveness of actual interventions to reduce barriers and examine the impact of initiating HDT in other settings and patient populations. The microsimulation model possesses flexibility to simulate the impact of initiating HDT in other populations through the adjustment of the characteristics of the dialysis population. In this manner, the model can also predict the impact after expected changes in the patient population with time. For instance, if patients initiating dialysis become older and present with more co-morbidities, the model reflects this with the following effects: fewer patients will commence dialysis on HDT and, for those who do, their duration on HDT before transitioning to another modality (such as transplantation) or experiencing mortality will be shorter. While we limit our analysis to a UK context, there may also be relevant insights for other countries, such as the USA, Greece, Romania and the Czech Republic, which might consider conducting similar analyses given their low HDT rates [3].

While patient characteristics can be modified to reflect different populations, key cost, treatment transition and health utility model inputs are based on UK-specific data. In our model, the costs for HDT are calculated as a weighted average of peritoneal dialysis and home haemodialysis costs, reflecting the proportion of patients using each modality in the UK. These proportions are sourced from the UK Renal Registry and may not be representative of other healthcare systems where the uptake of peritoneal dialysis versus home haemodialysis is different. Additionally, healthcare costs for dialysis and transplant will vary between countries on the basis of staffing models, capital investment and patient hospitalisation rates. Similarly, health utility estimates are based on UK specific EQ-5D data, which will not be generalisable to other populations owing to differences in treatment protocols, healthcare access and country-specific EQ-5D utility weights. The transitions between treatment modalities in the

model also reflect UK care pathways, which may be different in other countries. To adapt the model for other settings, possible researchers should apply local data, for example, the micro-costing data of treatments.

5 Conclusions

This study demonstrated the cost-effectiveness of initiating patients on dialysis on HDT compared with ICHD, using a model where patient characteristics and current renal replacement therapy influences dynamic renal replacement therapy modality changes over the lifetime of patients. This is the first study to use data on the barriers to initiate HDT present in UK dialysis centres to show the impact of addressing two key obstacles: the absence of quality-improvement initiatives and stresses on staff capacity. Eliminating these barriers is not cost-effective, as it results in more time spent on dialysis, and dialysis exceeds the typical UK cost-per-QALY thresholds owing to its high costs and limited health gains.

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Declarations

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Availability of Data and Material Data on dialysis patient characteristics and their health outcomes is from the UK Renal Registry, which is not available publicly. Data on economic outcomes (e.g. costs) is taken from research studies cited in the manuscript.

Ethics Approval Ethics approval has been granted by the Health Research Authority (reference no. 20-WA-0249). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Code Availability The code and model were made available to the peer reviewers. The research team will consider requests for code individually. Any requests for code should be directed to the corresponding author.

Author Contributions Harry Hill, James Fotheringham, Jessica Potts, Ivonne Solis-Trapala, Mark Lambie, Sarah Damery, Kerry Allen, Allan Wailoo, Iestyn Williams and Simon Davies contributed to the conceptual design of the economic model, the multistate modelling and the drafting of the manuscript. Jessica Potts, Ivonne Solis-Trapala, Harry Hill and James Fotheringham contributed to the multistate statistical modelling. Harry Hill gathered evidence sources for the economic model, constructed and coded the model and produced the health economic results.

References

1. Jha V, Al-Ghamdi SM, Li G, et al. Global economic burden associated with chronic kidney disease: a pragmatic review of medical costs for the Inside CKD Research Programme. Adv Ther. 2023;40(10):4405–20.
2. Francis A, Harhay MN, Ong A, et al. Chronic kidney disease and the global public health agenda: an international consensus. Nat Rev Nephrol. 2024;3:1–3.
3. Brown EA, Brivio GB, Van Biesen W. Towards a better uptake of home dialysis in Europe: understanding the present and looking to the future. Clin Kidney J. 2024;17(Supplement_1):i3-12.
4. Fissell RB, Cavanaugh KL. Barriers to home dialysis: unraveling the tapestry of policy. Semin Dial. 2020;33(6):499–504.
5. Schreiber MJ Jr. Changing landscape for peritoneal dialysis: optimizing utilization. Semin Dial. 2017;30(2):149–57.

6. Yang F, Liao M, Wang P, et al. The cost-effectiveness of kidney replacement therapy modalities: a systematic review of full economic evaluations. Appl Health Econ Health Policy. 2021;19:163–80.
7. Howell M, Walker RC, Howard K. Cost effectiveness of dialysis modalities: a systematic review of economic evaluations. Appl Health Econ Health Policy. 2019;1(17):315–30.
8. Tshimologo M, Allen K, Coyle D, et al. Intervening to eliminate the centre-effect variation in home dialysis use: protocol for InterCEPt—a sequential mixed-methods study designing an intervention bundle. BMJ Open. 2022;12(6): e060922.
9. UK Kidney Association. Renal registry. 2024. Available at. https://ukkidney.org/about-us/who-we-are/uk-renal-registry. Accessed 19 Oct 2024.
10. Damery S, Lambie M, Williams I, et al. Centre variation in home dialysis uptake: a survey of kidney centre practice in relation to home dialysis organisation and delivery in England. Perit Dial Int. 2024;17:08968608241232200.
11. Husereau D, Drummond M, Augustovski F, et al. Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022). Explanation and elaboration: a report of the ISPOR CHEERS II Good Practices Task Force. Value Health. 2022;25(1):10–31.
12. Krijkamp EM, Alarid-Escudero F, Enns EA, et al. Microsimulation modeling for health decision sciences using R: a tutorial. Med Decis Making. 2018;38(3):400–22.
13. Andersen PK, Keiding N. Multi-state models for event history analysis. Stat Methods Med Res. 2002;11(2):91–115.
14. UK Renal Registry. UK Renal Registry 25th Annual Report—Data to 31/12/2020. Bristol, UK. 2022. Available from https://ukkidney.org/audit-research/annual-report. Accessed 19 Oct 2024.
15. Roberts G, Holmes J, Williams G, et al. Current costs of dialysis modalities: a comprehensive analysis within the United Kingdom. Perit Dial Int. 2022;42(6):578–84.
16. Pollock C, James G, Garcia Sanchez JJ, et al. Healthcare resource utilisation and related costs of patients with CKD from the UK: a report from the DISCOVER CKD retrospective cohort. Clin Kidney J. 2022;15(11):2124–34.
17. Eriksson JK, Neovius M, Jacobson SH, et al. Healthcare costs in chronic kidney disease and renal replacement therapy: a population-based cohort study in Sweden. BMJ Open. 2016;6(10): e012062.
18. Kent S, Schlackow I, Lozano-Kühne J, Reith C, et al. What is the impact of chronic kidney disease stage and cardiovascular disease on the annual cost of hospital care in moderate-to-severe kidney disease? BMC Nephrol. 2015;16:1–8.
19. Lee AJ, Morgan CL, Conway P, et al. Characterisation and comparison of health-related quality of life for patients with renal failure. Curr Med Res Opin. 2005;21(11):1777–83.
20. Alava MH, Sasso A, Si PE, Gittus M, et al. Relationship between standardized measures of chronic kidney disease-associated pruritus intensity and health-related quality of life measured with the EQ-5D questionnaire: a mapping study. Acta Dermato-Venereologica. 2023;103:11604.
21. Chuasuwan A, Pooripussarakul S, Thakkinstian A, et al. Comparisons of quality of life between patients underwent peritoneal dialysis and hemodialysis: a systematic review and meta-analysis. Health Qual Life Outcomes. 2020;18:1–1.
22. Goodkin DA, Bragg-Gresham JL, Koenig KG, et al. Association of comorbid conditions and mortality in hemodialysis patients in Europe, Japan, and the United States: the Dialysis Outcomes and Practice Patterns Study (DOPPS). J Am Soc Nephrol. 2003;14(12):3270–7.
23. Jones KC, Weatherly H, Birch S et al. 2025 Unit Costs of Health and Social Care 2024 Manual. Technical report. Personal Social Services Research Unit (University of Kent) and Centre for Health Economics (University of York), Kent, UK
24. Erbe AW, Kendzia D, Busink E, et al. Value of an integrated home dialysis model in the United Kingdom: a cost-effectiveness analysis. Value in Health. 2023;26(7):984–94.
25. NHS Blood and Transplant. October 2009. Cost-effectiveness of transplantation. Factsheet 7. Available at. https://nhsbtmediaservices.blob.core.windows.net/organ-donation-assets/pdfs/Organ_Donation_Registry_Fact_Sheet_7_21337.pdf. Accessed 11 Jan 2024.