Hidden Costs Associated with Conversion from Peritoneal Dialysis to Hemodialysis

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Key Points
• The number of patients initiating peritoneal dialysis each year in the United States is steadily increasing.
• Accordingly, the number of people discontinuing peritoneal dialysis and converting to hemodialysis will likely increase in future years.
• The transition is defined by high rates of hospitalization and health-care spending. Outcomes after the transition remain relatively poor.

Abstract
Background Increasing use of peritoneal dialysis (PD) will likely lead to increasing numbers of patients transitioning from PD to hemodialysis (HD). We describe the characteristics of patients who discontinued PD and converted to HD, trajectories of acute-care encounter rates and the total cost of care both before and after PD discontinuation, and the incidence of modality-related outcomes after PD discontinuation.

Methods We analyzed data in the United States Renal Data System to identify patients aged ≥12 years who were newly diagnosed with ESKD in 2001–2017, initiated PD during the first year of ESKD, and discontinued PD in 2009–2018. We estimated monthly rates of hospital admissions, observation stays, emergency department encounters, and Medicare Parts A and B costs during the 12 months before and after conversion from PD to HD, and the incidence of home HD initiation, death, and kidney transplantation after conversion to in-facility HD.

Results Among 232,699 patients who initiated PD, there were 124,213 patients who discontinued PD. Among them, 68,743 (55%) converted to HD. In this subgroup, monthly rates of acute-care encounters and total costs of care to Medicare sharply increased during the 6 months preceding PD discontinuation, peaking at 96.2 acute-care encounters per 100 patient-months and $20,701 per patient in the last month of PD. After conversion, rates decreased, but remained higher than before conversion. Among patients who converted to in-facility HD, the cumulative incidence of home HD initiation, death, and kidney transplantation at 24 months was 3%, 25%, and 7%, respectively.

Conclusions The transition from PD to HD is characterized by high rates of acute-care encounters and health-care expenditures. Quality improvement efforts should be aimed at improving transitions and encouraging both home HD and kidney transplantation after PD discontinuation.

883
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Introduction
Between 2008 and 2018, the census of patients performing home dialysis in the United States increased from 33,551 to 68,986 (1). That approximate doubling compares favorably to the concurrent increase of 38% in the number of patients undergoing in-facility hemodialysis (HD) (1). Home dialysis growth slowed during the second half of the 2010s, largely due to a shortage of peritoneal dialysis (PD) fluid and uncertainty about reimbursement for more frequent HD (i.e., more than three HD sessions per week) sessions in the home setting (2,3), but the Executive Order on Advancing American Kidney Health has reinvigorated interest in home dialysis in the United States (4,5).

Around the world, PD is the dominant modality in the home setting (1). From a statistical perspective, a growing census of patients performing PD will likely lead to a growing number of patients transitioning from PD to HD each year. There has been progress in lowering the rate of conversion from PD to HD, but, even among patients who initiated PD treatment in the United States in 2014, the rate of conversion from PD to HD remained >21 events per 100 patient-years (6,7). When conversion occurs, patients rarely reach home HD (8,9). Surprisingly, there are very few
published data about the epidemiology of the transition from PD to HD, a tumultuous period for patients and their families. Improved understanding of the transition can guide initiatives aimed at smoother, or even earlier, transitions from PD to HD, thereby lowering rates of hospitalization and related health-care expenditures and helping patients to maintain their lifestyle with home dialysis—if patients choose to transition from PD to home HD. In this study, we analyzed national data to describe the characteristics of patients who discontinue PD and convert to HD, trajectories of acute-care rates and the total cost of care both before and after discontinuation of PD, and the incidence of modality-related outcomes after discontinuation of PD.

Materials and Methods

Study Cohort

We analyzed the United States Renal Data System (USRDS) Standard Analysis Files. The study cohort comprised patients who were newly diagnosed with ESKD between January 1, 2001, and December 31, 2017; were aged 12–99 years at the date of ESKD incidence; initiated PD during the first year of ESKD; and discontinued PD between January 1, 2009, and September 30, 2018. We retained patients whose reason for discontinuation of PD was conversion to HD, death, or kidney transplantation; in the first case, we required that patients underwent HD for ≥2 weeks. All other patients who discontinued PD, including those who recovered kidney function, were excluded.

Before identifying discontinuation of PD, we processed dialytic modality records in the USRDS Standard Analysis Files. If two intervals of PD treatment were separated by ≤2 months, then the intervals were joined (i.e., the interruption in PD treatment was ignored).

Patient Characteristics

For each patient, we identified age (upon discontinuation of PD), sex, race, primary cause of ESKD, the duration of ESKD (upon discontinuation of PD), and the duration of PD (i.e., from initiation to discontinuation). We also identified the presence of heart failure; ischemic heart disease; cerebrovascular disease; the composite of either chronic obstructive pulmonary disease or tobacco use; and the composite of either inability to ambulate, inability to transfer, or need of assistance with daily activities, all according to the Centers for Medicare and Medicaid form CMS-2728 ("End Stage Renal Disease Medical Evidence Report"). Finally, we assessed whether each patient carried health insurance coverage with Medicare Parts A and B as the primary payer at exactly 2 weeks after the date of discontinuation of PD.

Outcomes

Among the subgroup of patients who converted to HD and carried Medicare coverage, we identified incidence of hospital admissions, observation stays, and emergency department (ED) encounters both before and after discontinuation of PD. Per USRDS methodology, all events were ascertained from Medicare claims: (1) admissions were ascertained from Part A claims by inpatient hospitals; (2) observation stays were ascertained from Part B claims by outpatient hospitals, with revenue center codes 0762; and (3) ED encounters were ascertained from Part B claims by outpatient hospitals, with revenue center codes 045x or 0981. We also ascertained length of stay after hospital admissions; admissions could have been as short as a single day. Cause-specific hospital admissions were identified by classifying principal discharge diagnoses into categories relevant to PD treatment; causes and sets of qualifying diagnosis codes are displayed in Supplemental Table 1. We also identified the cost of health-care services covered by Medicare Parts A and B both before and after discontinuation of PD. Cost was defined by the Medicare payment to the provider that submitted a claim; patient cost-sharing balances were not included.

Among all patients who discontinued PD and converted to HD, we identified incidence of home HD initiation, PD resumption, death, and kidney transplantation. Because the time to PD resumption is necessarily sensitive to the decision to join consecutive intervals of PD treatment that were separated by ≤2 months, we identified incidence of events under alternative scenarios in which consecutive intervals of PD treatment were joined if they were separated by (1) ≤1 month, and (2) ≤3 months. In the former scenario, a mere 5-week interruption of PD (e.g., due to hospitalization and postacute care with HD treatment) would constitute discontinuation of PD, whereas, in the latter scenario, the same interruption would be ignored.

Statistical Analyses

Using descriptive analysis, we compared characteristics among patients who discontinued PD and converted to HD, discontinued PD due to death, and discontinued PD due to kidney transplantation. We constructed histograms to estimate distributions of age upon discontinuation of PD and the duration of PD in patients who converted to HD. In the subgroup of patients who converted to HD after ≥1 year of PD treatment and carried Medicare coverage during the 1-year interval preceding discontinuation of PD, we estimated rates of all-cause and cause-specific hospital admissions, all-cause hospital days, observation stays, ED encounters, and total costs of care during each of the 12 months before and 12 months after discontinuation of PD. In the postdiscontinuation period, follow-up was censored at the earliest of discontinuation of HD, cessation of Medicare Parts A and B coverage, or December 31, 2018. As a sensitivity analysis, we estimated monthly rates of acute-care events and total costs in subgroups of patients who converted to HD after ≥3, ≥6, or ≥9 months of PD treatment (Supplemental Table 2). We also estimated trajectories of hospitalization rates in subgroups defined by timing of PD initiation, duration of PD, and year of PD discontinuation. In the subgroup of patients who converted to HD after ≥3 months of PD treatment, we used Poisson regression to estimate adjusted relative rates of all-cause hospital admissions during the 3-month interval before discontinuation of PD, and we used logistic regression to estimate adjusted odds ratios of avoiding hospitalization during that 3-month interval. Finally, in patients who converted from PD to in-facility HD, we estimated the cumulative incidence of PD resumption, home HD
initiation, death, and kidney transplantation, with follow-up ending at the earlier of the first event or December 31, 2018.

Study materials were accessed through a data-use agreement with National Institute of Diabetes and Digestive and Kidney Diseases, and research was approved by the institutional review board at the Hennepin Healthcare Research Institute (Minneapolis, MN). The board determined that the study was exempt, because study materials were limited datasets, so informed consent was waived. The study conformed to the Declaration of Helsinki.

Results

From 2001 to 2017, there were 1,932,420 patients with incident ESKD aged ≥12 years. In this cohort, 274,033 patients (14%) had initiated PD by the end of 2018; the majority (85%) had initiated PD during the first year of ESKD. In that subgroup, the incidence of conversion to HD was 21% at 1 year, 32% at 2 years, 40% at 3 years, and 47% at 5 years. Meanwhile, the incidence of death was 8% at 1 year and 25% at 5 years, whereas the incidence of kidney transplantation was 5% at 1 year and 16% at 5 years.

The study cohort included 124,213 patients whose reason for discontinuation of PD was conversion to HD (55%), death (27%), or kidney transplantation (18%). The distribution of the duration of PD was heavily skewed, with 44% of patients at <1.0 year, 23% at 1.0–1.9 years, 14% at 2.0–2.9 years, 13% at 3.0–4.9 years, and only 6% at ≥5.0 years (Figure 1). Among patients who converted to HD, the distribution of age was centered at approximately 60 years, with two thirds of patients aged 40–69 years (Figure 2). Compared with patients who discontinued PD due to death, those who converted to HD were younger, were more likely to be Black, and had lower comorbidity burden; they also performed PD for 6.9 fewer months (Table 1). Compared with patients who received a kidney transplant, those who converted to HD were older and had higher comorbidity burden; they also performed PD for 5.5 fewer months.

Among the 68,743 patients who converted to HD, 36,264 (53%) carried Medicare coverage. In this subgroup, monthly rates of hospital admissions, observation stays, and ED encounters exhibited a sharp increase during the 6 months preceding discontinuation of PD (Table 2). Rates also exhibited a sharp decrease during the 6 months after discontinuation of PD, but, between months 7 and 12 after discontinuation, rates settled at levels that were 53% higher than between months 7 and 12 before discontinuation of PD. Rates of hospital admissions (days) per 100 months were 20.7 (176.3) in the third-to-last month of PD, 31.0 (306.8) in the second-to-last month, and 72.1 (848.7) in the last month, before receding to 31.6 (245.2) in the first month of HD. In the last month of PD, the composite rate of hospital admissions, observation stays, and ED encounters was 96.2 events per 100 months, suggesting nearly 100% risk of acute care. In the first month of HD, the composite rate declined only to 59.1 events per 100 months, suggesting nearly 100% risk of acute care. In the first month of HD, the composite rate declined only to 59.1 events per 100 months, suggesting nearly 100% risk of acute care.

Figure 1. Distribution of months on peritoneal dialysis (PD), among patients whose reason for discontinuation of PD was conversion to hemodialysis (HD), 2009–2018.

Figure 2. Distribution of age at conversion from PD to HD, 2009–2018.
days in the last month of PD increased by 21% (Supplemental Table 4).

Regarding patient characteristics, adjusted relative rates of hospital admissions during the 3-month interval before PD discontinuation were generally modest in magnitude, although higher rates were apparent among patients aged <35 years (Table 3). Only 25% of patients who converted to HD avoided hospitalization during the 3-month interval before PD discontinuation. Female sex, GN and polycystic kidney disease as primary causes of ESKD, and shorter duration of PD were associated with much higher adjusted odds of avoiding hospitalization, whereas Black race and heart failure were associated with lower adjusted odds (Table 3).

Specific causes of hospitalization exhibited heterogeneous trajectories before and after discontinuation of PD (Figure 3). During the final months of PD, monthly rates of hospitalization due to PD catheter complications increased sharply, widely outpacing more modest increases in the rates of hospitalization due to cardiovascular disease, peritonitis, and noninfection-related complications of the digestive system. Immediately after PD discontinuation, hospitalization for cardiovascular disease was most likely. The distribution of causes of hospitalization around PD discontinuation varied little with increasing duration of PD (Supplemental Table 5).

The incidence of PD resumption, home HD initiation, kidney transplantation, and death after conversion from PD to in-facility HD is displayed in Figure 4. Given PD discontinuation defined by an interruption of ≥2 months, the cumulative incidence of subsequent PD resumption was 11% at 6 months, 14% at 12 months, and 15% at 24 months. The cumulative incidence of home HD initiation and kidney transplantation was only 3% and 7%, respectively, at 24 months. Cumulative mortality was 17% and 26% at 12 and 24 months, respectively. Defining PD discontinuation by treatment interruptions as little as $\leq 1$ month or as much as $\geq 3$ months had small effects on the apparent incidence of home HD initiation, kidney transplantation, and death.

### Discussion

In a large cohort of patients who discontinued PD from 2009 to 2018, we found that more than half converted to HD. These patients occupy a “middle” ground: they are older and less healthy than those who received a kidney transplant, but younger and healthier than those who

### Table 1. Patient characteristics, stratified by event resulting in discontinuation of peritoneal dialysis

| Characteristic                      | Conversion to HD | Death (on PD) | Kidney Transplant |
|------------------------------------|------------------|---------------|-------------------|
| Patients n                         | 68,743           | 32,954        | 22,516            |
| **Age, yr**                        |                  |               |                   |
| Mean, SD                           | 59.2 (15.0)      | 68.2 (12.9)   | 49.1 (15.3)       |
| Median, IQR                        | 60.6 (49.3–70.2) | 69.4 (60.6–77.6) | 50.7 (38.3–61.2) |
| **Sex, %**                         |                  |               |                   |
| Female                             | 42               | 41            | 45                |
| Male                               | 59               | 59            | 55                |
| **Race, %**                        |                  |               |                   |
| White                              | 68               | 79            | 71                |
| Black                              | 26               | 15            | 19                |
| Asian                              | 4                | 4             | 7                 |
| Other                              | 2                | 2             | 2                 |
| **Primary cause of ESKD, %**       |                  |               |                   |
| Diabetes mellitus                  | 47               | 50            | 26                |
| Hypertension                       | 26               | 28            | 21                |
| GN                                 | 13               | 8             | 30                |
| Polycystic kidney disease          | 4                | 2             | 10                |
| Other known cause                  | 8                | 9             | 10                |
| Unknown cause                      | 2                | 3             | 4                 |
| **ESKD duration, mo**              |                  |               |                   |
| Mean, SD                           | 23.1 (21.5)      | 29.7 (24.4)   | 27.8 (22.8)       |
| Median, IQR                        | 16.6 (7.8–32.0)  | 23.4 (11.8–40.8) | 21.3 (10.9–38.8) |
| **PD duration, mo**                |                  |               |                   |
| Mean, SD                           | 21.3 (21.7)      | 28.0 (24.5)   | 26.8 (22.6)       |
| Median, IQR                        | 14.7 (5.3–30.4)  | 21.6 (9.6–39.4) | 20.2 (9.9–37.6) |
| **Comorbid conditions, %**         |                  |               |                   |
| Heart failure                      | 19               | 30            | 6                 |
| Ischemic heart disease             | 12               | 21            | 5                 |
| Cerebrovascular disease            | 6                | 9             | 2                 |
| COPD or tobacco use                | 11               | 14            | 4                 |
| Needs assistance with ADL          | 5                | 9             | 1                 |

HD, hemodialysis; PD, peritoneal dialysis; IQR, interquartile range; COPD, chronic obstructive pulmonary disease; ADL, activities of daily living.

*On the date of the event.

*During episode ending on the date of the event.
discontinued PD due to death. Approximately 80% of patients who converted to HD had accumulated <3 years of PD treatment. Although 15% of patients resumed PD during the next 2 years, only 3% initiated home HD and 7% received a kidney transplant. In short, patients who transition from PD to HD are generally neither old nor frail, yet appear very likely to undergo in-facility HD during the remainder of their lives. Importantly, we found that the transition from PD to HD is characterized by high rates of acute care. During the last month of PD, the composite rate of hospital admissions, observation stays, and ED encounters exceeded 96 events per 100 months, with admissions constituting three fourths of events. PD catheter complications, cardiovascular disease, and peritonitis were leading causes of morbidity requiring hospitalization. The total cost of care during the transition greatly exceeded levels of monthly spending among stable patients on PD and those on HD with Medicare coverage.

Multiple federal initiatives are likely to spur increasing utilization of home dialysis—and, by extension, PD—in future years. Beginning in July 2022, End Stage Renal Disease (ESRD) Treatment Choices will award Medicare payment bonuses and penalties to both dialysis providers and nephrology practices throughout 30% of the United States, predominantly on the basis of home dialysis utilization (10). In Kidney Care Choices payment models, one of the quality performance measures is Optimal ESRD Starts, defined as pre-emptive kidney transplantation, home dialysis, or in-facility HD with an arteriovenous access at initiation of kidney replacement therapy (11,12). As the number of patients performing PD increases, so will the number of patients transitioning from PD to HD. According to a recent analysis of USRDS data, the rate of conversion from PD to HD reached a nadir after the advent of the ESRD Prospective System, at 20–21 events per 100 person-years among patients initiating PD in 2013–2014 (6).

Epidemiologic studies have offered relatively little insight into modifiable risk factors for conversion from PD to HD, let alone “healthy” conversion. Vrtovsnik et al. (13) reported that volume overload at PD initiation and/or 6 months thereafter was associated with 85%–174% increased risk of the composite of conversion to HD or death. In fact, risk was highest among patients with volume overload at both PD initiation and 6 months thereafter, thus suggesting that inability to correct hypervolemia may be an early warning sign of conversion to HD. McGill et al. (14) found that peritonitis was associated with 83% higher risk of conversion to HD. Sukul et al. (6) reported that risk of HD conversion was 36% higher in programs with six or fewer patients performing PD, relative to programs with ≥25 patients. Thus, volume control, avoidance of infection, and provider expertise could collectively extend the duration of PD. However, there are few studies that identify either clinical parameters or patient-reported

| Months | Hospital Admissions (n/100 Month) | Hospital Days (n/100 Month) | Observation Stays (n/100 Month) | ED Encounters (n/100 Month) | Total Cost of Care ($/Month) |
|--------|----------------------------------|-----------------------------|---------------------------------|-----------------------------|-----------------------------|
| -12    | 9.1                              | 52.7                        | 1.3                             | 9.2                         | 4597                        |
| -11    | 9.2                              | 51.1                        | 1.4                             | 9.7                         | 4592                        |
| -10    | 10.0                             | 59.1                        | 1.3                             | 9.9                         | 4806                        |
| -9     | 10.8                             | 65.4                        | 1.5                             | 10.5                        | 4974                        |
| -8     | 11.4                             | 69.2                        | 1.4                             | 10.5                        | 5067                        |
| -7     | 12.0                             | 75.4                        | 1.7                             | 11.2                        | 5202                        |
| -6     | 13.1                             | 85.0                        | 1.8                             | 11.8                        | 5549                        |
| -5     | 15.1                             | 101.1                       | 1.8                             | 13.0                        | 6149                        |
| -4     | 17.5                             | 129.1                       | 2.2                             | 13.8                        | 6946                        |
| -3     | 20.7                             | 176.3                       | 2.3                             | 14.9                        | 8319                        |
| -2     | 31.0                             | 306.8                       | 2.8                             | 17.2                        | 11,312                      |
| -1     | 72.1                             | 848.7                       | 3.9                             | 20.2                        | 20,701                      |
| +1     | 31.6                             | 245.2                       | 4.2                             | 23.3                        | 13,302                      |
| +2     | 23.7                             | 203.0                       | 3.6                             | 18.1                        | 9832                        |
| +3     | 21.2                             | 166.4                       | 3.2                             | 16.9                        | 9043                        |
| +4     | 19.8                             | 151.8                       | 3.1                             | 16.6                        | 8282                        |
| +5     | 18.2                             | 136.0                       | 3.1                             | 15.9                        | 7821                        |
| +6     | 17.8                             | 127.4                       | 2.9                             | 15.2                        | 7672                        |
| +7     | 17.3                             | 123.8                       | 2.8                             | 15.1                        | 7454                        |
| +8     | 16.8                             | 120.7                       | 2.9                             | 15.2                        | 7282                        |
| +9     | 15.4                             | 106.3                       | 2.9                             | 14.9                        | 7063                        |
| +10    | 15.7                             | 106.3                       | 2.7                             | 15.2                        | 7030                        |
| +11    | 15.7                             | 106.4                       | 2.7                             | 14.8                        | 6952                        |
| +12    | 15.6                             | 109.9                       | 2.8                             | 14.1                        | 6846                        |

ED, emergency department.

| Months | Hospital Admissions (n/100 Month) | Hospital Days (n/100 Month) | Observation Stays (n/100 Month) | ED Encounters (n/100 Month) | Total Cost of Care ($/Month) |
|--------|----------------------------------|-----------------------------|---------------------------------|-----------------------------|-----------------------------|
| -12    | 9.1                              | 52.7                        | 1.3                             | 9.2                         | 4597                        |
| -11    | 9.2                              | 51.1                        | 1.4                             | 9.7                         | 4592                        |
| -10    | 10.0                             | 59.1                        | 1.3                             | 9.9                         | 4806                        |
| -9     | 10.8                             | 65.4                        | 1.5                             | 10.5                        | 4974                        |
| -8     | 11.4                             | 69.2                        | 1.4                             | 10.5                        | 5067                        |
| -7     | 12.0                             | 75.4                        | 1.7                             | 11.2                        | 5202                        |
| -6     | 13.1                             | 85.0                        | 1.8                             | 11.8                        | 5549                        |
| -5     | 15.1                             | 101.1                       | 1.8                             | 13.0                        | 6149                        |
| -4     | 17.5                             | 129.1                       | 2.2                             | 13.8                        | 6946                        |
| -3     | 20.7                             | 176.3                       | 2.3                             | 14.9                        | 8319                        |
| -2     | 31.0                             | 306.8                       | 2.8                             | 17.2                        | 11,312                      |
| -1     | 72.1                             | 848.7                       | 3.9                             | 20.2                        | 20,701                      |
| +1     | 31.6                             | 245.2                       | 4.2                             | 23.3                        | 13,302                      |
| +2     | 23.7                             | 203.0                       | 3.6                             | 18.1                        | 9832                        |
| +3     | 21.2                             | 166.4                       | 3.2                             | 16.9                        | 9043                        |
| +4     | 19.8                             | 151.8                       | 3.1                             | 16.6                        | 8282                        |
| +5     | 18.2                             | 136.0                       | 3.1                             | 15.9                        | 7821                        |
| +6     | 17.8                             | 127.4                       | 2.9                             | 15.2                        | 7672                        |
| +7     | 17.3                             | 123.8                       | 2.8                             | 15.1                        | 7454                        |
| +8     | 16.8                             | 120.7                       | 2.9                             | 15.2                        | 7282                        |
| +9     | 15.4                             | 106.3                       | 2.9                             | 14.9                        | 7063                        |
| +10    | 15.7                             | 106.3                       | 2.7                             | 15.2                        | 7030                        |
| +11    | 15.7                             | 106.4                       | 2.7                             | 14.8                        | 6952                        |
| +12    | 15.6                             | 109.9                       | 2.8                             | 14.1                        | 6846                        |
outcome that could be measured to predict discontinuation of PD and guide proactive transitions between modalities.

The prevailing clinical approach to transitioning patients from PD to HD appears to lead to significant increases in morbidity and costs, not only during the final months of PD, but also during the months long after the conversion to HD. Although transitions from PD to home HD may be associated with better clinical outcomes than transitions from PD to in-facility HD (9), we found that only 3% of patients initiated home HD during the 2 years after conversion from PD to HD. We hypothesize that significant decompensation around the time of the transition may be chiefly responsible for the low incidence of home HD initiation, because recurrent hospital admissions, prolonged residency in skilled nursing facilities and other subacute facilities, and overall severity of illness may lead to unwillingness or outright inability to dialyze in the home. Novel strategies, including opening transitional care units to patients who discontinued PD, are needed to facilitate continued utilization of dialysis in the home (15).

An alternative—and more controversial—interpretation of our study is that PD may not have been the ideal therapy for some patients in the study cohort, despite a presumed preference for home dialysis. At 90 days after the diagnosis of ESKD, the ratio of PD to home HD exceeds 15:1 in the United States (1). It is plausible that subgroups of patients with incident ESKD who select home dialysis, such as those with preexisting heart failure, could benefit from home HD, relative to PD. Although rates of death and hospitalization are similar with PD and home HD among patients with incident ESKD, the rate of conversion to in-facility HD is lower with home HD (16).

This study has several limitations. First, although USRDS data provide clarity about dates of PD and HD treatment, the data do not provide explicit documentation of the clinical decision to discontinue PD, such as discharge from a

### Table 3. Adjusted relative rates of hospital admissions and adjusted odds ratios of avoiding hospitalization during the 3 months immediately preceding conversion from peritoneal dialysis to hemodialysis, among patients with Medicare coverage and ≥3 months of treatment with peritoneal dialysis

| Characteristic                              | Hospital Admissions, Adjusted Relative Rate (95% Confidence Interval) | Avoiding Hospitalization, Adjusted Odds Ratio (95% Confidence Interval) |
|---------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------|
| **Age, yr**                                 |                                                                        |                                                                        |
| 12–17                                       | 1.28 (1.09 to 1.51)                                                    | 0.63 (0.38 to 1.04)                                                   |
| 18–34                                       | 1.15 (1.09 to 1.20)                                                    | 0.98 (0.86 to 1.12)                                                   |
| 35–44                                       | 1.03 (0.99 to 1.07)                                                    | 1.06 (0.95 to 1.18)                                                   |
| 45–54                                       | 1.00                                                                   | 1.00                                                                   |
| 55–64                                       | 0.99 (0.96 to 1.03)                                                    | 1.00 (0.92 to 1.09)                                                   |
| 65–74                                       | 0.97 (0.93 to 1.00)                                                    | 0.98 (0.90 to 1.06)                                                   |
| ≥75                                          | 0.97 (0.94 to 1.01)                                                    | 0.95 (0.86 to 1.04)                                                   |
| **Sex**                                     |                                                                        |                                                                        |
| Female                                       | 1.00                                                                   | 1.00                                                                   |
| Male                                         | 0.87 (0.86 to 0.89)                                                    | 1.48 (1.40 to 1.56)                                                   |
| **Race**                                    |                                                                        |                                                                        |
| White                                        | 1.00                                                                   | 1.00                                                                   |
| Black                                        | 1.08 (1.06 to 1.11)                                                    | 0.80 (0.74 to 0.85)                                                   |
| Asian                                        | 0.98 (0.92 to 1.04)                                                    | 0.86 (0.74 to 1.00)                                                   |
| Other                                        | 0.94 (0.87 to 1.01)                                                    | 1.08 (0.91 to 1.29)                                                   |
| **Primary cause of ESKD**                   |                                                                        |                                                                        |
| Diabetes mellitus                            | 1.00                                                                   | 1.00                                                                   |
| Hypertension                                 | 0.94 (0.92 to 0.96)                                                    | 1.09 (1.02 to 1.16)                                                   |
| GN                                           | 0.91 (0.88 to 0.94)                                                    | 1.22 (1.12 to 1.33)                                                   |
| Polycystic kidney disease                    | 0.86 (0.81 to 0.91)                                                    | 1.32 (1.15 to 1.52)                                                   |
| Other known cause                            | 0.94 (0.90 to 0.98)                                                    | 1.14 (1.03 to 1.27)                                                   |
| Unknown cause                                | 0.88 (0.82 to 0.95)                                                    | 1.25 (1.05 to 1.49)                                                   |
| **PD duration, mo**                         |                                                                        |                                                                        |
| 3–5                                         | 0.91 (0.87 to 0.94)                                                    | 1.26 (1.14 to 1.40)                                                   |
| 6–11                                        | 0.95 (0.91 to 0.98)                                                    | 1.19 (1.08 to 1.30)                                                   |
| 12–23                                       | 0.97 (0.94 to 1.00)                                                    | 1.06 (0.97 to 1.15)                                                   |
| 24–35                                       | 1.00                                                                   | 1.00                                                                   |
| 36–47                                       | 0.98 (0.95 to 1.02)                                                    | 0.99 (0.90 to 1.10)                                                   |
| 48–72                                       | 0.97 (0.94 to 1.01)                                                    | 0.94 (0.85 to 1.04)                                                   |
| ≥72                                         | 0.99 (0.94 to 1.04)                                                    | 0.87 (0.77 to 0.99)                                                   |
| **Comorbid conditions**                     |                                                                        |                                                                        |
| Heart failure                                | 1.06 (1.04 to 1.09)                                                    | 0.86 (0.80 to 0.93)                                                   |
| Ischemic heart disease                       | 0.99 (0.96 to 1.03)                                                    | 1.09 (1.00 to 1.18)                                                   |
| Cerebrovascular disease                      | 1.04 (1.00 to 1.09)                                                    | 0.90 (0.81 to 1.01)                                                   |
| COPD or tobacco use                          | 1.09 (1.05 to 1.12)                                                    | 0.95 (0.88 to 1.03)                                                   |
| Needs assistance with ADL                   | 1.01 (0.96 to 1.07)                                                    | 0.92 (0.80 to 1.06)                                                   |

GN, glomerulonephritis; PD, peritoneal dialysis; COPD, chronic obstructive pulmonary disease; ADL, activities of daily living.
home therapies program. Thus, identification of conversion from PD to HD is challenging. One manifestation of this limitation is uncertainty about the cumulative incidence of PD resumption after ostensible conversion from PD to HD. For that matter, USRDS data regarding dialysis modalities primarily reflect outpatient status and may thus imply dates of PD discontinuation that are several days to several weeks after actual dates of transition from PD to HD, particularly when patients begin HD in the hospital. Second, analysis of acute-care encounters was limited to patients with Medicare Parts A and B coverage. Medicare beneficiaries are likely older and frailer than patients with private health insurance, thus resulting in event rates that are higher. In addition, cause-specific hospitalization relied on principal discharge diagnoses, which may not reflect root causes of morbidity. Third, the total cost of care was not adjusted for changes in reimbursement rates between 2009 and 2018, an interval that spanned the advent of the ESRD Prospective Payment System. Our estimates of the total cost of care understate actual costs incurred by Medicare today.

As the number of patients with ESKD initiating dialysis in the home setting likely increases in the future, patient-centered care requires an openness among physicians and patients to changes in dialytic modality to achieve clinical and lifestyle goals. Among prevalent patients on dialysis, the transition from PD to HD is likely to remain the common transition observed in clinical practice. Our study demonstrates that there are two clear opportunities for quality improvement during the transition: (1) reducing the rate of acute-care counters, particularly hospital admissions, and the related total cost of care; and (2) encouraging ongoing utilization of home dialysis, via either an immediate transition to home HD or a resumption of PD. These opportunities are important for patients wishing to maintain their lifestyle with home dialysis, and for dialysis providers and nephrology practices participating in either ESRD Treatment Choices or Kidney Care Choices (or both models). To move forward, nephrology will need to consider how to proactively address progressively deteriorating health in patients performing PD, because ill patients lacking information about treatment options are likely to be hospitalized and unlikely to continue dialysis at home. Predictive tools can be a part of the solution, but so can time-tested principles of PD catheter management, volume management, and patient education.

Disclosures
M. Aragon reports having other interests in or relationships with ESRD Network of Texas, and being employed by, and having ownership interest in, Outset Medical. T.L. Saffer reports serving on the board of directors of Home Dialyzors United, and being employed by, and having ownership interest in, Outset Medical. E.D. Weinhandl reports having consultancy agreements with Fresenius Medical Care North America, Outset Medical, and Quanta Dialysis Technologies; serving on the board of directors of Home Dialyzors United, on the board of directors of Medical Education Institute; and having other interests in, or relationships with, the University of Minnesota.

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Author Contributions
M. Aragon and E.D. Weinhandl were responsible for methodology; T.L. Saffer and E.D. Weinhandl wrote the original draft;
E.D. Weinhandl provided supervision and was responsible for data curation and formal analysis; and all authors conceptualized the study and reviewed and edited the manuscript.

Supplemental Material
This article contains the following supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0007692021/-/DCSupplemental.

Supplemental Table 1. International Classification of Diseases, 9th Revision, Clinical Modification and International Classification of Diseases, 10th Revision, Clinical Modification diagnosis codes defining cause-specific hospitalization.

Supplemental Table 2. Rates of all-cause hospital admissions (per 100 months) before and after conversion from peritoneal dialysis to hemodialysis, among patients with Medicare coverage, according to minimum duration of PD for inclusion in the study cohort.

Supplemental Table 3. Rates of all-cause hospital admissions (per 100 months) before and after conversion from peritoneal dialysis to hemodialysis, among patients with Medicare coverage, stratified by timing of PD initiation, duration of PD, and year of PD discontinuation.

Supplemental Table 4. Rates of all-cause hospital days (per 100 months) before and after conversion from peritoneal dialysis to hemodialysis, among patients with Medicare coverage, stratified by timing of PD initiation, duration of PD, and year of PD discontinuation.

Supplemental Table 5. Distributions of causes of hospital admissions before and after conversion from peritoneal dialysis to hemodialysis, among patients with Medicare coverage, stratified by duration of PD.

References
1. United States Renal Data System: 2020 USRDS Annual Data Report: Epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2020. Available at: https://adr.usrdos.org/2020. Accessed March 13, 2022
2. Jensen V, Throckmorton DC: Shortage of peritoneal dialysis solution and the Food and Drug Administration’s response. Clin J Am Soc Nephrol 10: 1484–1486, 2015 https://doi.org/10.2215/CJN.12061214
3. Wilk AS, Hirth RA, Messana JM: Paying for frequent dialysis. Am J Kidney Dis 74: 248–255, 2019 https://doi.org/10.1053/j.ajkd.2019.01.027
4. Pearson J, Turenne M, Leichtman A: The Executive Order on Kidney Care: An opportunity to improve outcomes for individuals with kidney disease. Kidney Int Rep 4: 1519–1522, 2019 https://doi.org/10.1016/j.eKid.2019.09.011
5. Lin E, Ginsburg PB, Chertow GM, Berns JS: The “Advancing American Kidney Health” Executive Order: Challenges and opportunities for the large dialysis organizations. Am J Kidney Dis 76: 731–734, 2020 https://doi.org/10.1053/j.ajkd.2020.07.007
6. Sukul N, Mukhopadhyay P, Schaubel DE, Pearson J, Turenne M, Saran R, Robinson BM, Pisoni RL: Peritoneal dialysis and mortality, kidney transplant, and transition to hemodialysis: Trends from 1996–2015 in the United States. Kidney Med 2: 610–619.e1, 2020 https://doi.org/10.1016/j.kmed.2020.06.009
7. Sloan CE, Coffman CJ, Sanders LL, Maciejewski ML, Lee SD, Hirth RA, Wang V: Trends in peritoneal dialysis use in the United States after Medicare payment reform. Clin J Am Soc Nephrol 14: 1763–1772, 2019 https://doi.org/10.2215/CJN.05910519
8. Nadeau-Fredette AC, Hawley C, Pascoe E, Chan CT, Leblanc M, Clayton PA, Polkinghome KR, Boudville N, Johnson DW: Predictors of transfer to home hemodialysis after peritoneal dialysis completion. Perit Dial Int 36: 547–554, 2016 https://doi.org/10.3747/pdi.2015.00121
9. Kansal SK, Mortin JA, Weinhandl ED: Survival and kidney transplant incidence on home versus in-center hemodialysis, following peritoneal dialysis technique failure. Perit Dial Int 39: 25–34, 2019 https://doi.org/10.3747/pdi.2017.00207
10. Paulus AB, Howard AD, Vinson BA: Implications of the end-stage renal disease treatment choices model among U.S. dialysis providers. Nephrol Nurs J 48: 11–17, 2021 https://doi.org/10.37526/1526-744X.2021.48.1.11
11. Jain G, Weiner DE: Value based care in nephrology: The Kidney Care Choices Model and other reforms. Kidney360 2: 1677–1683, 2021 https://doi.org/10.34067/KID.0004552021
12. Crooks PW, Thomas CO, Compton-Phillips A, Leith W, Sundang A, Zhou YY, Radler J: Clinical outcomes and healthcare use associated with optimal ESRD starts. Am J Manag Care 24: e305–e311, 2018
13. Vrtovsnik F, Verger C, Van Biesen W, Fan S, Shin SK, Rodriguez C, Garcia Méndez I, van der Sande FM, De Los Rios T, Ihle K, Gauly A, Ronco C, Heaf J: IPOD-PD Study Group: The impact of volume overload on technique failure in incident peritoneal dialysis patients. Clin Kidney J 14: 570–577, 2020 https://doi.org/10.1093/ckj/sfxz175
14. McGill RL, Weiner DE, Ruthazer R, Miskulin DC, Meyer KB, Lacson E Jr: Transfers to hemodialysis among US patients initiating renal replacement therapy with peritoneal dialysis. Am J Kidney Dis 74: 620–628, 2019 https://doi.org/10.1053/j.ajkd.2019.05.014
15. Bowman BT: Transitional care units: Greater than the sum of its parts. Clin J Am Soc Nephrol 14: 765–767, 2019 https://doi.org/10.2215/CJN.12301018
16. Weinhandl ED, Gilbertson DT, Collins AJ: Mortality, hospitalization, and technique failure in daily home hemodialysis and matched peritoneal dialysis patients: A matched cohort study. Am J Kidney Dis 67: 98–110, 2020 https://doi.org/10.1053/j.ajkd.2015.07.014

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