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RESEARCH ARTICLE

Persistent Variation in Medicare Payment Authorization for Home Hemodialysis Treatments

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Objective. To analyze variation in medical care use attributable to Medicare's decentralized claims adjudication process as exemplified in home hemodialysis (HHD) therapy.

Data Sources/Study Setting. Secondary data analysis using 2009–2012 paid Medicare claims for HHD and in-center hemodialysis (IHD).

Study Design. We compared variation across Medicare administrative contractors (MACs) in predicted paid treatments per standardized patient-month for HHD and IHD patients. We used ordinary least-squares regression to determine whether higher paid HHD treatment counts expanded HHD programs' presence among dialysis facilities.

Data Collection. We identified HHD and IHD treatments using procedure, revenue center, and claim condition codes on type 72x claims.

Principal Findings. MACs varied persistently in predicted HHD treatments per patient-month, ranging from 14.3 to 21.9 treatments versus 10.9 to 12.4 IHD treatments. The presence of facilities' HHD programs was uncorrelated with average HHD payment counts.

Conclusions. Medicare's claims adjudication process promotes variation in medical care use, as we observe among HHD patients. MACs' discretionary decision making, while potentially facilitating innovation, may admit inefficiency in care practice as well as inequitable access to health care services. Regulators should weigh the benefits of flexibility in local coverage decisions against those of national standards for medical necessity.

Key Words. Variation, Medicare, dialysis

It is a basic assumption of much of the geographic variation literature that Medicare beneficiaries have coverage for the same set of services if they receive care in Alaska or Alabama, New England, or New Mexico.

Consequently, it is inferred that regional differences in care use and outcomes for a given patient cohort should be attributed to differences in case mix or provider practice patterns. Often, however, a portion of observed variation in Medicare utilization should be attributed to heterogeneity in benefit administration.

Medicare relies on regional Medicare administrative contractors (MACs) to adjudicate and pay claims in accordance with established payment policy. (Prior to August 2013, this work was carried out for different claim types by a mix of MACs, fiscal intermediaries, and carriers [Centers for Medicare and Medicaid Services 2016]. Throughout this article, we refer to all such administrative contractors collectively as "MACs.") When judging which services are "reasonable and necessary" (or meet standards of "medical necessity") for the care of Medicare beneficiaries—as when evaluating new innovations in care practice—MACs have authority to make local coverage decisions (LCDs) or to determine local claims payment guidelines (Allen and Keysor 2005; Neumann, Kamae, and Palmer 2008). The Centers for Medicare and Medicaid Services (CMS) has issued national coverage decisions or other standard guidance for approximately one-fourth of services rendered in Medicare, leaving the majority to be evaluated independently by MACs (Government Accountability Office 2003).

Potential benefits of decentralized coverage decision making include increased ability to constrain spending. In particular, the MAC contract renewal process allows Medicare to award contracts to organizations with a demonstrated willingness to be more aggressive in denying claims for services they deem inappropriate or fraudulent (Government Accountability Office 2003; Neumann, Kamae, and Palmer 2008). Medicare representatives, providers, and the medical device community have argued in favor of this regional system, contending that it is more flexible

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and responsive to local innovations in medical care (AdvaMed 2001; McGinley 2003).

On the other hand, the system admits heterogeneous coverage decisions, leading "to different treatment for beneficiaries in different locations" (Government Accountability Office 2003). The Government Accountability Office (2003) described multiple services that—through varying LCDs—were formally covered by Medicare in some localities but not others, including whole body bone and/or joint imaging, audiology testing, diagnostic pap smears, and bilateral deep brain stimulation. Variation in the context of services unaddressed in formal coverage decisions may be greater still. Moreover, where variation in these coverage decisions meaningfully affects provider reimbursement, providers may respond by modifying their service offerings, discontinuing the provision of services unlikely to be reimbursed adequately, and making new service offerings for services more likely to receive adequate reimbursement.

Previously, researchers have identified effects on service utilization of payment rates in the Medicare Fee Schedule (Hadley et al. 2003, 2009/2010; Hadley and Reschovsky 2006), changes in Medicare payment rates (Escarce 1993; Yip 1998; Mitchell, Hadley, and Gaskin 2000; Dafny 2005; Clemens and Gottlieb 2014), and Medicare reimbursement structures (Acemoglu and Finkelstein 2008; Hirth et al. 2013; Pan and Sambamoorthi 2013). The existing research that examines heterogeneity in the subjective coverage determinations of Medicare's claims adjudication contractors significantly predates the reorganization of such contracts as provided for in the Medicare Modernization Act of 2003 (Smits, Feder, and Scanlon 1982; Demlo et al. 1984). More recent evidence of this variation is limited to the work of Carlson and colleagues, who found that how narrowly MACs interpret CMS's guidelines in hospice care reimbursement can significantly affect Medicare beneficiaries' care experiences (Carlson et al. 2009) and patient outcomes, including hospitalization, expenditures, and mortality (Carlson et al. 2010).

In this paper, we offer new evidence of variation in discretionary decision making in the Medicare program by MACs and underscore how this variation contributes to variation in the care received by Medicare beneficiaries. We illustrate these points using the example of patients undergoing home hemodialysis (HHD), comparing their experiences to those of patients undergoing in-center hemodialysis (IHD). Within this context, we also consider the implications of this administrative variation for outcomes and dialysis providers' service offerings.

Hemodialysis Reimbursement in Medicare

Medicare is the single largest payer for dialysis services in the United States. When undergoing traditional IHD therapy, which was received by over 90 percent of Medicare dialysis patients in 2011 (Hirth et al. 2013), most patients attend a dialysis facility three times per week. This pattern is codified in Medicare's current payment policy, which provides that dialysis facilities may be reimbursed for only three hemodialysis sessions weekly. Payment for additional sessions may be authorized only if justified on the basis of medical necessity (Medicare Claims Processing Manual 2014).

Home hemodialysis therapy, an alternative to IHD, is often performed more than thrice weekly with smaller machines designed for shorter-duration, more frequent use (National Kidney Foundation 2015). Growing evidence suggests greater hemodialysis frequency—five or six sessions weekly versus the conventional three—is associated with improved mortality, overall physical health, and cardiovascular health indicators but more frequent access-related interventions and hospitalization for infections (Chertow et al. 2010; Foley et al. 2011; Perl et al. 2012; Weinhandl et al. 2012, 2015; Springel et al. 2013; Chan et al. 2014). This largely positive evidence and the small but growing number of patients undergoing HHD therapy have brought attention to Medicare's "thrice-weekly" payment policy, which is applied likewise to IHD and HHD. Editorials and patient information sources have argued the limitation to three paid treatments weekly is a barrier to more widespread use of HHD, offering anecdotal evidence that providers have found it difficult to provide sufficient medical justification to obtain reimbursement for additional treatments (Knotek 2005; Rodenberger 2009; Lebeau 2012; National Kidney and Urologic Diseases Information Clearinghouse 2013).

Home peritoneal dialysis (HPD), another alternative dialysis modality, is comparable to HHD in terms of its logistical management: patients undergo treatment at home with some nurse visitation and training support. However, HPD is different from IHD and HHD both clinically—hemodialysis patients' blood is filtered using an external artificial kidney machine, while in HPD therapy the inside lining of patients' abdominal cavity is used as a natural filter —and in terms of its administered frequency—HPD patients undergo treatment either once a day for an extended period of time or throughout the day, performing dialysate exchange procedures three to five times per day, versus the treatment frequency of three to six times per week for IHD or HHD patients. Medicare payment for HPD is on a per-day basis with the amount set to be the equivalent of three IHD treatments per week. Consequently, we focus our comparative analysis on HHD and IHD patients, although we leverage the logistical similarities between HHD and HPD programs in models of dialysis provider operations.

Dialysis facilities' scheduling routines and capacity constraints inhibit rendering additional treatments per week to IHD patients. However, for HHD patients, these constraints do not apply. In addition, while a facility incurs certain variable costs (e.g., additional dialysate) when rendering additional HHD treatments, total per-treatment costs for these additional treatments are substantially less than for preceding treatments because the costs of many dialysis-related prescriptions and services are relatively fixed (e.g., incurred monthly regardless of the number of treatments) (Klarenbach et al. 2014; Walker et al. 2014; Liu et al. 2015). Consequently, for dialysis facilities each additional home dialysis treatment per month has the potential to be more profitable than the last. Moreover, the financial attractiveness of HHD relative to IHD improves with each additional HHD treatment the facilities expect will be approved for payment as medically necessary.

Recent developments in Medicare's dialysis reimbursement policies make providing HHD therapy still more attractive. Prior to 2011, Medicare's per-treatment reimbursements covered a fixed set of "composite rate" services, which excluded many "separately billable" prescription drugs and laboratory services commonly used by dialysis patients. Beginning January 1, 2011, several of these previously separately billable services were added to the bundle of services included in Prospective Payment System (PPS) payments. These additional services (e.g., erythropoietin, vitamin D, and iron injections), like other composite rate services before 2011, are typically provided monthly regardless of the number of treatments. However, the average expected use of these services per treatment at the population level —which is used to inform PPS payment levels—largely reflects the per-treatment costs associated with IHD treatments rendered only thrice weekly (Hirth et al. 2013). Consequently, following the expanded bundle PPS's implementation, payments increased from approximately \$159 per treatment (composite rate payment) to \$230 per treatment (base rate for the expanded bundle before any adjusters are applied) (Hornberger and Hirth 2012), while the costs to facilities of providing formerly separately billable services during additional HHD treatment sessions have not risen commensurately (Hirth et al. 2013).

Because of these changes in incentives and because of the anecdotal evidence that payments for additional HHD treatments were provided inconsistently, we explored variation in paid-for HHD treatments per patient-month across MACs and over time, before and after the implementation of Medicare's expanded bundle PPS. For comparison, we likewise examined variation in payment for IHD treatments per patient-month.

Materials and Methods

We determined the extent and persistence of variation in the frequency of paid HHD and IHD treatments for a large (near 100 percent) sample of Medicare hemodialysis patients in 2009–2012 by MAC. We used ESRD Medicare claims data files to count paid HHD and IHD treatments, identifying hemodialysis treatments (including both regular and training treatments) using current procedural terminology codes 90935, 90937, 90989, or 90993 and revenue center code 0821 on bill type 72x claims. To avoid misinterpreting other administrative differences as differences in decision making among MACs, counted treatments were restricted to those with positive paid amounts, and counts of treatments per month were rescaled to standardize month lengths to 30 outpatient days (i.e., excluding days in hospital) and capped at 30 treatments (one per day). We distinguished HHD treatments from IHD treatments using claim condition code 74 (indicating home dialysis service). We then defined HHD and IHD patient-months as months in which the plurality of the patient's paid dialysis treatments was HHD or IHD treatments, respectively (minimum one HHD or IHD treatment). We retained patient-months during which exactly one MAC could be identified adjudicating all of the patient's dialysis claims. Because HHD remains uncommon, we limited our analysis of variation across HHD patient-months to MAC-years during which the MAC adjudicated claims for at least 100 HHD patient-months to increase the reliability of MAC-level estimates.

Approximately two-thirds of dialysis facilities submit their claims to the MAC with jurisdiction over their geographic region (C. Klots, Center for Medicare and Medicaid Services, personal communication, July 2014). The remaining third submits claims to MACs with jurisdiction over different localities; these out-of-jurisdiction relationships result from exceptions granted by CMS prior to the establishment of the current regulations pursuant to Section 911 of the Medicare Modernization Act of 2003. (We present additional details describing our method for identifying MACs in the Appendix SA2.)

To quantify the variation in MACs' discretionary decision making in this context, we estimated separate ordinary least-squares (OLS) regressions by year by modality (HHD vs. IHD) at the patient-month (pm) level. Specifically, we use these models to identify the conditional average number of paid HHD or IHD treatments per month within each MAC by year, controlling for other observable differences between MACs. In these models, our dependent variable T_{pm} represents the number of paid treatments, and our independent variables of interest are represented by MAC_{pm}, a vector of indicators of the MAC that adjudicated patient *p*'s treatment claims during month *m*. The set of MAC indicators, which number between 14 and 24 across models, varies by year and by modality as MAC contracts begin and lapse and as some MACs adjudicate claims for at least 100 HHD patient-months in some years but not others. An F-statistic was computed to determine the joint statistical significance of these indicators.

We would expect paid treatment counts to vary with patient characteristics associated with clinical need for additional treatments (or "risk"). It has been argued—as in the somewhat differentiated LCDs established by three MACs (First Coast Service Options, Inc. [FCSO, MAC for jurisdiction 9], Novitas Solutions, Inc. [Novitas, MAC for jurisdictions 4, 7, and 12], and Palmetto GBA, LLC [Palmetto, MAC for jurisdiction 11]) (Medicare Coverage Database 2013)—that additional dialysis treatments may be needed by patients experiencing hyperkalemia, pregnancy, fluid overload, acute pericarditis, congestive heart failure, pulmonary edema, or severe catabolic state. Where these patient characteristics varied across MACs, paid treatments per patient-month should vary likewise. To remove the variation across MACs due to differences in the populations whose claims MACs adjudicate, we risk-adjust for such potential imbalances by including in our regressions an extensive set of patient- and patient-month-level controls X_{pm} potentially related to individual patients' needs for additional dialysis treatments. Among these are both time-invariant patient-level indicators captured at the time of the onset of renal replacement therapy, as identified in the patient's CMS Form 2728—age (>18, 18–44, 60–69, 70–79, or <79, vs. 45–59 (ref.)), race (American Indian or Alaskan Native, Asian or Pacific Islander, black, or other or multiracial, vs. white (ref.)), body mass index ($BMI < 18.5$, $25 \leq BMI < 30$, $30 \leq BMI < 40$, or $BMI \geq 40$, vs. $18.5 \leq BMI < 25$ (ref.)), difficulty ambulating (yes or no), and difficulty transferring (yes or no)—and also patient-month-level indicators of the presence of comorbid conditions during the previous 3 months as identified using all (dialysis- and non-dialysis-related) claims: pericarditis, septicemia, pneumonia, opportunistic infections, gastrointestinal bleeding, cancer, cardiac arrhythmia or dysrhythmia, hepatitis, anemia, monoclonal gammopathy, myelodysplastic syndrome, sickle-cell anemia, alcohol or drug dependency, congestive heart failure, cardiovascular accident, diabetes, ischemic heart disease, pulmonary edema, pulmonary vasculitis, and HIV/AIDS. The International Classification of Disease, Ninth Revision (ICD-9) codes we used to identify these clinical conditions are based on those used in CMS's hierarchical condition categories and ESRD PPS risk adjustment models (Pope et al. 2004; Leavitt 2008). The use of comorbid condition indicators derived from both the CMS Form 2728 and claims data as controls (in addition to other correlated covariates) compensates for observed discordance in these data sources (Krishnan et al. 2015). We also included patient-month-level indicators of total inpatient days (obtained from Medicare Part A claims), died during the month (yes or no, obtained from Medicare enrollment files), and that the month is one of patient p's first 3 months of renal replacement therapy ("vintage," derived from the date of first renal replacement therapy obtained from the patient's CMS Form 2728). Standard errors were clustered at the MAC level.

Equation 1 presents the estimating equation in full.

$$T_{\mathrm{pm}} = MAC_{\mathrm{pm}} + X_{\mathrm{pm}} + \eta_{\mathrm{pm}} \tag{1}$$

To test the sensitivity of our findings to the incompleteness of our claims-based comorbidity indicator variables during patients' first three Medicare-enrolled months—which reflect zero, one, or two preceding months of claims rather than three, as we are limited to Medicare claims data in our analyses—we also re-estimate our models restricting to those patients with age greater than 65 and those under 65 undergoing dialysis at least 7 months after the patient's first month of renal replacement therapy. For dialysis patients under age 65, "Medicare coverage usually starts on the first day of the fourth month of your dialysis treatments" (Medicare.gov 2016). Therefore, 7 months is long enough to ensure that we have at least three prior months of claims to ascertain comorbidities.

We used our OLS regressions' results to calculate predicted counts of paid treatments per patient-month by MAC for IHD and HHD patient-months, assuming every MAC treated a "typical" dialysis patient. Specifically, for each MAC-year and each modality, we multiplied our model coefficients by the appropriate MAC indicators as well as characteristics of a typical dialysis patient across our entire sample (including IHD and HHD patients and all four data years), omitting only the residual. To represent the typical dialysis patient, we selected the modal patient-month characteristics for discrete variables (e.g., male, white, did not die during month), and we selected the population mean for the sole continuous variable body surface area. We then summed these products to generate MAC-year-level predicted paid treatments per patient-month by modality and compared these measures across MACs to quantify and analyze variation in MAC payments strictly due to the identity of the MAC adjudicating claims. We assessed persistence in this variation for each modality by examining changes in the range of predicted paid treatments by MAC across years, and we assessed persistence in predicted paid treatments by modality within each MAC over time using an intraclass correlation statistic.

Finally, we assessed the extent to which variation in MACs' discretionary decision making may have influenced dialysis facilities' operations and modality offerings. Specifically, we conducted a facility-year (fy)-level analysis of whether dialysis facilities are more likely to have a HHD program ($HHDProg_{fy}$)—defined as having two or more unique patients, each with at least one HHD patient-month, during the year. Our key independent variable $T_{f(y-1)}$ is the average, unadjusted number of HHD treatments paid for per patient-month by the facility f's MAC during the preceding calendar year—a marker for how the facility may perceive its MAC's patterns of paying for additional HHD treatments relative to other MACs. While the specification of this variable exploits the longitudinal nature of our data, the one-year lag necessitates that we restrict our analysis to facility-years during the period 2010–2012. Similarly, to increase the reliability of our estimates, facility-years were excluded from our analysis if the facility's assigned MAC had less than 100 HHD patient-months during the previous calendar year.

In this analysis, our controls X_{fy} include indicators for the presence of an IHD program (a small number of facilities specialize in home dialysis modalities and so do not offer IHD therapy) and the presence of a HPD program—facilities with programs for these alternative dialysis modalities may be able to leverage clinical and technical expertise or logistical expertise, respectively, and ease the process of initiating a new HHD program. We identify HPD treatments using current procedural terminology codes 90935, 90937, 90989, or 90993, and revenue center codes 0831, 0841, or 0851 on bill type 72x claims. We specify our IHD and HPD program indicators in parallel with the HHD program indicator's specification. We also include year fixed effects to control for secular trends in HHD care. Standard errors are clustered at the MAC-year level.

Equation 2 represents the estimating equation for our linear probability (OLS) model in this analysis.

$$HHDProg_{fy} = T_{f(y-1)} + X_{fy} + \varepsilon_{fy} \tag{2}$$

All analyses were conducted using *SAS* version 9.2 (Cary, NC, USA).

Results

Unadjusted descriptive statistics for our HHD and IHD patient-month samples are presented in Table 1. After applying our sample inclusion criteria, thereby excluding 2.8 percent of HHD patient-months and 2.2 percent of IHD patient-months, our analytic samples remained large for each modality: 186,072 HHD and 12,447,294 IHD patient-month-level observations in total across years. IHD is significantly more common than HHD, representing 98.5 percent of hemodialysis patient-months. However, HHD's share grew each year. As expected, HHD patient-months average significantly more paid

Table 1: Select Descriptive Statistics, Home Hemodialysis and In-Center Hemodialysis Patient-Month Samples (2009–2012)

	HHD		*IHD*		
Variable	*Mean/%*	*SD*	*Mean/%*	*SD*	*Difference t stat.*
Mean treatments per month	17.8	5.6	12.0	2.6	446.7
Age	56.7	15.3	63.2	15.0	179.4
Female	39.4%		45.7%		55.4
White	66.8%		54.7%		110.6
Black	28.3%		38.6%		97.2
Asian/Pacific Islander	3.4%		4.3%		21.8
Am. Indian/Alaskan Native	0.9%		0.6%		33.1
Other/multiracial	0.6%		0.9%		16.0
Body mass index	29.2	7.8	28.3	7.4	44.8
Body surface area	2.0	0.3	1.9	0.3	102.0
New dialysis patient (vintage)	2.7%		4.8%		52.5
Days in hospital	1.3	3.8	1.2	3.5	11.9
Died during month	1.4%		1.2%		9.1
Cancer	8.5%		7.5%		15.8
Diabetes	64.2%		77.5%		118.4
Ischemic heart disease	60.5%		69.7%		80.4
Year 2009	19.9%		24.4%		48.3
Year 2010	23.2%		25.3%		21.3
Year 2011	27.1%		24.9%		21.2
Year 2012	29.8%		25.4%		41.3
N (patient-months)	186,072		12,447,294		

treatments than IHD patient-months (17.8 treatments vs. 12.0 treatments), not accounting for differences such as the number of days spent in hospital or deaths during the month. HHD patients are somewhat younger, are more likely to be male and white, and have a higher average BMI than IHD patients. Our sample of HHD patient-months is also less likely to include patients undergoing early dialysis care than our sample of IHD patient-months. In general, fewer comorbidities are observed during HHD patient-months than during IHD patient-months.

Regression results for our 2012 models of HHD and IHD are presented in Table 2 and Table 3, respectively. (Model results for other years are available upon request.) In our model of paid HHD treatments per patient-month, 15 of 17 estimates for MAC-specific effects were statistically significant; the joint *F*-test of statistical significance for these effects was also strongly significant ($p < .0001$). Among these estimates, the range of associated marginal effects (approximately 6.1 treatments) was large relative to the overall mean. Our estimates for many patient- and patient-month-level controls, including days in the hospital, death during the month, body surface area, vintage, difficulty ambulating, select age and racial/ethnic groups, sex, and several indicators for comorbid conditions, were also statistically significant. Owing to our models' large sample sizes, most estimates were statistically significant at 0.01 percent levels.

In our model of paid IHD treatments per patient-month, 15 of 20 estimates for MAC-specific effects were statistically significant, as was the joint *F*-test of statistical significance for these effects ($p < .0001$). Compared with our observed effect estimates for HHD, however, the range of associated marginal effects in this model (approximately 0.8 treatments) was much smaller relative to the overall mean for IHD. Again, many estimates for patient- and patient-month-level controls were statistically significant, most at 0.01 percent levels.

In Figure 1, we present predicted paid treatments per patient-month (hereafter "predicted treatments") by MAC for IHD and HHD during 2009 and 2012. (Comparable statistics for 2010 and 2011 are available upon request.) Our estimates of HHD treatments greatly exceeded our estimates of IHD treatments. We estimated predicted treatments for a typical dialysis patient by modality by MAC-year and found that the HHD estimate of 18.8 predicted treatments was significantly greater than the IHD estimate of 12.1 predicted treatments ($p < .0001$).

Home hemodialysis predicted treatments varied dramatically across MACs, ranging between 14.3 and 21.9 treatments across 2009–2012. This

Table 2: Ordinary Least-Squares Regression Results, Model of Home Hemodialysis Treatment Counts in 2012 at the Patient-Month Level

Variable	*Est.*	*SE*
AdminaStar	1.808	0.191**
CGS Admin 1	−0.563	0.189*
CGS Admin 2	1.394	0.216**
Mutual of Omaha	−0.492	0.328
Noridian 1	3.794	0.369**
PBSI	0.767	0.316
UGS	5.520	0.230**
MAC 1	4.462	0.181**
Noridian 2/MAC 2	3.074	0.213**
MAC 3	4.412	0.296**
MAC 4	0.993	0.182**
MAC 5	4.695	0.209**
MAC 9	1.300	0.201**
MAC 10	3.311	0.180**
Palmetto/MAC 11	−0.718	0.204*
MAC 12	3.604	0.202**
MAC 13	3.265	0.197**
Days in hospital	−0.050	0.006**
Died during month	−8.076	0.184**
BMI < 18.5	0.045	0.124
25 ≤ BMI < 30	−0.028	0.057
30 ≤ BMI < 40	0.088	0.069
BMI ≥ 40	0.201	0.105
BSA	0.970	0.121**
Vintage	−1.939	0.132**
Diff. ambulating	−0.925	0.150**
Diff. transferring	−0.184	0.187
Age < 18	−0.967	0.526
18 ≤ Age < 45	0.238	0.056**
60 ≤ Age < 70	−0.431	0.057**
70 ≤ Age < 80	−0.753	0.069**
Age ≥ 80	−1.550	0.095**
Am. Indian/Alaskan Native	−0.697	0.220*
Asian/Pacific Islander	−0.152	0.115
Black	−0.479	0.047**
Other/multiracial	−1.128	0.247**
Female	−0.231	0.052**
Pericarditis	−0.025	0.265
Septicemia	−0.465	0.069**
Bac. pneumonia	−0.600	0.122**
Pneumonia	0.445	0.222
Opp. infection	−0.514	0.234
GI bleed	−0.332	0.152

Continued

Table 2 *Continued*

Variable	*Est.*	*SE*
Cancer	−0.080	0.072
Cardiac arrhythmia	−0.019	0.188
Hepatitis	−0.539	0.181*
Her. hemo. anemia	0.184	0.274
Mono. gammopathy	0.648	0.223*
Myelodyplastic syn.	0.558	0.218
Sickle-cell anemia	−0.551	0.477
Alcohol dependence	−0.323	0.099*
CHF	0.294	0.051**
CV disease	−0.316	0.047**
Diabetes	−0.062	0.048
Drug dependence	−0.478	0.098**
Dysrhythmia	0.384	0.046**
Ischemic heart disease	0.061	0.050
COPD	−0.183	0.045**
Peri. vascular disease	0.061	0.047
HIV/AIDS	0.564	0.135**
Intercept	13.628	0.292**

Notes $N = 54{,}575$ patient-months.
*$p < .01$; **$p < .0001$.
BMI, Body mass index; BSA, body surface area; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CV disease, cardiovascular disease; GI bleed, gastrointestinal bleed; HIV/AIDS, human immunodeficiency virus/acquired immunodeficiency syndrome; SE, standard errors.

variation across MACs persisted over time. The range in HHD predicted treatments across MACs—from lowest to highest predicted treatments—was at least 5.7 in each year. Moreover, the intraclass correlation statistic for this sample of HHD treatments was 0.677, indicative of moderate-to-strong correlation and persistence in predicted treatments over time within MACs.

By contrast, IHD predicted treatments did not vary meaningfully across MACs or over time. Across 2009–2012, the range of IHD predicted treatments was between 10.9 and 12.4 treatments.

Our results were comparable when estimated restricting to those patients with age greater than 65 and those under 65 undergoing dialysis at least 7 months after the patient's first month of renal replacement therapy (representing 95.2 percent and 96.4 percent of our main analytic sample's HHD and IHD patient-months, respectively; results not shown).

The results of our facility-year-level regression of HHD program presence are presented in Table 4. Our main estimate suggests that, when a

Table 3: Ordinary Least-Squares Regression Results, Model of In-Center Hemodialysis Treatment Counts in 2012 at the Patient-Month Level

Variable	*Est.*	*SE*
AdminaStar	−0.090	0.012**
Arkansas BC	−0.712	0.094**
CGS Admin 1	−0.106	0.011**
CGS Admin 2	−0.107	0.012**
Mutual of Omaha	0.078	0.045
Noridian 1	−0.239	0.022**
PBSI	0.089	0.017**
UGS	−0.024	0.013
MAC 1	−0.023	0.009
Noridian 2/MAC 2	−0.077	0.013**
MAC 3	−0.263	0.013**
MAC 4	−0.097	0.009**
MAC 5	−0.018	0.014
MAC 7	−0.041	0.018
MAC 8	−0.049	0.012**
MAC 9	−0.159	0.011**
MAC 10	−0.105	0.009**
Palmetto/MAC 11	0.032	0.011*
MAC 12	−0.067	0.011**
MAC 13	0.039	0.010*
Days in hospital	−0.004	0.000**
Died during month	−6.239	0.013**
BMI $<$ 18.5	−0.061	0.007**
25 $\leq$ BMI $<$ 30	0.032	0.004**
30 $\leq$ BMI $<$ 40	0.091	0.004**
BMI $\geq$ 40	0.171	0.007**
BSA	−0.009	0.008
Vintage	−1.039	0.006**
Diff. ambulating	0.011	0.008
Diff. transferring	0.001	0.012
Age $<$ 18	0.358	0.039**
18 $\leq$ Age $<$ 45	−0.191	0.005**
60 $\leq$ Age $<$ 70	0.053	0.004**
70 $\leq$ Age $<$ 80	0.074	0.004**
Age $\geq$ 80	0.110	0.005**
Am. Indian/Alaskan Native	−0.110	0.011**
Asian/Pacific Islander	0.240	0.007**
Black	0.001	0.003
Other/multiracial	0.205	0.015**
Female	−0.056	0.003**
Pericarditis	−0.004	0.018
Septicemia	0.010	0.005
Bac. pneumonia	0.092	0.009**

Continued

Table 3 *Continued*

Variable	*Est.*	*SE*
Pneumonia	−0.007	0.015
Opp. infection	−0.122	0.018**
GI bleed	0.005	0.010
Cancer	−0.060	0.005**
Cardiac arrhythmia	0.123	0.013**
Hepatitis	−0.060	0.009**
Her. hemo. anemia	−0.014	0.022**
Mono. gammopathy	−0.011	0.014
Myelodyplastic syn.	−0.052	0.015*
Sickle-cell anemia	−0.155	0.031**
Alcohol dependence	−0.180	0.005**
CHF	0.090	0.004**
CV disease	0.020	0.003**
Diabetes	0.078	0.003**
Drug dependence	−0.226	0.006**
Dysrhythmia	0.036	0.003**
Ischemic heart disease	0.037	0.003**
COPD	−0.016	0.003**
Peri. vascular disease	0.099	0.003**
HIV/AIDS	−0.099	0.008**
Intercept	12.050	0.018**

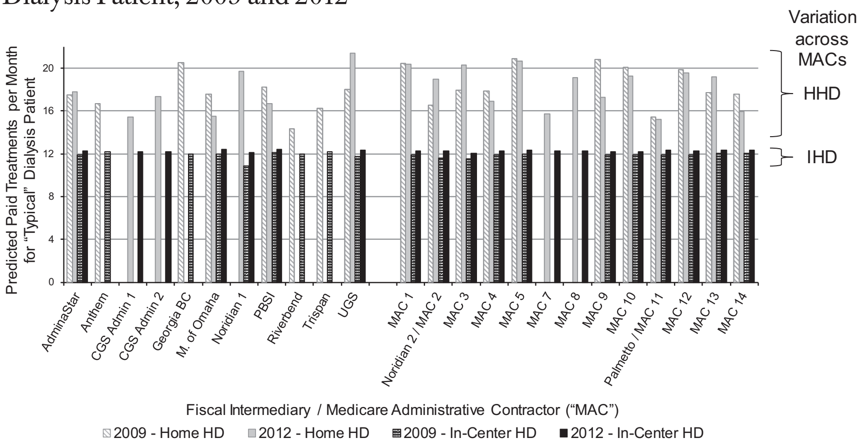
Notes: N = 3,130,342 patient-months.
*p < .01; **p < .0001.
BMI, Body mass index; BSA, body surface area; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CV disease, cardiovascular disease; GI bleed, gastrointestinal bleed; HIV/AIDS, human immunodeficiency virus/acquired immunodeficiency syndrome; SE, standard errors.

facility's MAC pays for one additional HHD treatment per patient month on average during the preceding year, the facility's probability of operating a HHD program rises 0.4 percentage points; this estimate is not statistically significantly different from zero. Our control variables capturing IHD program presence and HPD program presence are correlated (negatively and positively, respectively) with HHD program presence.

Discussion

While Medicare is a national insurance program, it administers benefits through regional MACs and, for many services, relies on their discretion to determine when it should make payments. This administrative structure may

Figure 1: Predicted Paid Home Hemodialysis (HHD) and In-Center Hemodialysis (IHD) Treatments per Month by MAC, "Typical" Medicare Dialysis Patient, 2009 and 2012



Notes. Predictions for the "typical" dialysis patient—defined using modal patient-month characteristics for discrete variables and mean body surface area—derived from results of OLS models with patient treatments per month as dependent variable and MAC dummies as individual variables (ref. MAC 14), adjusted for patient demographics, 23 important comorbidities, and other factors. Separate OLS models by modality by year. R^2 ranges across models (2009, 2010, 2011, and 2012): 0.193–0.223 for HHD, 0.069–0.097 for IHD.

Table 4: Linear Probability Model of Home Hemodialysis (HHD) Program Presence (2010–2012), Regression Results

Variable	*Est.*	*SE*
Lagged (-1) MAC-year average paid HHD treatments per patient-month	0.0037	0.0033
IHD program presence	−0.2434	0.0540**
HPD program presence	0.2925	0.0119**
Year 2011 (2010 ref.)	0.0033	0.0035
Year 2012 (2010 ref.)	0.0084	0.0071
Intercept	0.1999	0.0589*

Notes. N = 16,013 facility-years.
*p < .01; **p < .0001.
HPD, home peritoneal dialysis; IHD, in-center hemodialysis; MAC, Medicare administrative contractor; SE, standard errors.

generate efficiencies and offer greater responsiveness to local provider concerns than a uniform, national coverage decision-making process. However, the resulting heterogeneity in decision making by MACs admits the possibility of geographic variation in care experiences and outcomes among Medicare beneficiaries as well as providers' service offerings and patterns of care. Despite opportunities for reducing such administrative variation through regulatory interventions, this driver of variation in utilization has received relatively little attention in the literature on regional variation in health care.

In the case of patients undergoing hemodialysis care during 2009–2012, we find striking, persistent variation across MACs with respect to the number of paid HHD treatments per patient-month—controlling for differences in patient risk—and hence the number of treatments a given patient might be expected to receive. Dialysis facilities may have observed this variation—particularly large dialysis organizations submitting claims to different MACs in different geographic regions—just as hemodialysis equipment suppliers have (NxStage Medical, Inc. 2012). However, in our investigation of this variation's potential consequences for dialysis facility operations and service offerings, we found a positive but not statistically significant effect of a MAC's greater willingness to pay for additional HHD treatments on the presence of facility HHD programs.

The limitations of our analysis include that the financial incentives encouraging the use of HHD rather than IHD that were faced by dialysis facilities evolved during our study period, intensifying significantly as of 2011. Additionally, HHD use has continued to grow in recent years (United States Renal Data System 2015). Both trends could increase dialysis facilities' awareness of the variation in MAC payment decisions we observe and the opportunity to increase reimbursement in areas where MACs are more likely to pay for additional treatments. Consequently, in the future we may observe growth in HHD programs in areas where MACs typically pay for more treatments. On the other hand, these trends and associated rising aggregate costs of HHD treatments could also lead MACs to reconsider their interpretations of medical justification in this context and institute new standards more often restricting payment for HHD services, potentially reducing variation across MACs and, consequently, variation in provider responses. More recent data could reveal the net effects of these opposing mechanisms on patterns of facility operations and services offerings and implications for dialysis patients' access to and use of HHD therapy.

If further research demonstrates that the variation we observe in health care use due to MAC discretionary decision making represents inefficiency in care practice as well as inequitable access to health care services, CMS authorities may consider certain regulatory interventions to minimize this variation. For example, regulators could issue more explicit guidance to MACs to standardize protocols for assessing medical necessity.

In addition, policy makers may worry that large provider organizations interested in providing more HHD treatments could seek to have their claims adjudicated by MACs more likely to interpret medical justification regulations expansively, strictly for the purpose of increasing revenue. Current CMS rules governing the linkage of individual provider facilities to MACs, in place since 2006, assign them to the MACs with jurisdiction over the areas where their individual facilities are located. However, CMS is also permitted to grant large provider groups an exception to these rules, enabling the assignment of all facilities within the groups to the single MAC with jurisdiction over the region where the providers' home office is located (Centers for Medicare and Medicaid Services 2013). While this policy is somewhat restrictive (Assignment of Providers and Suppliers to MACs 2006), CMS could integrate an evaluation of claims payment denial rates under the provider group's current MAC assignments into the process by which it is determined whether such an exception should be granted.

A more comprehensive review of CMS's guidance to MACs as well as examinations of other, nondialysis services using recent data could be valuable in quantifying the contribution of MACs' heterogeneous claims adjudication practices to geographic variation in provider practice patterns (IOM 2013) as well as downstream variation in patients' outcomes and experiences of care.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix SA2: Identifying Unique Medicare Administrative Contractors (MACs).