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Factors Associated with Hospital Readmissions Among United States Dialysis Facilities

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Nursing at Virginia Commonwealth University.

by

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Abstract

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By Amber Brooke Paulus, Ph.D.

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Hospital readmissions are a major burden for patients with end stage renal disease (ESRD). On average, one in three hospital discharges among patients with ESRD are followed by a readmission within 30 days. Currently, dialysis facilities are held accountable for readmissions via the ESRD Quality Incentive Program standardized readmission ratio (SRR) clinical measure. However, little is known about facility-level factors associated with readmission. Additionally, unlike other standardized measures of quality in the dialysis setting, incident patients within their first 90-days of dialysis are included in the performance calculation. This study analyzed CMS Dialysis Facility Report data from 2013 to 2016 to examine dialysis facility and incident patient factors associated with SRR using multivariate mixed models. Among 5,419 dialysis facilities treating 104,768 incident patients, the mean SRR remained stable across all four study years at 0.99. Factors significantly associated with a lower SRR ($p<0.0001$) included Western geographic region and higher patient care technician ratios. Several incident patient pre-dialysis nephrology care characteristics were associated with lower SRRs including higher percentages of patients with a fistula present at first dialysis treatment, higher percentages of patients receiving 6-12 months or greater than 12 months of nephrology care prior to dialysis and higher facility average hemoglobin. Factors significantly associated with a higher SRR ($p<0.0001$) included Northeastern geographic region, higher registered nurse ratios, higher percentage of incident patients, and higher facility average GFR. Understanding facility-level and patient-level factors associated with higher SRRs may inform interventions to reduce 30-day hospital readmission among patients receiving dialysis.

Keywords: Dialysis facilities, hospital readmissions, incident patients, ESRD

Vita

Amber Brooke Paulus was born April 25, 1990, in Albemarle County, Virginia. She graduated from Rockbridge County High School, Lexington, Virginia in 2008. She received a Bachelor of Science in Exercise Science from Virginia Commonwealth University, Richmond, Virginia in 2011 and subsequently a Bachelor of Science in Nursing from Jefferson College of Health Sciences, Roanoke, Virginia in 2012. She began her clinical career as a nurse in progressive care in Roanoke for three years and transitioned to quality improvement serving the renal community in 2015. She received a Doctor of Philosophy in Nursing from Virginia Commonwealth University in 2019.

Introduction

As a requirement of the Doctor of Philosophy program within the School of Nursing at Virginia Commonwealth University, the content below is to meet the dissertation requirements as established and approved by the School of Nursing. In lieu of the traditional dissertation, I have chosen to complete an alternative dissertation approved by my advisor and dissertation committee chair, Marianne Baernholdt. A grant application will replace Chapters I-III (i.e., statement of the problem, theoretical framework/review of literature, and methods). The grant follows the National Health Institutes (NIH) PHS 398 form. Chapters IV and V (i.e., findings and discussion and conclusion) follow the grant application. Finally, this introduction and a concluding narrative (Chapter VI) are intended to tie the grant and chapters IV and V into a comprehensive project. Results of this dissertation will be used to submit a manuscript to a peer reviewed nephrology journal.

The proposed research study focuses on patients with chronic kidney disease (CKD). CKD is defined as “lasting damage to the kidneys that can get worse over time” (AKF, 2018). The progression of CKD is measured in five stages. The fifth and final stage of kidney disease, known as end stage renal disease (ESRD), occurs when the kidneys permanently fail to work (AKF, 2018). Patients with ESRD can choose conservative management for their kidney failure including palliative care, pursue a kidney transplant, or initiate dialysis. Dialysis is a treatment that takes over kidney functions (AKF, 2018). Dialysis can be administered via three modalities: hemodialysis in a dialysis facility, hemodialysis at home, or peritoneal dialysis offered in a facility or at home. This research proposal includes patients with ESRD receiving dialysis regardless of modality. The purpose of this dissertation is to evaluate the association between dialysis facility performance in readmission measured by the Standard Readmission Ratio (SRR), dialysis facility characteristics and incident patient pre-dialysis nephrology care characteristics (i.e., patients that are within 90 days of first dialysis treatment for ESRD).

Grant Application

Specific Aims

Admissions and readmissions to the hospital represent major burdens for patients with ESRD. The frequency of 30-day readmissions for patients with ESRD receiving dialysis, regardless of modality, remained stable from 2007-2011 at approximately 39% (USRDS, 2018). However, the first reduction in readmission was noted in 2012-2013 and has remained relatively stable at 37% (see Appendix 1, Figure 1 pg. 91). Prior research has evaluated characteristics of patients with ESRD receiving dialysis associated with readmission including social support and comorbidities (Flythe, Hilbert & Gilet, 2017; Flythe et al., 2016). Studies have also assessed hospital discharge characteristics (i.e., day of discharge and discharging service) and intervention studies have identified prevention strategies, such as frequent physician visits that impact readmissions in patients with ESRD receiving dialysis (Golestaneh, Bellin, Southern & Melamed, 2017; Erickson, Winkelmayer, Chertow & Bhattacharya, 2014). However, prior readmission research has not considered the impact of the setting in which the majority of patients with ESRD receive care for kidney failure, the dialysis facility. Characteristics of dialysis facilities have been associated with performance on various quality measures. For-profit dialysis facilities have been associated with increased hospitalization while not-for profit facilities have been associated with increased transplant waitlisting, and rate of transplantation (Dalrymple et al., 2014; Zhang, Thamer, Kshirsagar, Cotter & Schlesinger, 2014; Kucirka, Grams, Balhara, Jaar & Segev, 2011; Balhara, Kucirka, Jaar & Segev, 2012; Devereaux et al., 2002). Further, a prior study evaluating facilities offering hemodialysis to patients with ESRD found those associated with a dialysis chain to have increased mortality rates (Zhang, Cotter & Thamer, 2011). Additionally, prior research has found that when the number of dialysis stations (i.e., facility size) within a facility was less than or equal to fifteen, there was a significant increase in mortality among patients receiving hemodialysis (Yan et al., 2013). Of the facilities included in the study, approximately 38.87% had 15 or less stations with 16-30 stations being the largest percentage of enrolled facilities (55.3%). Even with the adjustments for patient socioeconomic status (SES), facility characteristics, geographic region, and facility zip code SES (i.e., median household income, percentage of persons who completed high school, percentage of persons in poverty, and percentage of black population) the strong association between facility size below 15 stations and mortality remained statistically significant. Two additional studies, one completed in 2008 and another completed in 2018 also found small facility size was associated with an increased mortality risk in patients with ESRD receiving hemodialysis (Eisenstein et al., 2008; Yao, Chou & Huang, 2018). Finally, a facility's length of operation has also been found to influence quality performance. Length of operation in relation to facility ownership has been shown to impact mortality. A study completed in 2010 found that hemodialysis facilities acquired by a large dialysis organization with less than two years of operating time have a significantly higher relative risk for death compared to facilities with longer tenure and consistent ownership (Van Wyck, Robertson, Nissenson, Provenzano & Kogod, 2010). The component that has not been previously evaluated is the relationship between dialysis facilities' characteristics and the standardized readmission ratio (SRR), the quality measure used to evaluate dialysis facility performance in readmission.

The SRR is a measure of 30-day unplanned hospital readmission for dialysis patients discharged from any acute care hospital in the United States (CMS, 2017). While other standardized measures of quality for dialysis facilities (e.g., standardized mortality ratio, standardized hospitalization ratio) exclude patients within the first ninety days of care (called incident patients), this is not so for the SRR. This is of concern since the highest risk of mortality for incident patients occurred in the first two weeks of dialysis treatment with the risk of death 2.72-fold higher, and the risk of hospitalization 1.95-fold higher when compared to patients who survived the first year of chronic dialysis (Chan et al., 2011). Additionally, over the first ninety days, the risk of mortality and hospitalizations remained elevated for incident patients (Chan et al., 2011; Broers, Cuijpers, van der Sande, Leunissen & Kooman, 2015). Given the inclusion of incident patients when the SRR is calculated, it is critical to examine the specific influence these patients may have on a facilities performance in readmission.

Guided by the conceptual model, *Shared Accountability in Readmission Outcomes within Dialysis* (see Appendix, Figure 2, pg. 91), the proposed longitudinal descriptive study will evaluate the association between dialysis facilities' SRR and dialysis facility characteristics and incident patient pre-dialysis nephrology care characteristics. This study will use four consecutive years (2013-2016) of data provided within the publicly available Dialysis Facility Report (DFR) dataset released in fiscal year 2018. The time period included in this dataset is of particular importance given that the Centers for Medicare and Medicaid Service (CMS) began using risk-adjusted measures of readmissions (i.e., SRR) for public reporting on the Dialysis Facility Compare (DFC) website and for value-based purchasing as part of the ESRD Quality Incentive Program (QIP) in 2015 (USRDS, 2018). The **Specific Aims** of this project are:

Specific Aim 1. Describe incident patient pre-dialysis nephrology care characteristics, dialysis facility characteristics and the standardized readmission ratio (SRR) among United States dialysis facilities over four years: 2013-2016.

Specific Aim 2. Examine the associations between incident patient pre-dialysis nephrology care characteristics, dialysis facility characteristics and the standardized readmission ratio (SRR) among United States dialysis facilities over four years: 2013-2016.

Significance

Reducing avoidable hospital readmissions is a key component of efficient, high-quality healthcare. The CMS began evaluating hospital readmissions in 2013 after a provision in the Affordable Care Act established the Hospital Readmission Reduction Program (HRRP) (CMS, 2011). The HRRP requires Medicare to reduce payments to hospitals with readmission rates that exceed the national average (CMS, 2011). While penalty for readmissions was initiated among hospital providers, CMS broadened the scope of accountability by including dialysis facilities in 2015 (CMS, 2015). This was the first year the Final Rule included a readmission dialysis clinical performance measure (i.e., SRR) in the CMS ESRD QIP reimbursement penalty program.

Efforts to reduce or prevent the occurrence of hospital readmissions through penalty programs such as the HRRP and ESRD QIP are necessary given the burden readmissions place on the >700,000 patients receiving dialysis. Patients with ESRD remain less than 1% of the total Medicare population; however, spending continues to rise. Between 2015 and 2016, spending rose by 4.6% from $33.8 billion to $35.4 billion in paid Medicare claims among beneficiaries with ESRD (USRDS, 2018). This marks the fifth year of modest growth relative to historical trends (USRDS, 2018). A major cost inflator for patients with ESRD receiving dialysis is the use of hospital services for patient care. Overall, utilization of hospital services accounts for $11.7 billion (33%) of total Medicare expenditures (USRDS, 2018). The average readmission rate of patients with ESRD receiving dialysis is 37%, equating to $4.3 billion spent on readmissions alone. This cost includes potentially preventable hospital readmissions. A meta-analysis completed in 2011 showed that approximately 25% of unplanned readmissions among a wide variety of patients were preventable (van Walraven et al., 2011). Additionally, readmissions pose a significant emotional burden to patients and their caregivers. Prior research among patients with chronic conditions such as heart failure and chronic obstructive pulmonary disease has found that anxiety and poor quality of life are correlated with a higher risk of readmission (Volz et al., 2010; Raymond, Arrigain, Landers & Gorodeski, 2012; Osman, Godden, Friend, Legge & Douglas, 1997). A hospitalized patient with ESRD is also at risk for hospital-acquired infections and declines in weight, hemoglobin and albumin levels (Chan, Lazarus, Wingard & Hakim, 2009). Given the economic burden and significant impact of hospital readmission on patients with ESRD receiving dialysis, a high priority area for research is to examine dialysis facilities as these entities deliver the majority of care to this patient population.

Conceptual Framework

The conceptual model for this study, *Shared Accountability in Readmission Outcomes within Dialysis*, (see Appendix 1, Figure 2, pg. 91) was developed using the

Quality Health Outcomes Model (QHOM) (Mitchell, Ferketich & Jennings, 1998) and the Open Systems Theoretical Framework (Katz & Kahn, 1978). Concepts from these models capture elements needed to evaluate and compare health care quality by relating multiple factors affecting quality of care to desired outcomes. The theoretical foundation of the model is derived from Katz and Kahn's framework using Open Systems Theory. This theory adds to the model the idea that outcomes are produced through management of inputs. Patients with ESRD are the input to the system and are managed while receiving dialysis by interprofessional facility staff. Katz and Kahn refer to this as "transformation" indicating that inputs are transformed to effectively reach their output goal (Katz & Kahn, 1978). This is relatable to dialysis facility staff who follow clinical practice guidelines to manage the care of patients receiving dialysis. A dialysis facility's goal is to assist patients in continuing to live a life compatible with their unique expectations. Further, dialysis facilities have performance goals established by federal regulations to ensure clinical processes (transformation) are appropriate. Dialysis facilities receive yearly feedback in the form of the ESRD QIP outcomes which reflect the effectiveness of the clinical processes. If a facility performs below the national average on the ESRD QIP, profit margins may be impacted due to associated reimbursement penalty. Thus, a facility is incentivized to identify opportunities for improvement (Borelli, Paul, & Skiba, 2016).

In addition to the theoretical foundation provided by Open Systems Theory, the QHOM's application of dynamic relationships between system, intervention, patient, and outcome, is utilized to demonstrate that these components not only act upon but reciprocally affect the other components. The four components of the model used for this study are the dialysis facility (system), nursing/interprofessional team (interventions), incident patients on dialysis (patient), and hospital readmissions (outcome). Five reciprocal relationships exist in this model. The first relationship is between the dialysis facility and the nursing/interprofessional team. The nursing/interprofessional team implements dialysis clinical processes that influence the dialysis facility in which they work. But also, the dialysis facility influences how the team carries out their work by providing the necessary resources. Resource availability may be influenced by dialysis facility characteristics. The second relationship includes incident adult patients on dialysis (i.e. incident patients) and the nursing/interprofessional team. Incident adult patients on dialysis may possess specific characteristics (e.g., age, gender, race, ethnicity, comorbidity status, etc.) that impact not only the dialysis facility in which they dialyze, but also the way the dialysis team cares for them. Additionally, incident patients possess an additional characteristic conceptualized as pre-dialysis nephrology care (i.e., length of nephrology care, vascular access placement and primary dialysis modality: in-center hemodialysis, home hemodialysis, peritoneal dialysis, or kidney transplant) that impacts how the dialysis team provides care. The third relationship includes incident patients on dialysis and the dialysis facility. Patients' clinical lab values and adherence to recommended treatment influence how a dialysis facility performs in quality measures. These quantifiable measures may ultimately impact a facilities financial viability, which in turn may influence the care the incident patient receives. The fourth relationship is between incident patients on dialysis and the outcome of hospital readmissions. Patients can decide to seek care at a hospital for any medical reason regardless of elapsed time since prior hospitalization. Finally, the fifth relationship is between the dialysis facility and hospital readmissions. Readmissions attributed to a dialysis facility throughout the ESRD QIP SRR calculation may impact how a dialysis facility performs financially. In turn, how a dialysis facility coordinates care for their patient population impacts the occurrence of hospital readmissions.

It is important to note that there are two ways to analyze the dialysis patient population: incident and prevalent patients. Incident patients refer to those with new cases of ESRD within a given year and are commonly tracked during the first ninety days of dialysis care to evaluate outcomes (USRDS, 2018). Prevalent patients refer to individuals with existing cases of ESRD within a given year (USRDS, 2018). Both groups of patients possess characteristics that may be significant in understanding the occurrence of hospital readmissions however, only incident patients will be included in this study due to their unique inclusion in the SRR measure and exclusion in all other standardized measures. This is the first study using the concepts in the *Shared Accountability in Readmission Outcomes within Dialysis* model. However, there is empirical evidence from the literature supporting the relationships between the four model components: dialysis facility, nursing/interprofessional team, incident adult patients on dialysis, and readmissions with other measures of quality within dialysis facilities including hospitalization, mortality, and transplantation. These relationships are described in the following paragraphs.

Dialysis facility. The dialysis facility is the clinical unit providing treatment for kidney failure and is defined as “a group of people working together on an ongoing basis with business and clinical aims, linked clinical processes and a shared information environment to produce performance outcomes" (Batalden, Godfrey, & Nelson, 2007, pg. 7). Dialysis facility characteristics considered for this study include staffing, profit status, size, chain membership, length of operation, geography (urban vs rural), and ESRD geographic network region (Northeast, South, Midwest, West).

Adequate nursing staff is a frequent attribute analyzed in readmission prevention literature. The impact of staffing has been previously evaluated among readmissions in patients with heart failure. A study completed in 2016 found that readmission rates among patients with heart failure are significantly higher in hospitals with lower nurse staffing (Giuliano, Danesh & Funk, 2016). Dialysis facilities are known to have smaller patient care technician (PCT) to patient ratios compared to registered nurses to patient ratios (UM-KECC, 2018). PCTs typically care for fewer patients whereas nurses are responsible for a greater number of patients. PCTs are unlicensed personnel who carry out patient care under the supervision of registered nurses (RNs) or licensed practical nurses (LPNs). Prior research has shown staffing patterns vary based on dialysis facility characteristics including profit status, chain affiliation, and geographic region. In a study published in 2013, researchers found that ratios of RNs and LPNs to patients in for-profit facilities were 35% lower, but the PCT to patient ratio was 16% higher compared to non-profit dialysis facilities (Yoder, Xin, Norris & Yan, 2013). Additionally, dialysis facilities associated with a dialysis chain had significantly lower RN and LPN to patient ratios than facilities not associated with a dialysis chain. Further, the study found regional differences in RN to patient ratios in dialysis facilities. Compared to the Northeast, ratios were 14% lower in the Midwest, 25% lower in the South and 18% lower in the Western regions of the United States. While prior research has not investigated the association of readmissions and staffing among dialysis facilities, Zhang et al (2010) reported significantly higher mortality rates in for-profit dialysis facilities and lower numbers of RNs and LPNs per patient. The significant variation in staffing levels and empirical evidence on the influence of dialysis facility characteristics, warrants further investigation of the potential associations of staffing and readmissions.

Profit status and the size of a dialysis facility are important dialysis facility characteristics to consider when examining structural characteristics influence on hospital readmissions. Prior research has shown that patients receiving hemodialysis in for-profit facilities had a 15% higher rate of hospitalization compared with those in non-profit facilities (Dalrymple el al., 2013). Increased hospitalization creates index discharges initiating the vulnerability for rehospitalization post discharge. Further, a recent study published by Mathew et al., (2018) evaluated potentially avoidable readmissions in United States patients receiving hemodialysis. The researchers found that treatment at a for-profit-facility was associated with potentially avoidable 30-day readmissions. In addition to profit status, facility size has been evaluated in overall quality among dialysis facilities. A 2016 study by Zhang et al. utilized Dialysis Facility Compare (DFC) data to analyze overall dialysis facility quality and facility characteristics. This study found an inverse relationship between facility size and overall quality performance score. Specifically, the larger the facility the lower the total performance score on the ESRD QIP. The association between for-profit status and increased hospitalization and preventable readmissions as well as dialysis facility size with overall lower quality warrants further investigation related to readmissions.

The geographic location of dialysis facilities (urban versus rural) has been previously investigated concerning pre-dialysis nephrology care. A study completed in 2013 found that large urban and rural counties had lower percentages of patients receiving pre-dialysis nephrology care (25.7% and 26.9%) compared to small/medium size urban counties (31.6%) (Yan et al., 2013). Further, researchers found that the percentage of patients who received pre-ESRD nephrologist care for greater than 6 or 12 months was lowest in large metropolitan (50.1% or 25.7% respectively) and rural (51.6% or 26.9%) and highest in medium/small metropolitan counties (56.6% or 31.6%). Additionally, a recent study evaluated potentially avoidable 30-day readmissions in the United States and found that readmission occurrence varied by state (Mathew et al., 2018). However, no study was found that evaluated the occurrence of readmissions by geographic region as commonly used in the literature (i.e., Northeast, South, Midwest, West) (Saunders & Chin, 2013; Zhang, 2016). The significant association of rural and urban location with variation in incident patient pre-dialysis nephrology care as well as empirical evidence on variation in readmission by state, warrants further investigation of the relationship between location and the SRR.

Incident adult patients on dialysis. Whether or not an incident patient receives nephrology care prior to initiating dialysis is an important characteristic to consider when evaluating a potential relationship among incident patients and dialysis facility performance on the SRR. Several studies suggest that pre-dialysis nephrology care is associated with cost-effectiveness and decreased mortality and morbidity (Black et al., 2010; Kumar, Jeganathan & Amruthesh, 2012; Smart & Titus, 2011). Care prior to initiation of dialysis not only manages patients through the five stages of kidney failure, but also provides ample time to prepare a patient for dialysis (Smart, Dieberg, Ladhani & Titus, 2014). Additionally, timely receipt of nephrology care is associated with slower CKD progression, lower rates of adverse outcomes, and improved quality of life (MCClellan et al., 2009; Smart, Dieberg, Ladhani & Titus, 2014; Diegoli, Silva, Machado & Cruz, 2015). Further, a systematic review published in 2011 revealed that patients receiving nephrology care prior to dialysis initiation had reduced mortality and hospitalizations, better uptake of peritoneal dialysis, and earlier placement of arteriovenous fistula with hemodialysis (Smart & Titus, 2011). Given the positive impact of pre-dialysis nephrology care on patients with ESRD, further research is warranted to understand the influence of pre-dialysis care on the incident population and subsequently on the SRR.

Although pre-nephrology care is beneficial to patients with kidney failure, not all patients receive nephrology care prior to initiating dialysis. Additionally, the length of nephrology care received remains variable among incident patients receiving dialysis. In fact, 36% of patients newly diagnosed with ESRD received little or no pre-dialysis nephrology care with 21% of patients receiving no nephrology care prior to ESRD onset and 15% with unknown duration of pre-nephrology care (USRDS, 2018). Given the positive outcomes associated with nephrology care received prior to dialysis initiation, further research is needed to understand how the length of pre-dialysis nephrology care impacts dialysis facility performance on the SRR quality measure.

One important component of pre-dialysis nephrology care is vascular access planning and placement. Patients can receive hemodialysis or peritoneal dialysis. Peritoneal dialysis requires placement of a catheter into the peritoneal cavity that can be used shortly after placement. Hemodialysis requires the patient to have one of three vascular access types including: central venous catheter (CVC), arteriovenous fistula (AVF) and arteriovenous graft (AVG). Pre-dialysis nephrology care includes preparation and/or placement of a permanent access (i.e., AVF or AVG). Placement of an AVF is considered the gold standard vascular access for hemodialysis that requires time to mature before use (Santoro et al., 2014). While only 33% of incident patients initiate hemodialysis with an AVF in place, those with pre-nephrology care often have vein mapping completed and are scheduled for AVF placement shortly after initiation of dialysis (Santoro et al., 2014). The use of CVCs as a vascular access for hemodialysis has been associated with increased hospital readmissions (Flythe et al., 2016). Given the risk associated with CVC use among incident patients receiving hemodialysis, understanding the relationship of vascular access type and dialysis facility performance on the SRR is warranted.

The level of an incident patients' kidney function at the time of dialysis initiation is an important characteristic to consider when evaluating the relationship between incident patient characteristics and dialysis facility performance on the SRR. Prior research has focused on timing of dialysis initiation in relation to level of kidney function, measured by the estimated glomerular filtration rate (GFR) (Yu, Wong, Liu, Hebert & O'Hare, 2018). Observational data suggests that the level of kidney function at the time of dialysis initiation may be an important determinant of mortality (Clark et al., 2011). There are a number of factors associated with the decision to start dialysis in patients with CKD, however, a GFR <10mL/min is often associated with severe symptoms that require dialysis intervention (Chen, Lee & Harris, 2018). In addition to GFR, serum creatinine can be measured as a sign of progression of kidney disease. Creatinine is a waste product that comes from normal wear and tear on muscles of the body (Counts, 2015). Since serum creatinine levels rise as kidney disease progresses, a creatinine level greater than 1.2 milligrams for women and greater than 1.4 milligrams for men is a clinical indicator that the kidneys are failing. The relationship between incident population's GFR, serum creatinine levels and a facility's hospital readmissions is unknown. Given the inclusion of incident patients in the SRR measure, analysis of GFR and serum creatinine is necessary to provide insight on how the monitoring of these values through nephrology care prior to dialysis initiation impacts dialysis facility performance on the SRR.

Additional laboratory values that can serve as measures of nephrology care for incident patients prior to dialysis initiation are hemoglobin and albumin. Hemoglobin reflects anemia management and can be reviewed in tandem with erythropoiesis-stimulating agent (ESA) administration prior to initiating dialysis to understand pre-dialysis nephrology care interventions. Anemia is associated with higher morbidity and mortality among patients with CKD (Babitt & Lin, 2012). Hemoglobin thresholds for patients with CKD are 12.0 grams per deciliter (g/dL) for females and 13.0 g/dL in men (Count, 2015). A recent study evaluated anemia treatment with ESAs before dialysis initiation and the impact on mortality in incident patients starting dialysis (Wetmore et al., 2018). Researchers found that a hemoglobin level greater than or equal to 9.0g/dL with ESAs before and after hemodialysis initiation was generally associated with lower post-initiation all-cause and cardiovascular mortality compared with a pre-dialysis hemoglobin less than 9.0g/dL in patients whose level subsequently improved with ESAs after hemodialysis initiation (Wetmore et al., 2018). The impact of anemia management on mortality prior to initiating dialysis warrants further investigation of the influence of anemia on facility performance on the SRR quality measure.

Albumin is an additional clinical measure captured among patients initiating dialysis. Albumin levels reflect dietary care interventions that are commonly implemented in patients suffering from CKD. Dietary care interventions include managing weight, avoiding foods high in sodium and eating the proper amounts and types of protein. As kidney disease progresses, patients may experience dietary issues as the disease impacts gastrointestinal nutrient absorption and muscle and fat wasting, thus dietary interventions may be needed (Vaziri, Yuan & Norris, 2013; Kalantar-Zadeh & Fouque, 2017). The protein-energy malnutrition and hypoalbuminemia at the initiation of dialysis is highly predictive of future hospitalization and mortality (Kliger, 2002 Grange, Hanoy, Le Roy, Guerrot & Godin, 2013; Plantinga et al., 2007; Rocco, Frankenfield, Hopson & McClellan, 2006; Tentori et al., 2007). Given the association of mortality and hospitalization with albumin management, further investigation is warranted to understand this value in incident patients starting dialysis and readmissions.

The primary dialysis modality utilized by incident patients with ESRD to receive treatment may influence the occurrence of readmissions. Based on 2016 USRDS data, 87.3% of incident patients began treatment with hemodialysis (HD), 9.7% started with peritoneal dialysis (PD), and 2.8% received a preemptive kidney treatment (USRDS, 2018). In a 2017 study, Perl et al. examined a cohort of 28,000 adults receiving dialysis in Canada. The authors followed patients after discharge for 30 days and found that the risk for readmission among patients on PD therapy was higher compared with those on in-center HD therapy (adjusted HR, 1.19; 95% CI, 1.08-1.31). Another study completed in 2017 by Chan et al. utilized a national representative cohort of patients with ESRD and found that the readmission rate among patients on PD were considerably lower (14.6%) compared to patients on HD (37%) (Chan et al., 2017). While these findings are conflicting, the literature has presented considerable explanations addressing why patients on PD may experience increased readmissions. Patients receiving in-center HD have more frequent contact with health care providers and closer supervision to quickly address issues that arise (Shen, Dave & Erickson, 2017; Perl et al, 2017). In contrast patients on PD may wait longer after a hospital discharge to see a nurse or physician impeding the opportunity to address clinical issues to prevent a readmission in a timely manner (Shen, Dave & Erickson, 2017; Perl et al, 2017). While the evidence is inconclusive concerning whether or not a particular dialysis modality increases patients' risks for hospital readmissions, the calculation of the SRR does not differentiate patient's dialysis modality. Dialysis facilities are held accountable for readmissions regardless of the distribution of their patients by dialysis modality type (i.e., hemodialysis patients and peritoneal dialysis patients). The inclusion of primary dialysis modality at dialysis initiation provides insight to the unique challenges associated with modality type that may further influence a dialysis facilities performance on the SRR and warrants further investigation. In summary, when evaluating the SRR the literature supports the inclusion of pre-dialysis characteristics of incident patients that capture nephrology care received prior to initiating dialysis. The characteristics include recipient of pre-dialysis care, length of pre-dialysis care received, vascular access type, level of kidney function (GFR), values including serum creatinine, hemoglobin and use of erythrocyte stimulating agent (ESA), albumin, and primary dialysis modality.

Nursing/interprofessional team. The QHOM model identifies an intervention component. The interventions are conceptualized as dialysis care processes. These processes include interventions provided by the team to manage patients with ESRD such as vascular access, mineral metabolism, anemia management, and dialysis adequacy (i.e., how well dialysis removes waste from the blood), as well as ensuring the patient has access to appropriate treatment options based on their care preferences (i.e., home dialysis, in-center hemodialysis, transplant waitlisting) (Gomez, 2008). This study does not include concepts or variables for interventions due to the lack of such variables in the publicly available datasets.

Hospital Readmissions. Hospital readmissions are defined as an unplanned admission to an acute care hospital within 30 days of discharge from the same or another acute care hospital (CMS, 2017). The accepted quality measure for readmissions among dialysis facilities is the SRR, which is the outcome measure of this study.

There is a noticeable gap in the literature concerning how structural differences of dialysis facilities may influence performance on the SRR. In addition to dialysis facility characteristics, the pre-dialysis characteristics of a facility's incident patients may influence the SRR. Whether the incident patients have received pre-dialysis care is associated with how they do when dialysis is started. Given the SRR is the only standardized measure that does not exclude the incident population in dialysis facility performance calculations, research is needed to better understand how this specific population influences a dialysis facility's performance on the SRR.

Innovation

The proposed study evaluates the association between dialysis facility performance in readmission measured by the SRR, dialysis facility characteristics, and incident patient pre-dialysis nephrology care characteristics. This study is innovative because it focuses on incident patient's influence on the SRR over time. Dialysis facilities who receive incident patients without nephrology care prior to initiating dialysis (i.e., potentially sicker patients) has not been previously analyzed in relation to a dialysis facility's performance on the SRR measure. The structure of dialysis facilities may not be equipped to appropriately manage incident patients in a way that prevents negative outcomes, such as hospital readmissions. Additionally, all other standardized quality measures used to evaluate dialysis facilities exclude incident patients within the first 90 days of initiating treatment. This exclusion is due to the increased morbidity and mortality associated with this population as they transition to dialysis therapy (Chan et al., 2011; Broers, Cuijpers, van der Sande, Leunissen & Kooman, 2015). Findings examining structural characteristics can be used to draw attention to current policies related to facility's evaluation in regard to readmissions. For example, the findings will inform whether certain staff compositions (i.e., nurse/PCT ratios) are warranted in outpatient dialysis facilities. In addition, the results of this study may draw attention to the need for new nursing roles to support incident patients' transitions to dialysis. This transition may require care coordination and therefore new tasks and nursing roles not currently being practiced in dialysis settings. One example is the nurse navigator that has grown in popularity among acute care facilities since the implementation of reimbursement penalty for readmission among the heart failure population (Di Palo, Patel, Assafin & Piña, 2017; Monza, Harris & Shaw, 2015). Nurse navigators are currently being trialed in dialysis facilities associated with ESRD Seamless Care Organizations (ESCO) which uses a comprehensive ESRD care model (The Lewin Group, Inc., 2017). There are only 37 ESCOs in the U.S., and they are partnerships with CMS and health care providers that evaluate the effectiveness of a new payment system and service delivery model (CMS, 2018). Finally, this is the first study to analyze dialysis facility performance on the SRR longitudinally. In 2015, CMS began publicly reporting risk-adjusted measures of readmissions and value-based purchasing. A longitudinal study will allow for evaluation of dialysis facility responses to these programs.

Approach

Research Design

The proposed study is a descriptive, longitudinal, retrospective analysis using multivariate regression analysis on publicly available data to evaluate the association between dialysis facility performance in readmission measured by the SRR, and dialysis facility characteristics and incident patient pre-dialysis nephrology care characteristics. This study will use four years (2013-2016) of data from the Dialysis Facility Report (DFR) released in fiscal year 2018. The DFR allows for comparison of characteristics of a dialysis facility's patients, patterns of treatment, transplantation, hospitalizations (admission, readmission, emergency department visits), and mortality to local and national averages. The primary aim of this study is to describe differences in dialysis facility characteristics, incident patient pre-dialysis nephrology care characteristics, and facility performance in readmissions (SRR) across four years: 2013-2016. The secondary aim examines how dialysis facility characteristics and incident patient pre-dialysis nephrology care characteristics affect facility performance in readmissions (SRR) across four years: 2013-2016.

Study population*.* A total of 6,574 dialysis facilities are included in the DFR 2013-2016 data. SRRs are not reported for facilities that have fewer than 11 index hospitalizations over the 4-year period due to the instability of the estimates. In this study, analysis will be restricted to dialysis facilities that reported an SRR for each year of the proposed study (i.e., 2013 through 2016). Additionally, facilities must have at least one incident patient within a study year to be included in the study. Overall, 1,146 (17%) facilities were excluded for not meeting these criteria (1,068 for not having an SRR for all four years and 78 for not having any incident patients). Given the exploratory nature of this study and that the sample (5,428 dialysis facilities) is more than sufficient to investigate the aims, no power analysis is planned.

Source of data*.* The primary data source for this study is the DFR-database. The University of Michigan Kidney Epidemiology and Cost Center (UM-KECC) produces the DFR with funding from CMS (CMS, 2017). The DFR database is compiled using the UM-KECC ESRD patient database derived from multiple data sources that are comprehensive for Medicare patients (e.g., CMS CROWNWeb [the ESRD National Patient Registry & Quality Measure Reporting System], payment records, Organ Procurement and Transplant Network, Social Security Death Master File, etc.). The DFR can be downloaded as one comma-separated values (CSV) file and does not require access to multiple files or databases. Since the DFR only captures profit status and chain membership based on the last year of collected data and this is a longitudinal study, the Dialysis Facility Compare (DFC) database will be utilized to extract facility characteristics that may change over time due to facility acquisition (i.e., profit status and chain membership). The DFC is available as a CSV file and will be retrieved for all four years 2013-2016. This study will also use data obtained from the Area Resource File (ARF) to identify dialysis facilities as urban or rural based on county location. The ARF is publicly available data compiled from more than 50 databases to provide comprehensive county-level information on a variety of health care utilization, health professions and facilities, environmental, and socio-demographic topics (HRSA, 2018). The ARF dataset provides current as well as historic data for more than 6,000 variables for each of the nation’s counties, in addition to as state and national data (HRSA, 2018). The ARF database can be downloaded in Statistical Analysis System (SAS) format and has county, state, and national level files available.

Study variables and measures. All variables are aggregated to the facility level. Variables for analysis are presented in table 1 (see Appendix 1, pg. 92) based on those suggested in the literature and data available in the DFR dataset. The primary outcome variable is the SRR. Potential factors associated with SRR include dialysis facility characteristics: staffing, profit status, chain membership, clinic size, length of operation, geographic location [urban vs rural], and geographic region [Northeast, South, Midwest, West] , and incident patient pre-dialysis characteristics: recipient of pre-dialysis nephrology care, length of pre-dialysis nephrology care, vascular access type, level of kidney function (GFR), creatinine, hemoglobin, use of ESA, albumin, and primary dialysis modality. All variables used for this analysis are aggregated to the facility-level and described below in detail.

SRR. The primary outcome variable is the SRR, calculated separately for each dialysis facility. The SRR reflects a dialysis facility's performance in unplanned readmissions within 30 days following an index hospital discharge. Each year the SRR is calculated as the total number of observed readmissions that occurred over twelve months divided by the total number of expected readmissions within a facility resulting in a ratio. A value less than 1.0 indicates that a facility's total number of readmissions are less than expected (i.e., high performing dialysis facilities), greater than 1.0 indicates more readmissions than would be expected (i.e., low performing dialysis facilities), and equal to 1.0 indicates the facility performed as expected given national rates (i.e., average dialysis facilities) (CMS, 2017). The probability that a given discharge results in a readmission is based on a hierarchical logistic model that makes adjustments for the discharging hospital and for patient characteristics at the time of discharge including: age, sex, diabetes, BMI, duration of ESRD, comorbidities in the preceding year, the presence of a high-risk diagnosis, and length of hospital stay. The SRR is not calculated for dialysis facilities that have fewer than eleven index discharges in a year due to the small group of patients and resulting unstable statistics (CMS, 2017).

SRR exclusions. The SRR excludes unplanned readmissions to an acute care facility that occur 0-3 days post hospital discharge. These patients are excluded given the short readmission timeframe and inability for a dialysis facility to see a patient for assessment and intervention prior to the return to a hospital (CMS, 2017). Further exclusions from the SRR include discharges from skilled nursing facilities, long-term care hospitals, rehabilitation hospitals, cancer hospitals, as well as separate dedicated units in hospitals for hospice, rehabilitation, and psychiatric care, patients discharged against medical advice, and hospitalizations occurring with a primary diagnosis of treatment of cancer, certain psychiatric conditions, or rehabilitation for prosthesis (CMS, 2017).

Readmission attribution for SRR. The attribution of hospital readmissions to dialysis facilities depends on which dialysis facility a patient was discharged to for dialysis treatment (CMS, 2017). This discharge is termed the index discharge and serves as the starting point for identifying readmissions. An index discharge is defined as the number of Medicare-covered hospital discharges occurring at acute-care hospitals in the calendar year for patients receiving dialysis treatment (CMS, 2017). In order to assign index discharges to dialysis facilities to initiate surveillance for readmissions, patient's dialysis facilities are identified using a combination of Medicare dialysis claims, the Medical Evidence form (CMS-2728) and data from CROWNWeb (CMS, 2017). These data sources link the patient to a dialysis facility and treatment at the time of hospital discharge. Patients are included in a dialysis facility's SRR from the first day of dialysis treatment. In other standardized measures (i.e., mortality and hospitalizations), patients are required to receive dialysis for more than 90 days before they are included in quality measure analysis. Additionally, if a patient transfers to a new facility the patient is included in the SRR immediately. In other standardized measures, patients must be in the dialysis facility to which they transfer for at least 60 days in order to be included in the quality measure analysis. Finally, patients are removed from the SRR analysis upon withdrawal from dialysis treatment or are identified as lost to follow-up rather than 60 days later, as done in other standardized measures (CMS, 2017). This difference is to prevent inflation of a facilities' SRR by readmissions that occur when a patient is no longer receiving dialysis care from the facility.

Dialysis facility characteristics. *Staffing* represents the total number of full- and part-time staff classified by job title: nurses and PCT. These values are then compared with the number of certified dialysis stations to create a ratio described as the number of nurses or PCTs per dialysis chair. *Profit status* identifies the for-profit or non-profit status of the dialysis facility. *Clinic size* refers to the total number of certified stations or "chairs" within a facility. *Chain membership* identifies dialysis facility association with a dialysis organization (e.g., DaVita, Fresenius, Dialysis Clinic Inc.) and is classified as yes or no in the DFC database. *Length of operation* identifies how long a dialysis facility has been open based on their CMS certification date. *Geographic location* reflects dialysis facilities classified as urban or rural based on county location obtained from the DFR dataset and matched to the ARF county-level file. *Geographic region* refers to the classified geographical region by ESRD Network in which a dialysis facility is located. There are eighteen ESRD Networks in the U.S. which are divided into four regions: Northeast, Midwest, South, and West (Saunders & Chin, 2013).

Adult incident patients on dialysis. Incident patient characteristics included in the DFR are based on the total number of patients with submitted CMS-2728 forms. This is a medical evidence form required by CMS for each new patient receiving dialysis (CMS, 2017). *Recipient of pre-dialysis nephrology care* identifies the percentage of patients who have and who have not received nephrology care prior to initiating dialysis. *Length* *of pre-dialysis nephrology care* captures the percentage of patients under the care of a nephrologist prior to the start of ESRD therapy and is stratified by length of time (never, <6 months, 6-12 months, >12 months, and missing/unknown). *Vascular access type* at start of dialysis identifies the percentage of patients on hemodialysis with central venous catheters, grafts, or fistulas at their first outpatient renal replacement treatment. Average lab values reflect those measurements obtained prior to initiating dialysis including level of kidney function measured by *GFR* (mL/min; ranging from 0-30), *serum creatinine* (mg/dL; ranging from 0-33), *hemoglobin* (g/dL; ranging from 3-18), and *serum albumin* (g/dL; ranging from 0.8-6.0). These values are collected at the time of ESRD diagnosis as reported on the CMS-2728 and averaged among all incident patients to create a facility average. *Use of ESA* describes the percent of patients who received ESA prior to initiating dialysis. *Primary dialysis modality* describes a facility's percentage of patients receiving dialysis treatment by modality type including hemodialysis, continuous ambulatory peritoneal dialysis (CAPD)/continuous cycling peritoneal dialysis (CCPD).

Data Collection*.* Since the proposed study is using publicly available, de-identified data, aggregated to the dialysis facility-level that does not involve human subjects the study is exempt from IRB approval. Data will be extracted from the UM-KECC DFR dataset for fiscal year 2018, Archive DFC datasets (10/20/2016, 10/08/2015, 10/23/2014, 9/12/2013) and ARF separately. The DFC database will be used to extract yearly ownership and profit status facility characteristics based on CMS certification number (CCN) and the ARF dataset will be used to extract information on rural and urban geographic location of dialysis facilities based on county location. Additionally, urban and rural classifications will be coded into nine categories correlating to population size using the Rural-Urban Continuum Codes developed by the U.S. Department of Agriculture in 2013 (see Appendix 1, Table 2, pg. 90). These codes will be transformed into four categories obtained from ARF as done in prior studies (Yan et al., 2013). The DFR and DFC will be combined for corresponding years based on the CCN. Then the new file will be combined with ARF data for the corresponding years based on dialysis facility county location. Data elements to be extracted from the database are listed in table 1 (see appendix 1, pg. 92). Data will be analyzed using SAS 9.4 (SAS Institute, Cary, NC, USA).

Data Analysis. The statistical analysis for this study is described below.

Aim 1. *Describe differences in **incident patient pre-dialysis nephrology care characteristics**, **dialysis facility characteristics** and the **standardized readmission ratio (SRR)** among United States dialysis facilities over four years: 2013-2016.*

To address this aim, descriptive statistics will be calculated to describe the facilities' incident patient pre-dialysis nephrology care characteristics: recipient of pre-dialysis nephrology care, length of pre-dialysis nephrology care, vascular access type, level of kidney function (GFR), serum creatinine, hemoglobin, use of ESA, albumin, and primary dialysis modality, dialysis facility characteristics: staffing, profit status, chain membership, size, length of operation, geography (urban v. rural), ESRD geographic Network (Northeast, South, Midwest, West), and facility performance on the SRR. Descriptive statistics will include means, medians, standard deviations, and ranges for the continuous variables, as well as counts with frequencies for the categorical variables. Descriptive statistics will be calculated for all four-performance years (2013-2016). Chi-square tests for categorical variables and analysis of variance (ANOVA) for continuous variables will be used to determine differences in variables across the four years (2013-2016).

Aim 2. *Examine the associations of* ***incident patient pre-dialysis nephrology care characteristics*** *and* ***dialysis facility characteristics*** *with the* ***standardized readmission ratio (SRR)*** *among United States dialysis facilities over four years: 2013-2016.*

To address this aim, a series of analyses will be performed. The data used in this study are longitudinal meaning that variables of interest are measured four times. Statistical analysis of longitudinal data requires accounting for possible between-subjects heterogeneity and within-subject correlation (Delwiche & Slaughter, 2012). The assumption of independence is violated in this study, as each dialysis facility provides more than one data point for each variable (Bakdash & Marusich, 2017). In order to account for the correlation within the same dialysis facility, mixed linear model (MLM) regression will be used to test associations between independent variables and SRR in a univariate fashion while accounting for within-subject (facility) variability. In subsequent regression analyses, variables achieving statistical significance in the univariate analysis will be considered candidate variables for the final model. Next, multivariable regression using an MLM will be used to evaluate incident patient pre-dialysis nephrology care characteristic and dialysis facility characteristics associated with SRR.

Potential issues with variables that are closely related (i.e., multicollinearity) will be assessed during the analysis and signs of the parameter estimates will be observed to see if they are in the expected direction. If variables are identified as being multicollinear, models will be fit with only one of the variables at a time and then simultaneously to see if there are any substantive differences in results. The Wald statistic will be used to test whether the variable is making a significant contribution to the prediction of the outcome, specifically, whether the explanatory variable's coefficient is significantly different from zero (Hosmer & Lemeshow, n.d.). The Wald statistic will be interpreted with attention paid to the standard error and deviance (goodness of fit) to mitigate false conclusions about the contribution of an explanatory variable. If there is doubt about the relevance of an explanatory variable, a prior model without the variable will be compared to a model with the variable to see whether the reduction in deviance is statistically significant (Hosmer & Lemeshow, n.d.). The effect size of the explanatory variables will be evaluated based on odds ratios to determine the size or magnitude of the association of explanatory variables with the SRR. Additionally, outliers may severely affect statistical output. To compensate for this potential threat, regression analyses will be performed with attention paid to the entry method of explanatory variables. Entry method will be completed in two manners: forward selection and backward elimination. Stepwise methods will not be completed because empirical evidence is available to support the importance of selected explanatory variables for this study.

Missing Data*.* With any observational database, missing data are inevitable. Patterns and quantity of missing data within the sample will be documented. Various strategies will be considered for missing data. Listwise deletion will be considered to handle dialysis facilities with large amounts of missing data for the explanatory variables (Kang, 2013). Prior research using the DFR dataset found that <2.9% of data were missing for covariates therefore, listwise deletion is a reasonable strategy (Patzer, Plantinga, Krisher & Pastan, 2014; Kang, 2013). If missing data is larger than previous estimates, regression imputation is another strategy that will be considered to handle missing data. Imputation is the process of replacing missing data with estimated values. This technique preserves available data by replacing missing data with a probable value estimated by other available information (Kang, 2013). Given the longitudinal nature of this study a third method, last observation carried forward, may be an additional strategy to handle missing data. (Hamer & Simpson, 2009).

Limitations*.* The proposed study will perform secondary analysis using existing observational datasets; therefore, the results will reveal associations and not causality. The accuracy of the data and its ability to be appropriately interpreted through this study is dependent upon the original data source from which the DFR is produced. Data sources retrieved by the University of Michigan responsible for developing the DFR dataset, is dependent upon dialysis facility data entry. Accuracy of facility reported data is a limitation due to the retrospective nature of this study and inability to validate data. Selection bias is an inherent limitation of this study due to the data's retrospective nature and dependence on this specific database to investigate the study as proposed.

Chapter IV: Findings

Data Management

Data management for this study consisted of six distinct tasks that supported the construction of eight independent variables from disparate data sources. These six tasks included: one task using the dialysis facility compare (DFC): 1) recoding of profit status and chain association variables for 2014, two tasks using the Area Resource File (ARF): 2) construction of the geographic location and 3) construction of geographic region variables, and three tasks using the Dialysis Facility Report (DFR): 4) calculations to support the development of the years in operation, 5) calculations for the creation of patient care tech (PCT) and registered nurse (RN) ratios and 6) creation of dialysis modality variables.

The first data management task involved recoding profit status and chain association variables. The need to recode the profit status and chain association variables was identified after suspicious fluctuation was noted in data extracted from the DFC database. A large number of dialysis facilities switched ownership status between 2013 and 2014 but returned to their prior status in 2015 and maintained that status in 2016. This fluctuation was potentially caused by insignificant name changes from 2013 to 2014 that triggered a logic attribution change (e.g., American Renal Associates ARA to American Renal Associates; Regional-Beaumont Hospital to Beaumont Hospital; Dialysis Clinic, Inc. DCI to Dialysis Clinic, Inc., etc.). Additionally, the variable type for profit status (OWNTYPE) was changed from numeric (i.e., 1=Profit and 2=Non-Profit) in 2013 to character (i.e., Profit and Non-Profit) in years 2014-2016. The code for chain association (CHAINYN) was changed from single characters (i.e., Yes=Y and N=No) in

2013 to full-text (i.e., Yes and No) in years 2014-2016. Thus, dialysis chain names and corresponding profit status was identified using all four years of DFC databases (2013-2016) to validate facility chain association and profit status across years. A control table was created for chain name using the validated chain association and profit status. Binary variables were created for chain association (1 indicating yes and 0 indicating no) and profit status (1 indicating for-profit and 0 indicating not-for-profit) for each of the four years (2013-2016).

The second data management task involved converging data to create a geographic variable for rural/urban location. The DFR only contains an identification for city variable. To identify whether a facility was located in a rural/urban county, it was necessary to cross reference from the DFR database to the DFC which includes a county variable. After dialysis facility county location was identified, county names were matched to their corresponding federal information processing standards (FIPS) codes. The FIPS codes allow for matching to rural-urban continuum codes (RUCC). RUCC codes add geographic descriptions to locations (see Appendix 1, table 2, pg. 94). RUCC codes were compared with codes from the Area Resource file (ARF) to determine urban and rural classification of dialysis facilities as done in prior studies in the literature (see Appendix 1, table 2, pg. 94; Yan et al., 2013). A variable was constructed to indicate dialysis facility geographic location ranging from values 1-4; 1 large metropolitan counties, 2 medium/small metropolitan counties, 3 suburban counties, and 4 rural counties (Yan et al., 2013). However, data for additional U.S. territories and Islands included in the DFR data were not available in the ARF (e.g., Guam, Virgin Islands, and America Samoa). Therefore, nine dialysis facilities were excluded from the study.

The third data management task supported the creation of the geographic region variable. The end stage renal disease (ESRD) Network variable was extracted from the DFR which classifies networks into geographic regions (Saunders & Chin, 2013). Networks 1, 2, 3, 4 were classified as Northeast; Networks 5, 6, 7, 8, 13, 14 were classified as South; Networks 9, 10, 11, 12 were classified as Midwest; and Networks 15, 16, 17, 18 were classified as West (see Appendix 2, Table 3 & Figure 3, pg. 95). This classification is largely congruent with the U.S. Census Bureau's map of U.S. regions. However, the ESRD geographic region for this study was determined by how the majority of states classified based on ESRD Network association. For example, Kentucky which is associated with Network 9, containing primarily Midwest states, was classified as Midwest instead of South, as it is in the U.S. Census Bureau's classification. Additionally, Delaware is associated with Network 4 which contains Delaware and Pennsylvania. Since Pennsylvania is classified as a northeast state, Delaware was classified as northeast as well.

The three remaining data management tasks involved the creation of four independent variables from the DFR database: years in operation, patient care technician (PCT) and registered nurse (RN) ratios, and dialysis modality (i.e., in-center hemodialysis dialysis [ICHD] only, home only, ICHD and home). Years in operation was created using the initial Medicare certification date (MM/DD/YYYY) to calculate how many years a facility had been in operation in each study year (2013-2016; e.g., 2013 minus certification date). The PCT and RN ratios were calculated using staffing data. First, the numbers of full-time and part-time PCTs and RNs were extracted for each study year. Then, to create a ratio, the total number of certified dialysis chairs (i.e., clinic size) was divided by the total number of PCTs and RNs. The last variable that was created was facility services by modality type. The modality variables (i.e., hemodialysis, home hemodialysis, and home peritoneal dialysis) reported for all patients were used to create a facility modality service numeric variable ranging from 1 to 3. Facilities with 100% of their patient population receiving in-center hemodialysis were classified as “in-center hemodialysis (ICHD) only” coded as 1. Facilities reporting patient populations on ICHD and home (HHD, CAPD, or CCPD) were classified as “ICHD and Home” coded as 2. Facilities with 100% of their patient population receiving home hemodialysis (HHD) or peritoneal dialysis (CAPD or CCPD) were classified as “home only” coded as 3. Creating modality service variables for dialysis facilities included in this study was done using actual patient data, as described above, due to the fact that dialysis facilities can be certified for a modality but not currently offering that service at their facility. Using patient data allows for an accurate interpretation of services offered by dialysis facilities in real-time. Following the completion of the data management tasks there were 27 independent variables including 10 dialysis facility characteristics and 17 incident patient characteristics, and one outcome variable (SRR) for analysis.

Sample

A total of 6,574 dialysis facilities were available in the DFR 2013-2016 data. Dialysis facilities were only included if they reported standardized readmission ratio (SRR) for all 4 years (2013 to 2016). SRRs are not included in the DFR data set if a facility reports fewer than 11 index discharges within a year. Thus 1,068 facilities were excluded. An additional 78 facilities were excluded because they did not have at least one incident patient reported per study year. Finally, an additional nine facilities located in U.S. territories or islands (e.g., Guam, Virgin Islands, and America Samoa) were excluded due to the inability to extract geographic location data from the ARF for appropriate urban and rural assignment. Therefore, the study included 5,419 dialysis facilities located in all 50 states, the District of Columbia, and Puerto Rico. Table 4 reflects the total number of facilities across all four study years that were included for the descriptive analyses for the primary aim and the regression analyses for the secondary aim. Total observations reflects the total number of facilities across the four study years (2013-2016) included in each aim. The variation in the sample for the secondary aim (table 4) resulted from missing data. For the secondary aim facilities with missing data for any of the variables were excluded in that year.

Table 4

Number of Dialysis Facilities included in each aim for year studied

	2013	**2014**	**2015**	**2016**	**Total Observations 2013-2016**
Primary Aim	5,419	5,419	5,419	5,419	21,676
Secondary Aim	5,345	5,330	5,350	5,348	21,373

Analysis for Missing Data

A common problem associated with longitudinal studies is the prevalence of missing data. Overall, 4,089 (75%) of facilities had zero missing data for all independent variables included in the study. Over the course of the four study years, 25% of the sample dialysis facilities were missing data for at least one independent variable. Table 5 (see appendix 2, pg. 95) displays a breakdown of missing data by year. Missing data were reviewed for independent variables prior to the regression analyses. Of the study's 27 independent variables, only four had missing data in one or more years. Table 6 reviews missing data by independent variables.

Table 6

Missing Data by Independent Variable of Total Sample Dialysis Facilities (n=5,419)

Variable (n, %)	2013	2014	2015	2016
RN Ratio	74 (1.37%)	89 (1.64%)	69 (1.27%)	71 (1.31%)
PCT Ratio	258 (4.76%)	268 (4.95%)	246 (4.54%)	251 (4.63%)
Avg. Albumin	389 (7.18%)	457 (8.43%)	498 (9.19%)	532 (9.82%)
Avg. Hemoglobin g/dL	240 (4.43%)	302 (5.57%)	312 (5.57%)	351 (6.48%)
Avg. GFR mL/min	0 (0.00%)	1 (0.02%)	0 (0.00%)	0 (0.00%)

Note: RN= registered nurse, PCT=patient care technician, Avg.=average, GFR=glomerular filtration rate

Due to the random structure of missing data the sample size was not altered, and all variables were included for the descriptive statistics analysis. To examine potential impact of missing data for the secondary aim, a mixed linear model using the PROC MIXED procedure in SAS® was used to assess the correlational structures and variability changes between repeated measurements on dialysis facilities across time. PROC MIXED has the capacity to handle unbalanced data when the data are missing at random (Littell, Milliken, Stroup, Wolfinger & Schabenberger, 2006). PROC MIXED does not impute missing data, but instead ignores data for variables where it is missing (Littell, Milliken, Stroup, Wolfinger & Schabenberger, 2006). Average albumin had the highest rates of missing data across the four study years (2013-2016). The rate of missing hemoglobin values increased from 2013 to 2016 (4.43% to 6.48%) and average GFR had the lowest rate of missing data with only one facility missing average GFR data in 2014.

Results for Primary Aim

The primary aim was to describe differences in dialysis facility characteristics, incident patient pre-dialysis nephrology care characteristics, and the SRR among United States dialysis facilities over four years: 2013-2016. Descriptive statistics for the study's 27 variables across the 4 years are depicted in Table 7. Continuous variables have mean and standard deviation calculations displayed by year. Categorical variables have counts (n) and frequencies (%) displayed by year.

Table 7
Descriptive Statistics for dialysis facilities receiving an SRR 2013-2016

Dialysis Facility Characteristics	2013	2014	2015	2016
Incident Pts	19.48 (13.26)	19.53 (12.87)	19.53 (12.90)	18.80 (12.51)
Years in Operation	14.56 (9.94)	15.56 (9.94)	16.56 (9.94)	17.56 (9.94)
Clinic Size	18.52 (8.08)	18.63 (8.14)	18.74 (8.17)	18.82 (8.16)
RN Ratio	4.00 (2.53)	3.88 (2.33)	3.86 (2.33)	3.85 (2.36)
PCT Ratio	3.57 (2.59)	3.48 (2.61)	3.33 (2.37)	3.25 (2.25)
Chain Association				
Yes	4,659 (86%)	4,709 (87%)	4,753 (88%)	4,787 (88%)
No	760 (14%)	710 (13%)	666 (12%)	632 (12%)
Profit Status				
For-Profit	5,010 (92%)	5,008 (92%)	5,004 (92%)	4,996 (92%)
Not-for-Profit	407 (8%)	411 (8%)	415 (8%)	423 (8%)
Facility Services				
In-Center Hemodialysis Only (ICHD)	2,078 (38%)	1,979 (37%)	1,860(34%)	1,916(35%)
ICHD & Home Dialysis	3,294 (61%)	3,406 (63%)	3,537 (65%)	3,479 (64%)
Home Only	47 (0.9%)	34 (0.6%)	22 (0.4%)	24 (0.4%)
Geographic Region				
Northeast	796 (15%)	796 (15%)	796 (15%)	796 (15%)
South	2,340 (43%)	2,340 (43%)	2,340 (43%)	2,340 (43%)
Midwest	1,315 (24%)	1,315 (24%)	1,315 (24%)	1,315 (24%)
West	968 (18%)	968 (18%)	968 (18%)	968 (18%)
Geographic Location				
Large Metropolitan	2,824 (52%)	2,824 (52%)	2,824 (52%)	2,824 (52%)
Medium/Small Metro	1,617 (30%)	1,617 (30%)	1,617 (30%)	1,617 (30%)
Suburban	679 (13%)	679 (13%)	679 (13%)	679 (13%)
Rural	299 (6%)	299 (6%)	299 (6%)	299 (6%)
Incident Patient Characteristics				
Received Pre-Dialysis Care				
% No	25.69 (20.40)	24.87 (20.85)	22.82 (20.36)	21.14 (19.71)
% Yes	61.40 (25.15)	61.42 (25.60)	62.54 (25.79)	63.92 (25.98)
% Unknown	12.90 (21.59)	13.70 (22.36)	14.64 (23.34)	14.93 (23.31)
Length of Pre-Dialysis Care				
% < 6 Months	13.69 (15.82)	13.88 (16.35)	13.81 (16.49)	13.86 (16.31)
% 6-12 Months	19.04 (16.59)	18.83 (16.72)	19.33 (17.09)	19.31 (17.08)
% > 12 Months	28.67 (22.30)	28.71 (22.67)	29.40 (23.12)	30.75 (24.07)
Vascular Access 1st Tx				
% AVF	17.29 (14.44)	17.10 (14.55)	17.15 (14.75)	17.12 (15.16)
% AVG	2.85 (5.66)	3.07 (5.95)	3.08 (6.03)	3.04 (6.11)
% CVC	77.75 (18.88)	77.89 (18.78)	77.90 (18.83)	77.91 (19.31)
% AVF Present	35.67 (20.73)	34.29 (20.77)	33.88 (20.55)	33.64 (20.73)
Primary Dialysis Modality				
% HD	91.63 (18.24)	91.75 (17.97)	91.76 (17.92)	91.85 (17.75)
% PD	8.37 (18.24)	8.25 (17.97)	8.24 (17.92)	8.15 (17.75)
Facility Average Lab Values				
Albumin	3.15 (0.34)	3.14 (0.34)	3.16 (0.34)	3.16 (0.34)
Serum Creatinine	6.38 (1.32)	6.45 (1.32)	6.46 (1.31)	6.43 (1.32)

Hemoglobin	9.48 (0.63)	9.40 (0.64)	9.35 (0.66)	9.30 (0.66)
GFR	10.89 (1.92)	10.77 (1.92)	10.75 (1.97)	10.74 (1.90)
% Received ESA	14.80 (16.36)	14.10 (16.29)	12.92 (15.68)	12.77 (15.93)

Note: Pts=patients, RN=registered nurse, PCT=patient care tech, Tx=treatment, AVF=arteriovenous fistula, AVG=arteriovenous graft, CVC=central venous catheter, HD=hemodialysis, PD=peritoneal dialysis, ESA=erythropoietin stimulating agent

Dialysis Facility Characteristics. The average number of incident patients across the four study years remained relatively consistent (range: 18.80 to 19.53 patients). The average number of facility years in operation ranged across the four years from 14.56 to 17.56. The stepwise increase in the mean across the four study years reflects facilities included in the sample increase in years of operation by one each year. Clinic size remained stable across the four years with an average of 19 certified dialysis chairs. However, even though the average appeared stable across the four years, the number of certified dialysis chairs varied from year-to-year among 11% (n=575) of the facilities. Of the 575 facilities with variation, 75% increased the number of chairs (n=422) and 25% decreased their number of chairs (n=153). The differences in averages of the PCT and RN ratios decreased across the study years with 4.0 to 3.85 chairs per RN and 3.57 to 3.25 chairs per PCT. Chain association and profit status varied slightly across the four years. The majority of facilities included in the sample were associated with a dialysis chain (range= 86-88%) and were for-profit (92%). Facility services varied across the four years among the study sample with single service clinics showing a decline from 2013-2015 (ICHD went from 38% to 35% and Home only went from 0.9% to 0.4%) and multi-service clinics increasing (61% to 64%). The majority of dialysis facilities included in the sample were located in the south (43%) with the smallest portion of facilities located in the northeast (15%). Additionally, the majority of facilities were located in a large metropolitan county (52%) with the smallest portion of facilities located in rural counties (6%).

Incident Patient Characteristics. The majority of incident patients received pre-dialysis nephrology care and the rate increased across the four study years (61.40% to 63.92%). However, the variation among facilities was high demonstrated by standard deviations greater than 25%. The length of pre-dialysis nephrology care varied across the study years with means increasing as the length of care increased. For example, less than 6 months of pre-dialysis nephrology care ranged from 13.69% to 13.86%, 6-12 months ranged from 19.04% to 19.31%, and greater than 12 months ranged from 28.67% to 30.75%. The rates of vascular access used at first outpatient dialysis remained relatively stable across the four study years with the largest majority of patients dialyzing via a catheter (78%) and the smallest portion dialyzing via AV graft (3%). The rate of patients starting dialysis with a fistula in place decreased from 35.67% to 33.64% across the four years. The primary dialysis modality remained stable across the four study years with approximately 92% of patients receiving hemodialysis and 8% receiving peritoneal dialysis. Additionally, the facilities average patient lab values remained similar across the four study years with average serum albumin 3.2g/dL, serum creatinine 6.5mg/dL, and glomerular filtration rate (GFR) 10.7mL/min however, hemoglobin declined from 9.48 to 9.30. There is a noted decrease in administration of erythropoietin stimulating agent (ESA) across the four study years (14.80% to 12.77%). However, the standard deviation is large (~16) indicating variation in incident patients receiving ESA prior to dialysis initiation.

SRR. Among the 5,419 dialysis facilities, the mean observed index admissions decreased across the four study years but rebounded in 2016 (range: 90.16 to 92.00; table 8). Index admissions initiate the 30-day window of time a discharged patient is tracked for a readmission (CMS, 2018). Large variation exists among facilities in index admissions as noted by standard deviations greater than 55. The average readmission that occurred among the dialysis facilities was stable at approximately 24 from 2013 to 2015 and declining slightly in 2016 to 23. Expected readmission followed a similar pattern (range: 23-22). The average readmission that occurred was greater than those expected among dialysis facilities in all four study years. The mean SRR remained stable across all four study years at 0.99.

Table 8
Descriptive Statistics for SRR Performance 2013-2016

Metric	2013	2014	2015	2016
Index Admissions	92.00 (59.02)	90.59 (56.68)	90.16 (55.50)	91.29 (55.39)
Actual Readmissions	24.88 (18.79)	24.30 (18.21)	24.20 (17.83)	23.02 (16.69)
Expected Readmissions	23.95 (15.86)	23.47 (15.06)	23.45 (14.83)	22.37 (13.89)
SRR	1.00 (0.27)	0.99 (0.27)	0.99 (0.27)	0.99 (0.27)

Figure 4 displays the SRRs, or the ratio of observed to expected readmissions for dialysis facilities included in this study. The middle line represents an SRR of 1.0 where the observed number of readmission equals the expected number of readmissions. Facilities to the right of the line are performing worse than expected (SRR > 1.0) and facilities to the left of the line are performing better than expected (SRR < 1.0). Thirty-four dialysis facilities (6%) had zero readmissions within the four study years. These facilities had index admissions, but their patients were not readmitted to the hospital within the 30-day readmission window.

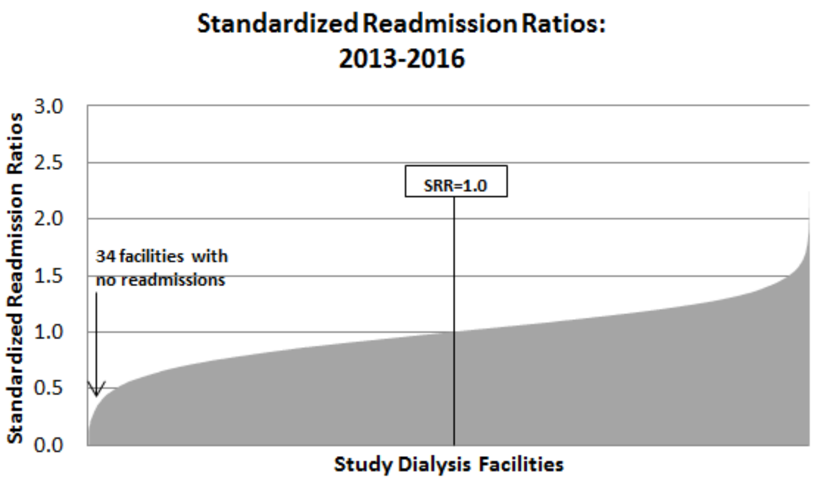

Figure 4. Standardized Readmission Readmissions (SRRs) among study dialysis facilities, 2013-2016

SRR correlation analysis. Spearman correlation coefficients were used to examine the associations between the dialysis facility characteristics, incident patient characteristics and SRR. Dialysis facility and incident patient characteristics that were significantly correlated with SRR are presented in table 9 (see appendix 3, pg. 96). Spearman's correlation is a statistical measure of the strength of a monotonic relationship between paired data. The closer r is to 1 the stronger the monotonic relationship (Royden & Fitzpatrick, 2010). The strength of a correlation can be classified by the r value: .00-.19=very weak, .20-.39=weak, .40-.59=moderate, .60-.79=strong, and .80-1.0=very strong. The percent of patients receiving pre-dialysis nephrology care, percent using an AVF at first dialysis treatment, percent AVF present (i.e., maturing AVF at dialysis initiation), and percent of patients who received greater than twelve months of pre-dialysis nephrology care had a very weak negative correlation with SRR. Clinic size, percent of patients with an unknown length of pre-dialysis nephrology care, percent using a CVC at first dialysis treatment, and the number of incident patients within a dialysis facility had a very weak positive correlation with SRR. All other variables showed no correlation with SRR. All Spearman correlation results of study variables can be viewed in table 10 (see appendix 3, pg. 97).

Results for Secondary Aim

The secondary aim was to examine the associations between incident patient pre-dialysis nephrology care characteristics, dialysis facility characteristics and the standardized readmission ratio (SRR) among United States dialysis facilities over four years: 2013-2016. Analysis for the secondary aim consisted of two tasks. First multicollinearity among independent variables was reviewed. Then a repeated-measures multivariable regression model was run to analyze associations among independent variables and SRR.

Analysis for Multicollinearity

Multicollinearity was a concern due to the numerous independent variables and their potential correlation with each other. Two statistical procedures were performed to better understand collinear relationships among the independent variables including a 1) pairwise Pearson correlation and 2) regression analysis using PROC Reg in SAS. First, to assess the correlation between variables, a pairwise Pearson correlation test was used to identify the strength of linear relationships between continuous numeric variables. A matrix of correlation coefficients is presented in table 11 (see Appendix 3, pg. 98). Correlations are considered to have collinear relationships if r is equal to or greater than 0.50 (Mukaka, 2012). The strength of a correlation can be classified by the r value: .00-.19=very weak, .20-.39=weak, .40-.59=moderate, .60-.79=strong, and .80-1.0=very strong (Royden & Fitzpatrick, 2010). Primary dialysis modality variables (i.e., hemodialysis and peritoneal dialysis) were very strongly correlation (r=-1.0). A very strong negative correlation was observed between serum creatinine and glomerular filtration rate (GFR) (r=-0.807). Additionally, a strong negative correlation was noted between vascular access at first treatment variables CVC and AVF (r=-0.673), strong positive correlation between AVF and AVF present (r=0.664), moderate negative correlation between yes received pre-dialysis nephrology care and no pre-dialysis nephrology care (r=-0.535), moderate positive correlation between yes received pre-dialysis nephrology care and length greater than 12 months of pre-dialysis nephrology care (r=0.598) and strong negative correlation between yes received pre-dialysis nephrology care and unknown if received pre-dialysis nephrology care (r=-0.649). These correlations are noted in red in table 10 (see appendix 3, pg. 97). Due to the numerous collinear relationships among independent variables, a second analysis was performed with PROC Reg to observe variance inflation factors (VIF) and tolerance limits to prioritize variables (i.e., average lab values, received pre-dialysis care, length of pre-dialysis care, and vascular access at 1st treatment) for removal prior to initiating aim 2 analyses. A VIF greater than 10 and tolerance limit less than 0.1 suggest multicollinear relationships between independent variables (Miles, 2014). All independent variables were run in the initial PROC Reg model to evaluate VIF and tolerance values. The results of the initial PROC Reg analysis evaluating relationships between independent variables are presented in table 12.

Table 12

Initial Model: Collinearity Results via PROC Reg

Variable	DF	Parameter	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.8821	0.6067	1.4500	0.1460	.	0.0000
Incident Pts	1	0.0022	0.0002	11.1400	<.0001	0.5874	1.7025
Years in Operation	1	-0.0002	0.0002	-0.9800	0.3285	0.8716	1.1473
Clinic Size	1	0.0004	0.0003	1.4000	0.1613	0.5854	1.7082
RN Ratio	1	0.0046	0.0009	5.1600	<.0001	0.8090	1.2361

PCT Ratio	1	-0.0037	0.0008	-4.3700	<.0001	0.8845	1.1306
Chain Associated	1	-0.0014	0.0061	-0.2300	0.8160	0.9411	1.0626
For-Profit	1	0.0335	0.0075	4.4500	<.0001	0.9622	1.0393
Received Pre-Dialysis Care							
% No	B	0.0006	0.0060	0.0900	0.9269	0.0003	3988.4659
% Yes	B	-0.0002	0.0060	-0.0400	0.9711	0.0002	6328.6990
% Unknown	B	0.0009	0.0060	0.1400	0.8857	0.0002	5006.1211
Length of Pre-Dialysis Care							
% < 6 Months	B	0.0006	0.0001	4.3700	<.0001	0.7883	1.2686
% 6-12 Months	B	0.0003	0.0001	2.3400	0.0195	0.7487	1.3356
% > 12 Months	0	0.0000	.	.	.	.	.
Vascular Access 1st Tx							
% AVF	1	-0.0009	0.0004	-2.4200	0.0154	0.1273	7.8545
% AVG	1	-0.0001	0.0005	-0.2400	0.8075	0.4914	2.0349
% CVC	1	-0.0006	0.0003	-1.7100	0.0867	0.1239	8.0742
% AVF Present	1	-0.0004	0.0001	-3.1100	0.0019	0.5533	1.8072
Facility Average Lab Values							
Albumin	1	0.0218	0.0061	3.5700	0.0004	0.9027	1.1078
Serum Creatinine	1	0.0139	0.0026	5.2900	<.0001	0.3133	3.1917
GFR	1	0.0142	0.0018	8.0400	<.0001	0.3271	3.0575
Hemoglobin	1	-0.0253	0.0034	-7.5100	<.0001	0.8347	1.1980
% Received ESA	1	-0.0002	0.0001	-1.1600	0.2447	0.8090	1.2361

Note: Mos.=Months; CVC=central venous catheter; AVF=arteriovenous fistula; Avg.=average; AVG=arteriovenous graft; Tx=treatment; RN=registered nurse; ESA=erythropoietin stimulating agents; PCT=patient care tech.

Variables previously identified as concerning for multicollinearity in the pairwise Pearson correlation test demonstrated high VIF and tolerance values in the initial PROC Reg model (see table 12, values highlighted in red). Multicollinear issues were noted with three pre-dialysis nephrology care variables including: %Yes (VIF=6328.6990; tolerance=0.0002), %Unknown (VIF=5006.1211; tolerance=0.0002), %No (VIF=3988.4659; tolerance=0.0003), two vascular access at first dialysis treatment %AVF (VIF=7.8545; tolerance=0.1273) and %CVC (VIF=8.0742; tolerance=0.1239), and two facility average lab values variables including: Serum Creatinine (VIF=3.1917; tolerance=0.3133) and GFR (VIF=3.0575; tolerance=0.3271). The process of elimination of variables with collinear relationships continued with the regeneration of

PROC Reg removing collinear variables one at a time. First the decision was made to remove % Yes of the received pre-dialysis care variables due to the high VIF and tolerance values (see appendix 4, table 13, pg. 99). The VIF and tolerance limits were revaluated for impact and then % Unknown was eliminated from the model (see appendix 4, table 14, pg. 99). Next, vascular access variables were assessed. Due to high VIF and tolerance values % CVC was eliminated and AVF was kept for aim 2 analysis (see appendix 4, table 15, pg. 100). Finally, facility average lab value variables were reviewed. GFR was kept for final analyses and serum creatinine was eliminated due to higher VIF and tolerance values. The final PROC reg model with collinear variables removed can be found in table 16 (see appendix 4, pg. 101). Additionally, due to the lack of variation across the four study years for the facilities percentages of incident patient's dialysis modality, hemodialysis (92%) and peritoneal dialysis (8%) and their perfect correlation (r=-1.0), the variables were excluded from final analyses. Finally, a year variable indicating the study year (2013-2016) was added to the list of independent variables. Thus, six independent variables were removed: 4 with collinear relationships and 2 with homogenous data, leaving 22 variables for the regression analyses including the study year variable.

Regression results

A repeated-measures multivariable regression model was developed using SAS PROC MIXED. The model was run with unstructured covariance parameter estimates using the restricted maximum likelihood method and the Kenward-Roger method for degrees of freedom due to the use of repeated measures and presence of missing data (Brown & Prescott, 2015). In the model, the time frame variable (range = 1-4 years for

2013-2016 study years) was the repeated measure, and the unique dialysis facility identifier (CCN) was the subject. Results of the initial model with all 22 independent variables are displayed in table 17.

Table 17

Fixed effects model of impact on dialysis facility SRR

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	54.42	<.0001
Years in Operation	1	6947	1.32	0.2513
Clinic Size	1	8439	0.34	0.5581
RN Ratio	1	1.40E+04	22.49	<.0001
PCT Ratio	1	1.20E+04	11	0.0009
Chain Associated	1	7628	1.14	0.2858
For-Profit	1	7040	7.01	0.0081
Facility Services	2	1	0	1
Geographic Region	3	7106	73.16	<.0001
Geographic Location	3	6968	109.5	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	3.65	0.056
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	6.53	0.0106
% 6-12 Months	1	1.60E+04	18.64	<.0001
% > 12 Months	1	1.30E+04	70.36	<.0001
Vascular Access 1st Tx				
% AVF	1	1.90E+04	0	0.9797
% AVG	1	1.90E+04	0.36	0.55
% AVF Present	1	1.70E+04	16.7	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	0.49	0.4856
Hemoglobin	1	1.90E+04	12.03	0.0005
GFR	1	1.80E+04	17.04	<.0001
% Received ESA	1	1.60E+04	7.27	0.007
Year (2013-2016)	3	1.40E+04	2.16	0.0907

To create a parsimonious model with statistically significant predictors of SRR, the most desirable covariate structure was determined using backwards elimination of independent variables. This procedure involves eliminating a variable whose removal results in a statistically insignificant deterioration of the model. Variables are removed one at a time and the process is repeated until remaining variables demonstrate a statistically significant p-value resulting in a parsimonious statistical model (Brown & Prescott, 2015). The process was initiated by adding all independent variables to the model. Variables were then eliminated based on size of the p-value (i.e., descending order) until all variables had a statistically significant p-value. Variables were eliminated based on p-value in the following order: facility services, % AVF, geographic location, years in operation, % AVG, chain associated, % Received ESA, year (2013-2016), albumin, received pre-dialysis care % no, length of pre-dialysis care % < 6 months, clinic size, and for-profit. Effects of removing these variables can be observed in tables 18-29 (see appendix 5, pg. 102). The final parsimonious model of dialysis facility and incident patient characteristics associated with SRR is displayed in table 30.

Table 30

Final Parsimonious Model: Dialysis Facility & Incident Patient Characteristics Associated with SRR

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.10E+04	159	<.0001
RN Ratio	1	1.40E+04	47.32	<.0001
PCT Ratio	1	1.20E+04	42.13	<.0001
Geographic Region	3	7226	82.04	<.0001
Length of Pre-Dialysis Care				
% 6-12 Months	1	1.80E+04	25.3	<.0001
% > 12 Months	1	1.40E+04	121.04	<.0001
% AVF Present	1	1.80E+04	25.4	<.0001
Facility Average Lab Values				
Hemoglobin	1	1.90E+04	22.88	<.0001
GFR	1	1.90E+04	18.05	<.0001

Results of the final model are described further in table 31 with parameter estimates, including variable categories for each dialysis facility and incident patient characteristic. The number of incident patients, RN ratio, and facility average GFR are associated with a higher SRR (e.g., worse than expected if > 1.0). PCT ratio, percent of patients with lengths of pre-dialysis nephrology care 6-12 months and greater than 12 months, percent of patients with an AVF present, and facility average hemoglobin are associated with a lower SRR (e.g., better than expected if < 1.0). Within the geographic region variable, facilities located in the Northeast are associated with a higher SRR whereas facilities in the West have lower SRRs.

Table 31

Parameter estimates for final model

Fixed Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	1.0325	0.0298	1.90E+04	34.65	<.0001
# of Incident Patients	0.0022	0.0002	1.10E+04	12.61	<.0001
RN Ratio	0.0062	0.0009	1.40E+04	6.88	<.0001
PCT Ratio	-0.0058	0.0009	1.20E+04	-6.49	<.0001
Geographic Region					
Northeast	0.1206	0.0077	7207	15.67	<.0001
South	0.0581	0.0062	7240	9.37	<.0001
Midwest	0.0586	0.0069	7273	8.53	<.0001
West	0.0000	n/a	n/a	n/a	n/a
Length of Pre-Dialysis Care					
% 6-12 Months	-0.0006	0.0001	1.80E+04	-5.03	<.0001
% > 12 Months	-0.0011	0.0001	1.40E+04	-11	<.0001
% AVF Present	-0.0005	0.0001	1.80E+04	-5.04	<.0001
Facility Average Lab Values					
Hemoglobin	-0.0147	0.0031	1.90E+04	-4.78	<.0001
GFR	0.0046	0.0011	1.90E+04	4.25	<.0001

Note: Coefficients of zero due to redundancy are reported “n/a”.

For geographic region, facilities located in the West demonstrated lower SRRs compared to facilities in the Northeast based on the estimated means shown in table 32.

Table 32

Estimated Means over time for SRR: Geographic Region

Fixed Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Geographic Region					
Northeast	1.0522	0.0057	7103	185.39	<.0001
South	0.9897	0.0033	7141	299.97	<.0001
Midwest	0.9903	0.0044	7202	223.85	<.0001
West	0.9316	0.0052	7225	179.59	<.0001

Table 33 displays differences in the geographic region variable identifying a statistically significant difference (p<.0001) among all regions except for the South and Midwest. Dialysis facilities in the Northeast have significantly higher SRRs compared to the West (p<.0001) followed by the South (p<.0001) and then Midwest (p<.0001). Facilities in the South have higher SRRs than facilities in the West (p<.0001) but lower SRRs than facilities in the Midwest (p=0.9996). Finally, facilities in the Midwest has higher SRRs than facilities in the West (p<.0001).

Table 33

Differences Among Estimated means: Geographic Region

Region	Region	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
Northeast	South	0.0625	0.0066	7159	9.45	<.0001	TK	<.0001
Northeast	Midwest	0.0620	0.0072	7185	8.56	<.0001	TK	<.0001
Northeast	West	0.1206	0.0077	7207	15.67	<.0001	TK	<.0001
South	Midwest	-0.0006	0.0055	7276	-0.1	0.9202	TK	0.9996
South	West	0.0581	0.0062	7240	9.37	<.0001	TK	<.0001
Midwest	West	0.0586	0.0069	7273	8.53	<.0001	TK	<.0001

Note: TK=Tukey-Kramer

In summary, the primary and secondary aims resulted in numerous informative findings. Variation in means by year for most analyzed dialysis facility and incident patient characteristics was minimal (table 7). The majority of dialysis facilities were for-profit, associated with a dialysis chain, located in the southern geographic region, were located in large metropolitan areas, and provided multiple modality services (i.e., ICHD and home dialysis). The average facility had been open for 14 years at the start of this study (2013), had an average of 19 certified dialysis chairs, approximately 20 incident dialysis patients per year, and a 4:1 chair to RN ratio and 3:1 chair to PCT ratio. The majority of incident patients received pre-dialysis nephrology care with most receiving greater than 12 months of care. Most incident patients initiated hemodialysis as their modality type with a CVC for vascular access. The percent of patients with an AVF present upon dialysis initiation declined over the four study years (36% to 34%). Average facility-level lab values (albumin, serum creatinine, hemoglobin, and GFR) remained relatively stable over the four study years (2013-2016). Patients receiving ESA prior to dialysis initiation declined over the study years (14.80% to 12.77%). For the secondary aim, several characteristics have favorable associations with SRR resulting in lower SRRs. An increase in facility average hemoglobin decreases SRR by 0.0147, higher PCT ratios decrease SRR by 0.0058, the percent of patients who had received greater than 12 months of pre-dialysis nephrology care decreases SRR by 0.0011, 6-12 months of care decreases SRR by 0.0006 and finally the percentage of patients with an AVF present at the initiation of dialysis decreases SRR by 0.0005. Conversely, there were characteristics with an unfavorable association with SRR resulting in higher SRRs. Higher counts of incident patients increase SRR by 0.0022, higher average GFR among facilities increases SRR by 0.0046, higher RN ratios increase SRR by 0.0062. Finally, location of dialysis facilities geographically contribute to higher SRRs specifically in the Northeast by 0.1206 followed by the Midwest (0.0586) and the South (0.0581).

Chapter V: Discussion and Conclusions

This study of 5,419 dialysis facilities treating an average of 104,768 incident patients across the four study years (2013-2016) revealed that dialysis facilities located in western region of the United States had significantly lower SRRs compared to facilities in the Northeastern region of the United States. Study findings concerning staffing demonstrated contrasting relationships among facility personnel with higher RN ratios associated with higher SRRs and higher PCT ratios associated with lower SRRs. Additionally, the number of incident patients a dialysis facility cared for within a given year was associated with higher SRRs. Several modifiable incident patient pre-dialysis nephrology care characteristics were found to be associated with lower SRRs including higher percentages of patients with an AVF vascular access present at first dialysis treatment, higher percentages of patients receiving 6-12 months or greater than twelve months of nephrology care prior to dialysis and higher facility average hemoglobin. Additionally, higher facility average GFR was associated with higher SRRs.

RN and PCT Ratios

Across the four study years mean staffing ratios for RNs and PCTs declined (RN: 4-3.85; PCT: 3.57-3.25) meaning fewer chairs per RN and PCT. The cause of this decline cannot be defined in this descriptive study, but further research may be done to investigate factors influencing increasing and decreasing staff ratios. The addition of a nurse could be due to the increase in clinic size (i.e., addition of a certified dialysis chair). It was found that 575 facilities included in this study had some change in their clinic size over the course of the four-year study period. The majority of clinics (422, 75%) with noted change in size increased the number of chairs operating in their clinic therefore, potentially growing the population they serve warranting increased staff. Additionally, the increased need for nurses could be due to the increased acuity of the patient population or change in patient characteristics however, more research is needed to better understand this construct.

The contrasting association of high RN ratios with high SRRs and high PCT ratios with low SRRs illuminates the need to continue to evaluate appropriate staffing within dialysis facilities. The increase in PCT ratios associated with a lower SRR warrants further investigation into the actual staffing mix. Higher PCT ratios were found to decrease SRR by 0.0058 ($p<.0001$). Perhaps in clinics where there were fewer PCTs there were more RNs and an appropriate mix of the two roles together made an impact on SRR performance. In contrast, high RN ratios were found to increase SRR by 0.0062 ($p<.0001$) meaning the more chairs an RN was responsible for, facility performance on the SRR measure declined. Prior research has demonstrated that readmission rates are significantly higher in hospitals with lower nurse staffing resulting in higher RN ratios (Giuliano, Danesh & Funk, 2016; Kim, Park, Han, Kim & Kim, 2016). These findings have been replicated in other healthcare settings and with various patient populations as well. A 2016 case study completed in the nursing home setting found that the staffing and competence level were suggested to affect hospital readmissions (Glette et al., 2018). An observational study completed in 2013 found that pediatric patients treated in hospitals in which nurses care for fewer patients each are significantly less likely to experience readmission illustrating the effectiveness of lower patient-to-nurse ratios (Tubbs-Cooley, Cimiotti, Silber, Sloane & Aiken, 2013).

In dialysis facilities with greater workloads or an increase in RN ratios (more chairs per RN) may be due to vacancy rates of staff within clinics. In the nursing home setting, research has demonstrated that licensed nurse retention rate is significantly associated with 30-day readmissions (Thomas, Mor, Tyler & Hyer, 2012). Further, nursing homes experiencing a 10% increase in their retention had a 0.2% lower rehospitalization equating to 2 fewer hospitalizations annually. Prior research in the dialysis setting has shown that the turnover of direct patient care staff (RNs, PCTs) (22.3%) is much higher than the national hospital nurse turnover rate (8.92%) (Tai & Robinson,1998). These rates are potentially higher today in dialysis facilities as these rates are from the late 1990's. More current research still echoes issues with staffing in dialysis facilities. An article published in 2015 found that only 57 to 68% of nurses working in nephrology settings agreed or strongly agreed that their unit had enough staff to handle the workload (Ulrich & Kear, 2015). Additionally, a follow-up study by Ulrich and Kear (2018) found additional factors that influence the retention of nurses include lack of support and education to safely perform roles and manage care of a highly complex patient population and the prevalence of intimidation and bullying by PCTs towards nurses new to nephrology practice. Other settings have found similar factors influence retention of nurses as well (Sawatzky, Enns & Legare, 2015; Tourangeau, Patterson, Saari, Thomson & Cranley, 2017). Further research on vacancy rates and the impact of decrease staff on patient outcomes in the dialysis setting is necessary to better understand this finding.

Further descriptive studies on dialysis facility staffing can be done using ESRD Facility Annual Survey (CMS-2744). This survey captures the number of employed full and part time staff as well as the number of open positions. The datasets (i.e., DFR) used for this study only report the number of staff employed. However, the United States Renal Data System (USRDS) has all staffing data reported on the CMS-2744, but it has not been further investigated or reported on in the literature.

In addition to the need for appropriate RN ratios, the role of nurses in outpatient dialysis facilities warrants further investigation. The majority of dialysis nurses are working in direct patient care solely focused on the clinical aspects of dialysis care with minimal opportunity to consider a patient’s care pre and post dialysis, or other factors that influence readmission. Therefore, the nurse may not be involved in care and treatment that directly impact SRR performance. In contrast, a comprehensive ESRD care (CEC) model currently being piloted in the ESRD Seamless Care Organizations (ESCOs) includes patient’s care pre and post dialysis, and other factors that influence readmission. The CEC model joins dialysis clinics, nephrologists, and other providers together to coordinate care for ESRD beneficiaries (CMS, 2018). This model encourages dialysis providers to think beyond their traditional roles in care delivery and supports them in providing patient-centered care that addresses beneficiaries needs both in and outside the dialysis clinic. Evaluation findings of the CEC model revealed that while both the ESCO facilities and the comparison group showed improvement over time. The combined ESCO SRR exhibited the greatest reduction compared to the comparison group in 2016 (The Lewin Group Inc., 2017). Further research is needed to investigate staffing mixes, nursing interventions in care coordination and their impact on patient outcomes, specifically readmissions.

Anemia Management

A facility's average hemoglobin g/dL among incident patients initiating dialysis reflects anemia management of the patients during their pre-dialysis nephrology care. Higher Hemoglobin averages were found to improve SRRs by 0.0147. Hemoglobin thresholds for patients with CKD are 12.0 grams per deciliter (g/dL) in female and 13.0g/dL in men are considered normal (Counts, 2015). The facility average hemoglobin among dialysis facilities in this study declined from 9.48 to 9.30 across the four study years. Prior research has found that a hemoglobin level greater than or equal to 9.0g/dL with ESAs before and after hemodialysis initiation was generally associated with lower post-initiation all-cause and cardiovascular mortality (Wetmore et al., 2018). While the use of ESAs was not found to be statistically significant in this study, the means of ESA use in pre-dialysis nephrology care demonstrated a decline across the four study years from 14.80 to 12.77. There are several possible explanations for this decline. First prior to 2012 ESA could bill separately for ESA. Then in 2012 ESA was included in the federal government's prospective payment system (PPS) bundle for dialysis care. This bundling eliminated ESA as a separately billable medication and brought about a new frugality and cost-consciousness in the use of this costly mediation for patients with ESRD (Charnow, 2017).

A second possible reason for the decline in ESA use pre dialysis, is a change in practice patterns associated with ESA use after the U.S. Food and Drug Administration made a major modification in 2011 to the ESA label stating that ESA should be used at the lowest possible dose to avoid a blood transfusion rather than based on the prior hemoglobin target range of 10 to 12 g/dL (Singh, 2011). Thus according to the Dialysis Outcomes and Practice Patterns Study, from August 2010 to December 2012, the percentage of ESA-treated patients with a hemoglobin concentration less than 10g/dL increased from 9% to 20% and those with a hemoglobin concentration greater than 12 g/dL decreased from 26% to 9% (Fuller, Pisoni, Bieber, Port & Robinson, 2013). In the present study facility average hemoglobin appears only mildly affected (i.e., 0.18 difference from 2013 to 2016) but it influences the SRR.

Finally, a decline in ESA use may lead to additional complications among patients with ESRD not measured in this study that could potentially impact the occurrence of readmissions. ESA is used to treat anemia, a common side effect of kidney disease experienced by many patients, by stimulating the erythroid progenitor cells to form and then release reticulocytes in bone marrow to mature into erythrocytes (Counts, 2015). The effects of kidney disease decrease the kidneys ability to make endogenous erythropoietin. Without exogenous erythropoietin, via a medication such as ESAs, the body may be deprived of the oxygen it needs as bone marrow begins to produce fewer red blood cells. Dialysis facilities ability to adequately manage patients' anemia has the potential to minimize risk for cardiac-related events or need for red blood cell transfusions that may result in subsequent hospital readmissions.

Number of Incident Patients

This study found that the number of incident patients a dialysis facility treated was statistically significant in predicting a dialysis facility's SRR performance. Higher counts of incident patients were associated with higher SRRs with an SRR increase of 0.0022. The average number of incident patients among 5,419 facilities evaluated in the study was 19. Therefore, on average 102,961 patients among study facilities could negatively impact a facilities performance on the SRR metric. The SRR is the only standardized quality measure that does not exclude the incident population in dialysis facility performance calculations. However, it is well-documented in the literature that the first ninety days of dialysis treatment, the incident period, possess the greatest risk for poor outcomes among incident patients. Over the first ninety days, the risk of mortality and hospitalizations are elevated for incident patients (Chan et al., 2011; Broers, Cuijpers, van der Sande, Leunissen & Kooman, 2015). In fact, the highest risk of mortality for incident patients occurs in the first two weeks of dialysis treatment with the risk of death 2.72-fold higher, and the risk of hospitalization 1.95-fold higher when compared to patients who survived the first year of chronic dialysis (Chan et al., 2011). Additionally, 36% of patients newly diagnosed with ESRD received little or no pre-dialysis nephrology care with 21% of patients receiving no nephrology care prior to ESRD onset (USRDS, 2018). Given the variation in care received prior to dialysis initiation incident patients may have varying levels of understanding of their kidney disease and how to implement self-management practices. As an incident population in a dialysis facility grows, facilities have to redistribute resources that may or may not be available to orient new patients to dialysis providing patient education for signs and symptoms to be concerned with and when to seek additional medical care. Patients with lacking experience may opt to seek emergency medical care at a hospital that results in a potential readmission. Further research is needed to better understand patients' utilization of healthcare resources within their first 90 days of dialysis, so that interventions can be implemented to reduce unnecessary hospital readmissions and better support patient's transition from CKD management to renal replacement therapy.

Length of Pre-Dialysis Nephrology Care

This study found that the percent of incident patients receiving 6-12 months and greater than 12 months of pre-dialysis nephrology care increased across the four study years and was associated with lower SRRs among dialysis facilities. The association of length of pre-dialysis nephrology care with SRR performance suggests the importance of access to care prior to initiating renal replacement therapy for treatment of ESRD. Current data shows that 36% of all patients newly diagnosed with ESRD received little or no pre-dialysis nephrology care with 21% of patients receiving no nephrology care (USRDS, 2018). In the current study about half of the incident population were receiving pre-dialysis nephrology care in 2016. Given, the percent of patients receiving 6-12 months of pre-dialysis nephrology care reduced SRR by 0.0006 and patients' receiving greater than 12 months of care reduced SRR by 0.0011 there is a need to educate primary care providers of the need for ongoing screening of patients with risk factors for CKD so that early referrals to nephrologist can be made. Additionally, so that patients can be educated of the need for nephrology care to better manage their kidney disease, slow down the advancement of kidney failure, and implement interventions to prepare for dialysis if necessary. Besides lack of knowledge of the importance of pre-dialysis nephrology care most patients are poorly prepared to begin renal replacement therapy often influenced by a lack of health insurance coverage that limits their access to care (Mehrotra & Kessler, 2014). Additionally, access to care can be influenced by racial disparities in the incidence of ESRD with blacks and Hispanics at higher risk as well as low-income Americans. Finally, less than 10% of patients with incident ESRD have had counseling by a dietitian, most are unaware of the possibility of home dialysis, pre-emptive kidney transplantation is rare among newly diagnosed ESRD patients, and a central venous catheter is used as a vascular access for the first dialysis treatment for 80% of patients first in-center hemodialysis (USRDS, 2018; Kutner, Zhang, Huang & Wasse, 2011; Mehrotra, Marsh, Vonesh, Peters & Nissenson, 2005). These observations strongly suggest that high burden of ESRD, disparities in the incidence of the disease and inadequate preparation for maintenance dialysis stem, in part, from challenges in access to care by many vulnerable populations.

Access to pre-dialysis nephrology care provides an opportunity for a nephrology provider to monitor a patient's renal function (GFR) over time to determine the most appropriate time to start dialysis. This study found that average facility GFR declined slightly over the four study years (10.89 to 10.74). However, higher facility average GFRs increased SRR by 0.0046. The Initiating Dialysis Early and Late (IDEAL) study found there was no detectable benefit of starting dialysis early (Tattersall et al., 2011). Additionally, late starts avoid the burden and inconvenience of an early start which has been associated with longer time on dialysis and greater resource use (Tattersall et al., 2011). New guidelines suggest that nephrology providers can wait to initiate dialysis until GFR drops below 10 to 12 mL/min. Potentially, starting a patient on dialysis earlier exposes them to increased risk factors (e.g., infection, vascular access malfunctions) that could be avoided if CKD was managed without renal replacement therapy until GFR declined below the recommended guidelines. The delay in initiating dialysis, may impact a facility's performance on SRR if dialysis associated factors cause a patient seek emergency medical care and subsequent readmission. Further research is needed to investigate patient outcomes based on residual renal function (measured by GFR) at the initiation of dialysis.

Several studies suggest that pre-dialysis nephrology care is associated with cost-effectiveness and decreased mortality and morbidity (Black et al., 2010; Kumar, Jeganathan & Amruthesh, 2012; Smart & Titus, 2011). Care prior to initiation of dialysis not only manages patients through the five stages of kidney failure, but also provides ample time to prepare a patient for dialysis (Smart, Dieberg, Ladhani & Titus, 2014). Additionally, timely receipt of nephrology care is associated with slower CKD progression, lower rates of adverse outcomes, and improved quality of life (MCClellan et al., 2009; Smart, Dieberg, Ladhani & Titus, 2014; Diegoli, Silva, Machado & Cruz, 2015). Further, patients receiving nephrology care prior to dialysis initiation have reduced mortality and hospitalizations (Smart & Titus, 2011). Access to pre-dialysis nephrology care provides ample time for patients to learn about their disease and feel empowered to make decisions for treatment that best suit their lifestyle and desired quality of life. Therefore, dialysis facilities with high rates of patients receiving pre-dialysis nephrology care of at least 6 months potentially have well-prepared patients initiating dialysis. The necessary patient education, disease management and appropriate interventions needed to correct the treatment course of incident patients that may not receive these services prior to ESRD diagnosis and initiation of dialysis treatment may tax facilities resources. Further research is needed to further evaluate characteristics (e.g., socioeconomic status factors) of patients receiving pre-dialysis nephrology care to identify populations that may lack access to care.

Presence of AVF Vascular Access

Over the course of the study years, the mean % AVF present among incident dialysis patients decreased from 35.67 to 33.65. However, higher percentages of patients initiating dialysis with an AVF present improved or reduced SRR by 0.0005. Placement of an AVF is considered the gold standard vascular access for hemodialysis (Santoro et al., 2014). AVFs need time to become adequately dilated and develop a thick-wall suitable for cannulation, often referred to as maturation. A mature AVF can be detected at four weeks, but often takes 8 to 12 weeks before it is ready to be used for dialysis treatment (Siddiqui, Ashraff & Carline, 2017). Patients with an AVF in place when they initiate dialysis require less exposure to the risks associated with dialyzing via a central venous catheter (CVC) which has been associated with increased hospital readmissions (Flythe et al., 2016).

Geographic Region

The majority of dialysis facilities included in this study were located in the South (43%). The higher rate of facilities located in the South is due to the higher incidence of ESRD in that area. Based on a review of the entire prevalent population among all the study's facilities, 41% of the prevalent dialysis population resided in a southern state (i.e., MD, WV, VA, DC, NC, SC, GA, FL, TN, AL, MS, AR, OK, LA, TX) (DFR FY2018 dataset). The smallest number of dialysis facilities included in this study are located in the Northeast (15%). Congruently, the smallest percent of prevalent patients (17%) reside in a Northeastern states (i.e., ME, NH, VT, MA, RI, CT, NY, NJ, VI, PR, PA, DE). Interestingly, this study found that facilities located in the Northeast are associated with a higher SRR whereas facilities in the West have lower SRRs. The geographic region findings of this study potentially draw attention to the management of dialysis facilities by large dialysis organizations. Areas with large market share (i.e., southern states) may receive more company attention in the form of resources or interventions to improve outcomes due to increased financial risk associated with pay for performance programs. Or perhaps the patient populations are different with more medically complex or sicker patients residing in the Northeast compared to the South. Further research is needed to investigate the impact of market share distribution as well as patient characteristics by geographic region on outcomes such as readmission.

Limitations

This study had several limitations. First, this is an observational study at the dialysis facility level and reported associations and should not be interpreted as causal effects. Second, the only dialysis facilities included in this study were those with at least 11 index discharges. Of the dialysis facilities included in the last year of this study, fiscal year 2016, 84% had at least 11 index discharges. Therefore, these results may only be generalizable to larger dialysis facilities with at least 11 index discharges per year. Third, the accuracy of the data is dependent upon the original data source from which the DFR is produced. Data sources retrieved by the University of Michigan, responsible for developing the DFR dataset, is dependent upon dialysis facility data entry. The ability to validate facility reported data is not possible due to retrospective nature of this study. However, the majority of data sources from which the variables utilized in this study are derived (e.g., Medical Evidence Form CMS-2728, ESRD Facility Annual Survey CMS-2744, CROWNWeb) are evaluated for completeness and accuracy by CMS contractors that may positively influence the validity of the data.

Implications for Practice

The results of this study suggest that patients with access to nephrology care prior to dialysis initiation may impact a facilities performance on the SRR. Anemia management and preparation for dialysis with placement of a permanent access (e.g., AVF) may improve SRR and should continue to be monitored and evaluated by a nephrology provider during CKD care. Pre-dialysis nephrology care provides an opportunity for a nephrology provider to best determine when to initiate a patient on dialysis based on GFR to avoid unintended consequences of renal replacement therapy. Additionally, dialysis facilities should reevaluate their policies and procedures around intake of a new patient to dialysis to ensure a smooth transition based on how much pre-dialysis nephrology care a patient was known to receive. An intervention such as this could allow facilities with high admissions of incident patients to ensure patients understand the implications of their disease, signs and symptoms of potential problems, and when to seek medical care when away from the dialysis facility. The availability of more RNs and PCTs to support these interventions may improve a facility's performance on the SRR.

Policy Implications

Dialysis facility RN and PCT ratios are modifiable characteristics that could be re-evaluated by dialysis organizations to develop staff mixes that support the inclusion of care coordination and comprehensive care interventions. A redesign of the current job roles staff serve in may allow for the ability to positively impact facility performance on the SRR. It's likely that the financial impact of adjusting staffing and the resources needed to facilitate care coordination intervention would need to be projected for nurses to be allocated for these kinds of roles within an outpatient dialysis facility. The landscape of dialysis roles may continue to evolve as results from the ESCO model demonstrate feasible practices that influence patient outcomes.

Additional policy implications of this research were identified concerning the impact pre-dialysis nephrology care may have on a dialysis facilities performance on the SRR. The quantity of incident patients served by unique dialysis facilities may impact a facilities ability to overcome the negative effect limited access to nephrology care prior to dialysis initiation has on facility performance in readmission prevention. Additionally, association of length of pre-dialysis care (i.e., at least 6 months) and having an AVF present at dialysis initiation with lower SRRs further highlights the potential need to reconsider SRR calculation. Currently, the SRR is calculated using a hierarchical logistic model that makes adjustments for the discharging hospital and for patient characteristics at the time of discharge including: age, sex, diabetes, BMI, duration of ESRD, comorbidities in the preceding year, the presence of a high-risk diagnosis, and length of hospital stay (CMS, 2017). In addition to the current covariates, a random effect could be incorporated in the SRR calculation to adjust for influential pre-dialysis nephrology care characteristics of incident patients including the length of pre-dialysis nephrology care, anemia management (i.e., hemoglobin values) and placement of an AVF. This adjustment would be similar to the already accepted adjustment for the discharging hospitals. The inclusion of a pre-dialysis nephrology care random effect would redistribute accountability from just the dialysis facility to include the nephrology provider overseeing the patients care during CKD, primary care, or the patient's lack of knowledge that they had CKD prior to ESRD. Finally, while the study design used in this study precludes causality, the associations reported between geographic region, dialysis facility, incident patient characteristics and SRR could potentially help target resources to facilities that are low performers.

Research Implications

The ultimate purpose of this descriptive study is to generate hypotheses for future research investigations. First, based on the results of this study further research is needed to understand staffing mixes, nursing interventions in care coordination and their impact on patient outcomes, specifically readmissions. Additional research is needed on the vacancy rates among RNs and PCTs in dialysis facilities across the United States and the impact of those vacancies on facility performance on quality metrics such as the SRR. Second, further research is needed to better understand utilization of healthcare resources of patients within their first 90 days of dialysis so that interventions can be implemented to reduce unnecessary hospital readmissions and better support patient's transition from CKD management to renal replacement therapy. Third, further research is needed to evaluate characteristics of patients receiving pre-dialysis nephrology care to identify populations that may lack access to care. Finally, research concerning the impact of geographic region on readmissions is needed to evaluate the distribution of market share as well as the clustering effect of incident patient characteristics on SRR performance.

Conclusion

In summary, this study presents the first facility-level analysis of dialysis facility characteristics and incident patient characteristics associated with SRR performance. The results show significant differences in geographic region with dialysis facilities located in the Northeast having higher SRRs compared to those in the West. Poorly performing dialysis facilities in these areas may benefit from a targeted intervention to improve care coordination among discharging hospitals, as well as interventions to improve processes within the facility to reduce patients' risk of readmission. Additionally, this study found that the number of incident patients dialyzing in a facility increase SRRs while length of pre-dialysis nephrology care of at least 6 months and percent of patients with an AVF present at dialysis initiation decreases or improves SRRs. These findings illustrate why health care policies must consider how access to care prior to dialysis initiation may create an accountability issue targeted at the wrong entity for quality measurement and in turn unintentionally inhibit improvement in outcomes of patients. Finally, this study found higher RN ratios to be associated with higher SRRs and higher PCT ratios to be associated with lower SRRs. These findings illustrate that fewer chairs per nurse (i.e., lower RN ratios) may influence patient outcomes and underline the need to further investigate staffing mixes and job roles in dialysis facilities to guide future interventions.

Chapter VI: Concluding Narrative

The SRR is a pay for performance quality metric used to evaluate dialysis facility performance in readmission prevention among patients with ESRD requiring dialysis treatment. A gap in the literature was identified concerning the potential impact of additional factors not currently considered in the hierarchical risk adjusted model used to calculate SRR. These factors included dialysis facility and patient characteristics. Specifically, incident patient characteristics as the SRR is the only metric included in the ESRD Quality Incentive Program that does not include the incident population. The issue was framed using the Quality Health Outcomes Model due to its inclusion of reciprocal relationships with components and theoretically rooted using the Open Systems Framework. A descriptive, longitudinal, retrospective study using multivariate regression analysis was completed to evaluate the association between dialysis facility performance in readmission measured by the SRR, and dialysis facility characteristics and incident patient pre-dialysis nephrology care characteristics. Factors found to be associated with poor performance on the SRR include high RN ratios, facility average GFR, and Northeast geographic location. Factors associated with low SRRs (better performance) include high PCT ratio, length of pre-dialysis nephrology care 6-12 months or greater than 12 months, initiation of dialysis with an AVF, facility average hemoglobin, and Western geographic location. These findings reveal the need for additional research in variables included in the hierarchical model currently used for risk adjustment in the SRR measure calculation that may reflect dialysis facility characteristics as well as characteristics of the incident patient population they serve.

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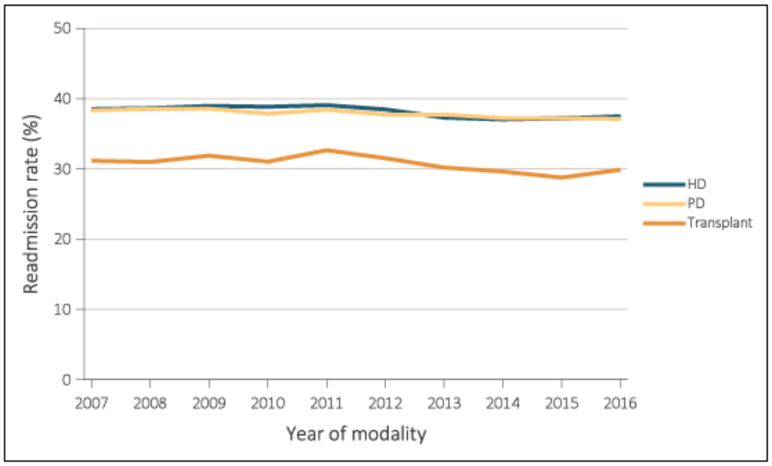
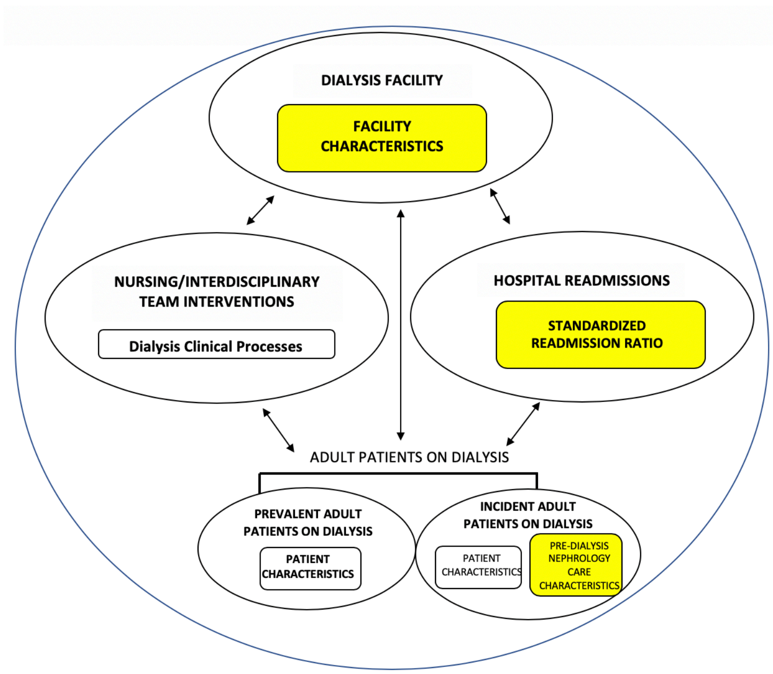
Appendix 1: Grant Application

Figure 1. Proportion of ESRD Patients Readmitted within 30 days, by treatment modality, 2007-2016



Source: USRDS Database; 2018 Annual Report. Abbreviations: ESRD, end stage renal disease; HD, hemodialysis; PD, peritoneal dialysis.

Figure 2. Shared Accountability in Readmission Outcomes within Dialysis



Adapted from the Quality Health Outcomes Model (Mitchell, Ferketich & Jennings, 1998) and Open Systems Theoretical Framework (Katz & Kahn, 1978); variables highlighted in yellow are investigated in this proposed study.

Table 1

Concepts and source of data

Concept	Variable	Operational Definition	Variables Specifics	Extracted Variable by Year			
				2013	2014	2015	2016
Incident Adult Patients on Dialysis							
Pre-Dialysis Nephrology Care	Incident Patients	# of Incident Patients with a CMS-2728	Count	nmy1_f	nmy2_f	nmy3_f	nmy4_f
	Recipient of Pre-dialysis nephrologist care (%)	Patients treated for CKD prior to initiating dialysis	Yes	**nephyesy1**	**nephyesy2**	**nephyesy3**	**nephyesy4**
			No	nephnomy1_f	nephnomy2_f	nephnomy3_f	nephnomy4_f
	Length of Pre-dialysis nephrologist care (%)	Length of CKD treatment prior to initiating dialysis	no care	nephnomy1_f	nephnomy2_f	nephnomy3_f	nephnomy4_f
			<6 months	nephy6my1_f	nephy6my2_f	nephy6my3_f	nephy6my4_f
			6-12 months	nephy612my1_f	nephy612my2_f	nephy612my3_f	nephy612my4_f
			> 12 months	nephy12my1_f	nephy12my2_f	nephy12my3_f	nephy12my4_f
			Unknown	nephunkmissmy1_f	nephunkmissmy2_f	nephunkmissmy3_f	nephunkmissmy4_f
	Incident Hemodialysis Patients	# of Incident Hemodialysis Patients	Count	hemomy1_f	hemomy2_f	hemomy3_f	hemomy4_f
	Access used at first outpatient dialysis (%)	Reflects management during CKD; vascular access type: central venous catheter (CVC), fistula or graft at dialysis start date of hemodialysis patients	Fistula	mefavfmy1_f	mefavfmy2_f	mefavfmy3_f	mefavfmy4_f
			Catheter	mefcathmy1_f	mefcathmy2_f	mefcathmy3_f	mefcathmy4_f
			Graft	mefgraftmy1_f	mefgraftmy2_f	mefgraftmy3_f	mefgraftmy4_f
	Arteriovenous fistula placed (%)	Gold standard vascular access; maturing at initiation of dialysis	Yes	avfpresentmy1_f	avfpresentmy2_f	avfpresentmy3_f	avfpresentmy4_f
	Received ESA prior to ESRD (%)	Erythropoietin-stimulating agent (ESA)	Yes	preepomy1_f	preepomy2_f	preepomy3_f	preepomy4_f
	Hemoglobin g/dL	Average lab values prior to start of	Facility Average	hgmy1_f	hgmy2_f	hgmy3_f	hgmy4_f
	GFR mL/min		Facility	gfrmy1_f	gfrmy2_f	gfrmy3_f	gfrmy4_f

		dialysis; Glomerular filtration rate = (GFR)	Average				
	Serum creatinine mg/dL		Facility Average	creamy1_f	creamy2_f	creamy3_f	creamy4_f
	Albumin		Facility Average	salbmy1_f	salbmy2_f	salbmy3_f	salbmy4_f
	Primary Dialysis Modality (%)	Hemodialysis	Primary modality at dialysis initiation	pdmodMEFHDmy1_f	pdmodMEFHDmy2_f	pdmodMEFHDmy3_f	pdmodMEFHDmy4_f
		CAPD/CCPD		pdmodMEFPDmy1_f	pdmodMEFPDmy2_f	pdmodMEFPDmy3_f	pdmodMEFPDmy4_f
Dialysis Facility							
Facility characteristics	Profit status	For profit or not-for-profit	For profit (1) Not for profit (0)	ownery1	ownery2	ownery3	ownery4
	Chain Membership	Chain Yes/No	Yes (1) No (0)	chainy1	chainy2	chainy3	chainy4
		Chain Name	Actual Name (QUAL)	organy1	organy2	organy3	organy4
	Clinic size	Number of certified stations or "chairs"		totstas_f			
	Staffing	Staff per certified stations (staffing ratios)	Total Staff	staffy1_f	staffy2_f	staffy3_f	staffy4_f
			Nurses per dialysis chair	nurseFTy1_f nursePTy1_f **nursey1_f**	nurseFTy2_f nursePTy2_f **nursey2_f**	nurseFTy3_f nursePTy3_f **nursey3_f**	nurseFTy4_f nursePTy4_f **nursey4_f**
			Patient Care Techs per dialysis chair	ptcareFTy1_f ptcarePTy1_f **ptcarey1_f**	ptcareFTy2_f ptcarePTy2_f **ptcarey2_f**	ptcareFTy3_f ptcarePTy3_f **ptcarey3_f**	ptcareFTy4_f ptcarePTy4_f **ptcarey4_f**
	Length of Operation	Years since initial Medicare certification date	Measurement Year **minus** Variable	2013 - FIRST_CERTDATE **certdatey1_f**	2014 - FIRST_CERTDATE **certdatey2_f**	2015 - FIRST_CERTDATE **certdatey3_f**	2016 - FIRST_CERTDATE **certdatey4_f**
	Geography	Urban vs. Rural (Yan et al., 2013)	1	Large metropolitan counties (situated in metropolitan areas with >1 million people)			
			2	Medium/small metropolitan counties (in metropolitan areas with <1 million people)			
			3	Suburban counties (nonmetropolitan counties adjacent to metropolitan areas)			
			4	Rural counties (nonmetropolitan counties and not adjacent to metropolitan areas)			
			Northeast	Network = 1,2,3,4			

	ESRD Geographic Network	Geographic Region (**GeoRegion**) (Saunders & Chin, 2013)	South	Network = 5,6,7,8,13,14			
			Midwest	Network = 9,10,11,12			
			West	Network = 15,16,17,18			
Hospital Readmissions							
SRR	Readmissions	Index Discharges	Facility Count	indexy1_f	indexy2_f	indexy3_f	indexy4_f
		Total Readmissions	Facility Count	readmy1_f	readmy2_f	readmy3_f	readmy4_f
		Expected Readmissions	Model Result	srrexpy1_f	srrexpy2_f	srrexpy3_f	srrexpy4_f
		Standardized Readmission Ratio	Facility Performance Ratio	srry1_f	srry2_f	srry3_f	srry4_f

*Note: Extracted data is at the facility-level; *variables reflect % of patients (i.e., total number of patients with submitted CMS-2728 within year of analysis) meeting the criteria; variables highlighted in yellow are calculated variables

Table 2

Urban and Rural Classification using RUCC 2013 and ARF Codes

RUCC 2013	RUCC Description	ARF Code	ARF Description
1	Metro – Counties in metro areas of 1 million population or more	1	Large metropolitan counties (situated in metropolitan areas with ≥1 million people)
2	Metro – Counties in metro areas of 250,000 to 1 million population	2	Medium/small metropolitan counties (in metropolitan areas with <1 million people)
3	Metro – Counties in metro areas of fewer than 250,000 population		
4	Non-metro – Urban population of 20,000 or more, adjacent to a metro area	3	Suburban counties (nonmetropolitan counties adjacent to metropolitan areas)
6	Non-metro – Urban population of 2,500 to 19,999, adjacent to a metro area		
8	Non-metro – Completely rural or less than 2,500 urban population, adjacent to a metro area		
5	Non-metro – Urban population of 20,000 or more, not adjacent to a metro area	4	Rural counties (nonmetropolitan counties and not adjacent to metropolitan areas)
7	Non-metro – Urban population of 2,500 to 19,999, not adjacent to a metro area		
9	Non-metro – Completely rural or less than 2,500 urban population, not adjacent to a metro area		

Source: United States Department of Agriculture, Rural-Urban Continuum Codes, 2013 https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx

Appendix 2: Data Management

Table 3

State Classification by ESRD Network and Geographic Region

Geographic Region	ESRD Network	States and Territories
Northeast	1, 2, 3, 4	ME, NH, VT, MA, RI, CT, NY, NJ, VI, PR, PA, DE
South	5, 6, 7, 8, 13, 14	MD, WV, VA, DC, NC, SC, GA, FL, TN, AL, MS, AR, OK, LA, TX
Midwest	9, 10, 11, 12	KY, OH, IN, IL, MI, WI, MN, ND, SD, MO, IA, NE, KS
West	15, 16, 17, 18	WY, CO, NM, AZ, UT, NV, MT, ID, WA, OR, AK, CA, HI, AS, MP, GU, CA

Figure 3. Map of 18 ESRD Networks in the United States

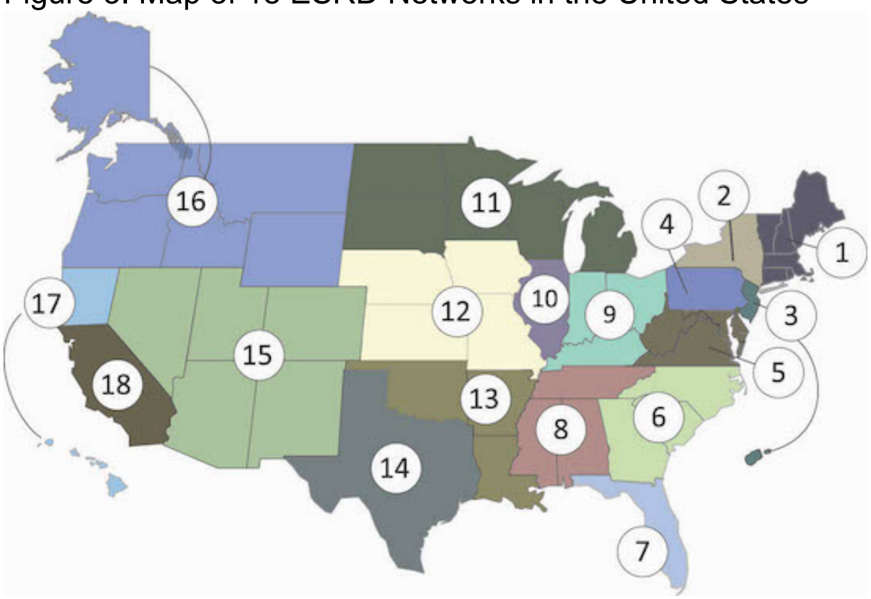


Table 5

Missing Data 26 Independent Variables and Outcome Variable

	No Missing Data	1 Year with Missing Data	2 Years with Missing Data	3 Years with Missing Data	4 Years with Missing Data
# of Facilities	4,089	508	278	193	351
%	75%	9%	5%	4%	6%

Appendix 3: Aim 1 Analysis

Table 9

Correlation between Dialysis Facility and Incident Patient Characteristics with SRR

	2013			2014			2015			2016		
	SCC	p-Value	Assoc. with SRR	SCC	p-Value	Assoc. with SRR	SCC	p-Value	Assoc. with SRR	SCC	p-Value	Assoc. with SRR
# Incident Pts	0.1325	<.0001	+	0.1248	<.0001	+	0.1245	<.0001	+	0.0902	<.0001	+
Clinic Size	0.1006	<.0001	+	0.0789	<.0001	+	0.0791	<.0001	+	0.0582	<.0001	+
Received Pre-Dialysis Care												
% Yes	-0.1180	<.0001	-	-0.0871	<.0001	-	-0.1072	<.0001	-	-0.0904	<.0001	-
% Unknown	0.1065	<.0001	+	0.0865	<.0001	+	0.1000	<.0001	+	0.0744	<.0001	+
Length of Pre-Dialysis Care												
% > 12 mos.	-0.1194	<.0001	-	-0.0887	<.0001	-	-0.1096	<.0001	-	-0.0775	<.0001	-
Vascular Access 1st Tx												
% AVF	-0.0652	<.0001	-	-0.1031	<.0001	-	-0.0984	<.0001	-	-0.0859	<.0001	-
% CVC	0.0573	<.0001	+	0.0869	<.0001	+	0.0766	<.0001	+	0.0764	<.0001	+
% AVF Present	-0.0786	<.0001	-	-0.0892	<.0001	-	-0.1134	<.0001	-	-0.0780	<.0001	-

Note: SCC=Spearman Correlation Coefficient; Assoc.=association; AVF=arteriovenous fistula; CVC=central venous catheters; Pts=patient

Table 10

Correlation between Dialysis Facility and Incident Patient Characteristics with SRR (All Study Variables)

	2013			2014			2015			2016		
	SCC	p-Value	Assoc. with SRR	SCC	p-Value	Assoc. with SRR	SCC	p-Value	Assoc. with SRR	SCC	p-Value	Assoc. with SRR
# Incident Pts	0.1325	<.0001	+	0.1248	<.0001	+	0.1245	<.0001	+	0.0902	<.0001	+
Years in Operation	0.0173	0.2031	+	-0.0131	0.3336	-	0.0165	0.2247	+	0.0146	0.2843	+
Clinic Size	0.1006	<.0001	+	0.0789	<.0001	+	0.0791	<.0001	+	0.0582	<.0001	+
RN Ratio	0.0232	0.0895	+	0.0155	0.2575	+	0.0022	0.8747	+	0.0130	0.3437	+
PCT Ratio	-0.0845	<.0001	-	-0.0796	<.0001	-	-0.0664	<.0001	-	-0.0159	0.2545	-
Chain Association												
Yes	0.0180	0.1842	+	-0.0090	0.5073	-	-0.0143	0.2932	-	0.0001	0.9947	+
For Profit	0.0530	<.0001	+	0.0539	<.0001	+	0.0416	0.0022	+	0.0383	0.0048	+
Facility Services												
ICHD Only	-0.0278	0.0407	-	-0.0495	0.0003	-	-0.0473	0.0005	-	-0.0050	0.7153	-
ICHD & Home	0.0285	0.0360	+	0.0434	0.0014	+	0.0350	0.0100	+	0.0022	0.8715	+
Home Only	-0.0010	0.9390	-	0.0246	0.0703	+	0.0469	0.0006	+	0.0103	0.4506	+
Received Pre-Dialysis Care												
% Yes	-0.1180	<.0001	-	-0.0871	<.0001	-	-0.1072	<.0001	-	-0.0904	<.0001	-
% No	0.0460	0.0007	+	0.0149	0.2728	+	0.0235	0.0842	+	0.0246	0.0703	+
% Unknown	0.1065	<.0001	+	0.0865	<.0001	+	0.1000	<.0001	+	0.0744	<.0001	+
Length of Pre-Dialysis Care												
% <6 mos.	-0.0054	0.6927	-	0.0015	0.9125	+	-0.0123	0.3657	-	-0.0121	0.3723	-
% 6-12 mos.	-0.0268	0.0484	-	-0.0132	0.3327	-	-0.0201	0.1382	-	-0.0254	0.0619	-
% > 12 mos.	-0.1194	<.0001	-	-0.0887	<.0001	-	-0.1096	<.0001	-	-0.0775	<.0001	-
Vascular Access 1st Tx												
% AVF	-0.0652	<.0001	-	-0.1031	<.0001	-	-0.0984	<.0001	-	-0.0859	<.0001	-
% AVG	0.0257	0.0581	+	0.0216	0.1113	+	0.0052	0.7019	+	0.0093	0.4932	+
% CVC	0.0573	<.0001	+	0.0869	<.0001	+	0.0766	<.0001	+	0.0764	<.0001	+
% AVF Present	-0.0786	<.0001	-	-0.0892	<.0001	-	-0.1134	<.0001	-	-0.0780	<.0001	-
Primary Dialysis Modality												
% HD	-0.0182	0.1801	-	-0.0391	0.0040	-	-0.0407	0.0027	-	0.0035	0.7995	+
% PD	0.0182	0.1801	+	0.0391	0.0040	+	0.0407	0.0027	+	-0.0035	0.7995	-
Facility Average Lab Values												
Albumin	-0.0096	0.4978	-	-0.0068	0.6337	-	-0.0073	0.6066	-	-0.0196	0.1698	-
Serum Creatinine	0.0341	0.0121	+	0.0083	0.5393	+	0.0017	0.8994	+	0.0135	0.3221	+
Hemoglobin	-0.0613	<.0001	-	-0.0385	0.0059	-	-0.0478	0.0006	-	-0.0611	<.0001	-
GFR	0.0234	0.0854	+	0.0398	0.0034	+	0.0367	0.0069	+	0.0376	0.0056	+
% Received ESA	-0.0576	<.0001	-	-0.0524	0.0001	-	-0.0486	0.0003	-	-0.0430	0.0015	-

Note: SCC=Spearman Correlation Coefficient; Assoc.=association; ESA=Erythropoietin-stimulating agent; Avg.=average; mos.=months; PCT=patient care tech; RN=registered nurse; AVG=arteriovenous graft; ICHD=in-center hemodialysis; PD=peritoneal dialysis; HD=hemodialysis; AVF=arteriovenous fistula; CVC=central venous catheters; Pts=patient

Table 11

Pairwise Pearson Correlation Coefficients for Non-Categorical Variables

	Pre-Care: Yes	Pre-Care: No	Pre Care: UnK	<6 Mos.	6-12 Mos.	>12 Mos.	HD	PD	AVF	AVG	CVC	AVF Pres.	ESA	Hb	GFR	Ck	ALB	Clinic Size	Yrs. Open	Incid. Pts	RN Ratio	PCT Ratio
Pre-Care: Yes	1	-0.535	-0.649	0.314	0.401	0.598	-0.233	0.233	0.276	0.082	-0.338	0.245	0.407	0.135	-0.061	-0.048	0.197	-0.040	0.018	-0.012	-0.067	0.020
Pre-Care: No	-0.535	1	-0.295	-0.191	-0.236	-0.288	0.168	-0.168	-0.228	-0.069	0.275	-0.175	-0.194	-0.099	-0.013	0.077	-0.163	0.036	0.012	0.013	0.027	0.011
Pre Care: UnK	-0.649	-0.295	1	-0.183	-0.241	-0.417	0.112	-0.112	-0.107	-0.031	0.134	-0.120	-0.286	-0.065	0.081	-0.016	-0.077	0.012	-0.032	0.002	0.051	-0.032
<6 Mos.	0.314	-0.191	-0.183	1	-0.119	-0.267	0.004	-0.004	-0.033	-0.005	0.031	-0.031	0.081	0.013	0.027	-0.032	-0.011	-0.001	-0.001	-0.026	0.007	-0.009
6-12 Mos.	0.401	-0.236	-0.241	-0.119	1	-0.201	-0.103	0.103	0.105	0.046	-0.139	0.106	0.104	0.048	-0.010	-0.015	0.076	-0.010	-0.002	-0.006	-0.002	0.005
12 Mos.	0.598	-0.288	-0.417	-0.267	-0.201	1	-0.186	0.186	0.253	0.061	-0.295	0.217	0.320	0.106	-0.079	-0.019	0.170	-0.036	0.023	0.009	-0.077	0.025
HD	-0.233	0.168	0.112	0.004	-0.103	-0.186	1	-1.000	0.022	0.021	0.455	0.107	-0.148	-0.196	0.006	0.027	-0.271	0.162	0.028	-0.088	0.210	-0.039
PD	0.233	-0.168	-0.112	-0.004	0.103	0.186	-1.000	1	-0.022	-0.021	-0.455	-0.107	0.148	0.196	-0.006	-0.027	0.271	-0.162	-0.028	0.088	-0.210	0.039
AVF	0.276	-0.228	-0.107	-0.033	0.105	0.253	0.022	-0.022	1	0.019	-0.673	0.664	0.157	0.087	-0.114	0.038	0.178	0.010	0.000	-0.025	-0.021	-0.049
AVG	0.082	-0.069	-0.031	-0.005	0.046	0.061	0.021	-0.021	0.019	1	-0.281	0.018	0.059	-0.022	-0.059	0.052	0.060	0.051	0.020	-0.017	0.027	-0.019
CVC	-0.338	0.275	0.134	0.031	-0.139	-0.295	0.455	-0.455	-0.673	-0.281	1	-0.368	-0.216	-0.151	0.111	-0.029	-0.278	0.155	0.038	0.074	0.089	0.039
AVF Pres.	0.245	-0.175	-0.120	-0.031	0.106	0.217	0.107	-0.107	0.664	0.018	-0.368	1	0.123	0.029	-0.132	0.069	0.111	0.030	0.008	-0.046	-0.009	-0.027
ESA	0.407	-0.194	-0.286	0.081	0.104	0.320	-0.148	0.148	0.157	0.059	-0.216	0.123	1	0.017	-0.094	0.038	0.127	-0.005	0.026	0.028	-0.099	-0.024
Hb	0.135	-0.099	-0.065	0.013	0.048	0.106	-0.196	0.196	0.087	-0.022	-0.151	0.029	0.017	1	0.266	-0.331	0.179	-0.116	-0.051	0.008	-0.048	0.048
GFR	-0.061	-0.013	0.081	0.027	-0.010	-0.079	0.006	-0.006	-0.114	-0.059	0.111	-0.132	-0.094	0.266	1	-0.807	-0.050	-0.149	-0.081	-0.009	0.010	0.078
Ck	-0.048	0.077	-0.016	-0.032	-0.015	-0.019	0.027	-0.027	0.038	0.052	-0.029	0.069	0.038	-0.331	-0.807	1	0.028	0.190	0.100	0.005	0.006	-0.088
ALB	0.197	-0.163	-0.077	-0.011	0.076	0.170	-0.271	0.271	0.178	0.060	-0.278	0.111	0.127	0.179	-0.050	0.028	1	-0.034	0.001	0.029	-0.096	-0.023
Clinic Size	-0.040	0.036	0.012	-0.001	-0.010	-0.036	0.162	-0.162	0.010	0.051	0.155	0.030	-0.005	-0.116	-0.149	0.190	-0.034	1	0.325	0.503	0.078	-0.059
Yrs. Open	0.018	0.012	-0.032	-0.001	-0.002	0.023	0.028	-0.028	0.000	0.020	0.038	0.008	0.026	-0.051	-0.081	0.100	0.001	0.325	1	0.161	-0.084	-0.052
Incid. Pts	-0.012	0.013	0.002	-0.026	-0.006	0.009	-0.088	0.088	-0.025	-0.017	0.074	-0.046	0.028	0.008	-0.009	0.005	0.029	0.503	0.161	1	-0.272	-0.256
RN Ratio	-0.067	0.027	0.051	0.007	-0.002	-0.077	0.210	-0.210	-0.021	0.027	0.089	-0.009	-0.099	-0.048	0.010	0.006	-0.096	0.078	-0.084	-0.272	1	0.214
PCT Ratio	0.020	0.011	-0.032	-0.009	0.005	0.025	-0.039	0.039	-0.049	-0.019	0.039	-0.027	-0.024	0.048	0.078	-0.088	-0.023	-0.059	-0.052	-0.256	0.214	1

Note: Mos.= Months; Unk=Unknown length of pre-dialysis care; HD=hemodialysis; PD=peritoneal dialysis; AVF=arteriovenous fistula; AVG=arteriovenous graft; CVC=central venous catheter; AVF Pres.=AVF Present; Hb=hemoglobin; GFR=glomerular filtration rate; Ck=creatinine; ALB=albumin; Yrs.open=years in operation; Incid. pts=incident patients; RN=registered nurse; PCT=patient care tech

Appendix 4: Multicollinearity Analysis

Table 13

Collinearity Results via PROC Reg, eliminating Received Pre-Dialysis Care: % Yes

Variable	DF	Parameter	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.8821	0.6067	1.4500	0.1460	.	0.0000
Incident Pts	1	0.0022	0.0002	11.1400	<.0001	0.5874	1.7025
Years in Operation	1	-0.0002	0.0002	-0.9800	0.3285	0.8716	1.1473
Clinic Size	1	0.0004	0.0003	1.4000	0.1613	0.5854	1.7082
RN Ratio	1	0.0046	0.0009	5.1600	<.0001	0.8090	1.2361
PCT Ratio	1	-0.0037	0.0008	-4.3700	<.0001	0.8845	1.1306
Chain Associated	1	-0.0014	0.0061	-0.2300	0.8160	0.9411	1.0626
For-Profit	1	0.0335	0.0075	4.4500	<.0001	0.9622	1.0393
Received Pre-Dialysis Care							
% No	1	0.0006	0.0060	0.0900	0.9269	0.0003	3988.4659
% Unknown	1	0.0009	0.0060	0.1400	0.8857	0.0002	5006.1211
Length of Pre-Dialysis Care							
% < 6 Months	1	0.0004	0.0060	0.0600	0.9516	0.0004	2578.9453
% 6-12 Months	1	0.0001	0.0060	0.0200	0.9879	0.0004	2761.8410
% > 12 Months	1	-0.0002	0.0060	-0.0400	0.9711	0.0002	5055.5017
Vascular Access 1st Tx							
% AVF	1	-0.0009	0.0004	-2.4200	0.0154	0.1273	7.8545
% AVG	1	-0.0001	0.0005	-0.2400	0.8075	0.4914	2.0349
% CVC	1	-0.0006	0.0003	-1.7100	0.0867	0.1239	8.0742
% AVF Present	1	-0.0004	0.0001	-3.1100	0.0019	0.5533	1.8072
Facility Average Lab Values							
Albumin	1	0.0218	0.0061	3.5700	0.0004	0.9027	1.1078
Serum Creatinine	1	0.0139	0.0026	5.2900	<.0001	0.3133	3.1917
GFR	1	0.0142	0.0018	8.0400	<.0001	0.3271	3.0575
% Received ESA	1	-0.0253	0.0034	-7.5100	<.0001	0.8347	1.1980

Table 14

Collinearity Results via PROC Reg, eliminating % Received Pre-Dialysis Care: % Unknown

Variable	DF	Parameter	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.9688	0.0623	15.5500	<.0001	.	0.0000
Incident Pts	1	0.0022	0.0002	11.1500	<.0001	0.5874	1.7025
Years in Operation	1	-0.0002	0.0002	-0.9800	0.3284	0.8716	1.1473
Clinic Size	1	0.0004	0.0003	1.4000	0.1612	0.5854	1.7082
RN Ratio	1	0.0046	0.0009	5.1600	<.0001	0.8090	1.2361
PCT Ratio	1	-0.0037	0.0008	-4.3700	<.0001	0.8845	1.1306
Chain Associated	1	-0.0014	0.0061	-0.2300	0.8165	0.9412	1.0625
For-Profit	1	0.0335	0.0075	4.4500	<.0001	0.9622	1.0393
Received Pre-Dialysis Care							
% No	1	-0.0003	0.0001	-2.7400	0.0061	0.6996	1.4294
Length of Pre-Dialysis Care							
% < 6 Months	1	-0.0005	0.0001	-3.5900	0.0003	0.7265	1.3765

% 6-12 Months	1	-0.0008	0.0001	-5.7700	<.0001	0.7288	1.3722
% > 12 Months	1	-0.0011	0.0001	-9.5400	<.0001	0.5555	1.8003
Vascular Access 1st Tx							
% AVF	1	-0.0009	0.0004	-2.4200	0.0154	0.1273	7.8545
% AVG	1	-0.0001	0.0005	-0.2400	0.8073	0.4914	2.0349
% CVC	1	-0.0006	0.0003	-1.7100	0.0868	0.1239	8.0741
% AVF Present	1	-0.0004	0.0001	-3.1100	0.0019	0.5534	1.8071
Facility Average Lab Values							
Albumin	1	0.0218	0.0061	3.5700	0.0004	0.9028	1.1077
Serum Creatinine	1	0.0139	0.0026	5.2900	<.0001	0.3133	3.1916
GFR	1	0.0142	0.0018	8.0400	<.0001	0.3271	3.0573
% Received ESA	1	-0.0253	0.0034	-7.5100	<.0001	0.8348	1.1979

Table 15

Collinearity Results via PROC Reg, eliminating Vascular Access 1st Tx: % CVC

Variable	DF	Parameter	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.9087	0.0515	17.6600	<.0001	.	0.0000
Incident Pts	1	0.0022	0.0002	11.1400	<.0001	0.5874	1.7024
Years in Operation	1	-0.0002	0.0002	-1.0000	0.3187	0.8717	1.1472
Clinic Size	1	0.0004	0.0003	1.2900	0.1982	0.5882	1.7001
RN Ratio	1	0.0046	0.0009	5.0900	<.0001	0.8107	1.2335
PCT Ratio	1	-0.0036	0.0008	-4.3200	<.0001	0.8853	1.1295
Chain Associated	1	-0.0012	0.0061	-0.2000	0.8402	0.9415	1.0622
For-Profit	1	0.0335	0.0075	4.4500	<.0001	0.9622	1.0392
Received Pre-Dialysis Care							
% No	1	-0.0003	0.0001	-2.8200	0.0048	0.7008	1.4269
Length of Pre-Dialysis Care							
% < 6 Months	1	-0.0005	0.0001	-3.5900	0.0003	0.7265	1.3765
% 6-12 Months	1	-0.0008	0.0001	-5.7000	<.0001	0.7299	1.3701
% > 12 Months	1	-0.0011	0.0001	-9.4700	<.0001	0.5566	1.7967
Vascular Access 1st Tx							
% AVF	1	-0.0004	0.0002	-1.9000	0.0577	0.5321	1.8793
% AVG	1	0.0004	0.0003	1.3500	0.1759	0.9740	1.0267
% AVF Present	1	-0.0004	0.0001	-3.2500	0.0011	0.5568	1.7961
Facility Average Lab Values							
Albumin	1	0.0226	0.0061	3.7100	0.0002	0.9083	1.1009
Serum Creatinine	1	0.0139	0.0026	5.3000	<.0001	0.3133	3.1916
GFR	1	0.0142	0.0018	8.0100	<.0001	0.3272	3.0564
% Received ESA	1	-0.0251	0.0034	-7.4700	<.0001	0.8354	1.1971

Table 16

Final Model Collinear Variables Removed via PROC Reg,

Variable	DF	Parameter	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	1.1035	0.0360	30.6200	<.0001	.	0.0000
Incident Pts	1	0.0021	0.0002	10.7500	<.0001	0.5910	1.6920
Years in Operation	1	-0.0002	0.0002	-0.9100	0.3636	0.8720	1.1468
Clinic Size	1	0.0006	0.0003	1.9500	0.0509	0.5972	1.6744
RN Ratio	1	0.0045	0.0009	5.0100	<.0001	0.8109	1.2332
PCT Ratio	1	-0.0038	0.0008	-4.5600	<.0001	0.8871	1.1272
Chain Associated	1	-0.0014	0.0061	-0.2200	0.8239	0.9415	1.0622
For-Profit	1	0.0340	0.0075	4.5200	<.0001	0.9624	1.0391
Received Pre-Dialysis Care							
% No	1	-0.0003	0.0001	-2.6400	0.0083	0.7016	1.4253
Length of Pre-Dialysis Care							
% < 6 Months	1	-0.0005	0.0001	-3.8400	0.0001	0.7281	1.3734
% 6-12 Months	1	-0.0008	0.0001	-5.9500	<.0001	0.7315	1.3671
% > 12 Months	1	-0.0011	0.0001	-10.0400	<.0001	0.5621	1.7791
Vascular Access 1st Tx							
% AVF	1	-0.0004	0.0002	-2.0900	0.0370	0.5328	1.8769
% AVG	1	0.0005	0.0003	1.4300	0.1514	0.9742	1.0265
% AVF Present	1	-0.0004	0.0001	-3.2300	0.0012	0.5568	1.7960
Facility Average Lab Values							
Albumin	1	0.0244	0.0061	4.0000	<.0001	0.9110	1.0977
GFR	1	0.0068	0.0011	6.2100	<.0001	0.8528	1.1727
% Received ESA	1	-0.0284	0.0033	-8.5800	<.0001	0.8645	1.1568

Appendix 5: Aim 2 Analysis

Table 18

Fixed effects model of impact on dialysis facility SRR, Removing Facility Services

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	67.8	<.0001
Years in Operation	1	6953	1.38	0.2403
Clinic Size	1	8452	0.39	0.531
RN Ratio	1	1.40E+04	19.99	<.0001
PCT Ratio	1	1.20E+04	9.9	0.0017
Chain Associated	1	7617	1.41	0.2344
For-Profit	1	7035	7.53	0.0061
Geographic Region	3	7107	73.23	<.0001
Geographic Location	3	6969	109.33	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	3.85	0.0499
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	6.02	0.0141
% 6-12 Months	1	1.50E+04	16.69	<.0001
% > 12 Months	1	1.30E+04	65.89	<.0001
Vascular Access 1st Tx				
% AVF	1	1.90E+04	0.01	0.9259
% AVG	1	1.90E+04	0.24	0.6239
% AVF Present	1	1.70E+04	18.65	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	1.18	0.277
Hemoglobin	1	1.90E+04	10.45	0.0012
GFR	1	1.80E+04	16.75	<.0001
% Received ESA	1	1.60E+04	7.35	0.0067
Year (2013-2016)	3	1.40E+04	2.16	0.09

Table 19

Fixed effects model of impact on dialysis facility SRR, removing % AVF

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	67.83	<.0001
Years in Operation	1	6951	1.38	0.2399
Clinic Size	1	8449	0.39	0.5316
RN Ratio	1	1.40E+04	20	<.0001
PCT Ratio	1	1.20E+04	9.89	0.0017
Chain Associated	1	7607	1.41	0.2354
For-Profit	1	7034	7.53	0.0061
Geographic Region	3	7089	73.73	<.0001
Geographic Location	1	1	0	0.9771
Received Pre-Dialysis Care: % No	1	1.40E+04	3.84	0.05
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	6.02	0.0142
% 6-12 Months	1	1.50E+04	16.73	<.0001

% > 12 Months	1	1.30E+04	66.57	<.0001
Vascular Access 1st Tx				
% AVG	1	1.90E+04	0.24	0.6218
% AVF Present	1	1.70E+04	29.73	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	1.17	0.2787
Hemoglobin	1	1.90E+04	10.51	0.0012
GFR	1	1.80E+04	16.8	<.0001
% Received ESA	1	1.60E+04	7.39	0.0066
Year (2013-2016)	3	1.40E+04	2.17	0.0896

Table 20

Fixed effects model of impact on dialysis facility SRR, removing Geographic Location

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	74.32	<.0001
Years in Operation	1	6868	0.51	0.4739
Clinic Size	1	8490	9.33	0.0023
RN Ratio	1	1.50E+04	28.32	<.0001
PCT Ratio	1	1.20E+04	37.83	<.0001
Chain Associated	1	7548	1.64	0.2003
For-Profit	1	6959	10.31	0.0013
Geographic Region	3	7004	79.7	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7.24	0.0071
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	9.64	0.0019
% 6-12 Months	1	1.60E+04	31.51	<.0001
% > 12 Months	1	1.30E+04	98	<.0001
Vascular Access 1st Tx				
% AVG	1	1.90E+04	1.22	0.2703
% AVF Present	1	1.70E+04	34.09	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	5.9	0.0151
Hemoglobin	1	1.90E+04	26.65	<.0001
GFR	1	1.80E+04	20.96	<.0001
% Received ESA	1	1.60E+04	3.36	0.0668
Year (2013-2016)	3	1.40E+04	2.42	0.0644

Table 21

Fixed effects model of impact on dialysis facility SRR, removing Years in Operation

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	74.8	<.0001
Clinic Size	1	8528	8.85	0.0029
RN Ratio	1	1.40E+04	29.45	<.0001
PCT Ratio	1	1.20E+04	37.67	<.0001
Chain Associated	1	7545	1.6	0.2057
For-Profit	1	6967	10.6	0.0011

Geographic Region	3	7004	79.68	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7.34	0.0067
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	9.68	0.0019
% 6-12 Months	1	1.60E+04	31.62	<.0001
% > 12 Months	1	1.30E+04	98.29	<.0001
Vascular Access 1st Tx				
% AVG	1	1.90E+04	1.21	0.2717
% AVF Present	1	1.70E+04	34.13	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	5.92	0.015
Hemoglobin	1	1.90E+04	26.69	<.0001
GFR	1	1.80E+04	21.15	<.0001
% Received ESA	1	1.60E+04	3.36	0.0667
Year (2013-2016)	3	1.40E+04	2.56	0.0533

Table 22

Fixed effects model of impact on dialysis facility SRR, removing % AVG

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	74.17	<.0001
Clinic Size	1	8515	9.13	0.0025
RN Ratio	1	1.40E+04	29.55	<.0001
PCT Ratio	1	1.20E+04	38.07	<.0001
Chain Associated	1	7543	1.68	0.1956
For-Profit	1	6967	10.59	0.0011
Geographic Region	3	7003	79.96	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7.54	0.006
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	9.62	0.0019
% 6-12 Months	1	1.60E+04	31.17	<.0001
% > 12 Months	1	1.30E+04	97.44	<.0001
% AVF Present	1	1.70E+04	34.99	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	6.29	0.0121
Hemoglobin	1	1.90E+04	26.78	<.0001
GFR	1	1.80E+04	20.88	<.0001
% Received ESA	1	1.60E+04	3.24	0.0718
Year (2013-2016)	3	1.40E+04	2.55	0.0535

Table 23

Fixed effects model of impact on dialysis facility SRR, removing Chain Associated

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	72.89	<.0001
Clinic Size	1	8509	9.62	0.0019
RN Ratio	1	1.40E+04	31.61	<.0001
PCT Ratio	1	1.20E+04	39.66	<.0001

For-Profit	1	6960	10.02	0.0016
Geographic Region	3	7007	79.41	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7.7	0.0055
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	9.73	0.0018
% 6-12 Months	1	1.60E+04	30.98	<.0001
% > 12 Months	1	1.30E+04	97.79	<.0001
% AVF Present	1	1.70E+04	34.49	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	6.33	0.0119
Hemoglobin	1	1.90E+04	26.53	<.0001
GFR	1	1.80E+04	20.66	<.0001
% Received ESA	1	1.60E+04	3.48	0.062
Year (2013-2016)	3	1.40E+04	2.51	0.0567

Table 24

Fixed effects model of impact on dialysis facility SRR, removing % Received ESA

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	73.02	<.0001
Clinic Size	1	8507	9.35	0.0022
RN Ratio	1	1.40E+04	32.45	<.0001
PCT Ratio	1	1.20E+04	39.27	<.0001
For-Profit	1	6952	10.56	0.0012
Geographic Region	3	6994	78.9	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7.9	0.0049
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	12.94	0.0003
% 6-12 Months	1	1.50E+04	36.74	<.0001
% > 12 Months	1	1.30E+04	121.76	<.0001
% AVF Present	1	1.70E+04	35.04	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	6.07	0.0138
Hemoglobin	1	1.90E+04	25.64	<.0001
GFR	1	1.80E+04	21.37	<.0001
Year (2013-2016)	3	1.40E+04	2.28	0.0768

Table 25

Fixed effects model of impact on dialysis facility SRR, removing Year

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.30E+04	74.28	<.0001
Clinic Size	1	8514	9.1	0.0026
RN Ratio	1	1.40E+04	32.97	<.0001
PCT Ratio	1	1.20E+04	38.05	<.0001
For-Profit	1	6953	10.52	0.0012
Geographic Region	3	6995	78.8	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7	0.0081

Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	12.81	0.0003
% 6-12 Months	1	1.50E+04	36.81	<.0001
% > 12 Months	1	1.30E+04	122.26	<.0001
% AVF Present	1	1.70E+04	33.47	<.0001
Facility Average Lab Values				
Albumin	1	1.80E+04	5.78	0.0162
Hemoglobin	1	1.90E+04	23.87	<.0001
GFR	1	1.80E+04	21.5	<.0001

Table 26

Fixed effects model of impact on dialysis facility SRR, removing Albumin

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.40E+04	77.42	<.0001
Clinic Size	1	8875	11.56	0.0007
RN Ratio	1	1.50E+04	33.29	<.0001
PCT Ratio	1	1.20E+04	40.69	<.0001
For-Profit	1	7124	10.68	0.0011
Geographic Region	3	7232	80.4	<.0001
Received Pre-Dialysis Care: % No	1	1.40E+04	7.54	0.0061
Length of Pre-Dialysis Care				
% < 6 Months	1	1.50E+04	11.83	0.0006
% 6-12 Months	1	1.60E+04	36	<.0001
% > 12 Months	1	1.30E+04	123.17	<.0001
% AVF Present	1	1.80E+04	26	<.0001
Facility Average Lab Values				
Hemoglobin	1	1.90E+04	20.49	<.0001
GFR	1	1.90E+04	18.96	<.0001

Table 27

Fixed effects model of impact on dialysis facility SRR, removing Received Pre-Dialysis Care: % No

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.40E+04	76.68	<.0001
Clinic Size	1	8874	11.81	0.0006
RN Ratio	1	1.50E+04	33.27	<.0001
PCT Ratio	1	1.20E+04	41.33	<.0001
For-Profit	1	7125	11.14	0.0009
Geographic Region	3	7227	79.57	<.0001
Length of Pre-Dialysis Care				
% < 6 Months	1	1.60E+04	6.73	0.0095
% 6-12 Months	1	1.70E+04	28.6	<.0001
% > 12 Months	1	1.40E+04	120.37	<.0001
% AVF Present	1	1.80E+04	24.15	<.0001
Facility Average Lab Values				
Hemoglobin	1	1.90E+04	20.35	<.0001
GFR	1	1.90E+04	20.47	<.0001

Table 28

Fixed effects model of impact on dialysis facility SRR, removing Length of Pre-Dialysis Care % < 6 Months

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.40E+04	77.63	<.0001
Clinic Size	1	8870	11.6	0.0007
RN Ratio	1	1.50E+04	33.76	<.0001
PCT Ratio	1	1.20E+04	41.63	<.0001
For-Profit	1	7115	11.87	0.0006
Geographic Region	3	7218	80.63	<.0001
Length of Pre-Dialysis Care				
% 6-12 Months	1	1.80E+04	24.09	<.0001
% > 12 Months	1	1.40E+04	114.39	<.0001
% AVF Present	1	1.80E+04	25.97	<.0001
Facility Average Lab Values				
Hemoglobin	1	1.90E+04	21.4	<.0001
GFR	1	1.90E+04	20.41	<.0001

Table 29

Fixed effects model of impact on dialysis facility SRR, removing Clinic Size

Effect	Num DF	DEN DF	F Value	Pr > F
# of Incident Patients	1	1.10E+04	159.13	<.0001
RN Ratio	1	1.40E+04	44.26	<.0001
PCT Ratio	1	1.20E+04	39.1	<.0001
For-Profit	1	7096	10.02	0.0016
Geographic Region	3	7232	79.11	<.0001
Length of Pre-Dialysis Care				
% 6-12 Months	1	1.80E+04	24.1	<.0001
% > 12 Months	1	1.40E+04	115.07	<.0001
% AVF Present	1	1.80E+04	25.31	<.0001
Facility Average Lab Values				
Hemoglobin	1	1.90E+04	23.42	<.0001
GFR	1	1.90E+04	17.22	<.0001