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Predictors and Outcomes of Non-Adherence in Patients Receiving Maintenance Hemodialysis

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Abstract

Purpose—Predictors of and outcomes associated with non-adherent behavior among patients on chronic hemodialysis (HD) have been incompletely elucidated. We conducted a post-hoc analysis of data from the SMILE trial to identify patient factors associated with non-adherence to dialysis-related treatments and the associations of non-adherence with clinical outcomes.

Methods—We defined non-adherence as missed HD and abbreviated HD. We used negative binomial regression to model the associations of demographic and clinical factors with measures of non-adherence, and negative binomial and Cox regression to analyze the associations of non-adherence with hospitalizations and mortality, respectively.

Results—We followed 286 patients for up to 24 months. Factors independently associated with missing HD included Tuesday/Thursday/Saturday HD schedule (Incident rate ratio: IRR 1.85, $p < 0.01$), current smoking (IRR 2.22, $p < 0.01$), higher pain score (IRR 1.04, $p < 0.01$), lower healthy literacy (IRR 3.01, $p < 0.01$), lower baseline quality of life (IRR 0.89, $p = 0.01$), and younger age (IRR 1.35, $p < 0.01$). Factors independently associated with abbreviating HD included dialysis vintage (IRR 1.07, $p < 0.01$), higher pain score (IRR 1.02, $p < 0.01$), current nonsmoking (IRR 1.32, $p = 0.03$), and younger age (IRR 1.22, $p < 0.01$). Abbreviating HD was independently associated

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Compliance with Ethical Standards

Conflict of Interest: None of the authors has any conflicts of interest to disclose.

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with an increased number of total (IRR 1.70, $p<0.01$) and ESRD-related (IRR 1.66, $p<0.01$) hospitalizations, while missing HD was independently associated with mortality (HR 2.36, $p=0.04$).

Conclusions—We identified several previously described and novel factors independently associated with non-adherence to HD-related treatments, and independent associations of non-adherence with hospitalization and mortality. These findings should inform the development and implementation of interventions to improve adherence and reduce health resource utilization.

Keywords

non-adherence; hemodialysis; missed; abbreviated

Introduction

At present, few interventions other than renal transplantation significantly improve the quality of life of patients receiving chronic dialysis. Thus, much of the care provided to this patient population is focused on reducing morbidity and attenuating the risk for mortality. Such care includes attaining adequate dialysis clearance and maintaining acceptable volume status. Optimizing patient adherence to dialysis sessions and dialysis-related treatments is essential to achieving such targets. Some have proposed that the lower observed survival rates of hemodialysis (HD) patients in the United States compared to other developed countries may relate to higher rates of non-adherence to dialysis therapy.[1] Therefore, identifying risk factors for non-adherence that are amenable to intervention is imperative.

Past research has not fully characterized which patient-related factors are independently associated with non-adherent behaviors, such as missing and abbreviating dialysis treatments. Moreover, while prior studies suggest that non-adherence among dialysis patients is associated with death, the strength of these associations has varied considerably. [2–6] This may be due, at least in part, to the use of large epidemiological databases in prior studies that contain missing data and do not have detailed information on individual patients. Our primary aim for the current study was to examine the associations of patients' demographic, socioeconomic, and clinical characteristics with non-adherence to dialysis-related therapy using prospectively collected data of patients receiving chronic hemodialysis. Our secondary aim was to evaluate the associations of non-adherent behavior with hospitalizations and mortality.

Methods

Study participants

For the current analysis, we used data from the previously described SMILE [Symptom Management Involving End-Stage Renal Disease] trial.[7, 8] In brief, SMILE was a multicenter, cluster randomized clinical trial comparing two strategies for the management of pain, sexual dysfunction, and depression in patients receiving chronic, in-center HD. We have used data from this clinical trial to describe the association of depression with adverse outcomes, as well as patient and provider preferences for the treatment of depression in individuals on chronic hemodialysis.[9–11] Patients from 9 outpatient HD units in Western

Pennsylvania were randomized to a ‘feedback arm’ (i.e., scores on monthly symptom surveys transmitted to renal providers who remained in charge of symptom treatment) or to a ‘nurse management arm’ (i.e., monthly assessment of symptoms with guideline-based treatment facilitated by a trained nurse). Randomization was performed within dialysis units based on dialysis shift. Patient participants were enrolled and followed longitudinally over a period of up to 24 months between January 2009 and April 2011. The Institutional Review Boards of the University of Pittsburgh, Veterans Administration Pittsburgh Healthcare System and the Western Institutional Review Board approved the SMILE trial and all patients provided informed consent prior to enrollment.

Data collection

Study personnel conducted patient interviews and reviewed medical records at baseline to assess participants’ demographic characteristics, dialysis vintage, form of vascular access, and burden of comorbid illness as measured using the Charlson Comorbidity Index. At baseline, we also assessed patients’ health literacy and quality of life and evaluated patients’ pain and depression using the Short Form McGill Pain Questionnaire and the Patient Health Questionnaire 9, respectively.[12, 13] Study personnel obtained data on missed and abbreviated dialysis sessions on a monthly basis through patient and dialysis staff interviews and dialysis chart review. Study personnel interviewed patients on a monthly basis to determine if they had been hospitalized over the past month, and if so, the reason for hospitalization. In addition, study staff reviewed dialysis charts to identify hospitalizations, confirm the primary reason for hospitalization, and to track all-cause mortality. All deaths were confirmed by interview of dialysis personnel.

Study outcomes

Our primary study outcomes were measures of non-adherence to dialysis-related therapy. We categorized non-adherence as missed dialysis sessions and abbreviated dialysis sessions and evaluated each separately. We defined missed treatments as the proportion of scheduled dialysis treatments that the patient missed other than for vacation or hospitalization and abbreviated treatments as the proportion of hemodialysis sessions that were shortened by patient request by at least 15 minutes. As the distribution of missed and abbreviated treatments was non-uniformly distributed, we report the proportion of patients who missed at a rate of 3 or more treatments per year and the proportion of patients who abbreviated at a rate of 4.5% or more treatments per year for descriptive purposes. Our secondary outcomes were total hospitalizations, ESRD-related hospitalizations, and all-cause mortality. We defined ESRD-related hospitalizations as hospital admissions related to dialysis and/or end-stage renal disease as determined by consensus of investigators SDW and JAG.

Statistical analyses

We used medians and interquartile ranges (IQRs) to describe continuous variables and frequencies/proportions to characterize categorical variables. For the primary analyses, we used negative binomial regression to model the associations of patient-related characteristics with missed and abbreviated HD considered as counts of events over the study period, clustering by patient. Results from these models are reported as incidence rate ratios (IRR), which denote the estimated rate of missed and abbreviated HD sessions among patients with

the characteristic of interest divided by the rate among those without the characteristic. For patients with the same follow-up time, the IRR can be interpreted as the relative change in the number of expected events for a patient with the variable of interest compared to a patient without. An IRR of 1 indicates no change in the rate of non-adherence. All models were adjusted for the following potential confounders: age, sex, dialysis vintage, type of vascular access, dialysis schedule, smoking status, baseline pain score, health literacy, race, comorbid illness burden, marital status, and baseline health-related quality of life. These analyses also included a fixed effect for the dialysis unit and SMILE study intervention arm. This allowed us to account for the unit of randomization in the parent trial, as well as any potential study intervention effect. In exploratory analyses, we assessed which day of the week was most commonly missed for each of the 2 dialysis shifts and used Rao Scott Chi Squared tests adjusted for the patient to analyze differences in the day of the week missed. For our secondary analyses, we used negative binomial regression to model the associations of missed and abbreviated HD with total hospitalizations and ESRD-related hospitalizations and Cox regression to model all-cause mortality over the course of the study adjusting for potential confounders. We confirmed that the proportional hazards assumption was not violated for the Cox regression. Patients who died or terminally withdrew from dialysis were considered deaths at the time of death and patients who withdrew from the study were censored at the time of withdraw. We considered 2-tailed p values <0.05 to be statistically significant. All analyses were conducted using SAS 9.3 (Cary, NC) and Stata 13 (College Station, TX).

Results

Baseline patient characteristics and incidence of non-adherence

Overall, 286 patients were enrolled in the SMILE trial and were included in the current analysis. Patients' median age was 64 (IQR: 56–73), 44% were female, and 40% were African American. More than half of patients (53%) had an educational level beyond high school, 11% were employed, and 49% were married. Median dialysis vintage was 2.2 years (IQR: 0.9–4.3) and 36% of patients received dialysis on a Tuesday/Thursday/Saturday (TTS) schedule. (Table 1)

Overall, 219 (77%) patients missed 2 or fewer HD treatments per year while and 67 (23%) missed 3 or more of their treatments yearly. Similarly, 144 (50%) patients abbreviated fewer than 4.5 HD treatments per year, while 142 (50%) abbreviated more than 4.5% of their treatments yearly (Table 2). Overall, 238 (83%) patients were hospitalized for any reason, 176 (62%) had an ESRD-related hospitalization, and 63 (22%) died during the study.

Associations of demographic and clinical factors with non-adherence

Clinical factors independently associated with missing dialysis included a TTS dialysis schedule (Incident Rate Ratio (IRR) 1.85, $p<0.01$), current smoking status (IRR 2.22, $p<0.01$), higher baseline pain score (IRR 1.04, $p<0.01$), younger age (IRR 1.37, $p<0.01$) and lower baseline healthy literacy (IRR 3.01, $p<0.01$). (Table 3) Factors independently associated with abbreviating dialysis included longer dialysis vintage (IRR 1.07, $p<0.01$), higher baseline pain score (IRR 1.02, $p=0.01$), younger age (IRR 1.23, $p<0.01$) and non-

smoking status (IRR 1.33, $p=0.03$). (Table 3) There was a non-statistically significant trend toward a higher number of abbreviated dialysis sessions among patients receiving dialysis on a TTS schedule (IRR 1.29, $p=0.07$). We found that race, sex, type of dialysis access, and baseline Charlson Comorbidity Index score were not independently associated with either measure of dialysis non-adherence.

We found no statistically significant difference in the day of the week that dialysis was missed among patients on a MWF schedule ($p=0.18$). Among patients on a TTS schedule, 20% of missed sessions occurred on Tuesday, 23% on Thursday, and 36% on Saturday ($p<0.01$).

Associations of non-adherence with hospitalizations and mortality

In multivariable analyses, abbreviating dialysis treatments was independently associated with an increased number of total hospitalizations (IRR 1.70, $p<0.01$), while missing HD was associated with a non-statistically significant trend toward increased number of total hospitalizations (IRR=1.29, $p=0.07$). (Table 4) Abbreviating dialysis was independently associated with an increased number of ESRD-related hospitalization (IRR 1.80, $p=0.001$). Missing dialysis was independently associated with higher mortality risk (HR 2.36, $p=0.04$). (Table 4)

Discussion

Using longitudinally collected data, we identified several previously described characteristics as well as novel factors, including pain and health literacy that are independently associated with missing and abbreviating HD. We also demonstrated that missing and abbreviating dialysis are independently associated with adverse outcomes. These observations build upon prior research and help elucidate the risk factors for non-adherence and underscore the importance of non-adherent behavior; findings that should help inform interventions to reduce non-adherent behavior and improve clinical outcomes.

Our study confirms that dialysis schedule is an important predictor of missing dialysis therapy. There have been relatively few prior studies examining the association of dialysis schedule with non-adherence. In a retrospective analysis of more than 15,000 patients from one of the major dialysis networks in the United States, Obialo *et al.* found that patients on a TTS schedule had 33% and 13% higher odds of missing and abbreviating dialysis sessions, respectively ($p<0.0001$). [3] In our study, patients on a TTS schedule were nearly twice as likely to miss dialysis and were generally more likely to abbreviate dialysis sessions than patients on a MWF schedule. Whether this is related to differences in patient characteristics across shifts or factors related to the dialysis shift itself remains unclear. Nonetheless, this finding, along with those of past studies, suggests that it may be reasonable, in certain instances, to consider using a MWF dialysis schedule for patients most likely to exhibit such non-adherent behavior.

We also found an independent association of baseline pain with missing and abbreviating dialysis. Pain is highly prevalent in the dialysis population and may be under-treated. [14, 15] Moreover, a recent study demonstrated that pain was associated with an increase in

mortality.[16] Based on our observations, it seems plausible that missing and abbreviating HD may mediate the association of pain with increased mortality risk. Whether alleviating pain in this population would improve adherence and/or mortality is not known, yet clearly warrants further study. In addition, we found that younger age, current smoking status, and limited health literacy were associated with missing dialysis. While younger age and smoking status have been associated with such non-adherence previously, no prior studies have identified an association of limited health literacy with missing HD in the dialysis population to our knowledge. [3, 6, 17–21] (Table 5) These findings help to establish a collective set of characteristics that may be useful in predicting non-adherent behavior. For example, certain younger dialysis patients who report pain and/or have low health literacy may benefit from being assigned to a MWF dialysis schedule to optimize attendance at dialysis. Whether such an approach could improve patient outcomes warrants future investigation.

Although we did not find race to be independently associated with missing or abbreviating HD, other studies have demonstrated an association of African American race with such non-adherent behavior. (Table 5) However, in exploratory analyses we did find that Saturday appears to be the most commonly missed day among patients on a TTS schedule; an observation that is consistent with prior research.[22] While we lacked statistical power to determine which patient characteristics were associated with missed Saturdays, we did observe this to be more common in general among African Americans (data not shown). Future studies should explore the reasons Saturdays appear to be more commonly missed, evaluate whether certain patient characteristics are associated with missing Saturday treatments, assess the clinical impact of missing Saturday dialysis, and develop interventions to limit this behavior.

In our cohort, missing dialysis was associated with increased mortality, while abbreviating dialysis was associated with increased total and ESRD-related hospitalizations. These observations suggest that such behavior translates into increased serious adverse outcomes and health-resource utilization. Prior studies that investigated the associations of non-adherence with patient-centered outcomes have been conflicting. While some failed to show these associations, others documented a relationship between non-adherence and risk of hospitalization and mortality.[2, 23] In a study of 6,251 patients, Leggat *et al.* demonstrated a 25% increased risk of death among patients who missed one or more dialysis session per month, yet found that abbreviating fewer than 3 dialysis treatments per month was not associated with higher mortality.[6] Among 295 patients followed for a mean of 26 months, Kimmel *et al.* reported a 23% decrease in the relative risk of mortality with increases in percent time compliance, a measure that combined both missing and abbreviating dialysis. [5] Differences in the findings between these studies and our analysis may relate to variation in the criteria used to define such non-adherence. Nonetheless, these observations collectively underscore the importance of non-adherence to dialysis-related treatment, highlight the need to develop and implement strategies to reduce such behavior, and suggest that such efforts may reduce hospitalizations and hence, health resource utilization.

Our study has several limitations. First, our patient cohort was drawn from a clinical trial and may not be generalizable to the broader hemodialysis population. Second, details about

the reasons patients missed and/or abbreviated dialysis sessions were not available. It is possible that hypotension, cramping, and/or other symptoms on dialysis contributed to abbreviated sessions. Third, our patient population was drawn from dialysis units in the United States and our findings may not be generalizable to other countries. Finally, we limited our measures of non-adherence to missing dialysis and abbreviating dialysis, while information about other measures such as intra-dialytic weight gain (IDWG) and hyperkalemia was not collected. Nonetheless, strengths of our study were the prospective nature of data collection and the evaluation of novel predictors of non-adherence such as pain and health literacy. Of note, we did find that while smoking was associated with increased risk of missing dialysis, it was associated with a lower likelihood of abbreviating dialysis. Most, albeit not all prior studies suggested that smoking is a risk factor for non-adherent behavior. (Table 5) Our findings suggest that the association of smoking with non-adherent behavior may not be as clear as previously shown.

The findings of this study broaden our understanding of patient factors that are associated with missing and abbreviating HD. We identified novel factors associated with such non-adherent behavior that could be addressed by providers to help improve patient adherence. Efforts to address factors associated with non-adherence with dialysis may help reduce hospitalizations, decrease health resource utilization, and potentially improve long-term outcomes in this chronically ill patient population.

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List of abbreviations

ESRD	end stage renal disease
HD	hemodialysis
HR	hazard ratio
IDWG	interdialytic weight gain
IQR	interquartile range
IRR	incident rate ratio
MWF	Monday/Wednesday/Friday
SMILE	Symptom Management Involving End-Stage Renal Disease
TTS	Tuesday/Thursday/Saturday

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Table 1**Baseline Patient Characteristics**

	Total (n=286)	Missed dialysis ** (N=67)	No missed dialysis (N=219)	p-value	Abbreviated dialysis *** (N=142)	No abbreviated dialysis (N=144)	p-value
Age (years), median (IQR)	64 (56–73)	62 (52–66)	65 (56–75)	0.01	61.5 (54–69)	66 (57–75)	0.01
Sex (female)	125 (44%)	27 (40%)	98 (45%)	0.57	57 (40%)	68 (47%)	0.24
Race (African American)	114 (40%)	35 (52%)	79 (36%)	0.02	56 (39%)	58 (40%)	0.90
Education				0.58			0.48
Less than high school	41 (14%)	9 (13%)	32 (15%)		22 (15%)	19 (13%)	
High school equivalent	92 (32%)	20 (30%)	72 (33%)		47 (33%)	45 (31%)	
More than high school	152 (53%)	38 (57%)	114 (52%)		73 (51%)	79 (55%)	
Employed	32 (11%)	4 (6%)	28 (13%)	0.18	17 (12%)	15 (10%)	0.71
Married	140 (49%)	30 (45%)	110 (50%)	0.49	67 (47%)	73 (51%)	0.55
Living alone	84 (29%)	20 (30%)	64 (29%)	1.00	41 (29%)	43 (30%)	0.90
Current smoker	58 (20%)	24 (36%)	34 (16%)	<0.01	34 (24%)	24 (17%)	0.14
CCI score ****				0.83			0.22
1–2	66 (23%)	16 (24%)	50 (23%)		27 (19%)	39 (27%)	
3–4	110 (38%)	24 (36%)	86 (39%)		57 (40%)	53 (37%)	
5	110 (38%)	27 (40%)	83 (38%)		58 (41%)	52 (36%)	
Years on Dialysis, median (IQR)	2.2 (0.9–4.3)	2.5 (1.0–4.0)	2.2 (0.9–4.5)	0.83	2.2 (1.0–4.8)	2.3 (0.9–4.1)	0.50
Dialysis schedule (TTS)	103 (36%)	23 (34%)	80 (37%)	0.77	55 (39%)	48 (33%)	0.39
Dialysis access							
AVF/AVG	229 (80%)	50 (75%)	179 (82%)	0.22	111 (78%)	118 (82%)	0.46
Management arm	100 (35%)	23 (34%)	77 (35%)	0.01	54 (38%)	46 (32%)	0.39
Feedback arm	120 (42%)	20 (30%)	100 (46%)		54 (38%)	66 (46%)	

	Total (n=286)	Missed dialysis ** (N=67)	No missed dialysis (N=219)	p-value	Abbreviated dialysis *** (N=142)	No abbreviated dialysis (N=144)	p-value
Baseline HR-QOL (SF-12 score), median (IQR)	7 (5–8)	6 (4–7)	7 (5–8)	<0.01	7 (5–8)	7.5 (5–9)	0.04
Baseline depression (PHQ-9 score), median (IQR)	4 (2–10)	6 (3–13)	4 (2–9)	<0.01	5 (3–11)	4 (2–8)	0.02
Baseline pain (SF-MPQ score), median (IQR)	8 (3–17)	13 (6–26)	6 (2–14)	<0.01	11 (4–21)	5 (2–12)	<0.01
Limited health literacy (REALM score 60)*****	41 (16%)	13 (22%)	28 (14%)	0.23	22 (18%)	19 (14%)	0.50

* Comparisons made using Wilcoxon rank sum test for continuous variables and Fisher’s exact tests for the discrete variables. For the Charlson and Education, comparisons based on Cochran-Mantel-Haenszel test for trend.

** missed cohort defined as 3 HD treatments/year missed

*** abbreviated cohort defined as 4.5% treatments/year abbreviated IQR: Interquartile range; TTS: Tuesday/Thursday/Saturday; AVF: arteriovenous fistula; AVG: arteriovenous graft; HR-QOL: health-related quality of life; SF-12: Short form 12; PHQ-9: Patient Health Questionnaire 9; SF-MPQ: short-form McGill Pain Questionnaire; REALM: Rapid Estimate of Adult Literacy in Medicine

***** Charlson Comorbidity Index

***** The assessment of health literacy was not available for 29 patients. For all other measures, missing data was low and ranged from 0–4 missing values.

Table 2

Rates of dialysis non-adherence

Missed HD	N=286
0–2 sessions/year	219 (77%)
3–12 sessions/year	46 (16%)
13–24 sessions/year	9 (3%)
>24 sessions/year	12 (4%)
Abbreviated HD	
0–4.4% sessions/year	144 (50%)
4.5–9.9% sessions/year	68 (24%)
10–14.9 sessions/year	22 (8%)
>15% sessions/year	52 (18%)

Table 3

Adjusted Association of Patient Factors with Dialysis Non-Adherence

Factor	Missed Dialysis Tx			Abbreviated Dialysis Tx		
	IRR [*]	95% CI	p-value	IRR [*]	95% CI	p-value
Age (years) ^{**}	0.73	0.61–0.88	<0.01	0.81	0.74–0.90	<0.01
Sex (female)	1.18	0.77–1.81	0.45	1.04	0.79–1.36	0.77
Dialysis time (years)	0.99	0.94–1.06	0.84	1.07	1.02–1.12	<0.01
Dialysis access (Catheter)	0.86	0.50–1.49	0.59	1.13	0.84–1.53	0.41
Dialysis schedule (TTS)	1.85	1.18–2.90	<0.01	1.29	0.98–1.68	0.07
Current smoker	2.22	1.30–3.79	<0.01	0.75	0.58–0.97	0.03
Baseline pain score ^{***}	1.04	1.02–1.07	<0.01	1.02	1.01–1.04	<0.01
Limited health literacy ^{****}	3.01	1.53–5.91	<0.01	1.20	0.83–1.74	0.33
Race (African American)	0.76	0.44–1.30	0.31	1.18	0.88–1.58	0.26
CCI score ^{*****}						
3–4	1.22	0.71–2.09	0.47	1.27	0.91–1.76	0.16
5+	1.38	0.80–2.37	0.25	0.98	0.71–1.34	0.89
Married	1.45	0.94–2.25	0.10	1.26	0.99–1.62	0.06
Baseline HR-QOL	0.89	0.81–0.98	0.01	0.99	0.94–1.04	0.63

* IRR determined using negative binomial regression

^{**} based on 10 year increments^{***} assessed with McGill Pain Questionnaire Short Form^{****} based on REALM score <60^{*****} based on Charlson Comorbidity score, 1–2 is the reference group

Table 4**Adjusted Associations of Non-Adherence with Hospitalization and Mortality**

	Total hospitalizations				ESRD-related hospitalizations				Mortality			
	IIR*	95% confidence interval	p value	IIR*	95% confidence interval	P value	HR**	95% confidence interval	p value	HR**	95% confidence interval	p value
Missed 3 Rx/year	1.29	0.98–1.69	0.07	1.08	0.79–1.47	0.64	2.36	1.04–5.33	0.04			
Abbreviated 4.5% sessions	1.70	1.29–2.24	<0.01	1.66	1.19–2.31	<0.01	1.48	0.60–3.66	0.40			
% Sessions with phosphorus > 6.5	1.22	0.75–1.97	0.42	1.32	0.71–2.44	0.38	0.62	0.10–4.02	0.62			
Age (years)*	1.14	1.02–1.28	0.02	1.04	0.90–1.21	0.57	1.99	1.44–2.75	<0.01			
Sex (female)	0.82	0.62–1.07	0.15	0.66	0.48–0.90	<0.01	1.40	0.66–2.96	0.38			
Dialysis time (years)	1.01	0.98–1.05	0.45	1.00	0.96–1.04	0.97	1.11	1.04–1.18	<0.01			
Dialysis access (Catheter)	1.44	1.03–2.02	0.03	1.75	1.12–2.74	0.01	1.41	0.62–3.21	0.42			
Dialysis schedule (TTS)	1.07	0.83–1.38	0.61	0.79	0.58–1.07	0.13	2.01	0.99–4.10	0.06			
Current smoker	0.87	0.64–1.19	0.40	1.24	0.86–1.79	0.24	1.64	0.70–3.87	0.26			
Baseline pain score**	1.01	1.00–1.02	0.12	1.01	0.99–1.02	0.27	1.00	0.97–1.04	0.75			
Limited health literacy***	1.11	0.78–1.58	0.55	1.55	1.04–2.32	0.03	0.95	0.39–2.31	0.91			
Race (African American)	0.98	0.73–1.33	0.92	0.98	0.68–1.40	0.91	0.72	0.24–2.21	0.57			
Comorbidity****												
3–4	1.07	0.78–1.48	0.67	1.05	0.69–1.60	0.81	0.59	0.24–1.44	0.24			
5+	1.25	0.88–1.78	0.22	1.18	0.76–1.85	0.46	0.62	0.22–1.73	0.36			
Married	0.90	0.70–1.15	0.39	0.97	0.72–1.30	0.83	1.43	0.73–2.80	0.29			
Baseline HR-QOL	0.92	0.87–0.96	<0.01	0.92	0.87–0.97	<0.01	0.86	0.76–0.97	0.02			

AVF: arteriovenous fistula; AVG: arteriovenous graft; HR-QOL: health-related quality of life; SF-12: Short form 12

* IRR determined using negative binomial regression

** HR determined using Cox regression

Table 5

Predictors of non-adherence in the literature*

	Young age	African American	Smoking	Depression	Schedule (TTS)	Dialysis vintage	Low Income	Pain	Health literacy	Living alone	Un- employed	Education
Tohme et al.	✓ Skipping Shortening	× ×	✓ ×	× ×	✓ ×	× ✓	× ×	✓ ✓	✓ ×	× ×	× ×	× ×
Obialo et al.	✓ Skipping Shortening	✓ ✓			✓ ✓							
Akman et al.	× Skipping Shortening			✓ ✓		× ×						× ×
Saran et al.	✓ Skipping Shortening	✓ ✓	✓ ×	✓ ✓		× ✓				× ×	✓ ✓	× ×
Kutner et al.	✓ Skipping Shortening	✓ ×	✓ ✓				✓ ×			× ×		× ×
Bleyer et al.		✓				×						
Leggat et al.	✓ Skipping Shortening	✓ ✓	✓ ✓			× ×				× ✓		× ×
Bane et al.	✓ Skipping Shortening	×					✓					×
# of positive associations	11	8	6	4	3	2	2	2	1	1	1	0

✓ Denotes presence of association

× Denotes absence of association

* definitions of skipping and shortening differ across studies