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Regional and Temporal Variations in Comorbidity Among US Dialysis Patients: A Longitudinal Study of Medicare Claims Data

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Abstract

Medicare claims data are commonly used to query comorbidities for case-mix adjustment in research of patients with end-stage renal disease (ESRD) in the United States. These adjustments may affect reimbursement and quality rating through comparative profiling and ranking of dialysis facilities. We studied regional and temporal variations in comorbidity from claims data in the United States Renal Data System. Patients with a previous 1-year Medicare history who initiated dialysis therapy between 2006 and 2009 were examined with a follow-up period until 2012. By linking pre- and post-ESRD Medicare claims with the Dartmouth Atlas, we carried out a longitudinal data analysis with multivariable adjustment to investigate regional and temporal variations in the Liu comorbidity index. We identified 23 336 incident hemodialysis patients who were covered by Medicare the year prior to dialysis initiation and had survived with complete 3 years of follow-up data. With the United States divided into 4 geographic regions, the Western region was found to have the lowest Liu index over all 3 follow-up years, compared with the respective years in the other regions (Midwest, Northeast, and South). In comparison with the first year, the Liu index dropped significantly during the second and third years of follow-up across all 4 regions. Significant regional and temporal variations observed in the comorbidity index cannot be explained by differences in reimbursement (average per state) or predialysis comorbidity. Based on our exploratory study, future studies should focus on identifying the factors and reasons for these variations which have the potential to affect health care policy and research.

Keywords

CMS, end-stage renal disease, Liu comorbidity index, Medicare claims, USRDS.

What do we already know about this topic?
Variations in practice based on geography are known to occur in US health care.
How does your research contribute to the field?
While confirming geographic variation, we also observed a significant, systematic pattern of temporal variations in patient comorbidity among incident dialysis patients, even after adjustments for reimbursement and predialysis comorbidity.
What are your research's implications toward theory, practice, or policy?
The Centers for Medicare & Medicaid Services may consider adjustment of regional and temporal variations in practice to allow for more equitable reimbursement to dialysis clinics.

By the end of 2014, there were a total of 678 383 patients with end-stage renal disease (ESRD) in the United States, with 421 219 on hemodialysis (62%). More than 104 000 incident cases of hemodialysis were reported in 2014.[1] The

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number of people living with ESRD on dialysis has continued to increase and is anticipated to exceed 530 000 by the year of 2020.[2]

The 2 major data sources for comorbidity ascertainment in kidney research and health policy of US dialysis patients are the Centers for Medicare & Medicaid Services (CMS) Medical Evidence Form 2728 and Medicare claims data.[3-6] The reliability and agreement of information from these 2 sources and the potential implications of their use in developing dialysis facility profiling and comparison (eg, standardized readmission ratio and 5-star rating) are issues that have been brought forth in recent studies.[7-9] A study that examined the intensity of health care delivery based on diagnostic and claim codes of Medicare patients who moved from one region of the country to another suggests that there are differences in practice patterns based on geography rather than solely on patient characteristics or actual illness.[10]

In this study, we aimed to evaluate regional and temporal differences in comorbid conditions of incident hemodialysis patients treated at US dialysis facilities, which remained under-researched.[11] Our goals for this study were 3-fold: (1) replication/validation of the finding by Song et al on regional variation in the intensity of health care services[10]; (2) extension of the finding to patients with ESRD, a population with high resource utilization; and (3) examination of the temporal variation of health care intensity as patients transition from predialysis through the first few years of ESRD. If substantial and systematic variations are observed, it suggests that the comorbidity index may be influenced by factors beyond those captured by claims, such as geographic practice pattern differences or other yet-to-be-defined variables. Consequently, it may be necessary to consider these variations when calculating case-mix–adjusted measures/payment in diverse geographic areas at different times.

Methods

Study Population, Setting, and Design

Our study used the United States Renal Data System (USRDS), a national registry that includes all patients in Medicare's ESRD program, the largest administrative database of its kind. This database incorporates extensive baseline and follow-up demographic and clinical data on patients with ESRD. The initial study cohort comprised elderly (aged ≥67) patients who were enrolled in Medicare before ESRD, with incidence of hemodialysis between 1 July 2006 and 30 June 2009 (N = 81 800; see Figure S1). This allows for "baseline," pre-ESRD Medicare claims data evaluation. To ensure Medicare enrollment, we linked USRDS (2006-2012) to pre-ESRD (2005-2009) Medicare claims data to ascertain Medicare plan A or B as primary payer for 1 year prior to dialysis initiation.

Both institutional claims and physician/supplier claims from pre- and post-ESRD Medicare claims were used in our study. We required diagnostic codes from at least 1 inpatient facility, home health agency, skilled nurse facility, or hospice claim or at least 2 different claims when using outpatient and physician/supplier claims to prevent overestimation. Similar algorithms were used by other investigators in earlier studies.[9,12] The final data set consisted of a longitudinal cohort of patients (N = 23 336) who had 3 years of dialysis follow-up, similar to the study by Song et al.[10]

Outcomes

We used the Liu index as the comorbidity summary score, which was developed based on the 2000 US incident dialysis population with mortality as the outcome. It has been independently validated, is more relevant to the ESRD context, and improves upon the Charlson comorbidity index among patients with ESRD.[13] The Liu index consists of 11 comorbidity conditions (with a score ranging from 0 to 21) with unequal weights: diabetes and atherosclerotic heart disease receive a score of 1, congestive heart failure receives a score of 3, and each of the remaining conditions gets a score of 2: peripheral vascular disease, cerebrovascular accident/transient ischemic attack, dysrhythmia, other cardiac diseases, cancer, liver disease, gastrointestinal bleeding, and chronic obstructive pulmonary disease. We computed the Liu index at 4 time points (predialysis baseline and years 1 through 3 when on hemodialysis). We additionally examined results for specific, individual comorbid conditions.

Geographic Regions and Reimbursement Measure

Four regions were assigned based on USRDS networks: Northeast (networks 1, 2, 3, 4), South (5, 6, 7, 8, 13, 14), Midwest (9, 10, 11, 12), and West (15, 16, 17, 18).[3] We linked USRDS to the 2006-2009 Dartmouth Atlas of Health Care by matching patient's resident state and year of dialysis initiation and selected the state average reimbursement per decedent for inpatient hospitalization during the past 6 months.[14] We termed this measure "reimbursement" and categorized it into quartiles. Thus, the reimbursement was a regionally defined time-invariant (over 3 years), categorical covariate (in 4 levels) in our analysis. A prior study on non-ESRD patients had used a similar "intensity of services" measure when looking at regional differences in quintiles, but did not designate the locations.[10]

Statistical Analysis

Standard descriptive statistics (eg, mean, standard deviation, median, and interquartile range) and box plots were used to summarize the data. To examine regional and temporal differences in the Liu comorbidity index with the 3-year follow-up data in the longitudinal cohort, we adjusted reimbursement along with other covariates in the model—ones traditionally incorporated in the ESRD setting based on administrative databases: age, sex, ethnicity, race, institutionalization, and prior nephrology care. Linear mixed-effects models with repeated measures for each patient and compound symmetry as covariance structure were fitted. We conducted secondary/sensitivity analyses to check the robustness of the findings from our primary analysis: (1) we fitted the model excluding reimbursement to avoid collinearity with region; (2) we fitted the model with unstructured covariance; (3) we evaluated regional difference with the full baseline cross-sectional data (N = 81 800); (4) we counted unique diagnosis codes per patient in different regions and years; and (5) we assessed the potential impact of survivor bias and checked the consistency of the patterns. All analyses were conducted using SAS version 9.4 and R version 3.3.1.

Results

We identified 81 800 elderly incident hemodialysis patients in the study period who had Medicare coverage during the year prior to dialysis initiation (Figure S1). The reasons for exclusion were as follows: 47 945 patients (59%) died before 3 years of hemodialysis, 922 (1.1%) received a kidney transplant within the first 3 years, 3207 (3.9%) had renal function recovery that allowed dialysis to be stopped, 503 (0.6%) were lost to follow-up, 2202 (2.7%) lost Medicare coverage, and 3685 (4.5%) were censored for moving out of their original State of residence. Table 1 outlines the characteristics of the patients in the final study cohort of 23 336 (29%) patients who completed 3 years of hemodialysis.

Table 1. Cohort Characteristics (N = 23 336).

Variable	Category	N	%
Age, y	[67,75)	10 984	47.1
	[75,85)	10 282	44.1
	≥85	2070	8.9
Race	Black	5429	23.3
	White	16 621	71.2
	Other	1286	5.5
Ethnicity	Non-Hispanic	21 167	90.7
	Hispanic	2169	9.3
Sex	Female	11 212	48.1
	Male	12 124	52
Prior nephrology care	<6 months	2926	12.5
	6-12 months	5485	23.5
	>12 months	7446	31.9
	No	5089	21.8
	Unknown	2390	10.2
Institutionalization	No	21 857	93.7
	Yes	1479	6.3
Region	Northeast	4698	20.1
	South	8527	36.5
	Midwest	6180	26.5
	West	3931	16.9
Reimbursement quartile	1	2038	8.7
	2	5093	21.8
	3	7183	30.8
	4	9022	38.7

Figure S2 shows the state-level reimbursement across regions from 2006 to 2009. We observed differences in reimbursement distribution across regions. Looking at the proportion of patients in the highest quartile of reimbursement within each region, we found a difference based on geography: 10% (833 of 8527) in the South, 32% (1964 of 6180) in the Midwest, 64% (2515 of 3931) in the West, and 79% (3710 of 4698) in the Northeast were in this highest reimbursement quartile (see Table S1).

The prevalence of 11 individual comorbidities included in the Liu index, along with the summed/total score for the 3 years of follow-up when on hemodialysis, is shown in Table 2. We noted that certain comorbid conditions such as cancer and liver disease were relatively stable during the follow-up. However, the prevalence of *all* comorbid conditions decreased after the first follow-up year, for example, congestive heart failure (55%, 42%, and 46% for years 1-3, respectively). Accordingly, the overall index was highest in the first dialysis year and decreased in the second and third years (6.9, 5.7, and 6.3 in mean, respectively). The same reporting pattern (ie, highest in year 1 of dialysis and lower afterward) was consistently observed across all 4 regions, as demonstrated in Figure 1.

The observed temporal variation was also confirmed by longitudinal analysis, controlling other factors and accounting for correlation within patient (Y2: –1.13 and Y3: –0.57 vs Y1; $P < .0001$). In the same model, in comparison with the West region as reference, all 3 other regions (Midwest, 0.54; Northeast, 0.71; South, 0.49; $P < .0001$) showed significantly higher Liu index values (Table 3). Notably, effect sizes and standard errors for regions and reimbursement quartiles were quite comparable when they were included in the same model. In addition, the oldest age group and nonwhites showed lower Liu index values, whereas institutionalization and the absence or unknown status of prior nephrology care showed higher values.

In the 3 sensitivity analyses that excluded reimbursement in the model and used either unstructured covariance or the baseline data only, qualitatively similar results were obtained (ie, ordering, relative magnitude, and statistical significance of differences remained). We also found the number of unique diagnosis codes per patient was highest at year 1 of dialysis but decreased during the follow-up 2 years across regions, confirming our original findings (see Table S2). Finally, in the additional analysis of a cohort of 9193 patients who were censored during the third year of follow-up (8401 died, 257 transplants, 50 lost to follow-up, 383 lost Medicare as main payer, and 102 changed resident state), the patients had similar Liu index values at baseline (mean = 5.5) and higher values during the 2 follow-up years on hemodialysis (Y1: 8.3 and Y2: 7.9). There was still a trend of decreasing Liu index during the second year of follow-up, although the magnitude (–0.39, $P <.0001$) was smaller compared with the primary analysis (see Table S3).

Table 2. Liu Index and the Individual Comorbidities for the Baseline Predialysis Year and the 3 Follow-up Years on Hemodialysis (N = 23 336).

Liu index		Baseline	Year 1	Year 2	Year 3
Mean ± SD		5.3 ± 4.0	6.9 ± 4.1	5.7 ± 4.0	6.3 ± 4.2
Median		5	7	5	6
Comorbidity	Weight	%	%	%	%
AHD	1	43.5	55.3	48.7	51.3
CHF	3	46.5	55.1	41.9	45.8
COPD	2	22.5	29.3	24.9	28.3
CVA/TIA	2	15.4	21.2	18.5	21.1
Cancer	2	13.1	13.9	12.4	12.9
Diabetes	1	58.5	67.8	65.3	65.2
Dysrhythmia	2	29.1	40.7	35.3	40.1
GI bleeding	2	9.1	11.4	7.8	9.8
Liver disease	2	1.6	7.8	6.3	6.0
Other cardiac	2	28.1	33.7	25.8	30.0
PVD	2	26.9	40.9	35.9	39.3

Note. SD = standard deviation; AHD = atherosclerotic heart disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; TIA = transient ischemic attack; GI = gastrointestinal; PVD = peripheral vascular disease.

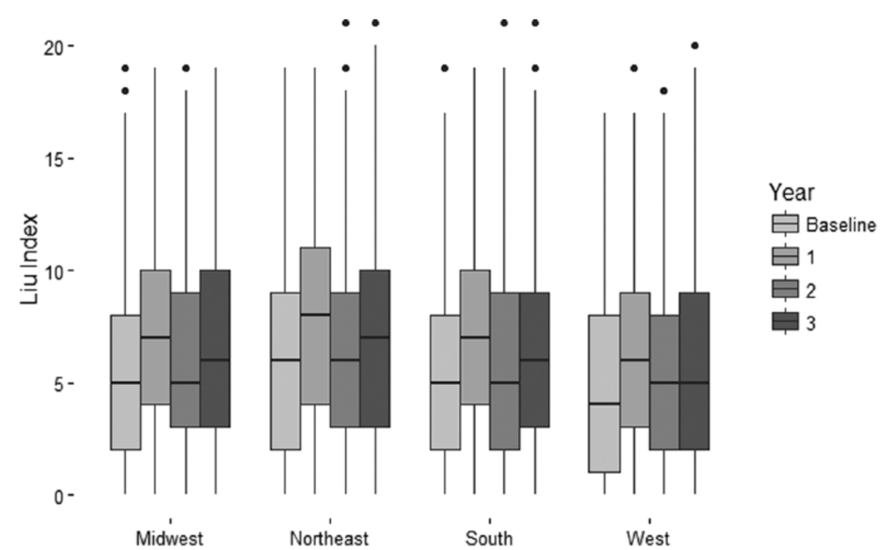

Figure 1. Box plots for the Liu index by year and region.
Note. The lines of box plot display first quartile, median, and third quartile. Data are at the patient level.

Discussion

In this study, we examined regional and temporal variations in comorbidities using Medicare claims records and the USRDS. We observed significant variation in the Liu comorbidity index over time and by region. This variation could not be explained by differences in reimbursement (average by state of residency) or by preexisting comorbidities. Similar patterns were observed in individual comorbidities as in the Liu index. The variation in the Liu index could be explained by 4 potentially overlapping factors: (1) differences in baseline characteristics captured and not captured by the Liu index, (2) more effective care in some regions than in other, (3) differences in patient adherence to recommended treatments, and (4) accumulation of more illness with time (eg, related to differential smoking behaviors that are correlated with region). Based on our *exploratory* study, a future study should investigate these 4 issues to determine the extent to which they may explain the variation and whether there may be additional factors.

Table 3. Longitudinal Analysis of Liu Index During 3 Years of Follow-up (N = 23 336).

Parameter	Estimate	SE	*P* value
Region			
Midwest	0.54	0.06	<.0001
Northeast	0.71	0.07	<.0001
South	0.49	0.06	<.0001
West	Reference		
Reimbursement			
Quartile 1	Reference		
Quartile 2	0.48	0.08	<.0001
Quartile 3	0.70	0.07	<.0001
Quartile 4	0.72	0.07	<.0001
Follow-up year			
1	Reference		
2	−1.13	0.03	<.0001
3	−0.57	0.03	<.0001
Baseline[a]	0.45	0.005	<.0001
Age, y			
[67,75)	Reference		
[75,85)	−0.08	0.04	.05
≥85	−0.35	0.07	<.0001
Sex			
Male	−0.09	0.04	.02
Female	Reference		
Ethnicity			
Hispanic	0.13	0.07	.05
Non-Hispanic	Reference		
Race			
Black	−0.13	0.05	.005
Other	−0.22	0.09	.01
White	Reference		
Institutionalization			
Yes	0.45	0.08	<.0001
No	Reference		
Prior nephrology care			
<6 months	0.10	0.05	.04
6-12 months	0.09	0.06	.14
>12 months	Reference		
No	0.46	0.05	<.0001
Unknown	0.45	0.07	<.0001

[a]Baseline: Liu index based on past year claims data prior to starting dialysis.

Using Hospital Referral Regions across the United States grouped by the intensity of hospital and physician services, Song et al found that the number of diagnosis codes and Hierarchical Condition Categories (HCC) score changed based on "moving status," that is, increased to a greater extent among Medicare beneficiaries who moved to a region with a higher intensity of practice than those who moved to a region with an equal or lower intensity of practice.[10] Due to the high mortality rate of elderly patients with ESRD, as well as the low frequency of patient residency movement, we could not carry out a similar analysis.

Building on the important work of Song et al by extending the idea of regional variation in health care intensity to patients with ESRD, we conducted our study with a focus on regional and temporal variations in comorbidities in incident hemodialysis patients. We feel that the dialysis population, one in which health care quality, policy, and costs are closely monitored, deserves this type of scrutiny.[8,15,16] Our finding appears to agree with the previous findings based on general Medicare beneficiaries, that a higher intensity of services as measured by reimbursement is associated with a higher reporting of common comorbidities.[10] However, adjustment for reimbursement did not eliminate the regional variation. Also, a much higher percentage of patients in the Northeastern and Western regions were in the highest reimbursement quartile. The significant difference in the Liu index between the Northeast and the West suggests varying practice patterns based on geography. Such practice pattern variances may be better captured by other measures, or it may turn out to be difficult to fully quantify these differences with available data or variables.

The observed temporal variation might be partly due to systematic, increased recording in the first year of observation and documentation of patients' medical conditions; some degree of such increased recording would be expected, as clinicians meticulously reconcile medical records of "new" dialysis patients in this critical juncture of their health care. Our study suggests, however, that the increased number of submitted diagnostic codes in the first incident year of hemodialysis is likely a true reflection of increased comorbidity. Consistently, the first year mortality rate of hemodialysis patients approaches 23% and is the greatest in the first 3 months of dialysis[1,17,18]; cost peak is also demonstrated in this period with ESRD onset.[19] Notably, elderly incident dialysis patients are more likely to initiate dialysis in the hospital setting, with 65% starting dialysis in the hospital and 24% of the index hospitalization being ≥2 weeks in duration.[20] Therefore, it is conceivable that the first year of dialysis entails more intensive medical monitoring and interventions than the predialysis or subsequent years in patients who survive. In future studies, it is perhaps worth utilizing both electronic health records and claims data to examine the differences in claim codes between the first and second dialysis years.[21]

Our findings may have health policy implications. The 30-day readmission rate is widely used in public reporting and value-based payments.[22-25] It is also one of the outcome measures adopted in the publicly available 5-star dialysis facility rating system.[15] In the current profiling models developed by CMS and health policy researchers, case-mix adjustment uses a broad range of comorbidities based on the past year's claims data (using various types of claim files as listed in the "Methods" section) prior to the index discharge date.[8] Current case-mix–adjusted payment systems do not account for differences in geography and collapse the first 2 years on ESRD as one category in adjustment. The potential impact of geographic and temporal variations has been studied with some suggestions and directions on how to handle regional variations in diagnostic practices.[9,10,25,26] Potential options include (1) using regions (eg, intensity of services/reimbursements and indicators of regions) and time (eg, percentage of new dialysis patients) as risk adjustors, or (2) taking regions into account in stratification (eg, budget allocation, distribution, or payment formula). In addition, the findings from our study might help to improve payment allocation for an individual facility in practice. Payments that are tied to an individual facility's case-mix burden would implicitly reflect the surrounding geography. Because geographic areas and temporal trends in comorbid conditions can be reflected in an individual facility's case-mix burden, information on these factors might not be considered a component in a case-mix adjuster for payments. However, given the significant regional and temporal variations found in this study, further investigation on these factors may lead to improved case-mix adjusters. For example, it may justify an opportunity to investigate the extent to which geographical and temporal variations in comorbidity can influence ESRD Prospective Payment System (PPS) patient-level adjustments. The PPS payment formula may benefit from being region-specific and being regularly updated to reflect case-mix changes. As part of any payment system update, CMS should consider examining the geographic variation as well as temporal trend of each comorbidity eligible for adjustment in ESRD PPS to potentially improve the rate-setting process.

Limitations

Limitations of our study should be noted. First, we only focused on incident in-center hemodialysis patients ≥67 years of age at the time of ESRD with 3 years of complete follow-up. The mortality rate of elderly patients experiencing incident dialysis is very high within 3 months of dialysis initiation. In fact, 59% of patients with pre-ESRD Medicare coverage were excluded from our study due to death during 3 years. Thus, our study cohort of patients with complete 3-year follow-up may suffer severe survival/selection bias. However, our intent was to thoroughly evaluate comorbidity over time in a "clean" cohort of survivors and to perform a standard longitudinal data analysis, thus necessitating a surviving cohort. In addition, it was important in our study design to ensure complete follow-up, just as it was similarly enforced in the study by Song et al.[10] Joint modeling of survival and longitudinal data accounting for competing risks may need to be applied in future studies. Notably, our secondary/sensitivity analyses using the entire baseline population and a cohort of censored patients (those who did not survive through the third dialysis year) showed qualitatively similar patterns.

Second, we used a single index/indicator for potentially complex variables and constructs so that residual confounding is quite possible. Specifically, we selected widely accepted "reimbursements per decedent for inpatient hospitalizations during the past 6 months of life" from the Dartmouth Atlas. In patients with ESRD, resource expenditures in the last month of life are higher than those of many other Medicare beneficiaries with severe chronic illnesses.[27] It could be worthwhile to explore other indexes, such as the End-of-Life Expenditure Index.[10,28] Also, reimbursements are often not based so much on value of care as they are on historical precedents resulting from effective lobbying by interested parties (eg, professional societies) and possibly misguided models of how to reimburse for health care—for example, Ricardo/Marx theories of payment for level of effort rather than more modern concepts of pay for value.[29] Moreover, we used the Liu index as the currently best-suited comorbidity index for the ESRD population in the United States, and it captures comorbidities from administrative claims data from days 91 through 270 after dialysis initiation. It has been reported that using different claim periods, such as days 0 through 90, can capture a larger number of patients with a wider breadth of health status and survival.[30] Besides the Liu index, other outcomes such as the ESRD-specific CMS-HCC score may be explored for the dialysis population in the future.[31,32]

Conclusions

We observed significant regional and temporal variations in patient comorbidity as recorded in claims data, even after adjusting for reimbursement measure and predialysis comorbidity. Current CMS case-mix–adjusted payment systems do not consider these variations. We hope our study, along with the body of related literature, encourages further discussion and actions, such as risk adjustment and new payment formulas, that will result in more equitable health care policies.

Authors' Note

The interpretation and reporting of the data are the responsibility of the authors and in no way should be seen as an official policy or interpretation of the US government. Dr Yi Mu's new affiliation is the Office of Population Health and Accountable Care, UCSF Medical Center, San Francisco, CA.

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Declaration of Conflicting Interests

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IRB Approval

The University of California has determined that studies using United States Renal Data System data do not constitute human subject research.

Supplementary Material

Supplementary material is available for this article online.

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References

1. United States Renal Data System. *US Renal Data System 2016 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States*. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2016.
2. Collins A, Foley R, Gilbertson D, Chen S. The state of chronic kidney disease, ESRD, and morbidity and mortality in the first year of dialysis. *Clin J Am Soc Nephrol*. 2009;4(suppl 1):S5-S11.
3. Dalrymple LS, Johansen KL, Romano PS, et al. Comparison of hospitalization rates among for-profit and nonprofit dialysis facilities. *Clin J Am Soc Nephrol*. 2014;9(1):73-81.
4. Dalrymple LS, Mu Y, Nguyen DV, et al. Risk factors for infection-related hospitalization in in-center hemodialysis. *Clin J Am Soc Nephrol*. 2015;10(12):2070-2080.
5. Erickson K, Tan K, Winkelmayer W, Chertow G, Bhattacharya J. Variation in nephrologist visits to patients on hemodialysis across dialysis facilities and geographic locations. *Clin J Am Soc Nephrol*. 2013;8(6):987-994.
6. Song Y. Varied differences in the health status between Medicare advantage and fee-for-service enrollees. *Inquiry*. 2014;51:1-12.
7. Krumholz HM, Lin Z, Drye EE, et al. An administrative claims measure suitable for profiling hospital performance based on 30-day all-cause readmission rates among patients with acute myocardial infarction. *Circ Cardiovasc Qual Outcomes*. 2011;4:243-252.
8. Centers for Medicare & Medicaid Services. *University of Michigan Kidney Epidemiology and Cost Center: Measure Methodology Report for the Proposed SRR Measure*. https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/ESRDQIP/Downloads/MeasureMethodologyReportfortheProposedSRRMeasure.pdf Published 2014. Accessed 30 October 2017.
9. Krishnan M, Weinhandl ED, Jackson S, Gilbertson DT, Lacson E. Comorbidity ascertainment from the ESRD Medical Evidence Report and Medicare claims around dialysis initiation: a comparison using US Renal Data System data. *Am J Kidney Dis*. 2015;66:802-812.
10. Song Y, Skinner J, Bynum J, Sutherland J, Wennberg JE, Fisher ES. Regional variations in diagnostic practices. *New Engl J Med*. 2010;363:45-53.
11. Garrity BH, Kramer H, Vellanki K, Leehey D, Brown J, Shoham DA. Time trends in the association of ESRD incidence with area-level poverty in the US population. *Hemodial Int*. 2016;20(1):78-83.
12. Baldwin L, Klabunde C, Green P, Barlow W, Wright G. In search of the perfect comorbidity measure for use with administrative claims data: does it exist? *Med Care*. 2006;44(8):745-753.
13. Liu J, Huang Z, Gilbertson D, Foley R, Collins A. An improved comorbidity index for outcome analyses among dialysis patients. *Kidney Int*. 2010;77(2):141-151.
14. Dartmouth Atlas of Health Care. Selected Measures of Inpatient Utilization During the Last Six Months of Life. http://www.dartmouthatlas.org/tools/downloads.aspx?tab=41. Published 2014. Accessed 30 November 2017.
15. Kshirsagar AV, Manickam RN, Flythe JE, Chin AI, Bang H. Area-level poverty, race/ethnicity & dialysis star ratings. *PLoS One*. 2017;12(10):e0186651.
16. Thamer M, Zhang Y, Kaufman J, Kshirsagar O, Cotter D, Hernan MA. Major declines in epoetin dosing after prospective payment system based on dialysis facility organizational status. *Am J Nephrol*. 2014;40(6):554-560.
17. Chan KE, Maddux FW, Tolkoff-Rubin N, Karumanchi SA, Thadhani R, Hakim RM. Early outcomes among those initiating chronic dialysis in the United States. *Clin J Am Soc Nephrol*. 2011;6(11):2642-2649.
18. Thamer M, Kaufman J, Zhang Y, Zhang Q, Cotter D, Bang H. Predicting early death among elderly dialysis patients: development and validation of a risk score to assist shared decision making for dialysis initiation. *Am J Kidney Dis*. 2015;66(6):1024-1032.
19. Cellini G.A call to action. Nephrologists: take the lead now in population health management. *Nephrology News & Issues*. November, 2017:16-9.
20. Wong SP, Kreuter W, O'Hare AM. Healthcare intensity at initiation of chronic dialysis among older adults. *J Am Soc Nephrol*. 2014;25(1):143-149.
21. Centers for Medicare & Medicaid Services. *Electronic Health Records (EHR) Incentive Programs*. https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/. Published 2017. Accessed 28 February 2018.
22. Manickam RN, Mu Y, Kshirsagar A, Bang H. Area-level poverty and excess hospital readmission ratio. *Am J Med*. 2017;130(4):e153-e115.
23. Martsolf GR, Barrett ML, Weiss AJ, et al. Impact of race/ethnicity and socioeconomic status on risk-adjusted readmission rates: implications for the Hospital Readmissions Reduction Program. *Inquiry*. 2016;53:1-9.
24. Chin DL, Bang H, Manickam RN, Romano PS. Rethinking thirty-day hospital readmissions: shorter intervals might be better indicators of quality of care. *Health Aff (Millwood)*. 2016;35(10):1867-1875.
25. Almachraki F, Tuffli M, Lee P, et al. Socioeconomic status of countries where dialysis clinics are located is an important factor in comparing dialysis providers. *Popul Health Manag*. 2016;19:70-76.
26. Ash AS, Mick EO, Ellis RP, Kiefe CI, Allison JJ, Clark MA. Social determinants of health in managed care payment formulas. *JAMA Intern Med*. 2017;177(10):1424-1430.
27. Wong SP, Kreuter W, O'Hare AM. Treatment intensity at the end of life in older adults receiving long-term dialysis. *Arch Intern Med*. 2012;172(8):661-663.

28. O'Hare AM. Palliative and End-of-Life Care in Patients With Kidney Disease. https://www.usrds.org/2014/pres/ASN_usrds_OHare_Presented.pdf. Published 2014. Accessed 30 November 2017.
29. Taylor KS. Human Society and the Global Economy. http://www.d.umn.edu/cla/faculty/jhamlin/4111/2111-home/value.htm. Published 1996. Accessed 30 November 2017.
30. Rigler S, Wetmore J, Mahnken J, Dong L, Ellerbeck E, Shireman T. Impact of a modified data capture period on Liu comorbidity index scores in Medicare enrollees initiating chronic dialysis. *BMC Nephrol*. 2013;14:51.
31. Pope G, Kautter J, Ellis R, et al. Risk adjustment of Medicare capitation payments using the CMS-HCC model. *Health Care Financ Rev*. 2004;25:119-141.
32. National Bureau of Economic Research. Index of Risk-Adjustment 2016 Midyear Final Model: ESRD Software E2116.87.H1. http://www.nber.org/risk-adjustment/2016/2016-Midyear-Final-Model/ESRD_software_E2116.87.H1/ Published 2016. Accessed 11 April 2018.