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Initial Session Duration and Mortality Among Incident Hemodialysis Patients

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Abstract

Background—The association of dialysis session duration with mortality in patients undergoing maintenance hemodialysis is unclear. We compared mortality rates of patients treated in dialysis facilities that used initial session durations of either 4 or more versus 3 hours for all incident patients.

Study Design—Retrospective cohort study

Settings & Participants—Patients with end stage renal disease (ESRD) beginning maintenance hemodialysis in January 2006–December 2010 and followed up through December 2012, including 39,172 patients in 852 facilities that initiated treatment for 4 or more hours and 47,721 patients in 631 facilities that initiated treatment for 3 hours.

Predictor—Initial session duration of 4 or more versus 3 hours

Outcome—2-year and 1-year mortality rates

Results—The total number of deaths observed within 2 years after initiating dialysis was 8,945 in the 4-hour group, and 15,624 in the 3-hour group. The corresponding numbers of deaths observed within 1 year were 5,492 and 10,372, respectively. The 2-year adjusted HR in the 4-hour versus 3-hour group was 0.79 (95% CI, 0.73–0.86). The corresponding 1-year adjusted HR was 0.77 (95% CI, 0.70–0.84). Results were robust when the analyses were restricted to specific subgroups of patients classified by age, gender, race, and select clinical characteristics.

Limitations—We did not observe hemodialysis duration in sessions subsequent to initiation. We only included patients treated in facilities with uniform session length (at initiation) for all of their patients. Furthermore, we lacked information on dialysis dosage and patients' baseline residual kidney function.

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Conclusions—Patients in facilities routinely initiating hemodialysis for 4 or more hours may have substantially lower mortality as compared with patients in facilities initiating for only 3 hours of treatment.

Keywords

Renal Hemodialysis; treatment time; session length; dialysis duration; Dialysis Facilities; death; Mortality rate; facility-level analysis; quasi-experimental design; end-stage renal disease (ESRD)

Since the Medicare program extended coverage to patients with end stage renal disease (ESRD) 4 decades ago, the average number of hours per hemodialysis session has declined from 6 hours in 1973 to 3.5–4 hours in 2010.¹ Although this decline may be partly explained by the improved efficiency of dialyzers¹, the clinical consequences of shorter session durations for this high-risk cohort remain unclear.

The National Cooperative Dialysis Study (NCDS) remains the only randomized controlled clinical trial to have tested the relationship between session length and hospitalization.² The relationship between longer session length and a lower risk of hospitalization in this study did not reach statistical significance. The landmark Hemodialysis (HEMO) trial found no evidence that more intensive dialysis, as compared with regimens recommended under accepted practice guidelines, reduce mortality.³ However, the study was not designed to assess the independent effect of longer session length. Observational studies of the association of dialysis session duration with mortality have not produced consistent findings. Some studies^{4–7} found evidence that longer session duration was associated with lower mortality, while others report longer session duration was associated with higher mortality⁸ and that the relationship between session length and mortality varied across countries.⁹

The primary challenge of observational studies is that providers may assign patients to shorter or longer dialysis session durations according to their clinical risk.¹⁰ We address this problem by focusing our primary analysis on the many dialysis centers in the United States that prescribe the exact same session duration to all patients initiating maintenance hemodialysis (either 4 or more or 3 hours) and therefore do not appear to select their incident patients for varying session lengths.

METHODS

Data Source and Study Population

We examined data from the Renal Information Management System (REMIS), available from the data repository at the Centers for Medicare & Medicaid Services (CMS). The data include information on patient demographic and clinical characteristics, facility-level characteristics, the date of first maintenance hemodialysis and the length of each hemodialysis session (hours), and the date of death. Brown University's IRB approved the study and waived the requirement for informed consent (approval # 1107000452).

From the REMIS data and, more specifically, the data entered from the Medical Evidence form, we identified 463,288 patients who initiated dialysis during January 1st 2006–December 31st 2010 and who were aged 20–90 years at the time of initiation. These data,

entered around the time of initiation, also include a question that asks the number of hours that a patient is undergoing hemodialysis (response to question 23 in the form) as well as information on the number of dialysis sessions per week. The data on hemodialysis hours is reported in integer values (i.e., 3 hours, 4 hours, 5 hours). The Medical Evidence form, including the report on hemodialysis hours, is expected to be submitted within 45 days of the patient initiating dialysis. Since we focused on patients who were undergoing in-center hemodialysis exactly 3 times per week and reported non-missing hemodialysis hours on the medical evidence form, we excluded 11,451 patients since they did not receive exactly 3 dialysis sessions per week, and a further 90,472 patients were excluded since no information on hemodialysis hours was provided. In addition, we excluded patients who were not in facilities that were uniformly treating patients to either 4 or more hours or 3 hours (269,251 patients), although a sensitivity analysis included these individuals as described in the Statistical Analysis section. We excluded those with missing observations on any of the individual-level variables shown in Table 1 (2,443 observations dropped). In addition, 2,778 observations could not be matched to the facility-level data base in REMIS. Thus, our final analytic sample included 86,893 patients (see Figure 1 for flowchart). Of this sample, 39,172 patients were in one of 852 facilities that initiated treatment for all patients for 4 or more hours while 47,721 patients were undergoing hemodialysis in one of 631 facilities that initiated treatment for all patients for 3 hours.

Measures

Our outcomes were 2-year and 1-year mortality following initiation of hemodialysis. Our primary independent variable was an indicator variable of whether the patient initiated hemodialysis in a facility that treated all incident patients with 4 or more hours per session of hemodialysis or in facilities that treated all incident patients with 3 hours of per session of hemodialysis. Of note, patients who switched their hemodialysis facility during the study period were retained in the analysis and assigned to their session duration at initiation of dialysis therapy.

Individual-level covariates included age, gender, race (i.e., indicator variables for black and other race groups), laboratory variables at initiation of dialysis reported on Medical Evidence Form 2728 (estimated glomerular filtration rate [eGFR] derived using the IDMS-traceable 4-variable MDRD [Modification of Diet in Renal Disease] Study equation, central venous catheter as vascular access, albumin level ≥ 3.5 g/dl, hemoglobin level (in g/dl), body mass index, primary cause of ESRD (hypertension, diabetes, other), history of cancer, and history of heart disease. Facility-level covariates included ownership status of the facility, number of dialysis stations and indicator variables denoting whether the facility was free-standing, accepted transient patients, had evening dialysis sessions, re-used dialyzers, only offered hemodialysis, and had isolation dialysis stations. All of the aforementioned individual-level variables were reported as of the date when the individual initiated dialysis. We also include indicator variables to denote the calendar year of incidence.

Statistical Analysis

Primary Analysis—In our main analysis, we modeled 2-year and 1-year mortality among incident patients undergoing maintenance hemodialysis in 4-hour and 3-hour facilities. We censored 5,094 patients who received kidney transplants at the date of their transplantation

We estimated Cox proportional hazards models for 2-year and 1-year mortality, with the hemodialysis session duration (4 versus 3 hours) as the main independent variable, adjusting for the aforementioned covariates. For each analysis (2-year and 1-year Cox model), follow-up time was censored at the respective time (i.e. 730 and 365 days).

We plotted Kaplan-Meier survival curves (using inverse probability weights) for patients treated in the two groups of facilities (i.e., 4 versus 3 hours), and calculated the 75th percentile on survival probabilities in each of the two groups. Finally, we estimated the proportional hazard model for 1-year mortality separately by age, gender, race, and by the presence or absence of heart disease, diabetes, and hypertension. All models are estimated using STATA/SE 12.0, (StataCorp LP, College Station, Texas).¹¹

Our primary analysis uses inverse probability weights calculated from the propensity scores to reweight the data.¹² We first estimate a logit model where the outcome is equal to 1 if the patient was treated in a 4-hour facility and the outcome is equal to 0 if the patient was treated in a 3-hour facility. The independent variables were all those included in Tables 1 and 2 (individual and facility level, respectively). The model was used to generate a predicted probability for each individual i denoted as $\hat{p}_i$. Using this probability, stabilized

weights were generated such that $\text{weight} = \sum_i \hat{p}_i / \hat{p}_i$ for patients treated in 4-hour facilities

and $\text{weight} = \sum_i (1 - \hat{p}_i) / (1 - \hat{p}_i)$ for patients treated in 3-hour facilities. These weights were used to reweight the observations prior to estimating the Cox proportional hazard model. Standard errors were clustered at the level of the facility.

Internal Validity of 4-Hour Versus 3-Hour Initial Treatment—Data on session duration is provided as discrete integers (i.e., 4 or 3 hours) and are available only at the time of initiation of hemodialysis. However, data we received for the year 2012 and 2013 also include information on continuous hemodialysis hours (measured at the hundredth decimal point) from the medical evidence form. Using these data we were able to match 82,404 patients (out of 111,329 patients) with non-missing continuous hours for a dialysis session around the time of initiation. We used this information on continuous hours to calculate the average hemodialysis session length among patients in 4-hour and 3-hour facilities. This approach allowed us to assess the validity of our main predictor: session duration at initiation when hours are reported in integer values.

Sensitivity Analysis—We tested the sensitivity of our estimates in 2 ways. First, rather than only including the 4-hour-only and 3-hour-only facilities, we slotted facilities into four mutually exclusive quartiles: (i) 0%–48% percent of patients with session length of 4 hours, (ii) 48.01%–76.65% of patients with session length of 4+ hours (iii) 76.66%–91.61% of patients with session length of 4 hours, and (iv) 91.62%–100% of patients with

session length of 4+ hours. We estimated a Cox proportional hazard model, after adjusting for all the variables used in our primary analysis, and using dummy variables for quartiles (quartile (i) is the reference). Second, we used Cox proportional hazard models to estimate 2-year mortality hazard ratios (HRs) separately for each year of dialysis initiation.

RESULTS

Patient and Facility Characteristics

Characteristics of the 86,893 patients in our study are summarized in Table 1. Individuals treated at 4-hour facilities were about 3 years younger than those at 3-hour facilities, and a larger proportion of patients treated in the 4-hour facilities were black (39% versus 21%). Most of the other average individual-level characteristics were similar across the 4-hour and 3-hour facilities.

In Table 2 we present the difference in the facility-level characteristics between the 4-hour and 3-hour facilities. The main differences were that the 3-hour facilities were 8 percentage points less likely to accept transient patients, 8 percentage points more likely to have evening dialysis sessions, 10 percentage points more likely to report isolation dialysis sessions, and 10 percentage points less likely to reuse dialyzers than facilities consistently treating patients to 4 hours. Further, ZIP Codes where the 4-hour facilities were located had a lower total number of patients (55) than ZIP Codes where the 3-hour facilities (71 patients) were located.

Primary Outcomes

The mortality outcomes of the patients in the study cohort are summarized in Table 3. The total number of deaths observed at 2 years was 8,945 in the 4-hour group, and 15,624 in the 3-hour group. The corresponding numbers of deaths observed within 1 year of initiating dialysis were 5,492 and 10,372, respectively. Among patients who underwent dialysis in 4-hour facilities, the 2-year mortality rate was 13.1 per 100 person-years, whereas this rate was 20.5 per 100 person-years among those in the 3-hour facilities. Corresponding numbers for 1-year mortality rates were 15.2 and 25.0 per 100 person-years, respectively.

Figure 2 plots the unadjusted inverse probability-weighted Kaplan-Meier survival curves separately for 4-hour and 3-hour facilities. Seventy five percent of the incident patients in a 4-hour facility were still surviving 2-years after initiation. However, for their counterparts in 3-hour facilities, 75% were still surviving about 1.5 years after initiation.

In Table 4, we present the unadjusted and adjusted estimates derived from a proportional hazard model. The 2-year hazard of death among persons dialyzed in 4-hour facilities was 0.72 (95% confidence interval [CI], 0.66–0.78) in a model that simply adjusted for the year of initiation (column 1). After adjusting for individual demographic and clinical characteristics (column 2), the HR was 0.78 (95% CI, 0.71–0.85). Finally, in a model that uses inverse probability weights to reweight the data (column 3), the HR was 0.79 (95% CI, 0.73–0.86). Corresponding HRs for 1-year mortality were 0.70 (95% CI, 0.64–0.76), 0.76 (95% CI, 0.69–0.83), and 0.77 (95% CI, 0.70–0.84), respectively.

In Figure 3, we present the estimates of HRs and 95% CI (based on a natural logarithm scale) stratified by age, gender, race, and presence or absence of heart disease and diabetes. The estimates were similar to those obtained in the primary analyses (Table 4) and suggest a consistent association of 4-hour initial session duration with lower mortality, as compared with 3 hours of initial session duration.

Validation and Sensitivity Analyses

We used information on continuous hemodialysis hours reported in the data for the years 2012 and 2013 to calculate the average hemodialysis session length among patients in 4-hour and 3-hour facilities. Among patients assigned to 4-hour facilities (based on initial session duration), the average session length was 3.81 (95% CI, 3.80–3.82) hours. Similarly, among patients assigned to 3-hour facilities, the average hemodialysis session duration during hospitalization was 3.20 (95% CI, 3.19–3.21) hours.

In our first set of sensitivity analyses, we found a moderately graded relationship between the facility's proportion of patients who were dialyzed with 4 hours of treatment time and that facility's adjusted mortality rate. Specifically, relative to facilities in the lowest quartile of the proportion of incident patients dialyzed with 4 hours of session length, 2-year mortality HRs were 0.82 (95% CI, 0.76–0.90) in the highest quartile, 0.93 (95% CI, 0.86–1.02) in the third quartile, and 0.94 (95% CI, 0.87–1.03) in the second quartile. The second set of sensitivity analyses split the sample by year of dialysis initiation. The HRs for 2-year mortality in the 4-hour facilities in 2006, 2007, 2008, 2009, and 2010 were 0.76 (95% CI, 0.69–0.83), 0.78 (95% CI, 0.71–0.85), 0.81 (95% CI, 0.73–0.89), 0.82 (95% CI, 0.73–0.91), and 0.82 (95% CI, 0.72–0.92) respectively.

DISCUSSION

In this quasi-experimental study of patients initiating maintenance hemodialysis from 2006 through 2010, we examined the effect on mortality of being treated in a facility that uniformly initiates hemodialysis for 4 or more hours versus being treated in a facility that uniformly initiates hemodialysis for 3 hours. Propensity matched patients in facilities that assigned all of their patients to 4 or more hours of hemodialysis had a significantly lower probability of death at one and two years following initiation of dialysis relative to their counterparts entering facilities exclusively providing 3 hours of hemodialysis. The propensity adjusted 2-year HR of mortality was 0.79 (95% CI, 0.73–0.86) and the 1-year HR was 0.77 (95% CI, 0.70 to 0.84) among patients treated in 4-hour facilities (relative to 3-hour facilities).

Although several studies have examined the association of hemodialysis session duration on mortality, to our knowledge no study has done so using a quasi-experimental design that compares mortality estimates between patients in “4-hour” and “3-hour” facilities. This is particularly important in light of our finding that, in the entire incident population of dialysis patients, those with lower eGFR are more likely to be prescribed 4-hour treatment. The actual prescription of hemodialysis session length is based on a multitude of factors, many of which might not be observed in our data. Nevertheless, observational studies that are based on patient-level variation in hemodialysis session duration will naturally be subject to

the potential bias due to confounding by indication.¹⁰ This further underscores the importance of the approach we used in this current analysis.

If patients' clinical risk does not influence their referral to facilities that exclusively offer either 4 or 3 hours of initial hemodialysis session duration, the results of our study may approximate the causal effect of increasing hemodialysis session length on mortality rates, particularly early in the implementation of hemodialysis treatment which we observe in our data. The characteristics of patients entering 4-hour facilities appeared to be fairly similar to those of patients entering 3-hour facilities, lending support to this assumption. The only notable difference was a higher proportion of black patients entering 4-hour facilities. However, our primary analysis included race as a covariate, and the results from the stratified analysis suggest statistically robust effects across racial sub-groups. Indeed, our estimates are slightly larger than those obtained in prior studies based on comparing patients assigned to 3-hour versus 4-hour treatments, which may reflect our quasi-experimental design.^{13–14}

A large pragmatic trial testing the effect of offering all incident patients 4.25 hours of hemodialysis session duration versus usual care is currently underway, reinforcing the importance of this issue for the clinical management of this vulnerable population.¹⁵ About 400 dialysis facilities across the United States are being randomized into these two groups, and it will be useful to compare these quasi-experimental findings with the forthcoming results from the experimental trial currently underway.

The first and main limitation of this study is that, by design, we focused on a relatively small subset of dialysis facilities in the United States that treated all incident patients with the same session duration (either 4 hours or 3 hours). It is therefore unclear to what extent our findings generalize to centers that vary treatment times for incident patients. Of note, in a sensitivity analysis, we found a graded relationship between the proportion of each dialysis facility's incident patient population who received 4 hours of initial treatment and lower mortality. Second, because we observed the large majority of patients to be treated with either 3 or 4 hours, our study cannot examine the association of treatment beyond 4 hours with survival. Third, we only have data on hemodialysis session duration at the time when the CMS 2728 (medical evidence) form was filled, and these data are provided to us in integers rather than a continuous measure. Patients could have switched dialysis providers or providers may have altered hemodialysis session length subsequently based on the clinical response of the patient to initial treatment, thus blurring the differences in exposures. However, we expect that any "switching" of session duration after initiation would bias our estimates to the null, since high-risk patients are probably more likely to be switched to longer session lengths.

Fourth, we do not have information on dialysis dosage or residual kidney function, two key variables that influence session length. Finally, it is possible that facilities that assigned every patient to 3-hours of hemodialysis treatment may provide care of lower overall quality, contributing to higher mortality outcomes due to factors causally unrelated to session length. The propensity scores are used to generate the inverse probability weights, but this exercise can only reduce potential bias in estimates due to "observable" differences in the quality of

care across 4-hour versus 3-hour facilities. It cannot address or correct for biases arising from unmeasured differences in the quality of care across the two aforementioned types of facilities.

In conclusion, we conducted a nationally representative, quasi-experimental study of hemodialysis outcomes in a select group of facilities that appear to assign the exact same initial treatment times to all of their incident patients, irrespective of clinical risk. We find that survival within 2 years is higher among patients who initiate hemodialysis in facilities that uniformly treat all incident patients with 4 or more hours of hemodialysis relative to their counterparts who initiate hemodialysis in facilities that treat all incident patients for 3 hours. This analysis suggests that longer hemodialysis session length may improve outcomes, although further study is needed to establish the degree to which these findings generalize to facilities that prescribe varying hemodialysis session durations.

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Contributions: Research idea and study design: SS; data acquisition: VM, SS; statistical analysis: SS; data analysis/interpretation: SS, ANT, RM, VM; supervision or Mentorship: SS, AT. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved. SS takes responsibility that this study has been reported honestly, accurately, and transparently; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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References

1. Lacson E Jr, Brunelli SM. Hemodialysis treatment time: A fresh perspective. *Clin J Am Soc Nephrol.* 2011; 6:2522–2530. [PubMed: 21885788]
2. Lowrie EG, Laird NM, Parker TF, Sargent JA. Effect of the Hemodialysis Prescription on Patient Morbidity: report from the National Cooperative Dialysis Study. *N Engl J Med.* 1981; 305(20): 1176–1181. [PubMed: 7027040]
3. Eknoyan G, Beck GJ, Cheung AK, et al. Effect of Dialysis Dose and Membrane Flux in Maintenance Hemodialysis. *N Engl J Med.* 2002; 347:2010–2019. [PubMed: 12490682]
4. Robinson BM, Bieber B, Pisoni RL, Port FK. Dialysis Outcomes and Practice Patterns Study (DOPPS): Its Strengths, Limitations, and Role in Informing Practices and Policies. *Clin J Am Soc Nephrol.* 2012; 7:1897–1905. [PubMed: 23099654]
5. Brunelli SM, Chertow GM, Ankers ED, Lowrie EG, Thadhani R. Shorter Dialysis Times are Associated with Higher Mortality among Incident Dialysis Patients. *Kidney Int.* 2010; 77(7):630–636. [PubMed: 20090666]
6. Miller JE, Kovesdy CP, Nissenson AR, et al. Association of Hemodialysis Treatment Time and Dose with Mortality and the Role of Race and Sex. *Am J Kidney Dis.* 2010; 55(1):100–112. [PubMed: 19853336]
7. Owen WF Jr, Chertow GM, Lazarus JM, Lowrie EG. Dose of Hemodialysis and Survival: Differences by Race and Sex. *JAMA.* 1998; 280(20):1764–1768. [PubMed: 9842952]

8. Ramirez SPB, Kapke A, Port FK, et al. Dialysis Dose Scaled to Body Surface Area and Size-Adjusted, Sex-Specific Patient Mortality. *Clin J Am Soc Nephrol*. 2012; 7(12):1977–1987. [PubMed: 22977208]
9. Saran R, Bragg-Gresham JL, Levin NW, et al. Longer Treatment Time and Slower Ultrafiltrations in Hemodialysis: Associations with Lower Mortality in the DOPPS. *Kidney Int*. 2006; 69:1222–1228. [PubMed: 16609686]
10. Daugirdas JT. Dialysis Time, Survival, and Dose-Targeting Bias. *Kidney Int*. 2012; 83:9–13.
11. StataCorp. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP; 2011.
12. Austin P. The use of propensity score methods with survival or time-to-event outcomes: reporting measures of effect similar to those in randomized experiments. *Statist Med*. 2014; 33:1242–1258.
13. Tentori F, Zhang J, Li Y, et al. Longer dialysis session length is associated with better intermediate outcomes and survival among patients on in-center three times per week hemodialysis: results from the Dialysis Outcomes and Practice Patterns Study (DOPPS). *Nephrology Dialysis Transplantation*. 2012; 27(11):4180–4188.
14. Flythe JE, Curhan GC, Brunelli SM. Shorter length dialysis sessions are associated with increased mortality, independent of body weight. *Kidney Int*. 2013; 83(1):104–113. [PubMed: 23014457]
15. [accessed on December 14th, 2014] Time to Reduce Mortality in End Stage Renal Disease (TIME). at <https://www.nihcollaboratory.org/demonstration-projects/Pages/TiME.aspx>

Figure 1.
Cohort Derivation Flowchart

Figure 2. Survival of Incident Hemodialysis Patients by Receipt of Initial Dialysis in 4-hour or 3-hour Facilities

Notes: graph adjusted using the Inverse Probability Weights

Cox test: equality of survivor distribution: Wald $\chi^2(1)=217.5$, $P>\chi^2=0.0000$

Figure 3. Adjusted 2-Year Mortality Hazard Ratio Associated with 4-Hour versus 3-hour Initial Session Duration

Notes: Estimates based on the Cox proportional hazard model with inverse probability weights. Estimates presented in the log (base e) scale. The model includes the same variables as shown in Column 3 of Table 4 (excluding the relevant sub-group). So, for example, the estimate shown here for heart disease does not include heart disease as one of the covariates. Robust standard errors clustered within the facility are used in calculating the 95% confidence intervals. *P-values for all sub-group models <0.001.

Table 1

Characteristics of Patients at Initiation of Hemodialysis, by Facility's Initial Hemodialysis Session Duration

Characteristic	4-h facilities	3-h Facilities
Sample Size	39,172	47,721
Age, y	61 ±15	64 ±16
Male sex	21,545 (55)	26,724 (56)
Race		
White	22,719 (58)	32,927 (69)
Black	15,277 (39)	10,022 (21)
Other/Unknown	1,176 (3)	4,772 (10)
eGFR, ml/min/1.73m ²	10.5 ±5.5	10.4 ±5.6
Central Venous Catheter	31,337 (80)	39,130 (82)
Albumin 3.5 g/dl	10,185 (26)	12,407 (26)
Initial Hemoglobin, g/dl	9.8 ±1.7	9.9 ±1.7
Body Mass Index, kg/m ²	29.2 ±7.3	28.2 ±7.3
Cause of ESRD		
Diabetes	19,194 (49)	21,950 (46)
Hypertension	9,793 (25)	11,930 (25)
Other	10,185 (26)	13,841 (29)
History of Cancer	2,350 (6)	2,863 (6)
History of Heart Disease	18,018 (46)	21,472 (45)

Note: Values for categorical variables are given as number or number (percentage); for continuous variables, as mean ± standard deviation.

eGFR, estimated glomerular filtratin rate; ESRD, end-stage renal disease

Table 2

Facility-Level Characteristics, by Initial Hemodialysis Session Duration

Characteristic	4-h facilities	3-h facilities
No. of facilities	852	631
Ownership		
For-profit dialysis center	664 (78)	486 (77)
Not-for-profit dialysis center	188 (22)	145 (23)
Type of facility		
Hospital-based	85 (10)	69 (11)
Free-Standing facility	767 (90)	562 (89)
No. of dialysis stations	20 $\pm$ 8.7	21 $\pm$ 9.2
Accepts transient patients	752 (88)	536 (85)
Evening dialysis	204 (24)	201 (32)
Reuse dialyzers	460 (54)	278 (44)
Only offers hemodialysis option	767 (90)	543 (86)
Has isolation dialysis stations	417 (49)	372 (59)
Total no. of patients in Zip Code who initiated dialysis 2006–2010	55 $\pm$ 12	71 $\pm$ 14

Note: Unless otherwise indicated, values for categorical variables are given as number (percentage); for continuous variables, as mean $\pm$ standard deviation.

Table 3

2-Year and 1-Year Mortality Event Rates by Facility's Initial Hemodialysis Session Duration

	4 Hour	3=Hour
No. of observations	39,172	47,721
2-y Mortality		
Events	8,945	15,624
% Dead (Events/N)	22.8	32.7
Events per 100 person-y	13.1	20.5
1-Y Mortality		
Events	5,492	10,372
% Dead (Events/N)	14.0	21.7
Events per 100 person-y	15.2	25.0

Table 4

Mortality Hazard Ratios Associated with Initiating Hemodialysis in Facilities with 4-Hour Initial Session Duration

Outcome	Model 1	Model 2	Model 3
Sample Size	89,893	89,893	86,893
2-Y Mortality	0.72 (0.66–0.78)	0.78 (0.71 – 0.85)	0.79 (0.73 – 0.86)
1-Y Mortality	0.70 (0.64 – 0.76)	0.76 (0.69 – 0.83)	0.77 (0.70 – 0.84)

Notes: Unless otherwise indicated, values are given as hazard ratios (95% confidence intervals), which are relative to hazard of initiating hemodialysis in facilities with 3-hour initial session duration. Estimates are from a Cox proportional hazard model. All durations are censored at the date of kidney transplantation or the end of the follow-up period (730 days for 2-year follow-up and 365 days for 1-year follow-up). Model 1 shows estimates including the treatment indicator (4-hour vs. 3-hour) and indicator variables for year of initiation of dialysis. Model 2 adds to model 1 all the individual-level covariates shown in Table 1. Model 3 provides estimates from a Cox model while using propensity scores to reweight the observations. The following variables are included in the logit model used to generate the weights for the propensity score: individual-level covariates in model 2 above, and facility-level indicator variables shown in Table 2. Robust standard errors clustered within the facility are used in calculating the 95% confidence intervals.