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Patient and Center Factors in Home Dialysis Therapy Uptake: Analysis of a UK Renal Registry Cohort and a National Dialysis Center Survey

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Rationale & Objective: Variation in home dialysis therapy (HT) use across centers and geography may reflect the interplay between dialysis center services and patient characteristics. We examined direct and indirect associations between these factors and HT uptake in England.

Study Design: UK Renal Registry (UKRR) cohort linked to a national survey of renal centers.

Setting & Participants: Adults who initiated kidney replacement therapy (KRT) between 2015 and 2019 at 51 English renal centers, totaling 32,400 individuals identified through the UKRR with center practices captured from a 2022 national survey of dialysis centers.

Exposure: Patient-level (demographics and clinical characteristics) and center-level (including availability of assisted peritoneal dialysis, quality improvement initiatives, and fostering staff engagement in research) factors.

Outcome: Use of HT (home hemodialysis or peritoneal dialysis) within 1 year of starting KRT.

Analytical Approach: Sequences of regressions, an extension of path analysis, used to examine direct and indirect associations between patient-level and center-level factors and the probability of HT uptake.

Results: Both center-level and patient-level factors were significantly associated with the probability of HT uptake. Patients at centers conducting quality improvement projects (odds ratio [OR], 1.94 [95% CI, 1.36-2.76]), offering assisted peritoneal dialysis (OR, 1.89 [95% CI, 1.39-2.57]), fostering staff research engagement (OR, 1.35 [95% CI, 1.03-1.77]), or hosting HT roadshows (OR, 1.22 [95% CI, 1.05-1.41]) had higher odds of HT uptake. Centers with greater stress on staff capacity to deliver HT had lower uptake (OR, 0.60 [95% CI, 0.45-0.81]). Patients on transplant lists at KRT start (OR, 2.55 [95% CI, 2.35-2.77]) or who lived farther from a treatment center (OR, 1.10 [95% CI, 1.08-1.12] per 10 km) had higher odds of HT uptake. Patients living in areas of higher deprivation or members of minoritized ethnic groups had lower HT uptake overall. However, some of these associations may have been indirectly mitigated in centers serving more diverse populations because these centers were more likely to implement practices associated with higher HT uptake.

Limitations: Health care professional–reported and aggregated survey data.

Conclusions: This study identified modifiable center-level factors associated with HT uptake, informing potential opportunities to reduce ethnic and area-level disparities.

Visual Abstract online

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Home dialysis therapy (HT), including peritoneal dialysis (PD) and home hemodialysis (HHD), are important for life participation, optimizing survival, and reducing health care costs, particularly as the prevalence of kidney failure continues to increase worldwide.[1] The critical importance of shifting health care delivery models toward community-based care has been emphasized.[2,3] This shift is particularly relevant for managing long-term conditions such as kidney failure. Expanding HT use aligns with recommendations to support patient-centered care and enhance accessibility, and it ultimately leads to better outcomes.[4]

Despite long-standing national policy favoring HT[5,6] and attempts to increase its use in high-income countries, uptake remains low.[7-11] In England, HT use varies significantly between renal centers and is particularly low among people from minoritized ethnic groups and living in areas of high deprivation. Previous studies examining the associations between patient demographics and HT uptake in renal centers have had variable success in explaining these inequalities in service provision.[12-17]

Inter-CEPt, a sequential mixed-methods study, aimed to identify modifiable center-level factors associated with HT uptake in England with the goal of developing interventions to increase HT use and reduce inequalities.[18] We conducted an ethnographic study[19] and used the findings to develop a national survey of center-level characteristics, including organizational culture, practices, and service organization.[20]

We examine the interplay between center-level and patient-level factors in relation to HT uptake. Using sequences of regressions,[21-24] an extension of path analysis, we assess both direct associations between patient-level and center-level factors and HT uptake and indirect associations where patient factors are associated with HT uptake through differences in center practices. By linking UK Renal Registry (UKRR) patient-level data to center survey data, we provide novel insights into how institutional

PLAIN-LANGUAGE SUMMARY

Some patients are less likely to use home dialysis, possibly due to both patient characteristics and how dialysis centers operate. We studied over 32,000 patients who began kidney replacement therapy between 2015 and 2019, linking national patient data with a 2022 survey of English dialysis centers. Using advanced statistical methods, we uncovered direct and indirect links between patient and center factors and home therapy use. Patients were more likely to use home dialysis if their center offered supportive practices like assisted dialysis, staff-led improvement projects, or home dialysis educational roadshows. Notably, centers serving diverse populations were more likely to implement such practices. This study highlights how center practices may contribute to improving and reducing disparities in access to home therapy.

practices and patient characteristics are associated with access to HT. These insights may help inform quality improvement (QI) and policies to reduce disparities in HT uptake.

Methods

National Survey of Renal Centers in England

The survey was conducted across all 51 English renal centers between June and September 2022.[20] It comprised 78 questions (dichotomous or Likert-type scale) related to center practice patterns and the organization of the home dialysis services. Details on data aggregation, transformation, and survey question selection for the analysis can be found in Item S1.

UK Renal Registry Data and Data Linkage

Our study population included patients (aged >18 years) starting kidney replacement therapy (KRT) between January 1, 2015, and December 31, 2019, in England who were identified through the UKRR. Center practices during this period were assumed to approximate those represented in the 2022 national survey. We used data provided by the UKRR, including demographics (age, sex, ethnicity, and Index of Multiple Deprivation [IMD] quintiles[25]) and clinical characteristics (diabetes as primary renal diagnosis, transplant waitlist status, distance to nearest renal center) at KRT initiation, and treatment timelines.

Ethnicity was self-reported by patients to center staff and was submitted to the UKRR by each dialysis center. It was categorized as Asian, Black, mixed, White, and other. Asian included Bangladeshi, Pakistani, Indian, Chinese, or "other Asian"; Black included African, Caribbean, and "other Black"; mixed included White and Asian, White and Black, or "other mixed"; White included British, Irish, or "other White"; and other included Arab or "any other ethnic group." This categorization aligns with UK government guidance for reporting ethnicity in public data.[26]

Neighborhood deprivation was measured using the IMD quintile, assigned via patient postcodes mapped to Lower-layer Super Output Areas (LSOAs). Higher quintiles reflect greater deprivation.[27] The center-level survey dataset was linked to the patient-level UKRR dataset by matching each patient record with their respective center information.

Primary Outcome Measure

The primary outcome was whether a patient used HT (PD or HHD) within 1 year of starting KRT. A patient was considered to have received HT if they used either HHD or PD at any time within the first year for any duration. Because HT may require setup time and training, particularly for HHD or late presenters, the period was extended to 12 months to ensure these patients were included. Patients who died or were lost to follow-up within 1 year were classified by their last recorded modality.

Hypothesized Sequence of Center-Level and Patient-Level Factors Associated With HT Uptake

Figure 1 shows our hypothesized sequence of interactions between center-level and patient- level factors potentially linked to HT uptake.[18] We hypothesized that center-level factors, such as a center's approach to HT and availability of resources, may relate to the patient's access to HT. Additionally, patient-level factors such as age, sex, residential distance from the dialysis unit, ethnic group, and area-level deprivation may be associated with the patient's probability of having HT. The decision to start HT is likely informed by a combination of these patient characteristics and the support provided by the dialysis center. For example, a patient from a neighborhood with high levels of deprivation may be less likely to choose HT, but if the center offers specific support, this could make HT more accessible. Thus, we postulated that the uptake of HT is shaped by the interplay between center-level and patient-level factors.

Statistical Analysis

We used sequences of regression[21-24] (SoR), a graphical model that builds on path analysis, to examine direct and indirect associations between center-level and patient-level factors and the probability of HT uptake. The model was fitted through an ordered series of regression models starting with HT uptake, the primary outcome, and working from left to right (Fig 1). HT uptake was the response variable to all the factors located within the boxes on the right-hand side and was modeled using a mixed-effects logistic regression model with a random intercept to account for center clustering. Odds ratios (OR) from this model represent center-specific (conditional) effects.

The second box contains multiple center-level factors that were modeled as response variables to patient characteristics and demographics, which are located within the third and

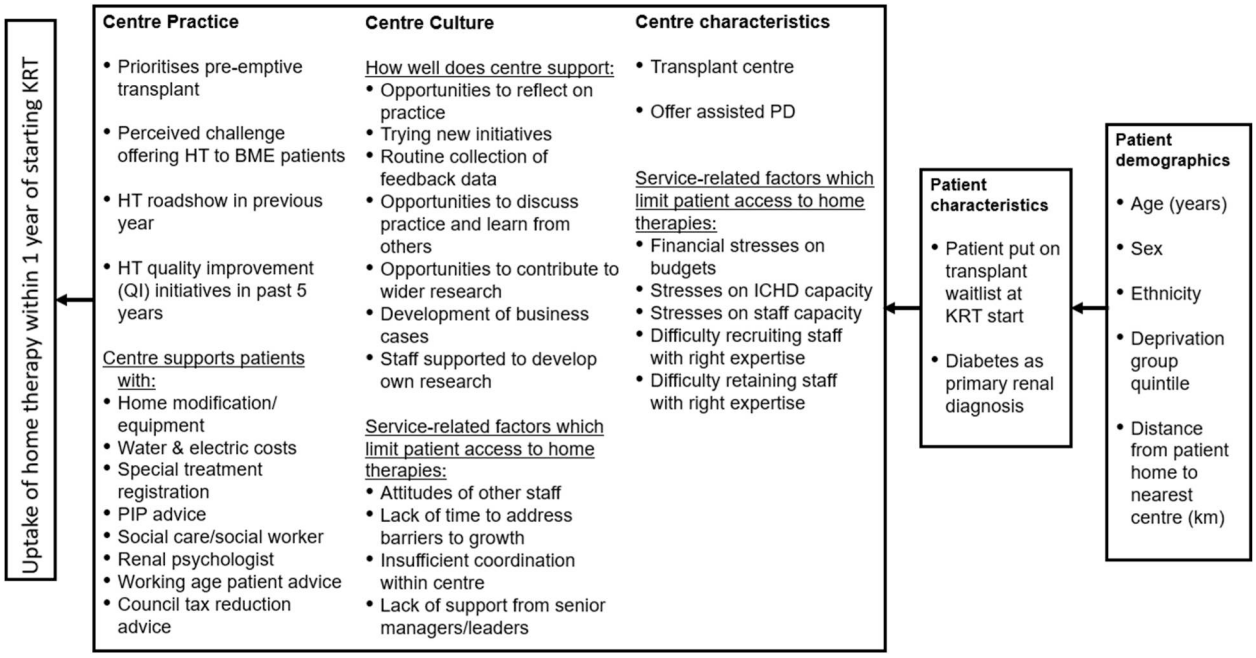

Figure 1. Proposed sequence of center- and patient-level factors in their association with HT uptake within 1 year of starting KRT. Abbreviations: BME, Black and minoritized ethnic group; HT, home therapy; ICHD, in-center hemodialysis; PD, peritoneal dialysis, PIP, personal independence payment (to provide help with extra living costs for people who have difficulty doing everyday tasks due to having a long-term health condition or disability); QI, quality improvement.

fourth boxes using standard logistic regression models. Finally, the patient characteristic variables were modeled as response variables to the patient demographics using standard logistic regression models. The best-fitting regression model for each outcome in the SoR analyses was selected by comparing nested models with different combinations of explanatory factors using likelihood ratio tests.

The SoRs are described using a regression graph in which 2 variables located in different boxes were linked by an arrow line emerging from a selected explanatory variable and pointing to a response variable if they are directly associated (ie, association not explained by any of the intermediary factors). A sequence of connected arrow lines between 2 variables represents an indirect association (ie, partially explained by intermediary factors). The strength of the associations depicted by the arrows in the graph were quantified using OR (exponential of partial regression coefficients). SoR also allows for the exploration of residual pairwise associations of multiple factors (center factors or patient characteristics) after accounting for their combined explanatory variables. We applied this approach to explore residual associations among center-level factors linked with HT uptake. Further details on model interpretation, estimation, assumptions, missing data, goodness of fit, and diagnostic checks are provided in Item S2.

The level of statistical significance was set at 0.05. The analyses were carried out using STATA version 18 (StataCorp) and the statistical software R (R Project for Statistical Computing).

Patient and Public Involvement Summary

Patients and family members/carers with lived experience of dialysis for kidney failure were involved at every stage of the Inter-CEPt study including its design, the grant funding application, the study management, and the interpretation and dissemination of findings. A patient advisory group, supported by the Keele University Patient and Public Involvement team, that was representative of diverse ethnicities, geographies, and backgrounds met 7 times over the course of the project and co-produced the final public-facing report of the research.

Ethics Approval and Informed Consent

Ethics approval for this study was granted by the UK Health Research Authority (Ref: 20-WA-0249). The center survey participants provided informed consent via an embedded form at the start of the survey. Pseudonymized patient data were provided by the UKRR under study approval (Ref: DSA93). The UKRR holds Section 251 approval under the National Health Service Act 2006 to process and share confidential patient data for research with ethics approval from the Research Ethics Committee (Ref: 16/NE/0042).

Results

Survey Data

There were 180 responses from 50 of 51 kidney centers,[20] with 1 to 10 responses per center (mean 3.5). We selected

Table 1. Frequency Table of Renal Unit Responses in English Renal Survey for Variables Selected for Analysis

Survey Question	No/Disagree	Yes/Agree	Missing
1. Was there a HT roadshow in previous year?[a]	48 (96%)	2 (4%)	0 (0)
2. Have there been QI initiatives in past 5 years?	6 (12%)	42 (84%)	2 (4%)
3. Is the center a transplant center?	32 (64%)	18 (36%)	0 (0)
4. Does the center prioritize pre-emptive transplant?	6 (12%)	41 (82%)	3 (6%)
5. Does the center offer assisted PD?	8 (16%)	42 (84%)	0 (0)
6. Is it challenging to offer HT to BME patients?	40 (80%)	6 (12%)	4 (8%)
Does the center offer patients support with—?			
7. Home and equipment purchase support	9 (18%)	37 (74%)	4 (8%)
8. Water and electricity cost support	3 (6%)	43 (86%)	4 (8%)
9. Special treatment registration support	3 (6%)	43 (86%)	4 (8%)
10. Offer PIP advice	4 (8%)	42 (84%)	4 (8%)
11. Social worker/care within center	14 (28%)	32 (64%)	4 (8%)
12. Renal psychologist within center	14 (28%)	33 (66%)	3 (6%)
13. Advice for working age patients	3 (6%)	42 (84%)	5 (10%)
14. Advice on council tax reduction	3 (6%)	42 (84%)	5 (10%)
Do the following service-related factors limit patient access to HT?			
15. Financial stress on center budgets	32 (64%)	18 (36%)	0 (0)
16. Stresses on ICHD capacity	22 (44%)	27 (54%)	1 (2%)
17. Stresses on staff capacity	10 (20%)	40 (80%)	0 (0)
18. Difficulty recruiting staff with correct expertise	10 (20%)	40 (80%)	0 (0)
19. Difficulty retaining staff with correct expertise	16 (32%)	34 (68%)	0 (0)
20. Attitudes of other staff in center	28 (56%)	22 (44%)	0 (0)
21. Lack of time to address barriers to growth	20 (40%)	30 (60%)	0 (0)
22. Insufficient coordination within renal center	36 (72%)	13 (26%)	1 (2%)
23. Lack of support from senior managers/leaders	35 (70%)	15 (30%)	0 (0)
Does the center support the following?			
24. Opportunities to reflect on practice	5 (10%)	44 (88%)	1 (2%)
25. Encouraging new initiatives	5 (10%)	44 (88%)	1 (2%)
26. Routine collection of feedback data	16 (32%)	34 (68%)	0 (0)
27. Discuss practice and learn from others	9 (18%)	41 (82%)	0 (0)
28. Opportunities to contribute to wider research	13 (26%)	37 (74%)	0 (0)
29. Support for developing business cases	14 (28%)	35 (70%)	1 (2%)
30. Support staff to develop own research	23 (46%)	27 (54%)	0 (0)

Values are frequency (percentage). Abbreviations: BME, Black and minoritized ethnic group; HT, home therapy; ICHD, in-center hemodialysis; PD, peritoneal dialysis, PIP, personal independence payment (PIP provides help with extra living costs for people who have difficulty doing everyday tasks due to having a long-term health condition or disability); QI, quality improvement.
[a]An HT roadshow is an initiative whereby a dialysis center is visited by a team including patients, family members, clinicians and industry to promote HT.

43 questions relevant to both PD and HHD from which we derived 98 factors because many questions addressed multiple aspects. After identifying potentially modifiable center-level factors that could be linked to HT uptake and excluding those with more than 10% missing data, 30 factors were included in the analysis (Fig S1, Table 1). Table S1 shows the patterns of missingness across centers. Of the 50 centers, 38 (76%) had complete responses for all factors. All available data were included in the SoR, although centers with missing data did not contribute to specific regression analyses.

UKRR Data

Of the 32,400 incident KRT patients between 2015 and 2019, 23,242 (72%) started on in-center HD (ICHD), 6,522 (20%) on HT, and 2,636 (8%) had a pre-emptive kidney transplant. HT as initial therapy ranged between 2% and 37% across centers (median, 19% [IQR, 16%-25%]) (Fig 2). Within the first calendar year of starting KRT, 8,147 patients (25%) had received HT. Table 2 shows a summary of the patient characteristics stratified by initial KRT modality.

Patients starting on HT were younger than those starting on ICHD. A greater proportion of patients from areas of least deprivation received HT or a transplant as their initial modality. The proportion of patients who received HT and were waitlisted for transplant at start of KRT was 3-fold that of those who started on ICHD. Tables S2 and S3 show the incident KRT patients by renal center and year and patient demographics over the study period, respectively. The proportion of patients receiving HT within 1 year varied between centers, and there was no apparent pattern across center sizes, defined as the proportion of the incident cohort (range, 0.5%-5.7%). The larger centers

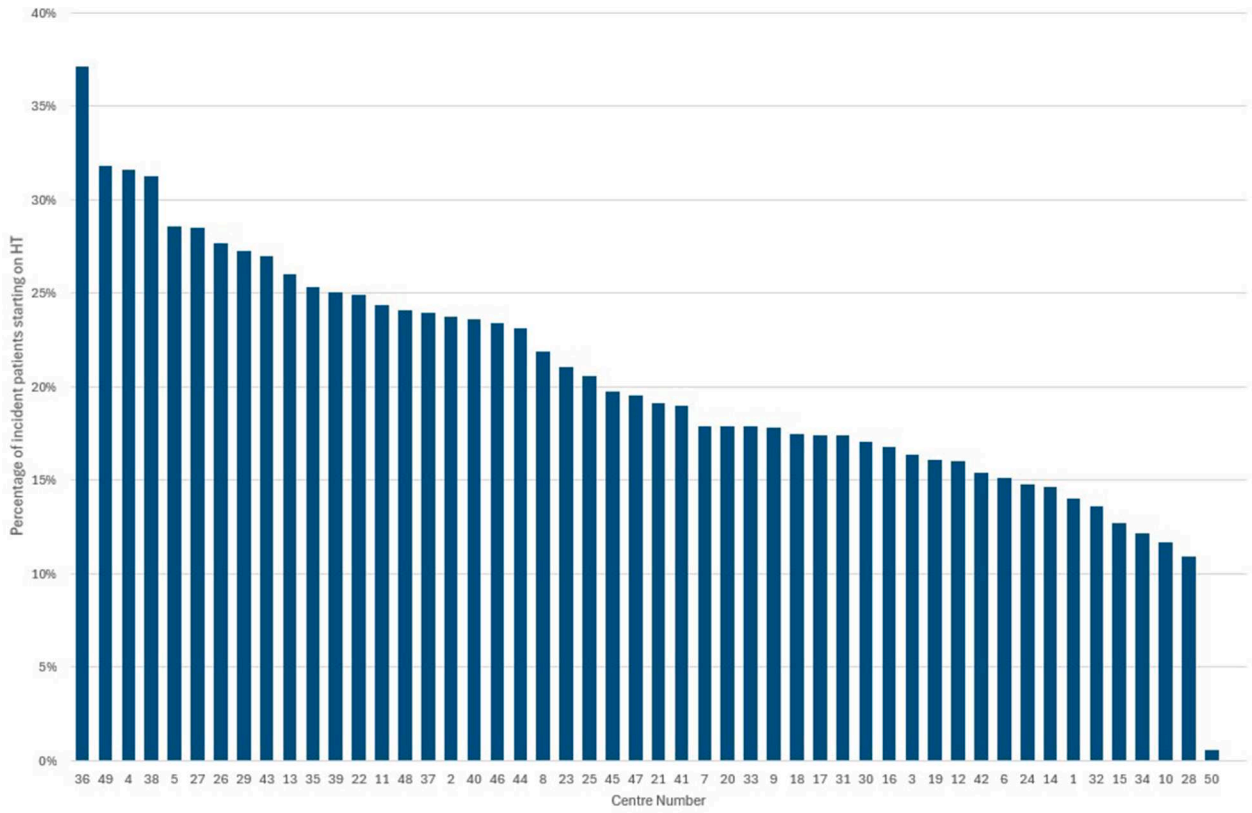

Figure 2. Percentage of incident kidney replacement therapy patients initiating HT as first treatment (2025-2019) by center. Abbreviation: HT, home therapy.

tended to have more ethnically diverse populations. Missing data across the variables used in the SoR analyses ranged from 0 to 8% (median, 0 [IQR, 0-4%]).

Direct Associations of Patient-Level and Center-Level Characteristics With HT Uptake

Table 3 presents the estimated direct associations of center-level and patient-level factors with HT uptake from the model of best fit. Figure 3 displays a subgraph visualizing these estimated direct associations alongside indirect associations.

Center-Level Factors

Higher odds of HT uptake were linked to renal centers that conducted QI projects in the last 5 years (OR, 1.94 [95% CI, 1.36-2.76]), offered assisted PD (OR, 1.89 [95% CI, 1.39-2.57], fostered research (OR, 1.35 [95% CI, 1.03-1.77]), or hosted home dialysis roadshows (OR, 1.22 [95% CI, 1.05-1.41]). Other center-level variables associated with HT uptake included stress on staff capacity to deliver HT (OR, 0.60 [95% CI, 0.45-0.81]) and a perceived lack of support from senior managers/leaders, which limited opportunities for HT (OR, 1.47 [95% CI, 1.13-1.92]). These associations are depicted in Figure S2 through predicted HT uptake probabilities.

Additionally, we identified 2 potential interaction terms on the probability of HT uptake: between research opportunities and perceived lack of support, which limits HT; and between research opportunities and running QI projects. However, due to data sparsity, the inclusion of these interactions led to wide confidence intervals in the regression estimates, indicating a high degree of uncertainty (Item S5).

Patient-Level Characteristics

The odds of HT uptake were 2.6-fold for patients waitlisted for transplant at the start of KRT (OR, 2.55 [95% CI, 2.35-2.77]). For patients living farther from the nearest treatment center by 10 km, the odds of HT uptake were 10% higher (OR, 1.10 [95% CI, 1.08-1.12]). Patients with diabetes as the primary cause of renal disease had 7% lower odds of HT uptake (OR, 0.93 [95% CI, 0.88-0.99]). Additionally, with a decade of difference in age at KRT initiation, the odds of HT uptake were 9% lower (OR, 0.91 [95% CI, 0.90-0.92]).

The patients from the Asian (OR,0.84 [95% CI, 0.77-0.92]), Black (OR, 0.84 [95% CI, 0.75-0.95]), or mixed (OR, 0.77 [95% CI, 0.62-0.96]) groups had lower odds of HT uptake compared with White patients. Compared with the reference IMD 3rd quintile, patients from lower deprivation areas (quintiles 1 and 2) had higher odds of HT uptake (Q1: OR, 1.34 [95% CI, 1.21-1.48] and Q2: 1.17 [95% CI, 1.06-1.28]) while those from higher deprivation areas (quintiles 4 and 5) had lower odds (Q4:

Table 2. Patient Characteristics for Incident KRT Patients Between January 1, 2015, and December 31, 2019, (n = 32,400) Collected From the UKRR

	ICHD n = 23,242 (72%)		Home Therapy n = 6,522 (20%)		Pre-Emptive Transplant n = 2,636 (8%)	
Age, y	66 [54-76]		61 [48-72]		51 [41-61]	
Distance (km) from closest center	5.8 [3.3-11.5]		6.6 [3.7-12.8]		7.2 [4.2-13.5]	
Sex						
Male	14,960	64.4%	4,138	63.5%	1,521	57.7%
Female	8,282	35.6%	2,384	36.5%	1,115	42.3%
IMD quintile						
(Least deprived) 1	3,112	13.4%	1,108	17.0%	595	22.6%
2	3,746	16.1%	1,234	18.9%	563	21.4%
3	4,549	19.6%	1,287	19.7%	551	20.9%
4	5,558	23.9%	1,431	21.9%	468	17.8%
(Most deprived) 5	6,261	26.9%	1,460	22.4%	434	16.5%
Missing	16	0.1%	2	0.0%	25	1.0%
Ethnicity						
Asian	3,227	13.9%	906	13.9%	304	11.5%
Black	1,913	8.2%	508	7.8%	65	2.5%
Mixed	363	1.6%	122	1.9%	59	2.2%
Other	390	1.7%	118	1.8%	25	1.0%
White	16,269	70.0%	4,670	71.6%	2,106	79.9%
Missing	1,080	4.7%	198	3.0%	77	2.9%
Waitlisted for transplant at start of KRT						
No	21,371	92.0%	4,911	75.3%	NA	NA
Yes	1,871	8.1%	1,611	24.7%	NA	NA
Missing	0	0	0	0	NA	NA
Diabetes as primary diagnosis						
No	14,954	64.3%	4,507	69.1%	2,115	80.2%
Yes	6,603	28.4%	1,750	26.8%	340	12.9%
Missing	1,685	7.3%	265	4.1%	181	6.9%

Values for continuous variables given as median [IQR]; for categorical variables, as frequency (percentage). Abbreviations: ICHD, in-center hemodialysis; IMD, index of multiple deprivation; KRT, kidney replacement therapy; NA, not applicable; UKRR, UK Renal Registry.

OR, 0.86 [95% CI, 0.79-0.95] and Q5: 0.74 [95% CI, 0.68-0.81]). Figures S3 and S4 illustrate these associations through predicted HT uptake probabilities.

Indirect Associations of Patient-Level Characteristics With HT Uptake

Figure 3 and Table 4 describe how patient-level characteristics are associated with centers that adopt specific practices, indicating potential indirect associations with HT uptake.

Centers that had implemented QI initiatives within the past 5 years tended to have a higher proportion of patients from the most deprived areas (IMD quintile 5) compared with quintile 3 (OR, 1.40 [95% CI, 1.22-1.61]) and the patients identifying as Asian or Black (OR, 2.43 [95% CI, 2.03-2.91] and 3.27 [95% CI, 5.50-4.27], respectively) compared with White patients. Centers that had hosted an HT roadshow in the previous year similarly showed a higher presence of Asian patients (OR, 1.20 [95% CI, 1.05-1.37]). Centers encouraging staff research opportunities are also more likely to have a diverse population, including a higher proportion of Asian, Black, mixed, and other ethnic groups compared with White patients. Conversely, the proportion of patients from higher deprivation areas (Q4: 0.86 [95% CI, 0.78-0.95] and Q5: 0.75 [95% CI, 0.68-0.83]) and those with diabetes as primary diagnosis (0.93 [95% CI, 0.86-0.99]) were lower in these centers.

Centers offering assisted PD had a higher proportion of patients who were initially waitlisted for KRT (OR, 1.15 [95% CI, 1.00-1.31]), who were from areas with the least deprivation (OR, 1.16 [95% CI, 1.09-1.44]) compared with those in the quintile 3 group, and belonged to Asian (OR, 4.12 [95% CI, 3.35-5.09]), Black (OR, 12.05 [95% CI, 7.73-18.79]), mixed (OR, 3.49 [95% CI, 4.08-5.86]), or other ethnic groups (OR, 3.37 [95% CI, 2.07-5.49]) compared with White patients. Centers experiencing stress on staff capacity had higher proportions of waitlisted transplant patients (OR, 1.16, [95% CI, 1.05-1.28]), of patients with diabetes as primary renal diagnosis (OR, 1.18 [95% CI, 1.10-1.26]), and of patients from less deprived areas. Additionally, the centers with a perceived lack of staff support saw higher proportions of patients with diabetes as their primary diagnosis (OR, 1.09 [95% CI,

Table 3. Direct Associations of Center- and Patient-Level Factors With the Probability of a HT Uptake Within 1 Year of Commencing KRT Based on Mixed-Effects Logistic Regression Model of Best Fit

Factor Level	Descriptor	OR (95% CI)
Patient demographic	Age (per 10-year increase at KRT start)	0.91 (0.90-0.92)
	Ethnicity	
	White (reference)	—
	Asian	0.84 (0.77-0.92)
	Black	0.84 (0.75-0.95)
	Mixed	0.77 (0.62-0.96)
	Other	0.93 (0.75-1.16)
	IMD quintile	
	(Least deprived) 1	1.34 (1.21-1.48)
	2	1.17 (1.06-1.28)
	(Reference) 3	—
	4	0.86 (0.79-0.95)
	(Most deprived) 5	0.74 (0.68-0.81)
	Living distance from center (per 10 km)	1.10 (1.08-1.12)
Patient characteristics	On the transplant waiting list at start	2.55 (2.35-2.77)
	Diabetes as primary diagnosis	0.93 (0.88-0.99)
Center characteristics	Center offers assisted PD	1.89 (1.39-2.57)
	Stresses on staff capacity limits HT access	0.60 (0.45-0.81)
Center culture	Opportunities to contribute to research	1.35 (1.03-1.77)
	Lack of support limits HT access	1.47 (1.13-1.92)
Center practices	Home dialysis–related QI initiative in the last 5 years	1.94 (1.36-2.76)
	HT roadshow in the last year[a]	1.22 (1.05-1.41)

[a]An HT roadshow is an initiative whereby a dialysis center is visited by a team including patients, family members, clinicians and industry to promote HTs. Abbreviations: HT, home therapy; IMD, Index of Multiple Deprivation; KRT, kidney replacement therapy; OR, odds ratio; PD, peritoneal dialysis; QI, quality improvement.

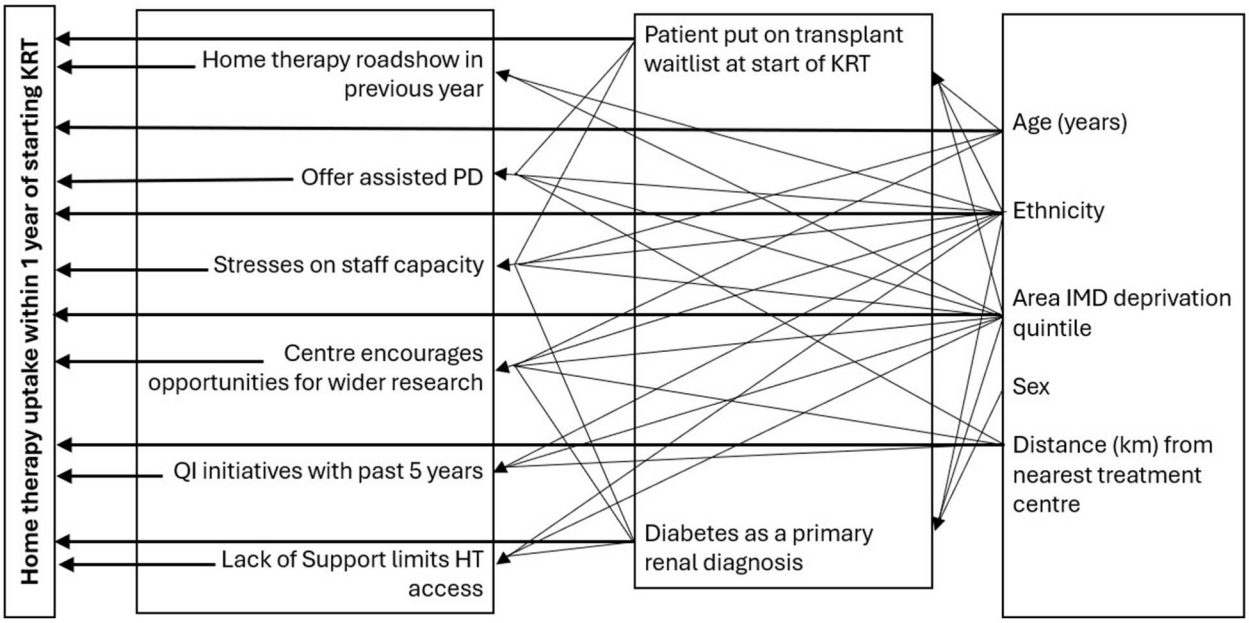

Figure 3. Estimated regression subgraph of direct and indirect associations of center- and patient-level factors with HT uptake, derived from sequences of regressions analysis. Two variables in separate boxes were connected by an arrow line, emerging from a selected explanatory variable and pointing to a response variable if they are directly associated (ie, association not explained by any of the intermediary factors). Direct associations with HT uptake are highlighted in bold arrow lines. A sequence of connected arrow lines between 2 variables represents an indirect association (ie, partially explained by intermediary factors). All center level factors showed strong pairwise associations, after controlling for their combined set of explanatory variables (lines between any 2 factors are not shown in the graph to maintain clarity and avoid overcrowding). Abbreviations: HT, home therapy; IMD, Index of Multiple Deprivation; KRT, kidney replacement therapy; PD, peritoneal dialysis.

Table 4. Indirect Associations: Associations Between Patient-Level Characteristics and Center-Level Characteristics That Were Directly Related to HT Uptake Based on the Logistic Regression Models of Best Fit

	Explanatory Variables					
Center-Level Factor as Response Variable	**Patient Waitlisted for Transplant at Start of KRT**	**Diabetes as Primary Renal Diagnosis**	**Distance (per 10 km) From Nearest Center**	**Age (per 10-Year Increase at Start of KRT)**	**Ethnicity[a]**	**IMD Quintile[b]**
Center offers assisted PD	1.15 (1.00-1.31)		0.78 (0.77-0.79)		Asian, 4.12 (3.35-5.09)	1: 1.16 (1.09-1.44)
					Black, 12.05 (7.73-18.79)	2: 1.03 (0.91-1.17)
					Mixed, 3.49 (2.08-5.86)	4: 0.99 (0.87-1.12)
					Other, 3.37 (2.07-5.49)	5: 0.80 (0.78-1.00)
Stresses on staff capacity limits HT access	1.16 (1.05-1.28)	1.18 (1.10-1.26)		0.99 (0.98-0.99)	Asian, 1.15 (1.05-1.26)	1: 1.34 (1.19-1.51)
					Black, 2.25 (1.97-2.59)	2: 1.06 (0.95-1.18)
					Mixed, 1.72 (1.30-2.28)	4: 0.93 (0.84-1.02)
					Other, 1.84 (1.40-2.43)	5: 0.51 (0.47-0.56)
Center encourages opportunities for wider research		0.93 (0.86-0.99)	0.96 (0.94-0.97)	0.99 (0.98-1.00)	Asian, 3.73 (3.25-4.28)	1: 1.07 (0.96-1.20)
					Black, 1.59 (1.39-1.81)	2: 1.02 (0.92-1.14)
					Mixed, 2.20 (1.61-3.02)	4: 0.86 (0.78-0.95)
					Other, 1.61 (1.23-2.13)	5: 0.75 (0.68-0.83)
Lack of support limits HT access		1.09 (1.02-1.16)			Asian, 0.98 (0.90-1.06)	1: 0.81 (0.74-0.89)
					Black, 1.64 (1.49-1.81)	2: 0.92 (0.84-1.00)
					Mixed, 5.14 (4.26-6.20)	4: 1.03 (0.95-1.11)
					Other, 0.90 (0.72-1.12)	5: 0.71 (0.65-0.77)
QI initiatives with past 5 years			0.88 (0.86-0.90)		Asian, 2.43 (2.03-2.91)	1: 1.00 (0.87-1.15)
					Black, 3.27 (2.50-4.27)	2: 0.96 (0.84-1.09)
					Mixed, 1.58 (1.07-2.31)	4: 1.02 (0.90-1.17)
					Other, 1.78 (0.90-1.81)	5: 1.40 (1.22-1.61)
HT roadshow in previous year[c]					Asian, 1.20 (1.05-1.37)	1: 0.95 (0.81-1.12)
					Black, 1.17 (0.98-1.39)	2: 0.91 (0.77-1.06)
					Mixed, 0.61 (0.38-0.97)	4: 1.07 (0.93-1.23)
					Other, 0.87 (0.58-1.29)	5: 0.76 (0.66-0.89)

Example of indirect association: Renal centers that conducted QI projects in the past 5 years, an activity that was directly associated with higher HT uptake (Table 3), also tended to serve higher proportions of patients from the most deprived areas (IMD quintile 5 vs 3) and from Asian or Black ethnic groups compared with White patients (Table 4). This pattern suggests that ethnicity and deprivation may be indirectly linked to higher HT uptake through their association with centers more likely to engage in QI activity. Abbreviations: HT, home therapy; IMD, index of multiple deprivation; KRT, kidney replacement therapy; PD, peritoneal dialysis; QI, quality improvement; QI, quality improvement.

[a]White is the reference group.

[b]1 = Least deprived; 3 = Reference group; 5 = Most deprived.

[c]An HT roadshow is an initiative whereby a dialysis center is visited by a team including patients, family members, clinicians and industry to promote HT.

0.102-1.16]) and patients who identified as Black (OR, 3.05 [95% CI, 2.66-3.52]) or mixed ethnicity (OR, 5.14 [95% CI, 4.26-6.20]).

Further regression models for center-level and patient-level factors from the SoR analysis are presented in Item S6.

Discussion

This study offers the most comprehensive analysis to date of the interplay between center practices, indicators of organizational culture, and patient characteristics associated with the probability of HT uptake. Using an innovative approach based on SoR applied to registry data linked to center national survey data in England, it constitutes a central component of a sequential mixed-methods design aimed at informing a service delivery intervention to address center-level variation in HT.[18]

Our findings suggest that renal centers running QI projects on home dialysis, hosting home dialysis road shows, fostering staff research engagement, and offering assisted PD were directly associated with higher odds of HT uptake. Conversely, centers in which there is perceived stress on staff capacity had lower HT uptake. Known patient demographic patterns were confirmed, including lower odds of HT use among ethnic minoritized groups compared with White patients, older patients, and those from higher deprivation areas according to the IMD.

Although the overall trend shows that patients from minoritized ethnic groups generally experience lower HT uptake, our analysis reveals that certain centers serving ethnically diverse populations have adopted practices that effectively enhance HT uptake among these groups. This suggests that individual-level disparities, although prevalent, may be mitigated through specific practices implemented within these centers. Collectively, our findings of both direct and indirect associations not only highlight these effective practices but also underscore their potential to inform targeted interventions designed to address inequities in HT access.

Our findings extend previous research on the association of center characteristics and physician practice patterns with home dialysis use.[17] The patient factors identified by Castledine et al[17] were broadly similar, although the number and type of center-level factors were more restricted, differently defined, or differently associated with HT use, partly because clinical practices have changed over time. For example, the availability of assisted PD was not investigated because its use was not common in 2013; since then, it has become more widespread and funded by a specific reimbursement tariff in England. This analysis provides the first national-level evidence that the use of assisted PD may increase access to HT, aligning with single-center data[28] and more informal survey data across Europe.[29] Equally, the ease with which a PD catheter can be inserted was previously associated with increased odds of HT use whereas we observed no such association in our survey[20]—this measure did not get into the model because of limited center variation. Again, this may reflect the development in services in response to the expectations of commissioners of dialysis in England.

Castledine et al[17] also reported a strong association between physician's enthusiasm for HT and its use, an observation that, in fact, helped motivate the Inter-CEPt study, which included an ethnography to explore its meaning. Our finding that pro-HT leadership fosters a strong pro-HT organizational culture informed our inclusion of several aspects that typified this center characteristic in our study.[30] Our finding that several of these factors are associated with greater use of HT does not contradict the importance of physician enthusiasm. Instead, it reveals the effects of this enthusiasm and how it might be emulated. A recent study in Australia found that centers with fewer patients tended to have lower rates of patients on HT within 6 months of starting treatment.[16] However, our survey did not identify any correlation between center size and HT use, consistent with previous observations in the United Kingdom, possibly due to the fact that dialysis centers are relatively large.

This study was conducted within a health care service free at the point of care and was funded through general taxation, where the health care professionals have no obvious financial incentives affecting modality selection. The issues identified are therefore likely to be valid in similar health care systems, although the strength of associations may differ. Given that unwarranted variation in practices and outcomes seems to be a universal feature of health care, the findings may also be relevant in other health care systems although the associations may be relatively weak where financial incentives have a dominant effect.

A strength of this study is that we used the UKRR cohort, which provides a representative, rich source of information about all KRT patients in England. By using a SoR analysis, we advanced previous research by not only examining the effect of center-level and patient-level factors on HT uptake but also by disentangling the complex interrelationships among these factors. This approach allowed us to separate direct from indirect associations, offering a more comprehensive understanding of multiple associations at play in a real-world context with many contributing factors.

There are several limitations to our study. We assumed that center practices remained stable between 2015-2019 and the 2022 survey, which may not fully capture temporal changes. The analysis was partly based on self-reported survey data, which is subject to error.[16] Some questions were excluded from the analysis due to missingness or limited response variation. We used aggregate center-level scores to account for multiple responses, potentially diluting strong individual opinions. A known limitation of UKRR data is the grouping of ethnicity into 5 broad categories aligned with UK government guidance. This approach masks diversity, particularly between South

and East Asians, limiting the interpretation of findings. However, South Asians make up most of the "Asian" group in the United Kingdom.

We could not include comorbidities other than diabetic status in our analysis because this information was incompletely reported to the UKRR by centers during the study period. Multimorbidity is strongly associated with income, education, and area-level deprivation in the United Kingdom and likely plays an important part in access to HT. We also lacked information on other potentially relevant factors, such as social support (eg, informal carer availability and living arrangements), that also may influence HT uptake. Although we identified 2 potential interactions (between research opportunities for staff and perceived HT lack of support from senior leadership, and research opportunities for staff and QI initiatives), we excluded them from the final model due to high uncertainty, as evidenced by wide confidence intervals from sparse data. The main effects still offer insight into the direct associations, but future research should further investigate these interactions.

Finally, there should always be caution in inferring causal relationships from observational data. In the SoR approach, we postulated a direction of associations to explore how a center's demographics may relate to HT uptake through center-level factors. However, causality should not be inferred because the true direction may differ. For instance, being waitlisted at the start of KRT is linked to a transplant center; however, causality flows from transplant center to patient status.

Our analysis has identified several factors associated with HT uptake that may be modifiable and could inform the development of service delivery interventions. This includes relatively straightforward components such as encouraging the use of assisted PD (already reimbursed in England through a national tariff) and HT roadshows, a process whereby a dialysis center is visited by a team—including patients, family members, clinicians, and industry—to promote HT modalities. Additionally, our findings suggest that organizational culture may play a greater role than service structures. This underscores the value of exploring interventions that support cultures of learning and improvement within renal centers.

Supplementary Material

Supplementary File (PDF)

Figure S1: Flow diagram showing the selection of variables from the renal survey for inclusion in the sequences of regression analysis.

Figure S2: Predicted probability of HT uptake for each center-level variables that were directly associated with HT uptake.

Figure S3: Predicted probability of HT uptake for categorical patient demographics/characteristics that were directly associated with HT uptake.

Figure S4: Predicted probability of HT uptake for continuous patient demographics that were directly associated with HT uptake.

Figure S5: Predicted probability (95% CI) of HT uptake for the interaction between lack of support limiting access to HT and centers providing staff with opportunities for research.

Figure S6: Predicted probability (95% CI) of HT uptake for the interaction between QI initiatives with past 5 years and centers providing staff with research opportunities.

Figure S7: Regression subgraph for direct associations between patient characteristics and center-level factors.

Item S1: Data aggregation, transformation, and survey question selection from the national survey of renal centers in England.

Item S2: Supplementary information on sequences of regression modeling.

Item S3: Distribution of incident KRT patients from UKRR by center and patterns of response by center.

Item S4: Predicted probabilities of HT update for center- and patient-level factors that were directly associated with HT uptake.

Item S5: Interaction terms on the mixed-effects logistic regression model for HT uptake.

Item S6: Regression models for center-level and patient level factors.

Table S1: Number of incident patients starting KRT in each English renal center, 2015-2019.

Table S2: Demographics of incident KRT patients in each English renal center, 2015-2019.

Table S3: Patterns of center response to each of the center-level variables selected for inclusion in the sequence of regressions analysis.

Table S4: OR (95% CI) for model including potential interaction terms between research opportunities and QI initiatives and research opportunities and lack of support on HT uptake.

Table S5: Regression models for center level factors as response variables based on the logistic regression models of best fit, OR (95% CI).

Table S6: Regression models for patient-level factors as response variables based on the logistic regression models of best fit, Odds Ratios (95% CI).

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Data Sharing: The data used in this study were obtained by linking survey data with registry data provided by the UKRR. Access to UKRR data is governed by strict data protection regulations, and the data cannot be made publicly available. To apply for access to UKRR data for research purposes visit https://www.ukkidney.org/audit-research/how-access-data/ukrr-data/apply-access-ukrr-data. The deidentified and aggregated survey data underlying the results presented in this manuscript are available by contacting the survey lead at University of Birmingham (Sarah Damery) on reasonable request from bona fide researchers with a methodologically sound proposal and the appropriate ethnical approvals. Any relevant analysis can be done on these data, which will be available for 5 years following manuscript publication.

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Patient and Center Factors in Home Dialysis Therapy Uptake

Setting & Participants

UK Renal Registry linked to national survey of 51 English renal centers

N = 32,400 patients who initiated kidney replacement therapy (KRT)

2015-2019

Outcome: Use of home dialysis therapy within one year of starting KRT

Results

Factors Directly Associated With Higher Home Dialysis Therapy Uptake

Center-Level Factors	OR (95% CI)
Conducted QI Projects Within Last 5 Years	**1.94** (1.36-2.76)
Offered Assisted Peritoneal Dialysis	**1.89** (1.39-2.57)
Fostered Staff Research Engagement	**1.35** (1.03-1.77)
Hosted Home Dialysis Therapy Roadshows	**1.22** (1.05-1.41)

Patient-Level Demographics	OR (95% CI)
On Transplant Lists at KRT Initiation	**2.55** (2.35-2.77)
Lived Farther From A Treatment Center	**1.10** (1.08-1.12), per 10 km

CONCLUSION: This study identified modifiable center-level factors associated with home dialysis therapy uptake, informing opportunities to reduce ethnic and area-level disparities.

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