ABSTRACT

Title of Dissertation: Home Hemodialysis Utilization and Health Outcomes among Racial and Ethnic Minority Populations

Ying Zhu, Doctor of Philosophy, 2023

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Background: Home hemodialysis (HHD) offers end-stage renal disease (ESRD) patients greater flexibility and advantages in terms of health outcomes over in-center hemodialysis. There is limited research on the differences between home and center hemodialysis (CHD) and preferences among racial/ethnic minorities, despite ESRD disproportionately affecting these groups.

Methods: This project aims to explore the usage and health outcomes of HHD vs. CHD with a focus on racial/ethnic differences using a systematic review of the global main academic database from 2004 to 2022 (study 1), logistic regression and negative binomial analysis of the U.S. Renal Disease System (USRDS) cumulative core data since 2010 merged with 2016-2019 Medicare clinical claims (study 2), and qualitative research using semi-structured interviews with 18 nephrologists and 5 other hemodialysis providers in 8 states of the U.S. (study 3).

Results: Study 1: from 3,114 unique studies, six studies met the inclusion criteria and all of them were comparative cohort studies; five out of six studies with a total of 3,172 White patients (68%) and 1,477 minority patients (32%) reported the utilization of HHD; in four of the six studies, the adjusted odds ratio for HHD treatment was shown to be significantly lower for patients of racial or ethnic minorities than for White patients; three out of six studies examined racial/ethnic differences in mortality and other outcomes indicating a lower risk of death for minorities in home hemodialysis. Study 2: minorities were significantly less likely to use HHD than Whites; most minority patients were younger and had fewer comorbidities than Whites, and all minority groups displayed significantly lower mortality and hospitalization incidences than the White group with adjustment on multiple covariates; in the overall and main racial/ethnic cohorts, HHD showed a significantly lower risk of death than CHD after confounding for major risk factors. Study 3: the majority of the interviewees felt that HHD was a viable, safe, and most cost-effective treatment for those with kidney failure, it offered many advantages over traditional CHD but there is a need for additional training and support for the patient, family, provider; minorities and White patients differed in their attitude toward dialysis care, social norms on HHD, and perceived control of personal health.

Conclusion: There were major obstacles and substantial racial/ethnic variations in HHD utilization and health outcomes in the US. This study showed that the promotion of HHD will probably require a systematic overhaul in kidney disease management and education.

HOME HEMODIALYSIS UTILIZATION AND HEALTH OUTCOMES AMONG RACIAL AND ETHNIC MINORITY POPULATIONS

by

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Dissertation submitted to the Faculty of the Graduate School of the
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Dedication

This dissertation is dedicated to my family, Fony, Derek, and Xinjia, who have been my source of inspiration, motivation, and support throughout my academic journey. Their unwavering faith, admiration, and encouragement have made it possible for me to pursue my Ph.D. dreams and achieve my goals. I am grateful for their sacrifices, love, and endless support. This work is a tribute to their unwavering commitment to my success.

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List of Abbreviations

adjusted HR – adjusted hazard ratio

adjusted OR – adjusted odds ratio

AAKH - Advancing American Kidney Health

CMS - Centers for Medicare & Medicaid Services

CORR – Canadian Organ Replacement Register

CI – confidence Interval

CHD – center hemodialysis

CKD - chronic kidney disease

CKF – chronic kidney failure

ESRD – end-stage renal disease

GAO -- Government Accountability Office

HD – hemodialysis

HHD – home hemodialysis

NIDDK - National Institute of Diabetes and Digestive and Kidney Diseases

NKF -- National Kidney Foundation

NOS – Newcastle-Ottawa Scale for quality assessment

UNOS -- United Network for Organ Sharing

PD – peritoneal dialysis

SEF – socioeconomic factor

SAFs - Standard Analysis Files

U.S. – United States
USRDS – United States Renal Disease System

Chapter 1

INTRODUCTION:

Unlike other chronic diseases, chronic kidney disease (CKD) is a major non-communicable condition that rapidly progresses into chronic morbidity and mortality among patients.[1] All racial and ethnic groups in the United States are seeing an increase in chronic diseases, such as CKD.[2] In fact, one-third of American adults are at risk of suffering from CKD.[3] One of the reasons behind this trend is that obesity, diabetes, hypertension, metabolic syndrome, and other renal dysfunction or cardiovascular risk factors have increased, particularly in ethnic and racial minorities.[2] The racial/ethnic differences that exist among patients more likely to develop a chronic disease in the U.S. are well documented. For example, in the U.S. Black individuals suffer from CKD 1.5 to 2 times as frequently as white patients.[4] They also have an increased prevalence of various risk factors, such as high blood pressure and diabetes mellitus, for chronic kidney failure (CKF).[1] Black Americans are four times and Hispanics are 1.3 times more likely to suffer kidney failure, which is the end stage of CKD and called end-stage renal disease (ESRD), than white patients. In 2018, there was a 3.4-fold increase in the adjusted prevalence of ESRD in black Americans compared to white Americans.[5]

Using glomeruli, the kidney filters blood. The body’s excess fluid and waste are removed from the blood to generate urine.[6] If the kidneys work properly, toxins, extra fluids, and additional impurities do not accumulate in the body, thus helping to control hypertension and maintain the balance of electrolytes and other elements.[7] When the kidneys fail, they can no longer work adequately for a person to survive without a transplant or dialysis. Dialysis is a medical treatment that filters blood by a mechanism similar to the kidney’s function and makes it possible for patients with CKF to continue living with ESRD for many years or decades.[8] Essentially, dialysis care is a kind of organ replacement therapy to sustain ESRD patients if they cannot have a kidney transplant – and this can be executed in a clinic or at home. Dialysis can be classified into two main types: hemodialysis (HD) and peritoneal dialysis (PD), as shown in Fig 1-1. In HD, blood is moved from the body and out of the body via a machine and tubes and at the same time is cleaned using a dialysis fluid in a filter known as a dialyzer.[8,9] In PD, dialysate, a solution used in dialysis that helps eliminate waste and surplus fluid from the blood, is usually injected into the abdomen using normal saline, either by hand or by a machine termed a PD cycler, to filter the blood via permeable exchange with blood vessels in the peritoneum.[8,9] Patients usually conduct PD at home. However, the most commonly used type of dialysis is hemodialysis. Conventionally, hemodialysis can be carried out three times a week in a hospital or a dialysis center, with each time lasting approximately four to five hours. Outpatient hemodialysis services are the mainstay for treating most of the ESRD patient population in the U.S.[10] Since the early 1960s in the U.S. and Britain, some patients have begun to perform hemodialysis at home. Home hemodialysis (HHD) is much more independent and flexible because it saves travel time and isn't constrained by the dialysis center's operating hours. Moreover, HHD allows for more treatment time each session, which could continue overnight, thus making the blood purification more complete. Long-term adequate dialysis can effectively control hypertension and reduce other chronic complications.[11–14]

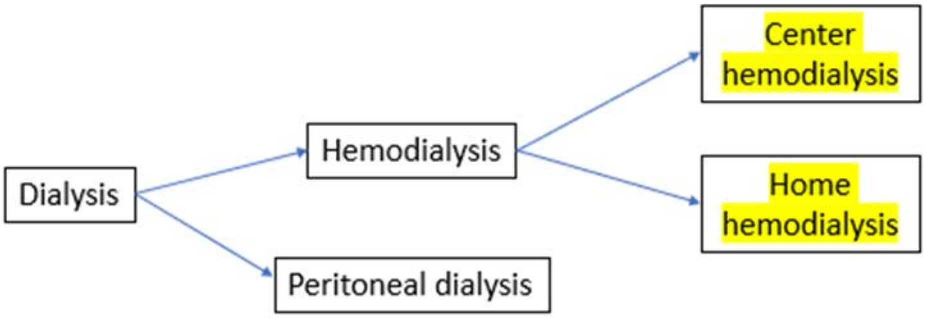


Fig 1-1 Dialysis type. This research focuses on the highlighted part: home hemodialysis, with a comparison to center hemodialysis.

A well-accepted metric to quantify hemodialysis is "Kt/Vurea", which refers to the competency of removing the amount of a toxic substance in a patient's blood through dialysis and it is generally adopted to assess dialysis adequacy or efficacy. Dialysis urea clearance K and treatment time t make up the numerator of this equation, and urea distribution volume V serves as the denominator.[8] Urea is a good surrogate marker of accumulated body toxins because it is a small, water-soluble molecule.[8] Urea nitrogen includes nitrogen-containing compounds other than protein in plasma, which is filtered through the glomerulus and excreted from the body. Further, urea comes from the breakdown and degradation of various amino acids.[8] Its concentration is based on protein intake. When renal insufficiency is decompensated, urea nitrogen will increase. Therefore, it is clinically used as an index to judge glomerular filtration function, and because of its abundance in renal failure and urea's good dialyzability, it can implicate the status of other pathogenic solutes in the blood.[15,16] By getting rid of toxins and superfluous fluid from the body, hemodialysis can maintain water and electrolyte homeostasis and, in the long run, it reduces a variety of morbidities and ultimately mortality.[17] Hence, the more effective the hemodialysis as represented by a large value of Kt/V, the better the removal of excess body water and toxins from the blood, the fewer uremia symptoms and morbidities, the better the clinical outcome, quality of care, and quality of life of the HD individuals, and ultimately the less the ESRD mortality. A patient's average Kt/V should be not less than 1.2 and can be raised either by prolonging time on dialysis or improving blood flow through the dialyzer.[18]

The subject of HHD has not been extensively studied in the United States.[19] The overwhelming majority of the available research on dialysis area only compared the benefits of peritoneal dialysis with hospital center hemodialysis.[19] Review of studies on HHD showed a lower hazard ratio for mortality and a survival benefit associated with home hemodialysis vs. the conventional thrice-per-week hemodialysis.[10,20,21] Limited data from international studies in Europe, North America, and Oceania with similar healthcare systems to the United States suggested that there was no distinction between HHD and CHD in terms of cardiovascular morbidity, which was the primary cause of death in the dialysis population, or in terms of all-cause hospitalization.[9,12,20,22,23] However, due to the high risk of selection bias, some registry studies have weak supporting evidence; few were prospective randomized cohort or retrospective controlled trials.[9,20,24] Additionally, the majority of these international studies used small sample sizes, only monitored patients for a brief period, and focused on the intermediate clinical outcomes instead of the long-term endpoint. Home hemodialysis also costs 7% less than center hemodialysis, a significant difference.[22] These discoveries have led researchers to suppose that HHD is the best renal replacement therapy other than kidney transplantation.[26,27]

The majority of the ESRD population were receiving hemodialysis at hospitals or dialysis clinics and very few individuals were being treated at home, despite a substantially lower relative risk of mortality than either hospital and clinic hemodialysis or peritoneal dialysis.[28–31] Besides, data from national registries demonstrated that compared to White patients, people of color were much less likely to begin either PD or HHD treatment.[32–34] This is not affected considerably when entirely controlled for demographic, clinical, and socioeconomic factors.[35]

Very recently, Medicare was provisioned to offer payment incentives to encourage more ESRD patients to select home therapy.[36] However, there was little evidence on health outcomes in the usage of HHD vs. CHD, especially in the U.S. and none of the previous studies explored barriers and racial/ethnic variations in the utilization of HHD vs. CHD. This project was intended to bridge this gap in previous literature.

Conceptual framework

The theoretical framework for this project is grounded upon the Aday-Andersen behavioral model of health service use. The Aday-Andersen behavioral model offers the most frequently used framework for conceptualizing the flow interactions among individual, medical, and environmental factors that influence people’s decisions on health service utilization and health outcomes.[37] Within three domains of the Aday-Andersen behavioral model, environmental factors and medical factors are contextual components.[38] The environmental factor mainly refers to the healthcare system, including political and economic external institutions as well as the health delivery system, whereas the medical factors indicate healthcare characteristics, including structure, staffing, and capacity factors.[38] Based on this Aday-Andersen behavioral model, individual factors influencing health services use can be grouped into three distinct categories: predisposing, enabling, and need.[37] These three categories contain various factors associated with healthcare utilization for consideration. Predisposing incorporates characteristics being inherent to the person, for example, these include demographic descriptions such as age, gender, race, etc. that affect a person to use the healthcare system in diverse ways. Enabling relates to access to care where the family's residential region and insurance coverage may play a role in the manner health services are used. Likewise, the domain of need is as far as individual health status and comorbidities are concerned.[37]

According to the Aday-Andersen model, factors at both the patient and healthcare provider levels, such as the number of chronic diseases a patient has and a nephrologist's lack of interest in prescribing home hemodialysis, may have an impact on the usage of home hemodialysis. The use of and barriers to home hemodialysis were examined about the effects of patient-level characteristics, healthcare providers, and other potential factors like racial/ethnic differences.

Innovation of this project

Research on HHD in the U.S. is very limited.[39] The majority of research on dialysis only compares the benefits of PD with hospital center HD.[39] This is the first time three kinds of different research methodologies, which are systematic literature review, quantitative research, and qualitative research, are being used to explore the usage and health outcomes of HHD vs. CHD with a focus on racial/ethnic differences. In previous work, there was no systematic review on utilization and health outcome of HHD in racial and ethnic minority groups and also no qualitative research addressing the analysis of racial/ethnic variations in terms of usage and quality of HHD vs. CHD. All the articles cited are quantitative in nature. The results and analysis would support a new strategy to shift current clinical practice and to implement system-based changes in long-term hemodialysis from hospital centers to home sites where hemodialysis access is more convenient, resulting in improved outcomes and a lower cost. Additionally, the use of the most recent USRD system's multiple years' data to compare home hemodialysis with center hemodialysis, specifically focusing on racial/ethnic differences, is itself innovative because it has not only produced a novel data set of HHD use and mortality to illustrate the health disparity in this high cost, high need a therapeutic area to date, but also has provided additional data on health outcomes, such as whether any hospitalization and hospitalization times regarding HHD vs. CHD in every stratified racial/ethnic cohort. The results showed existing racial/ethnic inequity for the chronic kidney failure population that racial/ethnic minority patients benefited more from HHD yet were less likely to use it. Other innovative aspects of this project include the use of qualitative research methods to further examine the clinical, operational, and policy obstacles that hold back US nephrologists from recommending home hemodialysis to CKF patients.

Chapter 2

Utilization and Mortality of Home Hemodialysis in Racial/Ethnic Minority Groups:

A Systematic Review

Background

In Chapter 1: Introduction sector, the fundamentals of kidney disease, different types of dialysis, and racial/ethnic inequalities in the prevalence of CKD and ESRD in the U.S. population were reviewed.

The duration of dialysis and the blood flow rate has a significant impact on the effectiveness of HD and the patient's dialysis quality.[29] HD has a faster blood flow than PD, and HHD, which is not available at most facilities, offers convenience, flexibility, and long-term effectiveness (e.g., the capacity to carry out dialysis treatments overnight). Since HHD was first introduced in the 1960s in the U.S. and Britain, many studies on different dialysis modalities have led nephrologists and researchers to conclude that HHD is the best renal replacement therapy other than kidney transplantation.[26,27] However, the percentage of ESRD individuals receiving HHD in the United States is incredibly low, especially among minority groups, despite the fact that underlying conditions that lead to ESRD (e.g., CKD and diabetes) disproportionately affect minorities. It is clear that there is a gap in understanding the history, current state, and racial/ethnic inequalities in HHD utilization and health outcomes. This systematic review was guided by the following question: Are HHD patients receiving better care than patients receiving in-center hemodialysis and how does this vary by race/ethnicity?

Methods

This systematic review followed the guidance outlined in the Cochrane Handbook for Systematic Reviews and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines[40] (see Supplemental material, Appendix 1). This study was enrolled in PROSPERO, International prospective register of systematic reviews (CRD42022338350)**.**[41]

Inclusion criteria

We included studies that focused on patients aged 18+ from different racial/ethnic groups with ESRD who received HHD versus those receiving CHD and/or any key measures of health outcomes (e.g., mortality, technical failure, clinical performance, etc.). Research methodologies include randomized controlled trials (RCT), cohort studies (both prospective and retrospective), cross-sectional/longitudinal studies in nature, and any relevant qualitative studies without geographical restrictions. Studies with ESRD individuals routinely receiving PD at home were excluded. Studies were also excluded if they contained self-reported patient data rather than using objective measures. Non-peer-reviewed literature such as technical reports, news, editorials, letters, commentaries, case-control studies, and case series/reports were also excluded.

Search strategy

Six electronic databases were searched from their initiation to March 28, 2022: Academic Search Ultimate (EBSCO), CINAHL (EBSCO), MEDLINE (EBSCO), Public Health (ProQuest), PubMed, and BIOSIS Previews (Web of Science). Keywords included synonyms, related terms, and controlled vocabulary terms for two concepts: Population (racial and ethnic minorities) and Intervention (hemodialysis). The reference lists of the included papers were examined to find pertinent studies. A random search in Google Scholar and the grey literature was conducted to find studies that might have been missed through database searches. Results were limited to peer-reviewed articles and those published in English. The specific search terms and full search strategies for databases are available in the Supplemental material, Appendix 2.

Selection process

All records from database searches were entered for deduplication in Zotero (https://www.zotero.org/), a citation management software. All unique records were exported to Rayyan (https://www.rayyan.ai/), a collaborative screening tool for systematic reviews.

Two reviewers [YZ, EP] separately reviewed titles and abstracts. Conflicts were resolved through discussion and all records marked as “included” or “maybe” were exported into an Excel spreadsheet. Full-text articles were supplied by the librarian [NT] and independently reviewed by two reviewers [YZ, EP]. Any conflicting decisions were resolved through discussion.

Data collection process

The included full-text studies were divided among two reviewers [YZ, EP] who independently extracted data with a third reviewer [NT] checking data for accuracy. Any discrepancies in the data were discussed and resolved between all reviewers. If there was missing data, study investigators were contacted for unreported data.

The following study characteristics were extracted: Author(s), year, the title of publication, nation, continent, study design, sample size, participants' characteristics (e.g., age, gender, geographic area, race/ethnicity), type of dialysis facilities, dialysis duration, data collection methods, and dates when data collection was initiated and completed, outcome(s), and limitations (see Supplemental material, Appendix 3).

Risk of bias (quality) assessment instrument

Using the Newcastle-Ottawa Quality Assessment Scale, which was created to evaluate the quality of nonrandomized case-control and cohort studies, the data quality from the included studies was evaluated.[42] Any discrepancies in the assessment were resolved through discussion between reviewers.

Synthesis methods

Data including usage and summary effect measures of outcomes were synthesized and thematic analysis was performed. The method of combining individual study data included adding demographic figures, calculating odds ratios for the usage of HHD, and/or risk differences for mortality by racial/ethnic groups.

Results

Study selection and study characteristics

A total number of 8,189 papers were detected across all databases and after removing duplicates, 3,114 studies were selected for title/abstract screening (see Fig 2-1). The full text of 37 studies was reviewed and an additional 15 studies were identified by checking the references lists (n=10) and a random Google Scholar search (n=5). After screening, we found six studies to meet our inclusion/exclusion criteria. All six studies are retrospective cohort studies. Study characteristics are presented in the Supplemental material, Appendix 3. The 45 excluded studies with causes are listed in Supplemental material, Appendix 4.

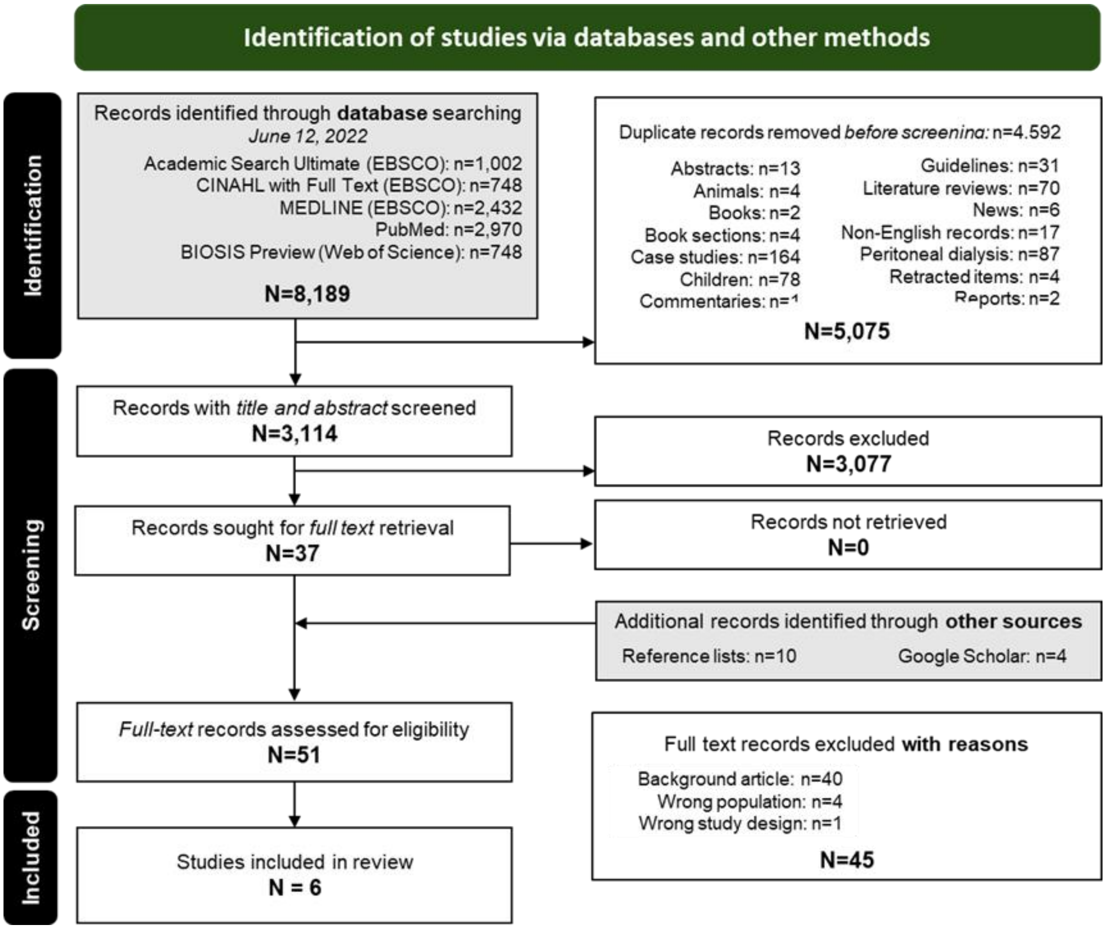


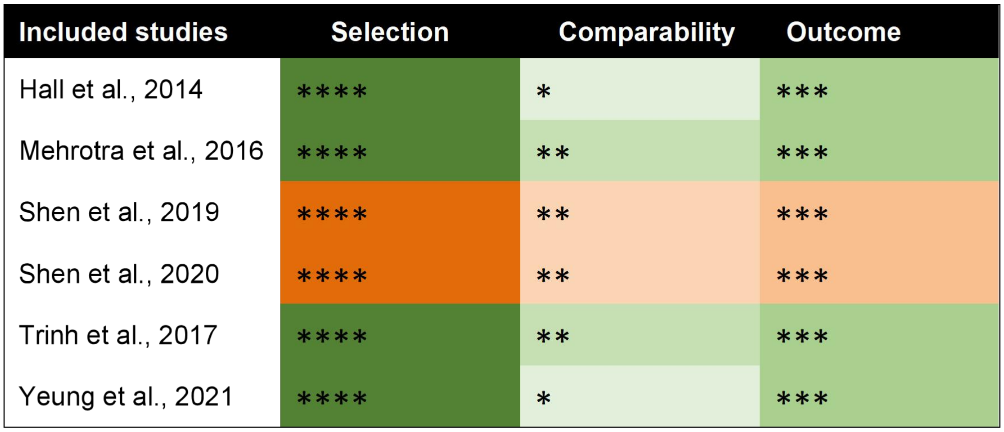
Fig 2-1 PRISMA Flow diagram of studies selected

Of our final selected studies, four were conducted in the U.S.,[32,35,43,44] one in Canada,[45] and one in Australia.[46] Three of the U.S. studies are national registry-based data from the United States Renal Disease System (USRDS), which is the national data system that gathers, evaluates, and disseminates data on ESRD in the United States.[35,43,44] Hall et al.[43] investigated the relationship between the racial/ethnic makeup of the dialysis center and center-level survival as well as the attainment of quality targets for anemia and dialysis adequacy using USRDS data from 2005 to 2008. Shen et al.[35,44] located all adult (>18 years old) ESRD patients in the USRDS who began maintenance dialysis with PD, CHD, or HHD between 2005 and 2013. Mehrotra et al.[32] examined information on patients who were admitted between 2007 and 2011 to any dialysis facility in 43 states administered by a single, sizable dialysis organization, and to initiate maintenance dialysis, including patients who underwent PD and HHD. Trinh et al.[45] looked into the relationship between race and home dialysis treatment, as well as racial/ethnic differences in all-cause mortality and method failure among patients beginning maintenance dialysis between 1996 and 2012 in the Canadian Organ Replacement Register (CORR). Yeung et al.[46] compared facility HD patients matched by age, gender, and cause of ESRD from the Australia and New Zealand Dialysis and Transplant Registry to HHD patients from a major hospital network in terms of all-cause mortality, transplantation, average biochemical values, and graft survival six months after transplant.

Outcomes sought were racial/ethnic differences by modalities of dialysis including but not limited to HHD in use, survival, risk of death or time to all-cause mortality, technique failure or transfer to CHD, taking a kidney transplant or transplantation rates, graft survival at 6 months, dialysis adequacy, and other clinical performance measure such as hemoglobin or anemia, calcium, parathyroid hormone, and phosphate levels.

Risk of bias (quality) assessment

The Newcastle-Ottawa Quality Assessment Scale, which has created a "star system" to evaluate a study from three general perspectives—the selection of the study groups, the comparability of the groups, and the identification of either the exposure or outcome of interest for case-control or cohort studies, respectively—was used to assess the quality of the studies that were included[42] (see Supplemental material, Appendix 5). Each item in the selection and result categories can earn a study no more than one star. For comparability, a maximum of two stars may be assigned.[42] In terms of how well different aspects of the studies were described, the average amount of “stars” the reporting earned was 8.6, ranging from a minimum of 8 to a maximum achievable of 9 (see Fig 2-2).

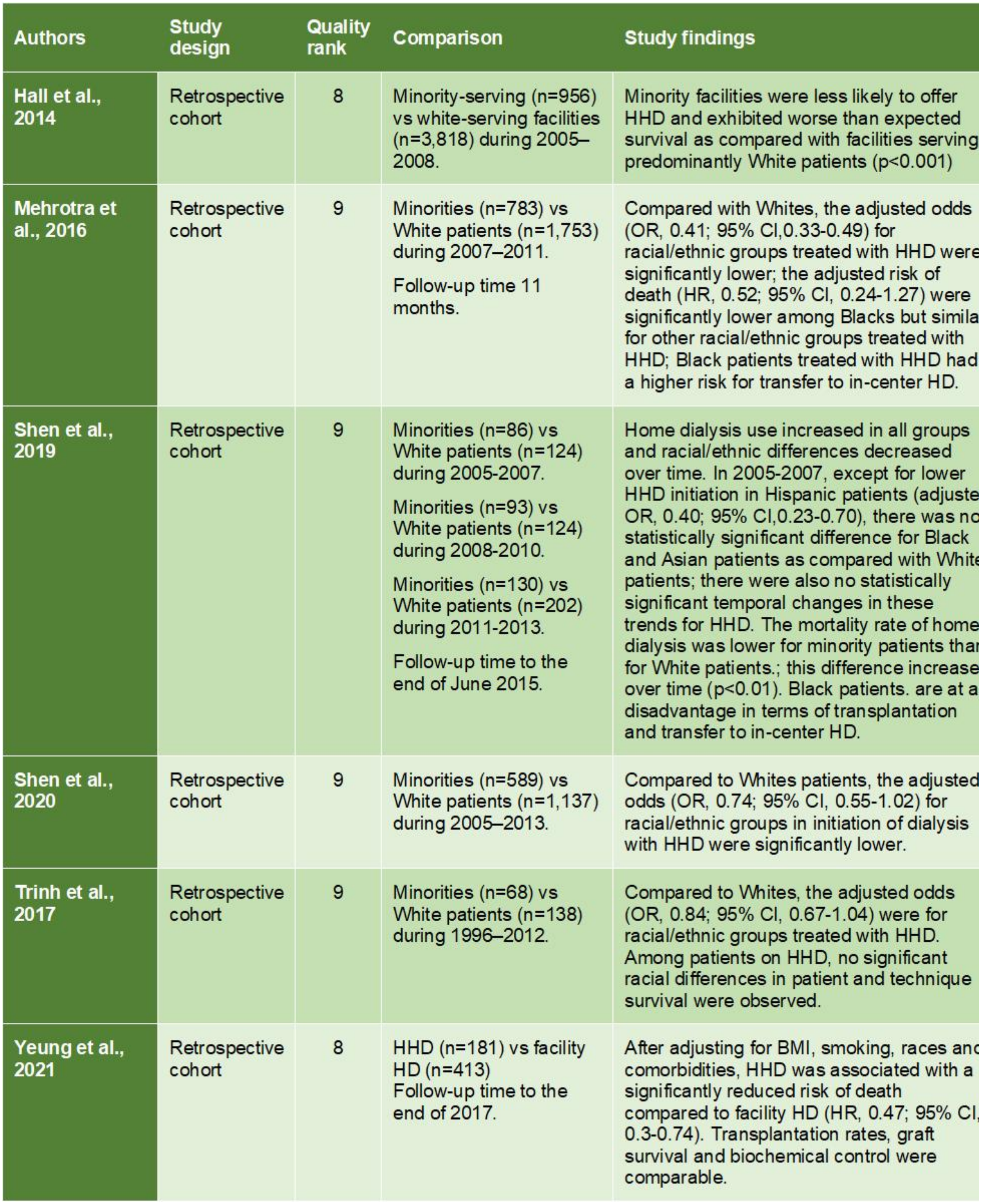


Included studies	Selection	Comparability	Outcome
Hall et al., 2014	****	*	***
Mehrotra et al., 2016	****	**	***
Shen et al., 2019	****	**	***
Shen et al., 2020	****	**	***
Trinh et al., 2017	****	**	***
Yeung et al., 2021	****	*	***

Fig 2-2 Quality assessment for cohort studies using Newcastle-Ottawa Scale

Results of individual studies

Table 2-1 exhibits a summary of the outcomes in the included studies comparing home with center hemodialysis in racial/ethnic minority groups.



Authors	Study design	Quality rank	Comparison	Study findings
Hall et al., 2014	Retrospective cohort	8	Minority-serving (n=956) vs white-serving facilities (n=3,818) during 2005–2008.	Minority facilities were less likely to offer HHD and exhibited worse than expected survival as compared with facilities serving predominantly White patients (p<0.001)
Mehrotra et al., 2016	Retrospective cohort	9	Minorities (n=783) vs White patients (n=1,753) during 2007–2011. Follow-up time 11 months.	Compared with Whites, the adjusted odds (OR, 0.41; 95% CI,0.33-0.49) for racial/ethnic groups treated with HHD were significantly lower; the adjusted risk of death (HR, 0.52; 95% CI, 0.24-1.27) were significantly lower among Blacks but simila for other racial/ethnic groups treated with HHD; Black patients treated with HHD had a higher risk for transfer to in-center HD.
Shen et al., 2019	Retrospective cohort	9	Minorities (n=86) vs White patients (n=124) during 2005-2007. Minorities (n=93) vs White patients (n=124) during 2008-2010. Minorities (n=130) vs White patients (n=202) during 2011-2013. Follow-up time to the end of June 2015.	Home dialysis use increased in all groups and racial/ethnic differences decreased over time. In 2005-2007, except for lower HHD initiation in Hispanic patients (adjuste OR, 0.40; 95% CI,0.23-0.70), there was no statistically significant difference for Black and Asian patients as compared with White patients; there were also no statistically significant temporal changes in these trends for HHD. The mortality rate of home dialysis was lower for minority patients than for White patients.; this difference increase over time (p<0.01). Black patients. are at a disadvantage in terms of transplantation and transfer to in-center HD.
Shen et al., 2020	Retrospective cohort	9	Minorities (n=589) vs White patients (n=1,137) during 2005–2013.	Compared to Whites patients, the adjusted odds (OR, 0.74; 95% CI, 0.55-1.02) for racial/ethnic groups in initiation of dialysis with HHD were significantly lower.
Trinh et al., 2017	Retrospective cohort	9	Minorities (n=68) vs White patients (n=138) during 1996–2012.	Compared to Whites, the adjusted odds (OR, 0.84; 95% CI, 0.67-1.04) were for racial/ethnic groups treated with HHD. Among patients on HHD, no significant racial differences in patient and technique survival were observed.
Yeung et al., 2021	Retrospective cohort	8	HHD (n=181) vs facility HD (n=413) Follow-up time to the end of 2017.	After adjusting for BMI, smoking, races and comorbidities, HHD was associated with a significantly reduced risk of death compared to facility HD (HR, 0.47; 95% CI, 0.3-0.74). Transplantation rates, graft survival and biochemical control were comparable.

Table 2-1 Summary of included studies' outcomes

Usage of home hemodialysis

Across all the included studies, 1,067,453 patients were analyzed, of which 583,985 were White patients (55%), and 483,468 were racial/ethnic minorities (45%). Five cohort studies[32,35,44–46] reported a total of 4,649 patients treated with HHD, among them 3,172 were White people (68%) and1,477 were in minority groups (32%).Four of these five studies compared the adjusted odds ratio for minority patients (adjusted OR, 0.66; 95% CI, 0.52 to 0.85) to White patients in HHD. Overall, all racial/ethnic minorities tended to initiate HHD at a lower rate than White patients.[32,35,44,45] There was no significant difference between facility HD and HHD among all races in Australia.[46] Hall et al.[43] examined a total of 4,774 dialysis facilities across the U.S. that offered dialysis care to 320,046 ESRD patients. In general, facilities with the highest quintile of minorities served roughly 96% of racial/ethnic minorities as compared to 4% of White patients. In comparison to institutions that mostly treated White patients, they discovered that minority-serving centers were noticeably larger, more frequently community-based, 10% less likely to provide home dialysis, and displayed worse than expected survival rates ($p<0.001$).

Mehrotra et al.[32] and Shen et al.[35,44] implemented logistic regression models to investigate racial/ethnic disparities in treatment with HHD or PD, accounting for health insurance or socioeconomic factors, and showed that racial/ethnic minority groups were markedly less likely to start on or to be treated with home dialysis than White patients. Shen et al.[44] also looked at comparisons between the earliest and latest eras of commencement (2005–2007 versus 2011–2013) for each minority group relative to White patients and found that home dialysis use rose across the board and that racial/ethnic inequalities diminished over time. Trinh et al.[45] used generalized linear models to examine the relationship between race and therapy with home dialysis adjusted for clinical characteristics. They came to the conclusion that Asian patients, Black patients, and other ethnicities did not differ significantly from White patients in their use of HHD therapy compared to Aboriginal Australians and subcontinent Indians.

Survival or risk of death

Five cohorts studies[32,43–46] examined survival or risk of death data of dialysis patients, especially among minority groups. They showed a lower risk of death (adjusted HR, 0.68; 95% CI, 0.33 to 1.52) for minorities in HHD than White patients in both the U.S. and Canada,[32,45] and a survival benefit (HR, 0.47; 95% CI, 0.3-0.74) associated with HHD versus the conventional facility hemodialysis.[46] Compared to dialysis centers treating mostly White patients, those with a higher percentage of patients from minority groups showed worse-than-expected survival rates.[43] Using the publicly accessible Centers for Medicare & Medicaid Services Dialysis Facility Compare database, which calculates a facility's expected patient survival rate based on case mix (i.e., age, gender, race/ethnicity, diabetes, and comorbidity), this measure compares the expected patient survival rate to the actual patient survival rate.[43] Two studies'[32,45] survival analyses were computed adopting Cox proportional hazards regression model to evaluate different racial/ethnic groups' probabilities of all-cause mortality for individuals treated with CHD, PD, and HHD. The primary analysis was conducted to statistically adjust differences in baseline characteristics between groups, such as age, sex, body mass index, cause of ESRD, and various comorbidities.[32,45] Over time, the unadjusted home dialysis mortality rate for patients in each minority group decreased from 13 to ten deaths per 100 person-years.[44] The risk of death was lower for all patients from minority groups than for White patients. The increasing survival disparity that has been observed over time has persisted for all minority groups.[44] Yeung et al.[46] adopted matched cohort design to demonstrate substantially higher survival in individuals with HHD compared to those with facility HD in the absence of major heterogeneity regarding age, racial/ethnic groups, and comorbidities.

Secondary health outcomes

Five cohort studies[32,43–46] observed secondary health outcomes of racial/ethnic minorities with different dialysis modalities. Hall et al.[43] used the chi-squared test, the Cochran-Armitage test for trend, or the Spearman rank correlation coefficient, as proper, to analyze the relationship between racial/ethnic composition and the measures of interest on clinical performance for anemia and dialysis sufficiency, and discovered no statistical significant differences between minority-serving status. Mehrotra et al.[32] and Shen et al.[44] performed the competing risk model by Fine and Gray to estimate cause-specific hazard ratios of transfer to CHD and transplantation rate for every ethnic group patient treated with different modalities. Black individuals receiving home dialysis were more likely than White patients to be transferred to CHD.[32,44] Significantly fewer patients from racial or ethnic minorities than White patients received kidney transplants.[32,44] A Fine and Gray proportional hazard model allowed Trinh et al.[45] to compare technique failure in Canada's HHD and PD across various racial/ethnic groupings, adjusting for censoring events, clinical characteristics, and socioeconomic factors. Asian patients exhibited a significantly reduced risk of technique failure compared to White patients, but Black and Indigenous patients had noticeably higher adjusted hazards ratio for technique failure. Other racial/ethnic groups did not exhibit any discernible variations in PD, and patients receiving HHD did not exhibit any discernible differences in their chance of method failure.[45] Yeung et al.[46] used a matched cohort design and competing risks analysis to assess transplantation, typical biochemical parameters, and graft survival six months after transplantation between HHD and facility HD patients. Except for considerably lower phosphate levels in HHD patients, the rest of the measures of interest did not vary significantly between the two cohorts.[46]

Missing data

At the beginning of PD, HHD, and CHD, respectively, Mehrotra et al.[32] observed that data were missing for, on average, 8%, 2%, and 7% of patients. For the competing risk analysis, multiple imputations were employed to fill up the gaps left by missing data. A fully conditional specification method of sensitivity analysis was carried out five times by Trinh et al.[45] to impute race (missing in 8% of cases) for individuals for whom it was unidentified to assess the validity of the results. To produce reliable statistics, the findings of the multiple imputation analyses were pooled. The primary outcome of having had home dialysis treatment was defined further utilizing another sensitivity analysis with a minimum treatment length criterion of 90 days. Shen et al.[35,44] employed sensitivity analyses, which defined the treatment at day 90 of dialysis and limited the sample to individuals on PD, to substitute other missing factors for race and ethnicity in order to guarantee that missing data did not significantly change the findings for the outcome of interest. In the investigations by Hall et al.,[43] Shen et al.,[35,44] and Yeung et al.,[46] there were no revealed missing data on HHD.

Discussion

In the three U.S. nationwide retrospective cohort studies,[32,35,44] minority groups were less likely to receive home dialysis care, especially HHD, after controlling for socioeconomic factors and clinical characteristics. In the Canada study by Trinh et al,[45] similar significant differences were observed on the basis of race but the result is the opposite, given that all non-White races, except for Indigenous patients, were more likely in the uptake of home dialysis modality.[45] Geographic remoteness may be a contributing factor, making it more challenging to acquire patient education, pre-dialysis treatment, and home dialysis facilities. Whatever racial/ethnic minority's location in the U.S. metropolitan area, or Indigenous' rural locations in Canada, the lack of regional resources to increase the home dialysis cohort could be another issue. Additionally, a higher prevalence of diabetic renal disease among racial and ethnic minorities and an increased burden of illness among Indigenous populations, for example, as vascular comorbidities that are related to lower home dialysis utilization, exacerbated the shortage of regional resources.[33,47]

The result that most racial/ethnic minority patients had a lower risk of death in home dialysis compared with their White counterparts in all three countries could be explained by the fact that minorities tended to be younger and had a lower incidence of concurrent cardiovascular diseases, elements that are typically linked to increased home dialysis utilization.[33,47–49] These differences were therefore indicative of characteristics of minority patients. Among individuals undertaking HHD, discrepancies were apparent only for Black patients and not for other racial and ethnic minorities.[32] This most certainly indicated that the samples in these other categories were quite tiny, undermining the ability of the analyses to draw firm conclusions.[32]

Nevertheless, similar to the study conducted in the U.S.,[32] the Canadian study[45] showed likewise that Black PD patients had a higher risk of transfer to CHD compared to White patients. The increased risk of technique failure among Black patients in

Canada justified previous studies, showing higher rates of peritonitis.[50] Furthermore, critical socioeconomic differences existed between Black Americans and Black Canadians. Although Canada has recently had a large percentage of Black immigrants, Black Americans are more likely to be descendants of long-term residents and discriminated populations.[51,52] Conversely, in contrast to the U.S., Black Canadian patients had fairly better education, career, and income.[53]

Implications for practice

Findings from the included studies revealed a survival benefit of HHD as compared to CHD, with a lower usage rate of HHD among racial/ethnic minorities in various regions worldwide. These variations may be caused by patient or physician preferences, providers' perceptions of patients and their families' capacity to perform home dialysis, individual social differences (e.g., whether there is enough space at home and whether one can afford extra expenses), or problems with health care delivery (e.g., accessibility of pre-ESRD care or availability of a home dialysis facility in neighborhoods populated by minorities). In fact, earlier studies have presented that non-White ethnicities have less access to pre-dialysis nephrology care in the United States, which may lead to predominated Black-White and Hispanic-White racial/ethnic inequalities in PD and HHD utilization.[51,54]

Given Canada's higher overall home dialysis usage, the lack of significant racial/ethnic variances in home dialysis use may be explicated by the country's extensive government-subsidized healthcare system, enhanced access to pre-ESRD patient education, and perhaps more nephrologists' home dialysis practices.[28] As a result, the sociocultural environment appears to have an impact on the link between race and health.[45] Despite potential racial/ethnic disparities in socioeconomic status in the U.S., Canadian experience suggests that the U.S. public health care service has the potential to ensure more equitable access to home dialysis and pre-ESRD care. Now more than ever, it is crucial to guarantee equal access to home dialysis before and throughout given the unprecedented rapid growth in the utilization of home dialysis care, and these racial/ethnic disparities warrant further improvement.[32]

Implications for future research

It is in line with earlier studies to find that minorities receiving home dialysis had a lower mortality hazard ratio than White patients.[32,55–57] In fact, in Hong Kong, where a PD-first policy happens, different matters including clinical indicators have been described.[58] Various comorbidities are inadequate to clarify this paradoxical survival advantage. The better health status of minorities initiating dialysis has been explained by several hypotheses, including the fact that they typically have kidneycentered diseases, are younger than White patients on average, and have an above-average risk of mortality in the early stages of renal disease, especially in Black patients.[32,45] It is also probable that lower transplant rates for minority groups may make racial/ethnic minorities more likely to have healthier patients with longer follow-ups, which may bestow a survivor bias.[32,59] However, there is no direct evidence to establish any of these propositions. Other mentioned mechanisms are associated with biological, inflammatory responses to disease and/or treatment, genetic variations, nutritional status, and additional SEFs.[60,61]

It is essential to underscore that both medical and socioeconomic factors engage in technique failure.[62] A better understanding of these problems is necessary due to the frequent severe morbidity suffered by patients who are switched from home dialysis to CHD, as well as the significant expenses to the healthcare system.[63] Creating interventions to reduce racial/ethnic variations in the risk of transferring to CHD is also urgently needed.[32] Future studies must look at racial and ethnic differences in the chance of receiving a referral for a kidney transplant, the impact of insurance coverage, especially for Hispanics, on such referrals, and the length of time to be listed.

Making sure that patients undergoing home dialysis have fair access and better health outcomes is even more important in light of the remarkable rise in the number of patients receiving PD and HHD in the United States.[32] Efforts should be made to identify barriers to HHD and PD, comprising cultural and logistical barriers that presently restrict minorities from equitably and notably improving sustainability and health outcomes for patients with ESRD.[45]

Chapter 3

Usage and Health Outcomes of Home Hemodialysis vs. Center Hemodialysis in Racial/Ethnic Minority Groups in the United States:

A Quantitative Research In 2016-2019 USRDS Using Multiple Regression Models

Background

In Chapter 1: Introduction sector, the fundamentals of kidney disease, different types of dialysis, and racial/ethnic inequalities in the prevalence of CKD and ESRD in the US population were covered.

The availability of dialysis and CKD data provided by the United States Renal Disease System offers the opportunity to provide new evidence for the U.S. on the impact of delivery models using home-based hemodialysis practices on effective treatment among racial and ethnic minority populations with ESRD. The objective of this study is: 1) to examine racial and ethnic differences in the use of home vs. center hemodialysis in this high-need population - specifically, to describe and compare the variations in healthcare used by people with home hemodialysis vs. with center hemodialysis, with a focus on racial and ethnic disparities; 2) to look at dialysis-related health outcomes and how they differ by race/ethnicity among individuals with ESRD; and 3) to understand how home hemodialysis can improve care quality among racial and ethnic minorities. Using the national consolidated data, it was possible to test the research hypothesis that home hemodialysis was significantly less common among Americans with ESRD but could have a positive impact on health outcomes, particularly for racial and ethnic minorities.

Methods

Data Sources: United States Renal Data System (USRDS)

This research created an individual-level data file that covered specific features and variables accumulated in inpatient core records, including deaths and hospitalizations, from 2010 to 2019, and merged with USRDS clinical claims from 2016 to 2019. The United States Renal Data System (USRDS), funded by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) in collaboration with the Centers for Medicare & Medicaid Services (CMS), the United Network for Organ

Sharing (UNOS), and the ESRD networks, is a national database that gathers, evaluates, and disseminates datasets about CKD and ESRD in the U.S.[64] This data contains demographic characteristics (age, sex, race/ethnicity), health care use (center hemodialysis visits and home hemodialysis use), health outcome and quality indicators (death, hospitalization, Kt/V), and spending (total per capita spending and total spending on dialysis services). Using the USRD system, a data set was created with the following parameters: individuals with ESRD diagnosis and HD treatment, indicators associated with dialysis outcome, and quality of care.

The Standard Analysis Files (SAFs), which were first launched by the USRDS Coordinating Center in 1994 and later improved to include ESRD clinical and claims data from CMS, were created to help address the demand for research data for a wide range of indicators among the ESRD population.[64] Within SAFs, all data are assigned by the unique USRDS-specified patient identification number.[64] One of the unique features of the USRDS is that it is structured around individual ESRD treatment events, rather than individual patients. An ESRD event is defined as the initiation of dialysis or kidney transplantation or the death of a patient with ESRD. This means that each observation in the USRDS represents a discrete treatment event, rather than a patient. Data from multiple data sources, such as CMS SAF claims, Facility Survey data, Patient Lists, Patient Events, Medical Evidence reports, and Death Notification data, is added to the USRDS ESRD database on a quarterly basis.[64] Generally, each patient for the entire ESRD therapy period is associated with one Medical Evidence form; however, if a patient changes insurance because of modality changes, multiple forms may be filed to USRDS. Datasets from final act claims offered by Medicare beneficiaries are included in the CMS ESRD Standard Analytical Files (SAFs).[64] The Treatment History Files in the USRDS Core SAF dataset keep track of each patient's usage of various modalities in order.[64] Every individual's file record details their time receiving therapy with a certain modality, and whenever that modality changes, a new record is created for that patient.[64] Given the structure of this database, there is a date associated with any claim lab value, making it possible to attribute any lab value with the type of dialysis at that point in time.

Sample

The overall cohort contained individuals continuously enrolled in hemodialysis for 12 months from 2016 to 2019, excluding those who are dually eligible. The estimated sample size of ESRD patients in the national USRDS annual report is nearly 790,000. Note that the unit is the hemodialysis episode, and some patients are counted more than once if they have more than one hemodialysis episode. A hemodialysis episode is defined as a period in which the patient is receiving hemodialysis with a given treatment modality. For example, if a patient is first receiving CHD and then switches to HHD, that patient has 2 hemodialysis episodes recorded in the data set. At the end of 2018 in the United States, there were more than 560,000 (roughly 70%) patients undergoing dialysis, which included hemodialysis and peritoneal dialysis, and 230,000 (roughly 30%)

patients experiencing a kidney transplant.[5] Approximately 69,000 (12.5%) of patients receiving home treatment were on peritoneal dialysis rather than hemodialysis.[5] Whereas nearly 60% of White ESRD individuals received CHD at the end of 2019, more than 70% of Black patients received CHD in the U.S.[5]

Outcome measures

The original core patient data set, a cumulative data set on hospitalization starting from 2010, and the Medicare clinical claim data set of 2016, 2017, 2018, and 2019 from the USRDS were merged using SAS 9.4 software and then transferred to Stata data format. The ESRD patients who were treated with HHD and CHD according to the dialysis treatment modality variable *RXCAT* of the 2016-2019 full-year consolidated file were contained in this research. Stata version 15.1 software was used to conduct subsequent statistical analysis.

	Categories	Variable Name and values in USRDS
Predisposing	Age	AGE AGEgroup 0=Less than 60 years old 1=Equal or older than 60 years old but less than 70 years old 2=Equal or older than 70 years old but less than 80 years old 3=Equal or older than 80 years old
	Race	ETHNIC: 0=White 1=Black 2=Hispanic 3=Asian 4=Other
	Gender	SEX: 1=Male 2=Female
Enabling	Residential Region	Region: 1=Northeast 2=Midwest 3=West 4=Southwest 5=Southeast
	Residential County and smaller area	COUNTY ZIPCODE
	Treatment modality	TREAT: 1=HHD 0=CHD
Need	Primary disease causing ESRD and other general health outcomes and status	PDIS Kt/V SYEAR: Dialysis duration (service years)
	Various comorbidities	COMO_CHF COMO_ASHD COMO_CANC COMO_COPD COMO_CVATIA COMO_HTN COMO_DRUG: 0=No, without above comorbidities 1=Yes, with above comorbidities

Table 3-1 Domain of Andersen Behavior Model and their corresponding variables in USRDS

Statistical Analyses

1. Home hemodialysis use

An exploratory analysis of differences in patients' use of home hemodialysis vs. center hemodialysis by race/ethnicity was conducted. This is a descriptive statistical analysis used to determine baseline differences and the usage of home hemodialysis vs. center hemodialysis in various racial/ethnic populations in the USRDS. Comparisons of descriptive parameters such as means, medians, and frequencies between HHD and CHD and these racial/ethnic groups were made using Student's t-test, one-way ANOVA, Wilcoxon rank-sum, Kruskal-Wallis, Chi-square, and further logistic regression to identify group differences with adjustment on multiple covariates.

$$\text{Using of Home HD} = (\text{Race})\beta 1 + (\text{AGE})\beta 2 + (\text{Gender})\beta 3 + (\text{Region})\beta 4 + (\text{Hypertension})\beta 5 + (\text{ASHD})\beta 6 + (\text{CHF})\beta 7 + (\text{Cancer})\beta 8 + (\text{COPD})\beta 9 + (\text{Cerebro})\beta 10 + (\text{Drug})\beta 11 + (\text{Dialysis duration})\beta 12 \ldots\ldots\ldots.(\text{equation 1})$$

The first dependent variable is whether the patient used home hemodialysis or center hemodialysis. This variable is dichotomous and was assigned a value of 1 if a patient received home hemodialysis and a value of 0 if a patient received center hemodialysis. The use of HHD in the renal replacement therapeutic field is peculiar; that is, the majority of ESRD patients use in-center hemodialysis. The major independent variable was race/ethnicity: White, Black, Hispanic, Asian, and others (values of 0, 1, 2, 3, and 4 respectively) based on variables of both *RACE* and *HISPANIC* of the final merged data set from USRDS. Other independent variables which were controlled for in this logistic regression model were age, gender, residential region, dialysis service years, and relevant comorbidities of hypertension, atherosclerotic heart disease, congestive heart failure, cerebrovascular disease, and relatively non-relevant chronic conditions such as cancer, chronic obstructive pulmonary disease, and drug dependence.

2. *Health outcomes (mortality and hospital utilization)*

The statistical analysis of patient assignment to HHD compared to in-center hemodialysis on health outcomes used logistic regression for mortality and negative binomial for hospital utilization with adjustments for age group, gender, race, region, dialysis service years, and various comorbidities to investigate the effect on mortality and hospitalization. The interaction term of treatment and age group was also included in these models since age was found to have an important impact on health outcomes. Additionally, these analyses also examined the associations of racial and ethnic groups with health outcomes by comparing minorities with Whites after confounding for variables that might explicate the association such as age, gender, dialysis service years, and other comorbidities.

Method 1): Logistic regression model

Logistic regression is the appropriate technique to analyze mortality (dead or alive) and hospitalization (any hospitalization or none) because the dependent variables are dichotomous (binary). It was used to describe data and to explain the relationship between mortality and hospitalization and the main independent variable treatment modality (adopting home or center hemodialysis) or other independent variables such as age, gender, race, region, dialysis service years, comorbidities, etc.

Mortality = (TREAT)β1 + (Race)β2 + (AGEgroup)β3 + (Gender)β4 + (Region)β5 + (Hypertension)β6 + (ASHD)β7 + (CHF)β8 + (Cancer)β9 + (COPD)β10 + (Cerebro)β11 + (Drug)β12 + (Dialysis duration)β13 + (AGEgroup)* (TREAT)β14 ………..(equation 2)

Hospitalization = (TREAT)β1 + (Race)β2 + (AGEgroup)β3 + (Gender)β4 + (Region)β5 + (Hypertension)β6 + (ASHD)β7 + (CHF)β8 + (Cancer)β9 + (COPD)β10 + (Cerebro)β11 + (Drug)β12 + (Dialysis duration)β13 + (AGEgroup)* (TREAT)β14 ………***(equation 3)***

Method 2): Negative binomial model

Negative binomial regression is the suitable approach for the over-dispersion outcome variable (mean is much lower than variance) and was used to analyze the number of hospitalizations because the values of this dependent variable (the count of hospitalization) were nonnegative integers.

Number of Hospitalizations = (TREAT)β1 + (Race)β2 + (AGEgroup)β3 + (Gender)β4 + (Region)β5 + (Hypertension)β6 + (ASHD)β7 + (CHF)β8 + (Cancer)β9 + (COPD)β10 + (Cerebro)β11 + (Drug)β12 + (Dialysis duration)β13 + (AGEgroup)* (TREAT)β14 ……..(equation 4)

Results

A sample size of 562,655 individuals whose treatment measure of receiving either home hemodialysis or center hemodialysis was confirmed in the final data file merged from 2016-2019 clinical claims and accumulated patient core characteristics such as comorbidities, mortality, and hospitalization data since 2010. Of these, 14,202 patients (2.52%) were on home hemodialysis and the vast majority of 548,453 patients (97.48%) were on center hemodialysis.

1. Descriptive analysis of the ESRD population who received HHD and CHD.

ESRD patient characteristics for receiving home hemodialysis or center hemodialysis were listed in Table 3-2. Within this population, people of 0-59, 60-69, 70-79, and 80+ were 23%, 23%, 28%, and 26% respectively, and males and females occupied approximately 57% and 43% respectively. Nearly 46.57% of the patients were Non-Hispanic Whites followed by Non-Hispanic Blacks (32.33%), Hispanics (14.60%), Asians (3.90%), and other races (2.59%). The mean age was found to be 70 years old (standard deviation=14 years old, the percentage of people whose age 0-59, 60-69, 70-79, >=80 is 23%, 23%, 28%, 26%) for CHD patients and 64 years old (standard deviation=15 years old, the percentage for people whose age 0-59, 60-69, 70-79, >=80 is 37%, 23%, 23%, 17%) for HHD patients respectively, a statistically significant difference. There was no significant difference in dialysis duration years and Kt/V value between CHD and HHD groups. However, among the already rare total number of HHD patients, minorities made up an even smaller percentage and were significantly less likely to use HHD than Whites. Major comorbidities such as congestive heart failure, atherosclerotic heart disease, hypertension, cerebrovascular disease, and drug dependence were much more prevalent among CHD patients. Except for the high proportion of patients living in the southeast region (33.58%), the percentages of patients in the other regions were comparable: Northeast 16.26%, Midwest 19.83%, West 16.40%, Southwest 13.92%.

	Overall cohort N= 562,655	CHD N=548,453	HHD N=14,202	P
Age (y), mean±SD	69±14	70±14	64±15	<0.001
Age group (y), n (%)				
0-59	131,452 (23)	126,191 (23)	5,261 (37)	<0.001
60-69	131,092 (23)	127,859 (23)	3,230 (23)	<0.001
70-79	155,195 (28)	151,900 (28)	3,289 (23)	<0.001
>=80	144,916 (26)	142,503 (26)	2,412 (17)	<0.001
Male sex, n (%)	318,449 (57)	310,001 (57)	8,448 (60)	<0.001
Dialysis duration (y), median(iqr)	7 (5, 11)	7 (5, 11)	8 (5, 12)	>0.05
Race/Ethnicity, n (%)				
non-Hispanic White	262,051 (46.57)	253,765 (46.27)	8,286 (58.36)	<0.001
non-Hispanic Black	181,916 (32.33)	177,713 (32.40)	4,203 (29.60)	<0.001
Hispanic	82,166 (14.60)	81,021 (14.77)	1,145 (8.07)	<0.001
Asian	21,928 (3.90)	21,552 (3.93)	376 (2.65)	<0.001
Others	14,594 (2.59)	14,407 (2.63)	187 (1.32)	<0.001
Comorbidities, n (%)				
Congestive heart failure	155,632 (27.60)	152,518 (27.75)	3,114 (21.93)	<0.001
Atherosclerotic heart disease	74,475 (13.21)	73,175 (13.31)	1,300 (9.15)	<0.001
Hypertension	505,579 (89.66)	493,067 (89.70)	12,512 (88.10)	<0.001
Cerebrovascular disease	46,908 (8.32)	45,925 (8.35)	983 (6.92)	<0.001
Cancer	33,624 (5.96)	32,666 (5.94)	958 (6.75)	<0.001
Chronic obstructive pulmonary disease	44,580 (7.91)	43,491 (7.91)	1,089 (7.67)	0.288
Drug dependence	6,655 (1.18)	6,566 (1.19)	89 (0.63)	<0.001
Kt/V, mean±SD	1.60±0.00	1.60±0.00	1.50±0.01	0.541
Region, n (%)				
Northeast	90,730 (16.26)	89,144 (16.39)	1,586 (11.18)	<0.001
Midwest	110,637 (19.83)	105,673 (19.43)	4,964 (34.99)	<0.001
West	91,524 (16.40)	90,205 (16.59)	1,319 (9.30)	<0.001
Southwest	77,657 (13.92)	76,330 (14.04)	1,327 (9.35)	<0.001
Southeast	187,376 (33.58)	182,387 (33.54)	4,989 (35.17)	<0.001

Table 3-2 Patient demographics and clinical characteristics by CHD/HHD

Table 3-3 showed the average age (standard deviation) and percentage of people who were 0-59, 60-69, 70-79, and >= 80 years old of each racial/ethnic group. Except for Asians, the average age of every minority group was significantly lower than that of Whites. It was also found that White patients had the highest percentage of various comorbidities, such as congestive heart failure, atherosclerotic heart disease, cerebrovascular disease, cancer, and chronic obstructive pulmonary disease. The percentages in HHD use of all racial/ethnic minority groups were appreciably lower than that of the White group.

	Overall cohort n= 562,655	White n=262,051	Black n=181,916	Hispanic n=82,166	Asian n=21,928	Others n=14,594	P
Age (y), mean±SD	69.39±0.02	72.48±0.03	66.08±0.03	66.07±0.05	72.41±0.10	65.88±0.12	<0.001
Age group (y), n (%)							
0-59	131,452 (23)	43,866 (17)	55,983 (31)	23,121 (28)	3,975 (18)	4,507 (31)	<0.001
60-69	131,092 (23)	53,016 (20)	47,132 (26)	22,794 (28)	4,272 (19)	3,877 (27)	<0.001
70-79	155,195 (28)	77,618 (30)	46,293 (25)	21,503 (26)	6,005 (27)	3,776 (26)	<0.001
>=80	144,916 (26)	87,551 (33)	32,508 (18)	14,748 (18)	7,676 (35)	2,434 (17)	<0.001
Male sex, n (%)	318,448(57)	153,164(58)	96,856(53)	48,438(59)	12,374(56)	7,616(52)	<0.001
Dialysis duration (y), median(iqr)	7 (5, 11)	7 (5, 9)	9 (6, 12)	8(5,11)	8(5,11)	8(5,11)	<0.001
Comorbidities, n (%)							
Congestive heart failure	155,154(28)	79,399(30)	48,323(27)	18,956(23)	4,917(22)	3,559(24)	<0.001
Atherosclerotic heart disease	74,273 (13)	44,145(17)	16,182(9)	9,457(12)	2,689(12)	1,800(12)	<0.001
Hypertension	504,548 (90)	229,314(88)	167,840(92)	74,282(90)	19,873(91)	13,239(91)	<0.001
Cerebrovascular disease	46,787 (8)	22,404(9)	16,414(9)	5,432(7)	1,628(7)	909(6)	<0.001
Cancer	33,481 (6)	22,316(9)	7,658(4)	2,313(3)	758(3)	436(3)	<0.001
Chronic obstructive pulmonary disease	44,400 (8)	29,916(11)	10,408(6)	2,787(3)	693(3)	596(4)	<0.001
Drug dependence	6,646 (1)	2,174(1)	3,681(2)	615(1)	46(0.2)	130(1)	<0.001
Kt/V, mean±SD	1.60±0.00	1.60±0.00	1.57±0.00	1.64±0.00	1.73±0.00	1.64±0.00	>0.05
HHD use, n (%)	14,197(2.52)	8,286(3.16)	4,203(2.31)	1,145(1.39)	376(1.71)	187(1.28)	<0.001

Table 3-3 Patient demographics and clinical characteristics by racial/ethnic groups

2. Utilization of HHD vs. CHD by race/ethnicity

The odds ratio (OR) and 95% confidence interval (95% CI) of the unadjusted model for predicting utilization of home hemodialysis vs. center hemodialysis by race/ethnicity showed that minorities were significantly less likely to use HHD than White patients (Blacks: OR, 0.724, 95% CI, 0.698-0.752; Hispanics: OR, 0.433, 95% CI, 0.407-0.461; Asians: OR, 0.534, 95% CI, 0.481-0.593; Others: OR, 0.398, 95% CI, 0.344-0.460; $p<0.001$). The adjusted logistic regression model included demographics such as age, sex, region, and year of hemodialysis service, and clinical factors such as various comorbid and chronic conditions. The adjusted model displayed similar ORs for each minority group compared with White Americans, but Black patients were even less likely to use HHD (Blacks: OR, 0.568, 95% CI, 0.546-0.592; Hispanics: OR, 0.510, 95% CI, 0.477-0.544; Asians: OR, 0.689, 95% CI, 0.619-0.766; Others: OR, 0.453, 95% CI, 0.390-0.525; $p<0.001$). In this adjusted regression model, for each additional year of age, the odds of having HHD decreased by a factor of 0.976 compared to having CHD. Table 3-4 and Figure 3-1 illustrate unadjusted and adjusted odds ratios and 95% confidence intervals for HHD utilization (vs. CHD) in minority groups (vs. Whites).

	Unadjusted model	P	Adjusted model	P
Race/Ethnicity, n (%)				
non-Hispanic White	Reference		Reference	
non-Hispanic Black	0.724 (0.698-0.752)	<0.001	0.568 (0.546-0.592)	<0.001
Hispanic	0.433 (0.407-0.461)	<0.001	0.510 (0.477-0.544)	<0.001
Asian	0.534 (0.481-0.593)	<0.001	0.689 (0.619-0.766)	<0.001
Others	0.398 (0.344-0.460)	<0.001	0.453 (0.390-0.525)	<0.001
Age (per 1 year increase)			0.976 (0.975-0.977)	<0.001
Sex				
Male			Reference	
Female			0.919 (0.888-0.951)	<0.001
Dialysis duration (per 1 year increase)			1.025 (1.022-1.028)	<0.001
Comorbidities (no)			Reference	
Congestive heart failure			0.859 (0.823-0.896)	<0.001
Atherosclerotic heart disease			0.789 (0.743-0.838)	<0.001
Hypertension			0.936 (0.889-0.987)	0.014
Cerebrovascular disease			0.942 (0.881-1.007)	0.078
Cancer			1.267 (1.184-1.356)	0.154
Chronic obstructive pulmonary disease			1.048 (0.983-1.119)	<0.001
Drug dependence			0.422 (0.342-0.522)	<0.001
Region				
Northeast			Reference	
Midwest			2.445 (2.308-2.590)	<0.001
West			0.843 (0.782-0.909)	<0.001
Southwest			1.014 (0.940-1.093)	0.721
Southeast			1.513 (1.428-1.603)	<0.001

Table 3-4 Odds ratios and 95% confidence intervals of home hemodialysis utilization (vs. center hemodialysis) in minority groups (vs. Whites) (From equation 1)

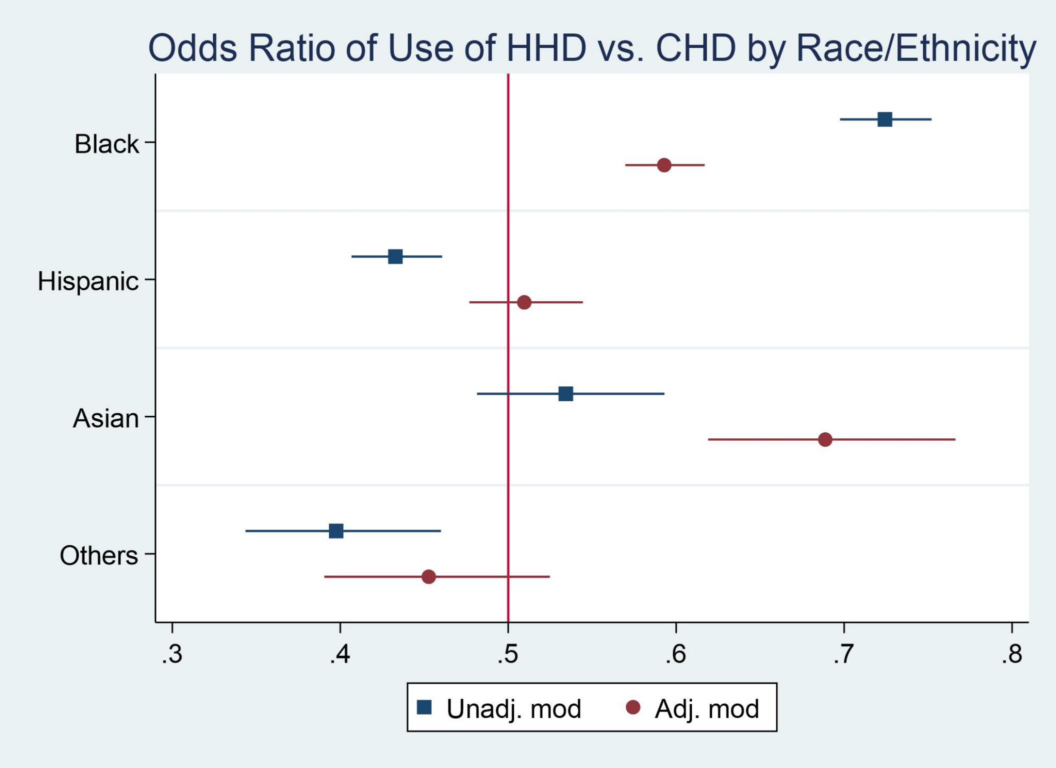


Fig 3-1 Unadjusted and adjusted odds ratios and 95% confidence intervals for home hemodialysis utilization (vs. center hemodialysis) in minority groups (vs. Whites).

The adjusted model included demographics such as age, gender, region, dialysis service years, and medical factors such as various comorbidities and chronic conditions.

3. Mortality of HHD vs. CHD patients by race/ethnicity

Risk factors for mortality in the overall cohort are contained in Table 3-5. The dialysis duration had a statistically significant risk impact on mortality: the data shows that for every one-year increase, the odds of death occurring are multiplied by 1.068. Additionally, the other factors were all categorical predictors. This can be interpreted as a significantly relative increase in the risk of death in people aged 60-69, 70-79, and older than 80 years old (as the age group moves into an older age range, the chance of death rises noticeably) compared to those age 0-59; in female compared to male; and in people with certain comorbidities like congestive heart failure, atherosclerotic heart disease, cerebrovascular disease, cancer, chronic obstructive pulmonary disease, and drug dependence compared to those without; Additionally, a relative decrease in the risk of death in treatment of HHD compared to CHD, in hypertensive ESRD patients, and each minority group compared to White patients. The odds ratios of the interaction term between HHD treatment and age group indicated how the effect of HHD treatment (vs. CHD) on mortality changed for individuals in the age group 60-69, 70-79, and >=80 years old compared to the reference group (age 0-59). The ORs meant that, for patients in all older age groups, the odds of death were significantly higher for those who received HHD treatment compared to those who received CHD treatment, after adjustment for other factors in the analysis. Fig 3-2 demonstrated these different adjusted ORs and 95% CIs for mortality in various minorities vs. Whites.

	Odds Ratio (95% Confidence Interval)	P
Age group (y)		
0-59	Reference	
60-69	1.830 (1.798-1.862)	<0.001
70-79	3.139 (3.087-3.193)	<0.001
>=80	6.378 (6.264-6.495)	<0.001
Sex		
Male	Reference	
Female	1.013 (1.001-1.024)	0.033
Dialysis duration (per 1 year increase)	1.068 (1.067-1.070)	<0.001
HHD (vs. CHD)	0.686 (0.641-0.734)	<0.001
Age group (y) interaction with treatment modality		
HHD*0-59	Reference	
HHD*60-69	1.517 (1.374-1.675)	<0.001
HHD*70-79	2.031 (1.838-2.244)	<0.001
HHD* >=80	2.843 (2.504-3.228)	<0.001
Race/Ethnicity		
non-Hispanic White	Reference	
non-Hispanic Black	0.677 (0.668-0.686)	<0.001
Hispanic	0.694 (0.681-0.707)	<0.001
Asian	0.583 (0.565-0.601)	<0.001
Others	0.770 (0.741-0.799)	<0.001
Comorbidities (no)	Reference	
Congestive heart failure	1.521 (1.500-1.541)	<0.001
Atherosclerotic heart disease	1.247 (1.225-1.270)	<0.001
Hypertension	0.844 (0.829-0.860)	<0.001
Cerebrovascular disease	1.327 (1.300-1.355)	<0.001
Cancer	1.138 (1.110-1.166)	<0.001
Chronic obstructive pulmonary disease	1.573 (1.539-1.609)	<0.001
Drug dependence	1.661 (1.578-1.749)	<0.001

Table 3-5 Odds ratios and 95% confidence intervals of risk factors for mortality in the overall cohort (From equation 2)

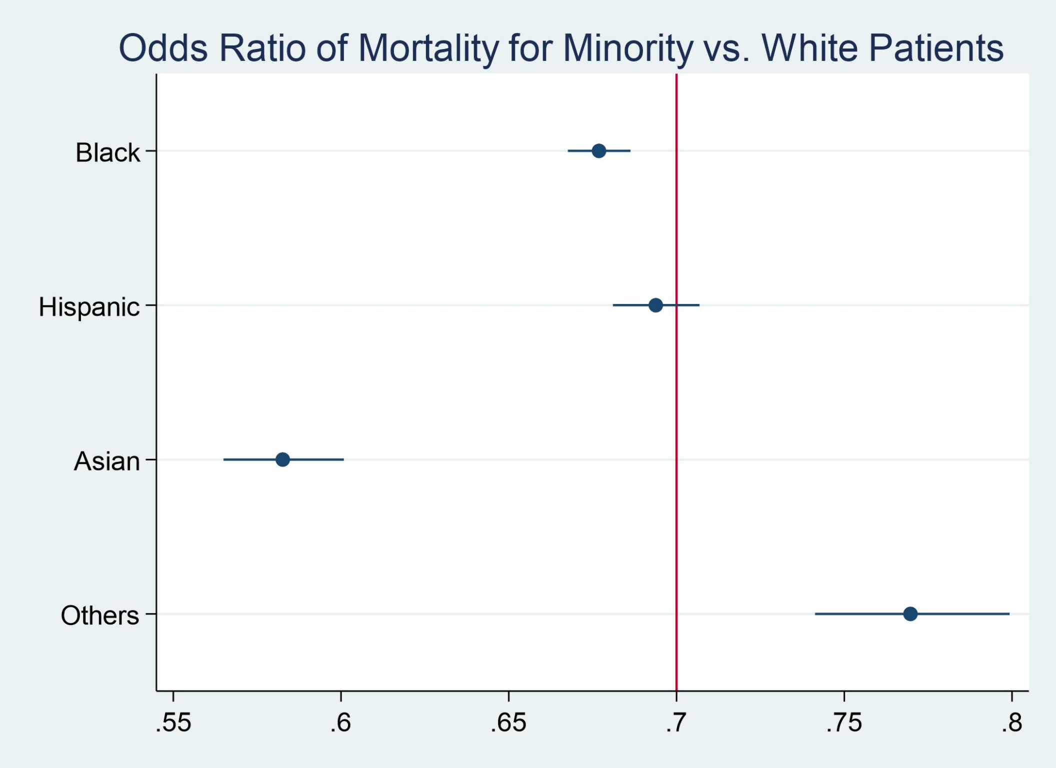


Fig 3-2 Adjusted odds ratios and 95% confidence intervals for mortality in minority groups (vs. Whites).

The adjusted model included demographics such as age group, race, gender, region, year of hemodialysis service, treatment (HHD or CHD), medical factors such as various comorbid and chronic conditions, and interaction of treatment and age group.

Table 3-6 revealed percentages of the overall ESRD population's and each minority cohort's mortality for HHD vs. CHD. The odds ratios and 95% confidence intervals of the overall cohort indicated HHD patients were less likely to die compared to CHD patients after confounding for age group, gender, race, dialysis service years, region, comorbidities, etc., and including the interaction of treatment modality with age group (overall cohort: OR, 0.686, 95% CI, 0.641-0.734; $p<0.001$). Except for Asians, within the rest ethnic cohorts, occurred same situation that HHD group had a lower risk of death compared to the CHD group (White: OR, 0.670, 95% CI, 0.612-0.734, $p<0.001$; Blacks: OR, 0.717, 95% CI, 0.644-0.799, $p<0.001$; Hispanics: OR, 0.715, 95% CI, 0.575-0.889, $p<0.01$; Asians: OR, 0.624, 95% CI, 0.383-1.019, $p>0.05$; Others: OR, 0.473, 95% CI, 0.265-0.844, $p<0.05$).

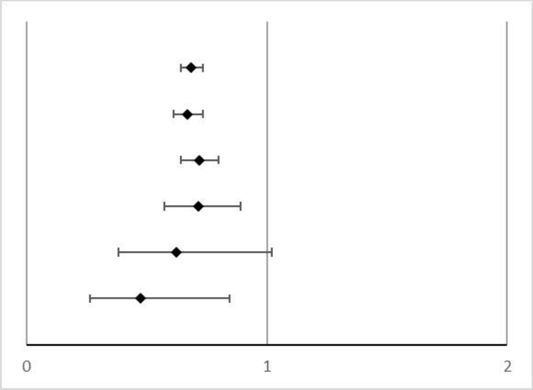
	CHD	HHD	Odds Ratio (95% Confidence Interval)	P
Overall cohort	49.61% (272,088/548,453)	47.71% (6,776/14,202)		<0.001
non-Hispanic White	57.28% (145,365/253,765)	51.19% (4,242/8,286)		<0.001
non-Hispanic Black	43.63% (77,534/177,713)	43.04% (1,809/4,203)		<0.001
Hispanic	42.26% (34,236/81,021)	42.97% (492/1,145)		0.003
Asian	43.34% (9,341/21,552)	44.41% (167/376)		0.059
Others	43.40% (6,253/14,407)	35.29% (66/187)		0.011

Table 3-6 Mortality of HHD vs. CHD in overall and every racial/ethnic cohort

4. Hospitalization of HHD vs. CHD patients by race/ethnicity

Risk factors for hospitalization in the overall cohort were contained in Table 3-7. There’s no significant difference between HHD and CHD. Except for the categories of minority and hypertension, all the rest risk factors in the table had an effect on increased hospitalization, much like they did for mortality. In terms of interaction between treatment and age group, only in the 70-79 age group, where the odds of hospitalization occurring are 1.311 times statistically significantly higher for those receiving HHD treatment compared to CHD treatment, after controlling for other covariates, was there a significant difference. Figure 3-3 illustrated the logistic model’s adjusted ORs and 95% CIs for hospitalization in minority groups vs. Whites.

	Odds Ratio (95% Confidence Interval)	P
Age group (y)		
0-59	Reference	
60-69	1.140 (1.114-1.166)	<0.001
70-79	2.142 (2.089-2.197)	<0.001
>=80	2.804 (2.727-2.883)	<0.001
Sex		
Male	Reference	
Female	1.155 (1.134-1.176)	<0.001
Dialysis duration (per 1 year increase)	1.210 (1.206-1.213)	<0.001
HHD (vs. CHD)	0.943 (0.868-1.024)	0.162
Age group (y) interaction with treatment modality		
HHD*0-59	Reference	
HHD*60-69	1.126 (0.980-1.295)	0.094
HHD*70-79	1.311 (1.112-1.546)	0.001
HHD* >=80	1.024 (0.853-1.229)	0.801
Race/Ethnicity		
non-Hispanic White	Reference	
non-Hispanic Black	0.750 (0.734-0.766)	<0.001
Hispanic	0.730 (0.710-0.750)	<0.001
Asian	0.486 (0.467-0.506)	<0.001
Others	0.706 (0.671-0.744)	<0.001
Comorbidities (no)	Reference	
Congestive heart failure	1.426 (1.395-1.458)	<0.001
Atherosclerotic heart disease	1.228 (1.191-1.267)	<0.001
Hypertension	0.861 (0.836-0.887)	<0.001
Cerebrovascular disease	1.267 (1.224-1.312)	<0.001
Cancer	1.149 (1.102-1.198)	<0.001
Chronic obstructive pulmonary disease	1.562 (1.500-1.626)	<0.001
Drug dependence	1.367 (1.261-1.481)	<0.001

Table 3-7 Odds ratios and 95% confidence intervals of risk factors for hospitalization in the overall cohort (From equation 3)

Fig 3-3 Adjusted odds ratios and 95% confidence intervals of whether have been hospitalized in minority groups (vs. Whites).

The adjusted model included demographics such as age group, race, gender, region, year of hemodialysis service, treatment (HHD or CHD), medical factors such as various comorbid and chronic conditions, and interaction of treatment and age group.

For the entire ESRD population as well as for each minority cohort, Table 3-8 displayed the percentage of hospitalizations for HHD and CHD. It also showed ORs, incident rate ratios (IRRs), and their corresponding 95% CIs for HHD compared to CHD within overall CKF cohort and each minority group (OR, Overall: 0.943, 95% CI, 0.868-1.024, $p>0.05$; White: 0.893, 95% CI, 0.794-1.004, $p>0.05$; Blacks: 0.953, 95% CI, 0.835-1.087, $p>0.05$; Hispanics: 1.116, 95% CI, 0.868-1.433, $p>0.05$; Asians: 1.338, 95% CI, 0.867-2.067, $p>0.05$; Others: 1.549, 95% CI, 0.844-2.845, $p>0.05$; IRR, Overall: 0.985, 95% CI, 0.965-1.005, $p>0.05$; White: 0.979, 95% CI, 0.953-1.006, $p>0.05$; Blacks: 0.952, 95% CI, 0.922-0.983, $p<0.01$; Hispanics: 1.130, 95% CI, 1.058-1.208, $p<0.001$; Asians: 1.186, 95% CI, 1.023-1.376, $p<0.05$; Others: 1.188, 95% CI, 1.007-1.401, $p<0.05$). There were no statistically significant differences between HHD and CHD in all cohorts for ORs of any hospitalization, and HHD had a lower IRR in all minorities for the number of hospitalizations.

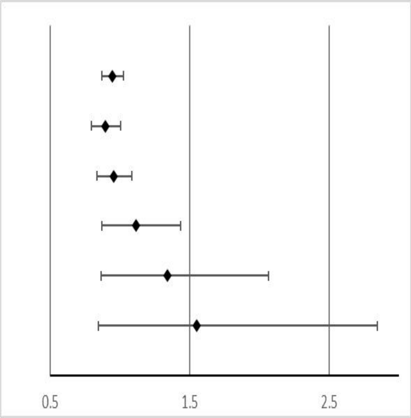
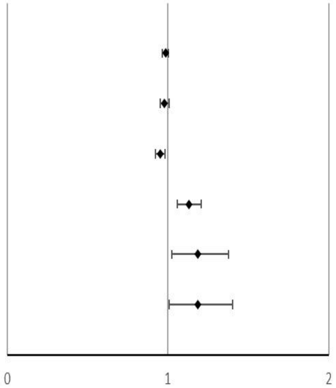
	CHD	HHD	Odds Ratio (95% CI) *Any hospitalization*	P	Incident Rate Ratio (95% CI)	P *Number of hospitalizations*
Overall	88.97% (487,959/548,453)	89.52% (12,713/14,202)		0.162		0.131
White	90.85% (230,554/253,765)	89.90% (7,449/8,286)		0.059		0.124
Black	88.97% (158,118/177,713)	89.41% (3,758/4,203)		0.474		0.003
Hispanic	85.80% (69,520/81,021)	89.00% (1,019/1,145)		0.392		<0.001
Asian	81.45% (17,555/21,552)	85.64% (322/376)		0.189		0.024
Others	84.36% (12,154/14,407)	85.56% (160/187)		0.158		0.041

Table 3-8 Hospitalization of HHD vs. CHD in overall and every racial/ethnic cohort

Discussion

Drawing on data from the USRDS' nationally representative sample of patients receiving maintenance dialysis since 2010, this study provides a comprehensive examination of racial/ethnic disparities in the utilization and outcomes of HHD versus CHD among maintenance dialysis patients in the U.S. and draws a few important findings. **First**, HHD was much less common in the United States for every racial or ethnic minority group than for white people, and demographic and medical factors alone were insufficient to account for this disparity. Therefore, the results supported the research hypothesis that HHD had lower use in the ESRD population in the United States, especially among minorities. **Furthermore**, all minority groups showed substantially lower mortality and hospitalization incidences than the White group when controlling for other risk factors; this may be due to the fact that the majority of minority patients were younger than Whites and less likely to have comorbid conditions. **Finally**, within the overall and major ethnic cohorts except for Asians, HHD patients' mortality was noticeably lower than CHD patients when controlling for demographic, dialysis service years, and major coexisting diseases; in all minority groups, HHD also showed a lower incident rate ratio for a number of hospitalizations than CHD after adjustment for other covariates. These findings agreed with the earlier literature review.

Racial and ethnic minorities were appreciably less likely to utilize HHD, according to long-standing data from the USRDS, the country's largest registry of dialysis patients.[34] This investigation proved that racial/ethnic minorities utilized HHD at lower rates than Whites, which cannot be explained by demographic or medical differences alone. Nevertheless, given that each minority group was much younger and less likely to have concurrent diseases, it made sense that they should use HHD more frequently.[47–49,65] In the absence of demographic and medical factors clarifying the differential utilization, it is probable that patient preferences, societal differences (such as having enough space at home or having a partner to help with the procedure at home), aspects of health care delivery (such as the availability of pre-ESRD nephrology therapy or an HHD training center in communities), or physician or other health care provider perception of patients are some of the causes of the discrepancies.[32] Except for two studies showing that the likelihood of patients receiving pre-dialysis nephrology care was much lower for those who resided in or were treated in areas with a black majority, most of these above-mentioned problems had never been thoroughly investigated, either in quantitative or qualitative research.[32,43,54] Additionally, other racial/ethnic groupings did not have access to such investigation. With HHD use experiencing historic and rapid expansion, it is more important than ever to guarantee fair access to pre-dialysis nephrology care, and these racial/ethnic variations required further research.

This analysis was the most recent nationally representative cohort study to compare HHD to CHD with a focus on the racial/ethnic variances in health outcomes such as mortality and hospitalization among patients treated with HHD in the United States. The decreased death and hospitalization in racial/ethnic minorities compared to Whites was in line with previous reports.[32] In terms of HHD vs. CHD, the results were also coherent with the past. The prevalence of age, gender, race, region, dialysis service years, vascular disease (cardiovascular disease, hypertension, and cerebrovascular accident), and other chronic coexisting conditions such as cancer and chronic obstructive pulmonary disease were significantly different at baseline. Although they were taken into account as potential confounders of survival outcomes, they might not reflect real variations between HHD and CHD characteristics; in particular, age and time of dialysis may act as the main changing modifier in the study of mortality assessment. This study made it obvious that minority patients had a lower risk of death and benefited considerably from the home therapy modality, yet they were even less prone to use the scheme. As far as the comparison of HHD with CHD was concerned, more matched samples and long-term patient follow-up would be necessary since the relatively small size of the HHD minority cohort made the analysis insufficient for drawing firm conclusions. Because discrepancy in hospitalization between HHD and center hemodialysis was evident for all minority groups, future research should examine racial/ethnic inequalities in hospital referral rates, the impact of insurance coverage, and other clinical and socioeconomic factors.

Chapter 4

Obstacles to Home Hemodialysis Use and Minority Patients' Preferences in the United States: Findings from Interviews with Nephrologists and Other Clinicians

Background

In Chapter 1: Introduction sector, the fundamentals of kidney disease, different types of dialysis, and racial/ethnic inequalities in the prevalence of CKD and ESRD in the US population were conferred.

Very recently, Medicare was provisioned to offer payment incentives to encourage more ESRD patients to select home therapy.[20] However, there was little evidence of health outcomes in the usage of in-home HD vs. CHD, especially in the United States and none of the previous studies explored barriers and racial/ethnic variations in the utilization of HHD vs. CHD. This project was intended to bridge this gap in previous literature.

Methods

This project is a prospective analysis of primary interview data from nephrologists in different states of the United States. Grounded theory is the main approach for this qualitative research as it is a creative process to be used during the interview when there is a lack of knowledge about the reason for the very low prescription of HHD.[66] The research goals of this study are to inquire about the reasons behind doctors' infrequent exposure to HHD and their resulting reluctance to suggest it to CKF patients. The working hypothesis is that barriers exist within the whole healthcare system, including patients' socioeconomic, clinical status, and policies that may discourage HHD use, which need to be altered to make sure that ESRD patients can choose their treatment modality. The research protocol was approved by the Institutional Review boards of the University of Maryland, College Park.

Data Collection

In-depth interviewing, as a data collection tool, was used to generate qualitative text data to help uncover perceptions, thoughts, beliefs, attitudes, and experiences physicians hold related to HHD and related issues. The interviews lasted roughly thirty minutes based upon the interaction between the researcher and participants. The conversation during the interview was recorded. Interviews took place at participants' offices, or via telephone, and appointments were made by email or telephone before interviews. Through an interactive and concurrent process of gathering and interpreting interview material, grounded theory (a useful approach in qualitative research for developing an explanation based on the data that has been systematically collected, analyzed, and interpreted, to generate a theory that is grounded in the data) helped to develop knowledge or explanation about the phenomenon surrounding nephrologists' prescription of HHD.[66]

Sample

Initially open sampling, interviewees were first introduced by personal contacts and then recruited through snowball sampling in which research participants were asked to identify other therapeutic peers in the area with different age groups, years of practice, gender, and opinions towards treatment formalities. Meaningful data were obtained through interviews conducted in-person, via telephonic audio, or video with 18 Nephrologists, 4 nurses, and 1 technician. The determination of this sample size was based upon the fact that data saturation was reached [66–68] after conducting 16 interviews with nephrologists who had a range of different backgrounds and experiences in the field of HHD. These interviews aimed to explore the professional perspectives on HHD, including its advantages and disadvantages, the obstacles to its use, the support available for patients who choose this treatment modality, and any racial or ethnic differences in its uptake. After analyzing the data, no new themes or insights emerged from subsequent interviews. The sample included nephrologists who identified as White, Black, Hispanic, and Asian, and who had between 8 and 23 years of experience in practicing HHD. Additionally, the sample included nephrologists who practiced in a variety of settings, including medical university-affiliated hospitals, non-profit chain hospital groups, Davita and Fresenius outpatient dialysis centers, Veterans Affairs (VA) healthcare system hospitals, and small private hospitals. The participants in this study also represented a diverse range of geographic locations, with some practicing HHD in seven different states across the United States. The diversity in the sample adds to the richness and complexity of the emerging themes and provides a more comprehensive understanding of the professional perspectives on HHD. The range of experiences and backgrounds of the participants allowed for a more nuanced exploration of the barriers and facilitators to HHD use and any potential racial or ethnic differences in its uptake.

Interview guide

Open-ended questions of semi-structured were created to ask physicians about available alternatives to ESRD therapeutics including HHD. Interview questions initially were broad and were progressively focused on the discovery of theoretical hypotheses in terms of the very low occurrence of prescriptions for HHD. Scripts, questions, or prompts included:

1)Script:

Opening greeting before the interview:

Good morning/afternoon, Dr. XX, thank you for taking the time here to participate in my interview. This research project's theme is as the consent form shows. Previous studies showed that HHD can provide more sufficient treatment, longer clinical benefits, and better quality of life at a reasonable cost than in-center hemodialysis. Prior works of economics including direct medical and nonmedical costs reinforce these conclusions. However, HHD is in a very low percentage in the U.S., this interview seeks to understand the reason why it is the case. Dr. XX, the content of our conversations will be protected, no one except I have the right to see them, and the relevant records will be destroyed after being kept for a period of time. Here is the informed consent and a personal information collection list with name, gender, age, and years of practice in nephrology and dialysis etc., would you please sign it and fill in the table before we talk about the detailed questions? (Dr. sign the consent form and fill in the table) Thanks. Then, would you like to say something regarding this topic?

2)Map interview questions

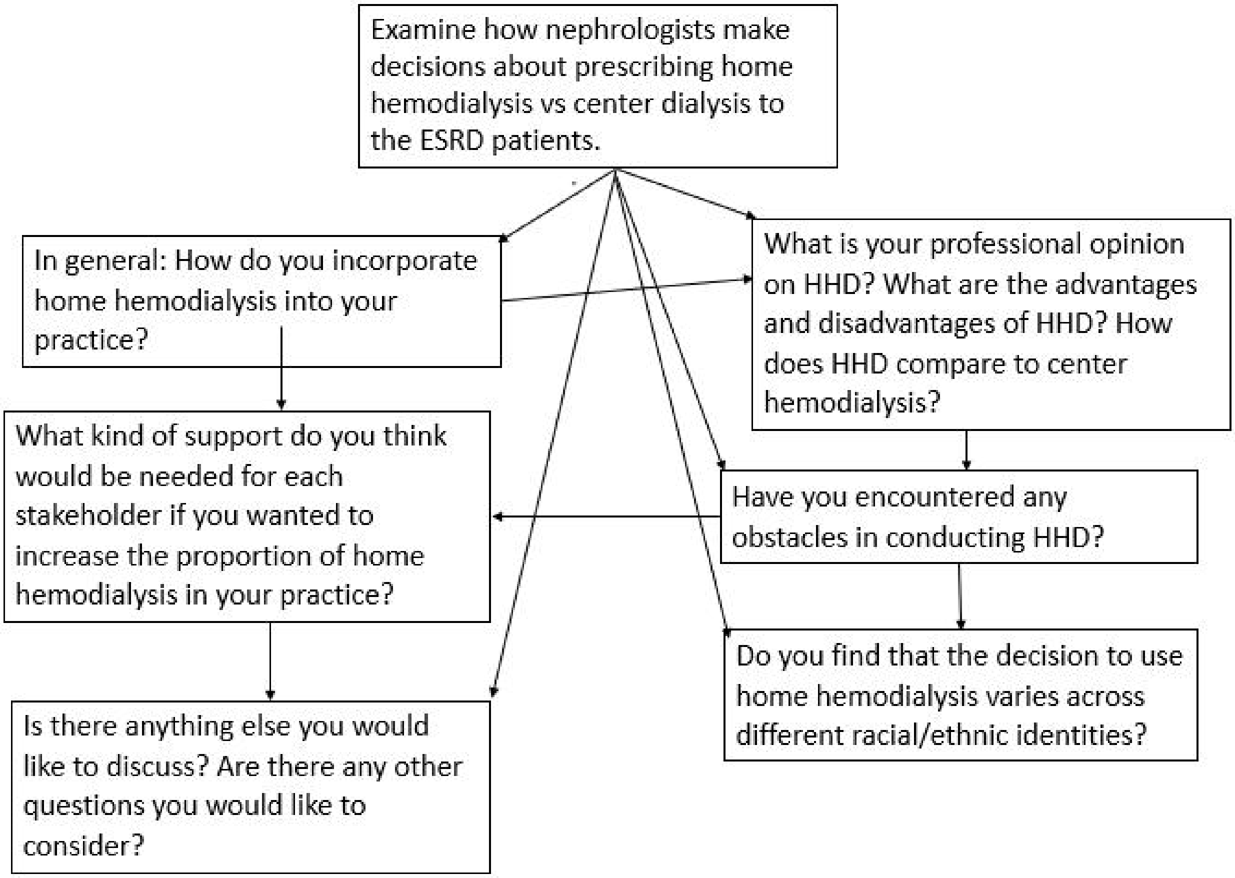


Fig 4-1: Map interview questions

Question 1. How do you incorporate HHD into your practice?

Prompt 1.1 How many hemodialysis patients are in your care? Among them, what is the percentage receiving HHD? Can you explain more about this discrepancy?

Prompt 1.2 What do you observe in patients' use of home versus center hemodialysis?

Question 2. What is your professional opinion on HHD?

Prompt 2.1 In your opinion, what are the advantages and disadvantages of HHD?

Prompt 2.2 How does HHD compare to CHD? Please rate the effectiveness of HHD if CHD is supposed to be scored 1 effectiveness and the effectiveness score range is from 0 to 4: 0 means ineffective, 1 means equally as CHD, and 4 means very effective. Please explain.

Question 3. Have you encountered any obstacles in conducting HHD?

Prompt 3.1 From the perspective of health care provider, any obstacles you would like to tell me? If yes, please explain.

Prompt 3.2 From the perspective of patients and/or family members on behalf of the very sick patients, any failures you would like to tell me about? If yes, please explain.

Prompt 3.3 From the perspective of the policy side, any obstacles you would like to tell me about? – i.e. hospital administrators? Legislators? Payers? If yes, please explain.

Question 4. What kind of support do you think would be needed for each stakeholder if you wanted to increase the proportion of HHD in your practice?

Prompt 4.1 From health care providers' side? If yes, please explain. (probe: professional education? Other support?)

Prompt 4.2 From the patient's and/or family members' side? If yes, please explain. (probe: patient and family training?)

Prompt 4.3 From hospital administrators, legislators, or payers' side? If yes, please explain. (probe: invest HHD machine or support to add a home dialysis training center within the clinic? Do stakeholders need incentives to use HHD)?

Question 5. Do you find that the decision to use HHD varies across different racial/ethnic identities? If yes, please explain the differences.

Prompt 5.1 What are the differences? For whom?

Prompt 5.2 How are the differences managed?

Question 6. Is there anything else you would like to discuss? Are there any other questions you would like to consider?

3)End after the interview:

Thank you for your time and effort in participating in this research.

Data analysis

Data analysis started after the interview records had been transcribed by the researcher. Guided by the overarching research questions and interview guide, the researcher read thoroughly and carefully throughout the interview data to develop the codes that emerged from conversation notes with the interviewees, for example, 1) positive or negative perspectives of the participants toward the interview questions; 2) texts of vertical structure in the sense that encompassed overarching questions; 3) texts of horizontal structure to represent relationships among and between explanation categories or domains. The comparative method of analysis was constantly employed to identify similarities and differences of these text data. The purpose of this constant comparison between the words and sentences of interviewees was to develop recognition, explanation, or answer to the research question about the low incidence of HHD for some populations.[66–68] Open-hand coding was applied to name and categorize similar meanings in the text data. A codebook informed by the interview questions was developed simultaneously when interviews progressed. For example, for the second question prompt 2.2 "How does HHD compare to CHD? please rate the effectiveness of HHD if CHD is supposed to be scored 1 and the effectiveness score range is from 0 to 4, 0 means ineffective and 4 means very effective", different level of opinions "HD is 4=very effective, 3=effective, 2=somewhat effective, 1=equally effective, 0=ineffective" can be categorized along a continuum according to interviewees' responses. Quotes of the respondents' views about effectiveness were used to illustrate the scale of different levels of effectiveness and a table of the quotes data was included. The interview introduced specific questions and sought replies in order to develop a taxonomy, which is a conceptual theme aimed at answering the research question. Hence propositions or working hypotheses were validated during the succeeding analytic process. In the coding scheme, inferred causal links between categories and subcategories were made by interconnecting themes into a storyline, which allowed a knowledge framework to emerge. The construction of the storyline to answer the research question was verified by constant comparing with further data collection and analysis.[66–68]

Results

A sample size of a total of twenty-three individuals who had practiced in HHD or center hemodialysis for years was included in this qualitative data analysis process. Among them, eighteen were nephrologists, of whom seven were women and eleven were men, and five were dialysis nurses from Washington D.C., Maryland, Virginia, Alabama, Texas, Florida, and Pennsylvania. The participants' median years of specializing in nephrology and hemodialysis were eleven, with minimum of five years and maximum of twenty-three years.

Question 1. How do you incorporate HHD into your practice?

The majority of the interviewees had only a few HHD patients, a very low percentage of their total patients, although they felt that HHD was a viable treatment option for people with ESRD and that it allowed for greater autonomy and a better quality of life. "*CKF Patient acceptance of HHD was very low, although all renal replacement alternatives including HHD were presented to them during the pre-nephrology care because the vast majority of patients are afraid to puncture or cannulate* *themselves in the arm, and some are very nervous about seeing blood flowing out of their bodies into the dialysis tube lines…*" several nephrologists and HHD nurses mentioned. Participants of the interview also felt that home hemodialysis was more convenient and less time-consuming than traditional in-center hemodialysis. Two nephrologists and one nurse said: "*Patients can hemodialyze at home, which is very convenient and saves travel time to and from the dialysis center. Patients are also able to travel easily throughout the United States.*"

Table 4-1 Participants' practice situation in HD and their patients' preferences for HHD or CHD

Practice situation	**Summary of data**	**No. of interviewees**
Number of hemodialysis patients		
Over 100	Some nephrologists have more than 100 HD patients	5
Less than 100	Most participants have less than 100 but more than 10 HD patients	18
Percentage of home hemodialysis	All participants have less than 5% HHD patients. They usually only have a few HHD patients.	23
Patients' preferences for home or center hemodialysis	The majority of participants' patients prefer to receive HD at an outpatient hemodialysis center. Few patients prefer to choose HHD because they want to work during the daytime and conduct HHD at nighttime after work. HHD allows for a flexible treatment schedule. Most patients are afraid to puncture or cannulate themselves in the arm, and some are very nervous about seeing blood flowing out of their bodies into the dialysis tube lines.	20

Question 2. What is your professional opinion on HHD?

Prompt 2.1 What are the advantages and disadvantages of HHD?

Explicit statements about advantages and disadvantages were coded and summarized to reflect physicians' and nurses' perceptions towards HHD. The majority of interviewees expressed that the advantage of HHD was: "*To provide better patient health outcomes, particularly survival benefit, better removal of fluid and toxins such as phosphorus.*"

Table 4-2: Advantage and disadvantage of HHD vs. CHD

Advantage or Disadvantage	**Summary of data**	**No. of interviewees**
Advantage		
Better health outcome	HHD provides better patient outcomes, particularly survival benefits, and better removal of fluid and toxins such as phosphorus.	22
Better quality of life	HHD allows for greater autonomy for the patient, allowing them to take control of their health, dialysis prescription, and process, thus resulting in more opportunities for employment and business travel and greater flexibility in scheduling based upon the patient's working demand.	20
Long-term dialysis adequacy	HHD is the best renal replacement therapy other than transplant. There are concerns about the long-term adequacy of another home dialysis, peritoneal dialysis. HHD allows for longer and more frequent dialysis treatments via high blood flow filtration, which can lead to better health outcomes	18
Low cost	Human capital is very high, particularly in the U.S. Home therapy can be more cost-effective than in-center HD, since it does not require the use of a dialysis center and its associated costs.	15
Disadvantage		
High burden on patient	A patient needs relatively long-term training on HHD operation and a self-management capability to daily	17

	experience therapy, during which a patient usually is in a state of stress.	
High burden on family member	Most HHD patients need a family member on-site to daily help them, for example, a puncture in the forearm, paying attention to a machine alarm…	22
High burden on HHD nurse	When a patient has HHD the nurse needs to be on call at all times in case of any emergency.	12

Prompt 2.2 How does HHD compare to CHD? Please rate the effectiveness of HHD if CHD is supposed to be scored 1 effectiveness and the effectiveness score range is from 0 to 4.

A codebook about HHD's effectiveness vs. CHD's according to different levels of interviewees' responses was developed in the following Table 4-3. Many nephrologists and nurses explicitly stated: "*HHD is a very effective treatment option for those suffering from kidney failure. It offers many advantages over in-center hemodialysis…because HHD allows for longer and more frequent dialysis treatments simulating normal kidney's filtering function.*" Some nephrologists said: "*HHD is effective because it can allow patients to schedule more frequent, such as daily hemodialysis at home, rather than three times a week conventional HD.*" A few participants admitted that: "*HHD is still somewhat effective compared to CHD when patients conduct hemodialysis 4 times weekly, with each time 3 hours at home.*" Only one physician mentioned: "*HHD and CHD are equally effective, no one treatment appears to be more effective.*"

Table 4-3: Level of the effectiveness of HHD vs. CHD

Level of opinions	**Summary of data**	**No. of interviewees**
4=very effective	HHD is a very effective treatment option for those suffering from kidney failure. It offers many advantages over in-center hemodialysis…HHD allows for longer and more frequent dialysis treatments.	10
3=effective	HHD is an effective therapy because it can allow patients to schedule more frequent hemodialysis at home.	7
2=somewhat effective	HHD is still somewhat effective for those ESRD patients	5

	when they conduct hemodialysis 4 times weekly, with each time for 3 hours.	
1=equally effective	HHD and CHD are equally effective, no one treatment appears to be more effective.	1
0=ineffective		0

In light of the above-weighted coding status, the overall effectiveness score for HHD vs. CHD (assumed to be 1 for effectiveness) was 3.1, which means that HHD is an effective treatment modality compared to CHD.

Question 3. Have you encountered any obstacles in conducting HHD?

Overall, the majority of participants felt that home hemodialysis was a safe option and that the risks of infection and other complications were minimal, at least not more than in-center HD. Five nephrologists and nurses said similarly: "*Actually, neither type of treatment—hemodialysis at home or a facility—is more likely than the other to experience technical issues and failures.*" In-depth interviews with physicians, clinicians, and technicians were used to elicit the following failure codes, which were experiences and perceptions regarding what they and their patients had encountered during HHD therapy. The clinical issue that happened more often was low blood pressure: "*Hypotension is frequently experienced. Particularly when patients are unfamiliar with their dialysis prescription, the dose and pace of the treatment might lead to the too fast evacuation of fluids from the blood……*", several participants said. Other obstacles were also coded, and sub coded quoting the opinions from the interviewees.

Table 4-4: Obstacles to conducting HHD

Obstacles/Failures	**Summary of data**	**No. of interviewees' response**
Failure in the technical and clinical domain		**10**

Set up machine	Creating access to hemodialysis, which enables the removal of blood from the body and its purification in a dialysis machine, has led to a lot of issues. Many warnings will sound from the HHD machine if the patient is unfamiliar with how to operate the device, especially at the start of hemodialysis when the device is set up to link to the body.	3
Bleeding	The risk of bleeding is typically thought to be higher. When a patient has uremia, they may experience bleeding due to an acquired primary hemostasis defect brought on by platelet dysfunction and a changed platelet-vessel wall interaction. The frequency of significant bleeding is increased by antiplatelet medications like aspirin and heparin.	4
Low blood pressure	During hemodialysis, hypotension is frequently experienced. Particularly when patients are unfamiliar with their dialysis prescription, the dose and pace of the treatment might lead to the too fast evacuation of fluids from the blood, naturally, and occasionally significantly, the interior pressure in the arteries will drop. Additional problems result from the imbalance of the body's fluid and electrolytes as well as its consequences on blood pressure and heart function.	5
Infection	In order to do hemodialysis, a synthetic access point must be made in the body. The closed vascular system is now open, which presents a risk for infection. Infection danger is a continual concern for hemodialysis patients. The access point gives bacteria and other microbes the	1

	chance to enter the bloodstream, which is why. The signs of local swelling, redness, warmth, and pain; the accumulation of pus beneath the skin; fever and/or chills would normally be present if an infection were to occur. The home environment, in particular, is far from sterile compared to a dialysis center.	
Fatigue	Hypokalemia is a condition where the blood contains low levels of potassium. One of the most critical electrolytes that the body utilizes to control fluid balance, muscular contractions, and nerve messages is potassium. All of these processes can be affected and fatigued when potassium levels go too low.	2
Patient/Family side		8
Patient	Very sick and older patients are not appropriate to receive HHD. People with lower education levels are not capable of being trained on HHD. Individuals without self-motivation to manage their health and life are not suitable for HHD. Some patients are unwilling or unable to get themselves pierced because they are terrified of seeing blood or thick needles. Patients are concerned that they should dialyze without direct supervision by an HD nurse and risk of social isolation.	6
Family	Patients without a partner or family member to help them at home choose CHD. Family members are not happy to be tied to this home treatment for long periods on a daily basis especially when they have to work, it is another kind of work and a huge burden for them to come home and help the patients to finish the treatment for several hours	8

	every day.	
Health care provider side		3
Lack of programs	Most nephrology training programs in the U.S. pay less attention to home HD due to very rare HHD patients. A very small number of home dialysis centers or experienced dialysis programs are available to train patients on HHD.	3
Lack of interest	Due to the extremely low proportion of HHD use in their practice, working nephrologists and clinicians lack interest in and expertise in it.	3
Policy domain		3
Outpatient HD facility chain	Due to the growth trend of CKD and ESRD patients in the nation, outpatient hemodialysis facilities, especially for-profit facilities have grown rapidly in recent years that discouraged HHD use.	2
Lack of incentive	There is no additional incentive specifically for HHD from Medicare or private insurance to pay back the labor costs, which mainly consist of HHD nurses.	2

Question 4. What kind of support do you think would be needed for each stakeholder if you wanted to increase the proportion of home hemodialysis in your practice?

Taxonomies of interviewees' considerations and suggestions regarding the major aspects of the kind of support, for example, patient, family member, health care provider, and policy were categorized and reported in Table 4-5. Text data tagged by subcodes under each major aspect can then be further refined into its key dimension in this table. For example, several nephrologists strengthened patient education's importance during the pre-ESRD nephrology care: "*It is critical to provide patients with a satisfactory explanation of the benefits and drawbacks of the various dialysis modalities during pre-nephrology care, and also enhance and enlarge HHD training programs and give careful consideration to patient practice* *throughout the first few months of the HHD scheme.*” These data were summarized under the major kind of support aspect - “patient” dimension.

Table 4-5: Taxonomy of support to increase HHD use

Aspects/Dimensions	**Summary of data**	**No. of interviewees**
Patient		
Patient education	It is critical to provide patients with a satisfactory explanation of the benefits and drawbacks of the various dialysis modalities during pre-nephrology care, enhance and enlarge HHD training programs, and give careful consideration to patient practice throughout the first few months of the HHD scheme.	23
Early prepare	Early discovery of potential HHD patients, early referral to an assigned HHD center or training program, and early setting or placement of an arteriovenous (AV) fistula are important preparation to introduce HHD to an increased number of patients.	18
Family member		
Early involvement	The positives of HHD, including freedom, method knowledge, independence, the availability of support, scheduling flexibility, and cost-effectiveness are being emphasized more to the family by the doctors and staff. During the HHD service, healthcare providers need to strengthen the bonds between patients and medical professionals.	18
Training	The presentation and demonstration of HHD to pre-ESRD patients and their carers are the focus of an ongoing technical and clinical training program that welcomes questions, discussion, and exercises.	12
Health care		

providers (nephrologists and clinicians)		
Regional home hemodialysis center	It would be most effective to create or add regional HHD centers that are centrally coordinated to save money and utilize trained personnel.	8
Add HHD component in nephrology training	It would be more effective to add or improve HHD sessions in most nephrology training programs in the U.S. to increase nephrologists' exposure to this modality and decrease their reluctance to prescribe to the ESRD population.	10
Policy		
Encourage innovation	To increase the percentage of HHD use, and to enable lower morbidity and streamline the procedure, novel access modalities and equipment are needed. The government and industrial circles should encourage venture capital financing in the development of new equipment technologies to make hemodialysis easier and safer for patients to undertake at home, with little assistance from a family member or other aid.	5
Change in reimbursement	Changes in the Centers for Medicare and Medicaid Services (CMS) reimbursement policies and financial incentives for home dialysis are needed because HHD, whether short daily or long nightly, saves money overall by reducing staff time, requiring fewer admissions and hospital days, and reducing the need for erythropoietin and antihypertensive medications.	3

Question 5. Do you find that the decision to use home hemodialysis varies across different racial/ethnic identities?

In general, some participants observed racial/ethnic differences when people decided against adopting HHD. Several participants mentioned that people of different ages and races usually had very different attitudes toward dialysis service, social norms on home therapy, and perceived control of their health. One nephrologist said about her patients: "*Some African American patients believe that medical care should be the responsibility of medical personnel rather than patients and families, let alone hemodialysis such a complex treatment process. They never thought they could handle it at home.*" "*Latino and African American are more likely to have diabetes and cardiovascular disease, thus less likely to use HHD...*" one physician mentioned. The text data from interviewees were tagged with the above-mentioned three psychosocial factors and were reported in Table 4-6.

This table also records explicit statements of participants and draws inferences from the implicit interpretation of interview data concerning the findings of the relationship between individual characteristics (age, race, comorbidities, availability the support from family or HHD services, etc.) and HHD use. For example, one HHD nurse mentioned the racial/ethnic difference in the availability of HHD service support: "*African American neighborhoods were less likely to have hemodialysis facility offering home HD training...*" "*One African American patient's house was not spacious enough to accommodate HHD machine and disposables...*" Three interviewees said: "*Within some minority groups, patients tended to have more comorbidities and less family support. Hence, their attitudes toward dialysis service were less willing to receive home therapy.*" The most common social norms described as influencing HHD pertained to caregiving labor and strong stress on self-health management. Considering racial/ethnic minorities as home HD recipients, several participants stated their patients' concern about burdening families and perceived incapable of control of their personal health.

Interviewees also talked about racial/ethnic differences concerning social isolation, social norms about caregiving obligations, and self-motivation. One participant said: "*Some minority dialysis patients come to a facility to be connected with their peers and nurses, that's the major attitude toward dialysis service.*" Another participant said: "*They don't want to impose upon themselves and their families such a strong stress to perform daily hemodialysis at home.*" Two participants said.

Table 4-6: Taxonomy of racial/ethnic differences toward HHD use

Conceptual/Relationship	**Summary of data**	**No. of interviewees**
Psychosocial factors		
Attitudes toward dialysis services	Some African American patients believe that medical care should be the responsibility of medical personnel rather than patients and families, let alone hemodialysis such a complex treatment process. They never thought they	2

	could handle it at home. Some racial/ethnic minority dialysis patients come to a facility to be connected with their peers and nurses.	
Social norms about HHD	Elderly people, some in racial/ethnic minority groups, might not understand HHD therapy: the machine operation is too complicated, the process is too long, patients cannot afford daily procedures, etc.	8
Perceived control of personal health	Some racial/ethnic minorities like Black and Hispanic patients felt a lack of competency to manage their own health, especially when they had a lot of comorbidities with many medications frequently to take at a routine rhythm.	5
Relationships		
Explicit statement	African American neighborhoods were less likely to have hemodialysis facilities offering home HD training. One Black patient's house was not spacious enough to accommodate HHD machines and disposables. Some racial/ethnic patients do not want to impose upon themselves and their families with such strong stress to perform daily hemodialysis at home.	2
Implicit interpretation	Within some racial/ethnic minority groups, patients tended to have more comorbidities and less family support. Hence, their attitudes toward dialysis service were less willing to receive home therapy.	3

Discussion

Dialysis patients are a very high-need high-cost population. According to the 2018 annual report of United States Renal Data (USRD), across the nation, an estimated nearly 40 million adults lived with chronic kidney disease, and 750,000 ESRD patients required dialysis or a renal transplant.[5,20] Because of the very few transplants available, every year more than 100,000 new ESRD patients had to use dialysis instead of transplants to replace their kidneys' functions. However, fifty percent of these patients lived less than five years.[20] While dialysis populations comprised less than one percent of the entire Medicare population, their care cost more than seven percent of all Medicare expenditures in a year.[39] In 2018, Medicare spent about $35.4 billion for all ESRD patients and a total of $28 billion for hemodialysis therapy, averaging $90,000 per year per patient.[28,39]

Home HD has better health outcomes, and a lower cost modality but uses in the U.S. was unacceptably low. There was a consensus among practitioners in the field of renal therapeutics that HHD can be the most cost-effective way to facilitate continuous quality of care and reduce various kinds of chronic comorbidities caused by inadequate dialysis among people with ESRD because HHD was able to provide more ample treatment, longer clinical benefit and better quality of life at reasonable cost than in-center hemodialysis. Prior works of economic assessment including direct medical and nonmedical costs reinforced these conclusions.[69,70]

In contrast to the increasingly common trend of medical treatments that can be done from the comfort of one's home, a small percentage of CKF dialysis patients received home HD and home PD despite multiple studies showing that they were cheaper and just as safe.[5,10,71] According to the U.S. Government Accountability Office(GAO), people receiving home dialysis declined during the period from 1988's 16% to 2008's 9% and thereafter slightly increased to 2018's 12%, 85% of whom were on peritoneal dialysis.[5,28,72] Recently Medicare's policy that set the same payment rate for dialysis treatment regardless of the type of dialysis had given dialysis facilities financial incentive to facilitate home dialysis because it was usually less costly, however, this policy's impact was limited.[72] GAO found that dialysis facilities also had incentives in the short term to increase HD provision because each hemodialysis machine can be used for six to eight patients without needing to purchase an additional machine, which saves the facility money.[72] Within the population undergoing hemodialysis, an even smaller proportion, less than 2% of the treatments, were currently in use at home, though research has shown HHD patients tended to be healthier compared to their in-center counterparts.[5,10,71] There were a number of reasons why, according to the research. Most people cited physicians' lack of training on HHD and their resulting reluctance to suggest it to CKF patients.[73] Another reason was that sometimes ESRD patients themselves were too sick or overwhelmed to take on the hemodialysis task at home, although it was convenient and flexible for them and can be done every day.[73] Simultaneously, data also showed that racial and ethnic minorities in the U.S. were more reluctant to initiate home dialysis.[44] However, similar to white patients receiving HHD, minority patients who transition to HHD were also less likely to transfer to clinic hemodialysis and their mortality rate do not worsen over time.[44]

In late 2017, the National Kidney Foundation (NKF) organized a conference to help identify the barriers to the use of home dialysis.[22,69] Experts in all areas of the medical field attempted to address the barriers to ensure that people with ESRD and their families have a holistic view of the choice of multiple therapeutic forms.[73] Participants noted that education for patients and family members as well as for physicians and nurses was usually offered in a hurried and inconsistent manner.[31] ESRD patients pointed out that they were never presented with available alternatives and hence they could not make an informed decision regarding their renal replacement therapy.[31,73] Low adoption of home dialysis was associated with the fact that the majority of US nephrologists lack training on home modalities. US physicians have minimal exposure to HHD in stark contrast to their peers in the United Kingdom and Commonwealth countries.[73,74] Additionally, they usually have various misconceptions. For example, health providers deemed home HD too complex and cumbersome for most CKF patients, particularly the elderly.[73,75,76] By and large, US nephrologists, especially those who have been in clinical practice for over ten years, have little interest in prescribing HHD.[73,77]

This research justified the above findings. The majority of this study's interviewees confirmed that HHD was a viable treatment and the most cost-effective alternative for those with kidney disease since it did not require the use of a dialysis facility and its associated costs and that it offered many advantages over in-center hemodialysis, including greater freedom, self-sufficiency, and flexibility in scheduling, longer and more frequent dialysis treatments, more control over the dialysis prescription and process, thus a better health outcome and an improved quality of life. When participants were asked about the HHD's effectiveness compared to conventional CHD, they rated the overall effectiveness of HHD a higher weighted score of 3.1. Participants also felt that HHD was more convenient and less time-consuming than traditional in-center hemodialysis, as well as that it was a safe option and that the risks of infection and other complications were minimal. Nevertheless, participants expressed concerns about the need for additional training and support on whatever patient and family's side, or health care provider and policy side.

This study's findings on putative determinants showed as well that psychosocial factors may act as a mediator between race and ethnicity and the usage of HHD services. Compared to Whites, minority patients thought that they might have less access to the pre-nephrology care and home dialysis training they needed, that family caregiving norms and supportive environments were less prevalent, and that perceived strong stress and less autonomy in long-term home care worried them more. To frame these factors, the Andersen behavior model can be used to identify comprehensive psychosocial influences and the complex relationships between race/ethnicity and HHD use. Fig 4-2 drew lines corresponding to relationship hypotheses, which were endorsed by explicit statements of participants or by inferences from implicit interpretations of different individuals' claims.

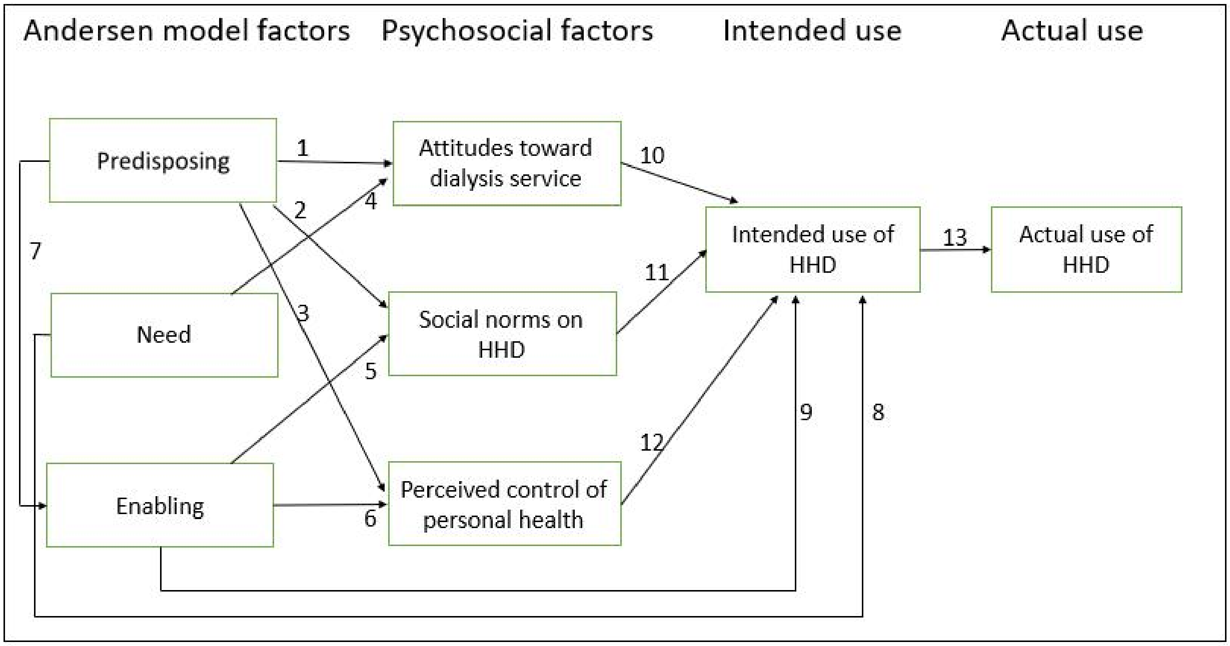


Fig 4-2: Andersen model and psychosocial factors of HHD use

Consistent with the prevailing Andersen model of health services use, predisposing, need, and enabling factors were identified as individual characteristics, patient comorbidities, and potential determinants of service use (the availability of both formal and informal support) respectively. Individual characteristics, such as age, race, sex, etc., had an impact on psychosocial factors (paths **1-3** in Fig 4-2) and enabling factors like availability of service support (path **7** in Fig 4-2). Illustrating this direct effect, one HHD nurse said: "*African American neighborhoods are less likely to have hemodialysis facility offering home HD training.*" Within some minority groups, patients tended to have more comorbidities and less family support. Hence, their attitudes toward dialysis service were less willing to receive home therapy (path **4** in Fig 4-2). "*Latino and African American are more likely to have diabetes and cardiovascular disease, thus less likely to have HHD...*" one physician mentioned (path **8** in Fig 4-2). Considering minorities as home HD recipients, some participants stated their patients' concern about burdening families and perceived incapable of control of their personal health (path **5-6** in Fig 4-2). One nurse said: "*Some minorities' houses were not spacious and clean enough to accommodate HHD machines and disposables...*" (path **9** in Fig 4-2). Concerns about social isolation, social norms about caregiving obligations, and self-motivation were all areas where racial/ethnic differences were found. "*Some racial/ethnic minority dialysis patients come to a facility to be connected with their peers and nurses, that's the major attitude toward dialysis service.*" "*And they don't want to impose upon themselves and families with such a strong stress to perform daily hemodialysis at home.*" Two interviewees said (path **10-12** in Fig 4-2). During pre-ESRD care, the intended use of HHD can influence the patient and family member's training effect, thus their actual use later (path 13 in Fig 4-2).

The main strength of this study is its approach, which was created to generate a logical framework for analyzing the usage of HHD care, specifically on racial/ethnic differences. The qualitative methodology was used to achieve this goal and was applied in a methodical and thorough manner. However, the study's limitation is important to mention, this includes the qualitative interview data coming from 23 nephrologists and healthcare providers, which provided insights into the barrier to using HHD only from the perspective of health care providers. Physician surveys tended to be less prone to talk about extensive aspects concerning ESRD patients, family members, facility owners, and policymakers.

Implications for future research and practice

The ideas derived from interview data suggest that more complex modeling of predisposing factors, such as race/ethnicity and age, is crucial for comprehending patterns of usage of HHD service among various groups, despite the fact that the impact of these variations in psychosocial factors is still an empirical issue. For example, several distinctions are apparent between the African American and White patients' norms concerning certain determinants in the use of HHD. This implies the need of future research to address various "isms" (e.g., ageism, racism, sexism, etc.) and their impact on healthcare decisions. Findings from these qualitative data may also help define ideas that will be formally explored in future quantitative research, even though statistical connections between race/ethnicity and these factors cannot be examined based on the current study design.

This research also reminds us that the healthcare system would probably need a refurbishment of professional education and clinical approaches to facilitate HHD. This may include, but not limited to, payment incentives for performing hemodialysis at home, as well as technological advances to support and simplify the operation.[45,69] Future projects will focus on identifying the best care alternatives that can improve the effective management of ESRD and co-existing conditions and eventually promote population health.

The Advancing American Kidney Health (AAKH) initiative was announced in July 2019 to transform the way kidney disease is prevented and treated in the US, which affects 37 million Americans and dialysis is one of the most burdensome, draining long-term resources in healthcare.[78] The AAKH initiative focuses on specific strategies to achieve goals such as: increasing the availability and effectiveness of person-centered treatment alternatives.[78] This includes a number of goals that enable more person-centered conversions to safe and efficient modalities for CKF, like HHD, and introduce novel value-based CKD payment models, like figuring out the particular costs associated with the available home dialysis resources that match patient preferences with health care provider incentives.[78] The AAKH initiative also includes objectives that encourage the development of novel therapeutics and integrate payment and regulatory strategies to encourage the creation of novel products such as add-on payment adjustments to support the use of certain HHD equipment or supplies furnished by ESRD facilities.[78]

Chapter 5

CONCLUSION:

As observed in Study 1, in the three U.S. nationwide retrospective cohort studies, racial/ethnic minorities were less likely to be treated with home dialysis, especially HHD, after controlling for socioeconomic factors and clinical characteristics. One factor that might contribute to this difference is a lack of regional resources to boost the home dialysis cohort in metropolitan areas where racial/ethnic minorities live. In addition, a higher prevalence of diabetic renal disease among racial/ethnic minority groups in the U.S. exacerbated the shortage of regional resources.[33,47] The result that most racial/ethnic minority patients had a lower risk of death in home dialysis compared with their White counterparts in all three countries could be explained by the fact that minorities tended to be younger and had a lower incidence of concurrent cardiovascular diseases, elements that are typically linked to increased home dialysis utilization.[33,47–49] These differences are therefore indicative of common characteristics of minority patients. Findings from the included studies revealed a survival benefit of HHD as compared with CHD, despite a lower usage rate of HHD among racial/ethnic minorities in various regions worldwide. These variations may be caused by patient or physician preferences, providers' perceptions of patients and their families' capacity to perform home dialysis, individual social differences (e.g., whether there is enough space at home and whether one can afford extra expenses), or problems with health care delivery (e.g., accessibility of pre-ESRD care or availability of a home dialysis facility in neighborhoods populated by minorities). In fact, earlier studies have presented that non-White ethnicities have less access to pre-dialysis nephrology care in the United States, which may lead to predominated Black-White and Hispanic-White racial/ethnic inequalities in PD and HHD utilization.[51,54]

The limitation of Study 1 is that there were very few studies available that specifically address the use and health outcomes of HHD versus center hemodialysis and preferences among racial/ethnic minority patients. This could limit the scope of the review and make it difficult to draw firm conclusions. Another limitation could be the heterogeneity of the studies included in the review, which includes differences in study design, patient populations, and outcomes measured. This could make it challenging to compare results across studies and could limit the generalizability of the findings. A further limitation could be missing data or incomplete reporting in some of the studies included in the review. This could introduce bias and limit the accuracy of any conclusions drawn.

In Study 2, a thorough examination of racial/ethnic disparities in HHD (vs. center hemodialysis) use and outcomes came from analysis of the USRDS' nationally representative patients starting maintenance dialysis since 2010. This enabled the researcher to draw a few important findings. **First**, HHD was much less common in the United States among every racial and ethnic minority group than it was among White people, and demographic and medical factors alone were insufficient to account for this disparity. Thus, the outcome justified the research hypothesis that HHD had lower use in the ESRD population of the United States, especially among minorities. **Furthermore**, all minority groups showed substantially lower mortality and hospitalization incidences than the White group when controlling for other risk factors; this may be because the majority of minority patients were younger than Whites and less likely to have comorbid conditions. **Finally**, within the overall and major ethnic cohorts except for Asians, HHD patients' mortality was noticeably lower than CHD patients when controlling for demographic, dialysis service years, and major coexisting diseases; and in all minority groups, HHD also showed a lower incident rate ratio for number of hospitalizations than CHD after adjustment for other covariates. These findings made it obvious that minority patients had lower risk of death and benefitted considerably from the home therapy modality, despite being less prone to use the scheme.

These results need to be interpreted in terms of their limitations, which principally resulted from the absence of information on some important clinical indicators, socioeconomic traits, or pre-dialysis nephrology care that would have provided insight into the causes of the therapeutic outcomes and racial/ethnic inequalities observed here. As far as comparing HHD with CHD was concerned, a more matched sample and long-term patient follow-up would be necessary since the relatively very small size of the HHD minority cohort made the analysis underpowered to draw a firm conclusion.

For Study 3, the majority of interviewees confirmed that HHD was a viable treatment and the most cost-effective alternative for those with kidney disease since it did not require the use of a dialysis facility and its associated costs. It also offered many advantages over in-center hemodialysis, including greater freedom, self-sufficiency, and flexibility in scheduling; longer and more frequent dialysis treatments; and more control over the dialysis prescription and process. Thus, home dialysis provided these patients with better health outcomes and greater quality of life. When participants were asked about the HHD's effectiveness compared to conventional CHD, they gave the overall effectiveness of HHD a higher weighted score of 3.1. Participants also felt that HHD was more convenient and less time-consuming than traditional in-center hemodialysis, and that it was a safe option with minimal risks of infection or other complications. Nevertheless, participants expressed concerns about the need for additional training and support for patients, family members and caregivers, healthcare providers, and policymakers. This study's findings on putative determinants also showed that psychosocial factors may act as a mediator between race and ethnicity and the usage of HHD services. Compared to Whites, minority patients thought they might have less access to the pre-nephrology care and home dialysis training they needed, that family caregiving norms and supportive environments were less prevalent, and that they would experience greater stress and less autonomy in long-term home care.

One limitation of Study 3 was that the qualitative interview data came from twenty-three nephrologists and healthcare providers, which provided insights on the barriers around HHD only from the perspectives of healthcare providers. Physician surveys tended to be less prone to talk extensively about concerns from ESRD patients, family members, facility owners, and policymakers.

Overall, the three studies presented in this dissertation contribute to our understanding of racial and ethnic inequalities in HHD treatment and outcomes. Study 1, a systematic review, found that racial and ethnic minorities had lower adjusted odds ratios for HHD treatment and lower mortality rates compared to White patients. Study 2, a quantitative research study, found that minorities were significantly less likely to use HHD than Whites but had significantly lower mortality and hospitalization rates after adjusting for covariates. These findings agreed with the earlier literature review and Study 1. Additionally, in every racial and ethnic minority cohort, HHD had both lower adjusted odds ratios for mortality and lower incident rate ratios for a number of hospitalizations compared to CHD. Study 3, a qualitative research study, found that the majority of nephrologists and health care providers in the interview viewed HHD as a viable and most cost-effective treatment option other than transplantation; however, minority and White patients might differ in their attitudes towards dialysis care and social norms surrounding HHD. Together, these studies propose that racial and ethnic inequalities in HHD utilization and outcomes may be driven by factors such as patient preferences, social norms, and access to resources.

The three studies in this dissertation have important implications for future study and clinical practice. Future studies should continue to examine the underlying factors that lead to racial and ethnic inequalities in HHD usage and outcomes, including social and community factors that may go beyond patient preferences and clinical factors.[79] The findings suggest that more complex modeling of predisposing factors, such as race/ethnicity and age, is crucial for comprehending patterns of usage of HHD service among various groups. Future research should also examine racial and ethnic variations in hospital referral rates, the impact of insurance coverage, and other clinical and socioeconomic factors.[80] Efforts should be made to identify barriers to HHD and peritoneal dialysis (PD), including cultural and logistical barriers that presently restrict minorities.[81] The research also suggests that the healthcare system needs to revamp professional education and clinical approaches to chronic kidney disease therapy, including through such measures as performing hemodialysis at home and technological advances to support and simplify the operation.[31,78,79] The findings have important implications for improving equity in dialysis treatment and pre-ESRD nephrology care, and for making sure that patients get the best care possible based on their unique needs and preferences.[32,82] By addressing these issues, we can work towards a more equitable and patient-centered approach to dialysis treatment.

The overall limitation of this Ph.D. project based on the three studies described is that the focus on racial and ethnic inequalities in HHD treatment and outcomes may not fully capture the complication of the issues that contribute to these inequalities. While the studies provide important insights into patient attitudes, preferences, and clinical outcomes, they do not address broader social and contextual factors that may result in inequalities in HHD use and outcomes, such as systemic racism, economic inequality, and geographic barriers to care.[79] Addressing these broader factors may require a more interdisciplinary approach that goes beyond the scope of the current project. Additionally, the studies may be limited by potential biases or confounding factors that were not completely accounted for in the analyses, highlighting the need for further research in this area.

In conclusion, there are major obstacles and considerable racial and ethnic variations in HHD utilization and health outcomes in the U.S. In order to make long-lasting progress for the overall population of individuals receiving maintenance dialysis, it is crucial to comprehend these barriers and causes of the racial/ethnic inequalities especially since ESRD disproportionately affects racial/ethnic minorities. The promotion of HHD therapy will probably require systematic regulation in chronic kidney disease management and education, additional incentives for implementing HHD, and technological innovation to simplify the operation of HHD schemes.[69,73]

Appendix

Appendix 1: PRISMA checklists

Abstract

Section and topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	p. 1
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	p. 2
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	p. 2
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	p. 2
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	p. 2
Synthesis of results	6	Specify the methods used to present and synthesize results.	p. 2
RESULTS			
Included studies	7	Give the total number of included studies and participants and	p. 2

		summarize relevant characteristics of studies.	
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favored).	p. 2
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	N/A
Interpretation	10	Provide a general interpretation of the results and important implications.	p. 2
OTHER			
Funding	11	Specify the primary source of funding for the review.	N/A
Registration	12	Provide the register name and registration number.	N/A

Source: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;**372**:n71.

Manuscript

Section and topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p. 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	p. 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p. 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p. 4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p. 4
Information sources	6	Specify all databases, registers, websites, organizations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p. 5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p. 5 and Appendix 2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p. 5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p. 5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p. 5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p. 5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p. 5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	p. 6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	N/A
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A

Section and topic	Item #	Checklist item	Location where item is reported
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	N/A
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	N/A
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	p. 6
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p. 6
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	N/A
Study characteristics	17	Cite each included study and present its characteristics.	Appendix 3
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Figure 2 and Appendix 4
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Appendix 3
Results of syntheses	20a	For each synthesis, briefly summarize the characteristics and risk of bias among contributing studies.	Table 1 and Figure 2
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	p. 5
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p. 9
	23b	Discuss any limitations of the evidence included in the review.	N/A
	23c	Discuss any limitations of the review processes used.	N/A
	23d	Discuss implications of the results for practice, policy, and future	pp. 10-11

Section and topic	Item #	Checklist item	Location where item is reported
		research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	p. 4
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	p. 4
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	p. 12
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Source: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;**372**:n71.

Search strategies

Section and topic	Item #	Checklist item	Location where item is reported
INFORMATION SOURCES AND METHODS			
Database name	1	Name each individual database searched, stating the platform for each.	p. 5 and Appendix 2
Multi-database searching	2	If databases were searched simultaneously on a single platform, state the name of the platform, listing all of the databases searched.	N/A
Study registries	3	List any study registries searched.	N/A
Online resources and browsing	4	Describe any online or print source purposefully searched or browsed (e.g., tables of contents, print conference proceedings, web sites), and how this was done.	N/A
Citation searching	5	Indicate whether cited references or citing references were examined, and describe any methods used for locating cited/citing references (e.g., browsing reference lists, using a citation index, setting up email alerts for references citing included studies).	p. 5
Contacts	6	Indicate whether additional studies or data were sought by contacting authors, experts, manufacturers, or others.	p. 9
Other methods	7	Describe any additional information sources or search methods used.	N/A
SEARCH STRATEGIES			
Full search strategies	8	Include the search strategies for each database and information source, copied and pasted exactly as run.	Appendix 2
Limits and restrictions	9	Specify that no limits were used, or describe any limits or restrictions applied to a search (e.g., date or time period, language, study design) and provide justification for their use.	p. 5 and Appendix 2
Search filters	10	Indicate whether published search filters were used (as originally designed or modified), and if so, cite the filter(s) used.	N/A
Prior work	11	Indicate when search strategies from other literature reviews were adapted or reused for a substantive part or all of the search, citing the previous review(s).	N/A
Updates	12	Report the methods used to update the search(es) (e.g., rerunning searches, email alerts).	Search not updated
Dates of searches	13	For each search strategy, provide the date when the last search occurred.	Appendix 2
PEER REVIEW			
Peer review	14	Describe any search peer review process.	N/A
MANAGING RECORDS			
Total Records	15	Document the total number of records identified from each database and other information sources.	Appendix 2
Deduplication	16	Describe the processes and any software used to deduplicate records from multiple database searches and other information sources.	p. 5

Source: Rethlefsen ML, Kirtley S, Waffenschmidt S, Ayala AP, Moher D, Page MJ, Koffel JB, Blunt H, Brigham T, Chang S, *et al.* PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. *Syst Rev* 2021;**10**:39.

Appendix 2: Search strategies

EBSCO databases: Academic Search Ultimate, CINAHL, and MEDLINE

Date: June 12, 2022

Search ID#	Search strategies	Academic Search Ultimate	CINAHL	MEDLINE
S1	TI ("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*) OR AB ("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*) OR SU ("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*)	2,080,251	433,430	1,461,788
S2	TI (("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*)) OR AB (("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*)) OR SU (("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*))	14,674	10,377	39,053
S3	S1 AND S2	1,147	944	3,167
S4	*Limiters* - Peer Reviewed; Published Date: 2004-2022 *Expanders* - Apply equivalent subjects *Narrow by Language:* English *Search modes* - Find all my search terms	**1,002**	**748**	**2,432**

Public Health (ProQuest)

Date: June 12, 2022

Search ID#	Search strategies	Results
S1	ti("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*) OR ab("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*) OR mainsubject("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*) *Limit to:* Peer reviewed, Scholarly journals, Publication date (2004-2022)	182,284
S2	ti(("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*)) OR ab(("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*)) OR mainsubject(("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*)) *Limit to:* Peer reviewed, Scholarly journals, Publication date (2004-2022)	2,185
S3	S1 AND S2	**289**

PubMed

Date: June 12, 2022

Search ID#	Search strategies	Results
#1	"American Indians or Alaska Natives"[MeSH Terms] OR "American Indian*"[Title/Abstract] OR "Alaska Native*"[Title/Abstract] OR "Native American*"[Title/Abstract] OR "Asian Americans"[MeSH] OR "Asian"[Title/Abstract] OR "Chinese"[Title/Abstract] OR "Filipino"[Title/Abstract] OR "Japanese"[Title/Abstract] OR "Korean"[Title/Abstract] OR "Vietnamese"[Title/Abstract] OR "Black*"[Title/Abstract] OR "African American*"[Title/Abstract] OR "African Americans"[MeSH Terms] OR "Hispanic or Latino"[MeSH Terms] OR "Hispanic"[Title/Abstract] OR "Latino"[Title/Abstract] OR "Chicano"[Title/Abstract] OR "Mexican"[Title/Abstract] OR "Puerto Rican*"[Title/Abstract] OR "Native Hawaiian or Other Pacific Islander"[MeSH Terms] OR "Native Hawaiian*"[Title/Abstract] OR "Other Pacific Islander*"[Title/Abstract] OR "Whites"[MeSH Terms] OR "White"[Title/Abstract] OR "Caucasian"[Title/Abstract] OR "race"[Title/Abstract] OR "racial"[Title/Abstract] OR "ethnicity"[Title/Abstract] OR "ethnic"[Title/Abstract] OR "minorit*"[Title/Abstract]	1,374,519
#2	"kidneys, artificial"[MeSH Terms] OR "artificial kidney*"[Title/Abstract] OR "hemodialysis, home"[MeSH Terms] OR "haemo dialys*"[Title/Abstract] OR "haemodialys*"[Title/Abstract] OR "hemo dialys*"[Title/Abstract] OR "hemodialys*"[Title/Abstract] OR "renal dialys*"[MeSH Terms:noexp] OR "renal dialys*"[Title/Abstract]	128,216
#3	"home"[Title/Abstract] OR "homebased"[Title/Abstract] OR "center*"[Title/Abstract] OR "clinic*"[Title/Abstract] OR "hospital*"[Title/Abstract] OR "satellite"[Title/Abstract] OR "facilit*"[Title/Abstract]	7,057,281
#4	#2 AND #3	45,645
#5	#1 AND #4	3,727
#6	#5 limited to 2004-2022 year range	3,065
#7	#6 limited to English	**2,970**

BIOSIS Preview (Web of Science)

Date: June 12, 2022

Search ID#	Search strategies	Results
#1	TI=("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*)	406,773
#2	AB=("American Indian*" OR "Alaska Native*" OR "Native American*" OR Asian OR Chinese OR Filipino OR Japanese OR Korean OR Vietnamese OR Black OR Blacks OR "African American*" OR Hispanic OR Latino OR Chicano OR Mexican OR "Puerto Rican*" OR "Native Hawaiian*" OR "Other Pacific Islander*" OR White OR Caucasian OR race OR racial OR ethnicity OR ethnic OR minorit*)	951,212
#3	#1 OR #2	1,108,664
#4	TI=(("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*))	2,417
#5	AB=(("artificial kidney*" OR haemo-dialys* OR haemodialys* OR hemo-dialys* OR hemodialys* OR "renal dialys*") AND (home OR homebased OR center* OR clinic* OR hospital* OR satellite OR facilit*))	12,881
#6	#4 OR #5	14,465
#7	#3 AND #6	1,195
#8	#7 limited to 2004-2022	878
#9	#8 limited to English	863
#10	#9 limited to Articles	**748**

Appendix 3: Characteristics of included studies

	Hall et al.	Mehrotra et al.	Shen et al.	Shen et al.	Trinh et al.	Yeung et al.
Authors	Yoshio N. Hall, Ping Xu, Glenn M. Chertow, and Jonathan Himmelfarb	Rajnish Mehrotra, Melissa Soohoo, Matthew B. Rivara, Jonathan Himmelfarb, Alfred K. Cheung, Onyebuchi A. Arah, Allen R. Nissenson, Vanessa Ravel, Elani Streja, Sooraj Kuttykrishnan, Ronit Katz, Miklos Z. Molnar, and Kamyar Kalantar-Zadeh	Jenny I. Shen, Kevin F. Erickson, Lucia Chen, Sitaram Vangala, Lynn Leng, Anuja Shah, Anjali B. Saxena, Jeffrey Perl, and Keith C. Norris	Jenny I. Shen, Lucia Chen, Sitaram Vangala, Lynn Leng, Anuja Shah, Anjali B. Saxena, Jeffrey Perl, and Keith C. Norris	Emilie Trinh, Yingbo Na, Manish M. Sood, Christopher T. Chan, and Jeffrey Perl	Emily K. Yeung, Kevan R. Polkinghorne, and Peter G. Kerr
Year	2014	2016	2019	2020	2017	2021
Study title	Characteristics and performance of minority-serving dialysis facilities	Racial and ethnic disparities in use of and outcomes with home dialysis in the United States	Expanded prospective payment system and use of and outcomes with home dialysis by race and ethnicity in the United States	Socioeconomic factors and racial and ethnic differences in the initiation of home dialysis	Racial differences in home dialysis utilization and outcomes in Canada	Home and facility hemodialysis patients: a comparison of outcomes in a matched cohort
Country	The United States	The United States	The United States	The United States	Canada	Australia
Continent	North America	North America	North America	North America	North America	Oceania
Study design	Retrospective cohort studies	Retrospective cohort studies	Retrospective cohort studies	Retrospective cohort studies	Retrospective cohort studies	Retrospective cohort studies
Sample size	n=320,046 No. of facilities=4,774	n=162,050 No. of facilities=2,217	n=523,526	n=523,526	n=66,600	n=594
Participants characteristics	Age: >18 years Gender: male, female.	Age: >18 years Gender: male, female.	Age: >18 years Gender: male,	Age: >18 years Gender: male, female.	Age: >18 years Gender: male, female.	Age: >18 years Gender: male,

	Hall et al.	**Mehrotra et al.**	**Shen et al.**	**Shen et al.**	**Trinh et al.**	**Yeung et al.**
	Geographic area: nation-wide Race: White, Black, Asian, other; categorize facility according to non-White patients' proportion	Geographic area: 43 states and District of Columbia Race: White, Black, Hispanic, Asian, other	female. Geographic area: nation-wide Race: White, Black, Hispanic, Asian, other	Geographic area: nation-wide Race: White, Black, Hispanic, Asian, other	Geographic area: nation-wide Race: White, Black, Asian, Aboriginal, Indian subcontinent, other	female. Geographic area: HHD pts. from Monash Health network and facility HD pts. from nationwide Race: White, Black, Asian, Aboriginal, Indian subcontinent, other
Type of dialysis facilities	Minority-serving facility v. White-serving facility	In-center HD facility, Home HD, PD	In-center HD facility, Home HD, PD	In-center HD facility, Home HD, PD	In-center HD facility, Home HD, PD	Facility HD v. HHD
Dialysis duration	During 2004–2008	During 2007–2011	During 2005–2013	During 2005–2013	During 1996–2012	During 2000–2017
Data collection methods	Obtained dialysis facility- and patient-level data from USRDS (the national data registry of patients with end-stage renal disease) and linked these data with clinical performance. measures from the CMS.	Analyzed data of patients who initiated maintenance dialysis and were admitted to any of the 2,217 dialysis facilities in 43 states operated by a single large dialysis organization.	Obtained dialysis facility- and patient-level data from USRDS (the national data registry of patients with end-stage renal disease).	Obtained dialysis facility- and patient-level data from USRDS (the national data registry of patients with end-stage renal disease).	Studied patients starting maintenance dialysis in the Canadian Organ Replacement Register (CORR).	Analyzed HHD patients from a major hospital network matched with 413 facility HD patients from Australia and New Zealand Dialysis and Transplant Registry.
Dates **(data collection initiated and completed)**	Between June 30, 2005 and September 30, 2008	Between January 1, 2007 and December 31, 2011	Between January 1, 2005 and December 31, 2013	Between January 1, 2005 and December 31, 2013	Between January 1, 1996 and December 21, 2012	Between January 1, 2000 and June 30, 2017
Outcome(s)	Minority facilities were less likely to offer HHD and exhibited worse than expected survival as compared with facilities serving	Compared with Whites, the adjusted odds for racial/ethnic groups treated with HHD were significantly lower; the adjusted risk of death were significantly	Home dialysis use increased in all groups and racial/ethnic differences decreased over time. In 2005-2007, except for	Compared to Whites patients, the adjusted odds ratio for racial/ethnic groups in initiation of dialysis with HHD were significantly	Compared to Whites, the adjusted odds ratio were for racial/ethnic groups treated with HHD. Among patients on HHD, no significant	After adjusting for BMI, smoking, races and comorbidities, HHD was associated with a significantly reduced risk

	Hall et al.	**Mehrotra et al.**	**Shen et al.**	**Shen et al.**	**Trinh et al.**	**Yeung et al.**
	predominantly White patients (p<0.001)	lower among Blacks but similar for other racial/ethnic groups treated with HHD; Black patients treated with HHD had a higher risk for transfer to in-center HD.	lower HHD initiation in Hispanic patients, there was no statistically significant difference for Black and Asian patients as compared with White patients; there were also no statistically significant temporal changes in these trends for HHD. The mortality rate of home dialysis was lower for minority patients than for White patients.; this difference increased over time (p<0.01). Black patients. are at a disadvantage in terms of transplantation and transfer to in-center HD.	lower.	racial/ethnic differences in patient and technique survival were observed.	of death compared to facility HD. Transplantation rates, graft survival and biochemical control were comparable.
Limitations	1) Administrative data for determining the racial-ethnic composition of the dialysis facilities that has the potential for misclassification bias. 2) Had no information on	The lack of availability of data on socioeconomic characteristics or pre-dialysis care could have shed light on the reasons for racial/ethnic differences.	1) Did not have data on physician and patient attitudes toward certain modalities, nor did have information on what kind of education patients received about the	1) Did not have data for physician and patient attitudes toward certain modalities, what kind of modality education they received, or individual-level educational attainment, income, and	1) Absence of validation of race could have led to misclassification. Racial data were missing in 8% of patients. 2) The relatively small number of patients treated with home HD could have	1) Matching controls (facility HD patients) to cases (HHD patients) were limited by the availability of suitable controls. Cases and controls were not matched by

	Hall et al.	Mehrotra et al.	Shen et al.	Shen et al.	Trinh et al.	Yeung et al.
	the racial-ethnic composition of persons employed by dialysis facilities. 3) The performance measures that we examined here may not adequately capture between-facility care differences that contribute to patient- and facility-level morbidity and mortality.		different dialysis modalities. 2) Race/ethnicity is primarily a social construct and may reflect a large number of additional unmeasured sociocultural factors.	language. 2) Also excluded patients with missing zip codes and data for pre-dialysis nephrology care, which may have led to selection bias. 3) Some of the analyses, particularly the ones for HHD and the geographic sub-analyses for Asians, were not well-powered.	limited the power to detect significant findings in this subgroup. 3)Information regarding language, immigration status, center-specific experience with home dialysis, data on the circumstances under which patients initiated dialysis, and data from the province of Quebec were not available.	dialysis vintage. While three controls were successfully matched to each case, some controls were matched to more than one case. 2) There is no variable that takes into account patient motivation and health literacy.

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