Clinical Kidney Journal

ckj

OXFORD

Leading European Nephrology

*Clinical Kidney Journal*, 2017, 552–559

doi: 10.1093/ckj/sfx011
Advance Access Publication Date: 15 March 2017
Original Article

ORIGINAL ARTICLE

# Reasons for admission and predictors of national 30-day readmission rates in patients with end-stage renal disease on peritoneal dialysis

Lili Chan[1,*], Priti Poojary[2,*], Aparna Saha[2], Kinsuk Chauhan[1], Rocco Ferrandino[3], Bart Ferket[4], Steven Coca[1], Girish Nadkarni[1,**] and Jaime Uribarri[1,**]

[1]Division of Nephrology, Department of Medicine, Icahn School of Medicine at Mount Sinai, New York, NY, USA, [2]Department of Public Health, Icahn School of Medicine at Mount Sinai, New York, NY, USA, [3]Graduate School of Biomedical Sciences, Icahn School of Medicine at Mount Sinai, New York, NY, USA, and [4]Institute for Healthcare Delivery Science, Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, New York, NY, USA

Correspondence and offprint requests to: Jaime Uribarri; E-mail: jaime.uribarri@mountsinai.org
*L.C. and P.P. contributed equally to this work.
**G.N. and J.U. contributed equally to this work.

## Abstract

**Background:** The number of patients with end-stage renal disease (ESRD) on peritoneal dialysis (PD) has increased by over 30% between 2007 and 2014. The Centers for Medicare and Medicaid has identified readmissions in ESRD patients to be a quality measure; however, there is a paucity of studies examining readmissions in PD patients.

**Methods:** Utilizing the National Readmission Database for the year 2013, we aimed to determine reasons for admission, the associated rates of unplanned readmission and independent predictors of readmissions in PD patients.

**Results:** The top 10 reasons for initial hospitalization were implant/PD catheter complications (23.22%), hypertension (5.47%), septicemia (5.18%), diabetes mellitus (DM) (5.12%), complications of surgical procedures/medical care (3.50%), fluid and electrolyte disorders (4.29%), peritonitis (3.76%), congestive heart failure (3.25%), pneumonia (2.90%) and acute myocardial infarction (AMI) (2.01%). The overall 30-day readmission rate was 14.6%, with the highest rates for AMI (21.8%), complications of surgical procedure/medical care (19.6%) and DM (18.4%). Concordance among the top 10 reasons for index admission and readmission was 22.6% and varied by admission diagnosis. Independent predictors of readmissions included age 35–49 years compared with 18–34 years [adjusted odds ratio (aOR) 1.35; 95% confidence interval (CI) 1.09–1.68; $P = 0.006$], female gender (aOR 1.27; 95% CI 1.12–1.44; $P < 0.001$), and comorbidities including liver disease (aOR 1.39; 95% CI 1.07–1.81; $P = 0.01$), peripheral vascular disease (aOR 1.33; 95% CI 1.14–1.56; $P < 0.001$) and depression (aOR 1.22; 95% CI 1.00–1.48; $P = 0.04$).

**Received:** December 7, 2016. **Editorial decision:** January 30, 2017

**Conclusions:** This study demonstrates the most common reasons for admission and readmissions in PD patients and several comorbidities that are predictive of readmissions. Targeted interventions towards these patients may be of benefit in reducing readmission in this growing population.

**Key words:** epidemiology, National Readmission Database, peritoneal dialysis, readmissions

## Introduction

As of 2013, there were 661 648 prevalent patients with end-stage renal disease (ESRD), 6.8% of whom were on peritoneal dialysis (PD) in the USA [1]. From 2007 to 2014, there has been over a 30% increase in prevalent patients on PD, likely driven by changes in reimbursement for dialysis care. While there have been improvements in the care of PD patients, admission rates remain high at approximately 1.6 per patient year in 2014, mainly for infection and cardiovascular causes [1].

Beginning in 2017, Centers for Medicare and Medicaid Services (CMS) will begin to penalize dialysis units for excessive readmission rates as determined by the standardized readmission ratio (SRR). The SRR compares the number of readmissions with the number of expected readmission as determined by patient demographics and socioeconomic factors and discharge hospital characteristics [2]. However, little is known about causes of hospitalization and readmission rates in PD patients and thus the impact of these penalties on facilities treating PD patients cannot be estimated.

Using a nationally representative sample, all-payer database of hospitalizations and readmissions, we aimed to determine the top reasons for admission, and their associated readmission rates in ESRD patients on PD. We also aimed to identify significant predictors for readmissions.

## Materials and methods

### Study population

Patients were extracted from the National Readmissions Database (NRD) from the Healthcare Cost and Utilizations Project (HCUP) [3]. The database includes discharge data that accounts for 49.3% of hospitalizations in the non-institutionalized US population and includes a weight variable that allows for national estimation. The year 2013 was selected as this was the most recent public release.

The NRD was queried using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) to identify admissions in patients with ESRD. We excluded admissions of patients younger than 18 years, on hemodialysis and with renal transplants. We also excluded admissions related to pregnancy and chemotherapy as these were likely planned admissions and with renal transplants. Admissions where the patient was readmitted the same day were considered a continuation of index admission, and therefore excluded. Lastly, we excluded admissions for patients who died during the index admission, those with missing discharge disposition, those that were planned readmissions as defined by the database and those whose index admissions were in December 2013 (since they lacked 30 days for accrual for readmissions). Please refer to Supplementary Table S1 for a list of codes to define variables. While both unweighted and weighted numbers are displayed in study flow diagram (Supplementary Figure S1), only weighted numbers were used in analysis.

### Definition of index admissions and readmissions

Index hospitalizations were defined as admissions without any hospitalizations in the preceding 30 days, while a readmission was defined as any admission within 30 days of a prior admission after excluding those that were flagged as elective. Therefore, while a patient could have multiple readmissions, our model was reflective of odds for first readmission. We performed our analysis on the admission level while considering that multiple readmissions may be correlated. Prior studies have compared modeling methods to adjust for correlations; however, they were not superior to results of modeling under the assumption that admissions per patient were independent [4]. Primary diagnosis of index admission and readmissions were grouped according to Clinical Classification Software (CCS) codes, which allowed for more clinically meaningful comparisons [5]. The CCS categories collapses all the ICD-9-CM codes into mutually exclusive groups; therefore, a readmission has only one primary CCS category. The top 10 CCS diagnoses were evaluated to determine cause-specific readmissions; however, comparisons between groups and multivariate analysis were done on all index hospitalizations.

### Definition of covariates for risk adjustment

Patient demographics (age, gender, comorbidities and median household income category for patient's ZIP code) and index admission characteristics [hospital size, hospital type, private versus government control, primary payer, discharge disposition, length of stay (LOS) and cost] were included in our predictive model. Primary payer was divided into Medicare, Medicaid, private insurance, self-pay or no charge; discharge disposition was divided into routine or self-care, short-term hospital nursing facility, home health care, against medical advice and alive (unknown). We utilized the All Patient Refined – Diagnosis Related Group (APR-DRG) score to account for severity of illness and patient complexity [6].

Patient comorbidities were identified using the NRD-defined comorbidity measures, and categorized using the CCS classification system, which groups ICD-9-CM codes into mutually exclusive categories [7].

### Statistical analysis

Descriptive statistics were utilized to compare patient, admission and hospital characteristics between index admission with and without readmissions. We used Student's *t*-test for normally distributed continuous variables, chi-square for categorical variables and Wilcoxon Rank-Sum test for non-normally distributed continuous variables. Survey logistic regression was used to assess the relationship between potential predictors for readmissions and the odds of at least one 30-day unplanned readmission.

Population attributable fractions (PAFs) were calculated for significant comorbidities with increased adjusted odds ratio (aOR) of readmission. These were derived from both the aOR and comorbidity prevalence, while taking into account

sampling weights, in order to provide a measure of comorbidity impact on readmission risk at the population level [8].

All significant levels were two-sided, with a $P < 0.05$ considered to be statistically significant. Analyses were primarily done using SAS 9.2 (SAS Institute Inc.). PAFs were calculated using the 'survey' package in R version 3.2.2 (R Foundation for Statistical Computing, Vienna, Austria) and 95% confidence intervals (CIs) were calculated by bootstrapping [9, 10]. As our analysis was done on publically available, deidentified data, the study was considered to be institutional review board exempt and informed consent was not needed.

## Results

### Reasons for admission and rates of readmission

During the year 2013, there were 27 904 admissions in patients with ESRD on PD. Of these admissions, 4061 (14.6%) were followed by 30-day unplanned readmissions. Of the index admissions, the top 10 diagnoses for hospitalization were due to implant/PD catheter complications (23.22%), hypertension (5.47%), septicemia (5.18), diabetes mellitus (DM) (5.12%), complications of surgical procedures/medical care (3.50%), fluid and electrolyte disorders (4.29%), peritonitis (3.76%), congestive heart failure (CHF) (3.25%), pneumonia (2.90%) and acute myocardial infarction (AMI) (2.01%) (Figure 1).

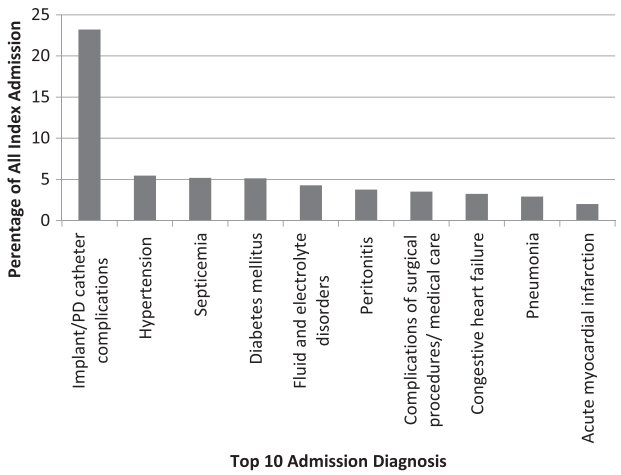


**Fig. 1.** Percent of all index admissions by top 10 admission diagnosis. The number of admissions for admission diagnosis divided by the all index admissions.

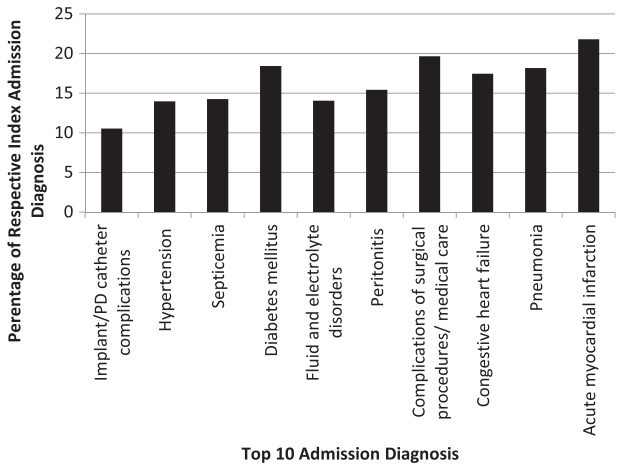


**Fig. 2.** Percent of readmissions by top 10 admission diagnosis. The number of readmissions divided by the number of index admission within each admission diagnosis.

Within the top 10 diagnoses for hospitalization, on average there were 16.4% 30-day unplanned readmissions. The index admissions reasons with the highest readmission rates were AMI (21.8%), complications of surgery procedure/medical care (19.6%) and DM (18.4%) (Figure 2).

### Baseline characteristics between admissions with and without readmissions

Hospitalizations with readmissions were more likely to be female (54.3% versus 47.6%, $P < 0.001$), more likely to have comorbidities such as CHF (20.2% versus 18.3%, $P = 0.005$), chronic pulmonary disease (17.3% versus 14.9%, $P < 0.001$), depression (12.1% versus 9.8%, $P < 0.001$) or peripheral vascular disease (17.0% versus 13.2%, $P < 0.001$). Notable differences in index admissions characteristics between hospitalizations with and without readmission included more likely to be admitted through the emergency department (ED) (79.4% versus 74.5%, $P < 0.001$), non-elective admissions (91.3% versus 88.3%, $P < 0.001$), longer LOS (median 4.3 versus 3.8 days, $P < 0.001$), to have Medicare insurance (79.5% versus 74.2%, $P < 0.001$) and to be discharged with home health care (22.6% versus 17.4%, $P < 0.001$). Additionally, hospitalizations with readmissions were more likely to be admitted to large metropolitan hospitals (56.2% versus 51.9%, $P < 0.0001$) (Table 1).

### Concordance between diagnosis of index admissions and readmissions

Among the top 10 reasons for index admission and readmission, only 22.6% of readmissions were for the same reason as index admission (Figure 3). The highest concordance was seen in index admissions for implant/PD catheter complications (50.0%), while the lowest concordance was seen in index admissions for peritonitis (14.1%).

### Predictors of readmission

Demographic variables associated with increased odds of readmission included age 35–49 years compared with 18–34 years (aOR 1.35; 95% CI 1.09–1.68; $P = 0.006$) and female gender (aOR 1.27; 95% CI 1.12–1.44; $P < 0.001$). Comorbidities associated with increased odds of readmission included liver disease (aOR 1.39; 95% CI 1.07–1.81; $P = 0.01$), peripheral vascular disease (aOR 1.33; 95% CI 1.14–1.56; $P < 0.001$) and depression (aOR 1.22; 95% CI 1.00–1.48; $P = 0.04$). Index admission characteristics predictive of readmission included LOS $\geq$5 days (aOR 1.28; 95% CI 1.04–1.57; $P = 0.01$ for 5–6 days and aOR 1.2; 95% CI 1.00–1.43; $P = 0.04$ for $\geq$7 days), and discharge home with home health care (aOR 1.31, 95% CI 1.15–1.50; $P < 0.001$) (Table 2).

The largest PAF was seen for peripheral vascular disease (aOR 3.7; 95% CI 1.6–5.7), followed by depression (aOR 1.9; 95% CI 0.1–3.7) and liver disease (aOR 1.04; 95% CI 0.2–2.0).

## Discussion

In this analysis of a nationally representative cohort of PD patients, the readmission rate in patients with ESRD on PD in this cohort is higher than in the general population but considerably lower than in ESRD patients on HD (37%) [1]. The most common causes for admission were due to catheter complications, infection and cardiovascular complications, with the highest readmission rates seen in admissions for AMI,

**Table 1.** Baseline patient, admission and hospital characteristics for PD patients with and without readmissions

| | PD admissions with no readmissions, N = 10 421 (23 843) | PD admissions with at least one readmission, N = 1771 (4061) | P |
|---|---|---|---|
| Patient characteristics | | | |
| Age in years, *n* (%) | | | 0.01 |
| Median (IQR) | 58.36 (46.43–68.15) | 59.00 (46.28–68.08) | |
| 18–34 | 2246 (9.42) | 442 (10.88) | |
| 35–49 | 4860 (20.38) | 780 (19.2) | |
| 50–64 | 8342 (34.99) | 1383 (34.06) | |
| ≥65 | 8395 (35.21) | 1456 (35.85) | |
| Gender, *n* (%) | | | <0.001 |
| Male | 12 503 (52.44) | 1855 (45.68) | |
| Female | 11 341 (47.56) | 2206 (54.32) | |
| Comorbidities, *n* (%) | | | |
| Liver disease | 769 (3.22) | 172 (4.25) | <0.001 |
| Peripheral vascular disease | 3147 (13.2) | 689 (16.97) | <0.001 |
| Depression | 2332 (9.78) | 493 (12.14) | <0.001 |
| Chronic pulmonary disease | 3551 (14.89) | 703 (17.32) | <0.001 |
| Pulmonary circulation disorder | 881 (3.7) | 131 (3.22) | 0.14 |
| Congestive heart failure | 4363 (18.3) | 819 (20.17) | 0.005 |
| Diabetes mellitus | 5100 (21.39) | 884 (21.77) | 0.58 |
| Drug abuse | 367 (1.54) | 79 (1.95) | 0.05 |
| AIDS | 119 (0.5) | 24 (0.59) | 0.42 |
| Hypertension | 19 126 (80.21) | 3302 (81.3) | 0.11 |
| Alcohol abuse | 198 (0.83) | 30 (0.74) | 0.53 |
| Median household income category for patient's ZIP code[a], *n* (%) | | | 0.26 |
| 0–25th percentile | 7758 (33.02) | 1312 (32.66) | |
| 26–50th percentile | 6344 (27.01) | 1044 (25.98) | |
| 51–75th percentile | 5717 (24.34) | 1031 (25.68) | |
| 76–100th percentile | 3673 (15.64) | 630 (15.68) | |
| Index admission characteristics | | | |
| Admission source[b], *n* (%) | | | <0.001 |
| Non-emergency department | 6084 (25.51) | 838 (20.63) | |
| Emergency department | 17 760 (74.49) | 3223 (79.37) | |
| Admission type, *n* (%) | | | <0.001 |
| Non-elective | 21 014 (88.33) | 3702 (91.25) | |
| Elective | 2777 (11.67) | 355 (8.75) | |
| APR-DRG severity scale[c], *n* (%) | | | <0.001 |
| Minor loss of function | 393 (1.65) | 31 (0.75) | |
| Moderate loss of function | 5698 (23.9) | 935 (23.02) | |
| Major loss of function | 14 539 (60.97) | 2569 (63.26) | |
| Extreme loss of function | 3193 (13.39) | 527 (12.97) | |
| Length of stay in days, *n* (%) | | | <0.001 |
| Median (IQR) | 3.82 (2.08–7.11) | 4.33 (2.36–7.78) | |
| <2 days | 5652 (23.71) | 829 (20.41) | |
| 3–4 days | 6803 (28.53) | 1069 (26.33) | |
| 5–6 days | 3886 (16.3) | 749 (18.45) | |
| ≥7 days | 7502 (31.46) | 1413 (34.81) | |
| Primary payer type, *n* (%) | | | <0.001 |
| Medicare | 17 672 (74.22) | 3220 (79.46) | |
| Medicaid | 576 (2.42) | 81 (2) | |
| Private | 4187 (17.58) | 532 (13.12) | |
| Self-pay or no charge or others | 1374 (5.77) | 220 (5.42) | |
| Discharge disposition | | | <0.001 |
| Routine | 16 747 (70.24) | 2625 (64.65) | |
| Short-term hospital | 202 (0.85) | 38 (0.93) | |
| Nursing facility | 2480 (10.4) | 434 (10.68) | |
| Home health care | 4152 (17.41) | 917 (22.57) | |
| Against medical advice | 246 (1.03) | 47 (1.16) | |
| Cost of hospitalization in USD, Median (IQR) | 9711.75 (5679.69–17 515) | 6145.68 (10 034–18 529) | 0.6748 |

(continued)

**Table 1.** (continued)

| | PD admissions with no readmissions, $N = 10\,421$ (23 843) | PD admissions with at least one readmission, $N = 1771$ (4061) | $P$ |
|---|---|---|---|
| Hospital characteristics | | | |
| Hospital bed size[d], *n* (%) | | | 0.45 |
| Small | 1376 (5.77) | 252 (6.21) | |
| Medium | 4940 (20.72) | 855 (21.06) | |
| Large | 17 527 (73.51) | 2953 (72.73) | |
| Hospital type[e], *n* (%) | | | <0.001 |
| Metropolitan non-teaching | 8630 (36.19) | 1513 (37.26) | |
| Metropolitan teaching | 13 675 (57.35) | 2372 (58.4) | |
| Non-metropolitan hospital | 1539 (6.45) | 176 (4.33) | |
| Hospital control[f], *n* (%) | | | 0.67 |
| Government, non-federal | 2657 (11.14) | 435 (10.7) | |
| Private, not-for-profit | 18 152 (76.13) | 3100 (76.32) | |
| Private, for-profit | 3035 (12.73) | 527 (12.98) | |
| Hospital urban–rural designation, *n* (%) | | | <0.001 |
| Large metropolitan | 12 376 (51.91) | 2283 (56.21) | |
| Small metropolitan | 9928 (41.64) | 1602 (39.45) | |
| Micropolitan areas | 1434 (6.01) | 164 (4.05) | |
| Non-urban residual | 106 (0.44) | 11 (0.28) | |

Frequencies (%) in the columns may not sum to 100% since there might be missing data.

[a]This represents a quartile classification of the estimated median household income of residents in the patient's ZIP code. These values are derived from ZIP code-demographic data obtained from Claritas. The quartiles are identified by values of 1–4, indicating the poorest to wealthiest populations.

[b]HCUP criteria for evidence of ED services includes: (i) emergency department revenue code of 450–459 on record; (ii) positive emergency department charge, when revenue center codes are not available; (iii) emergency department CPT code of 99 281–99 285 reported on record; (iv) condition code of P7 (NUBC preferred coding for public reporting as of 1 July 2010); (v) point of origin of ED (NUBC preferred coding from 1 October 2007 to 30 June 2010); (vi) admission source of ED (NUBC preferred coding prior to 1 October 2007).

[c]The All Patient Refined – Diagnosis Related Groups (APR-DRGs) are assigned using software developed by 3M Health Information Systems.

[d]Bed size categories are based on hospital beds, and are specific to the hospital's location and teaching status. Bed size assesses the number of short-term acute beds in a hospital. Hospital information was obtained from the AHA Annual Survey of Hospitals.

[e]The hospital's teaching status was obtained from the AHA Annual Survey of Hospitals. A hospital is considered to be a teaching hospital if it has an American Medical Association-approved residency program, is a member of the Council of Teaching Hospitals or has a ratio of full-time equivalent interns and residents to beds of 0.25 or higher. Non-metropolitan hospitals were not split according to teaching status, because rural teaching hospitals were rare. The metropolitan categorization is a simplified adaptation of the 2003 version of the Urban Influence Codes and includes both large and small metropolitan areas.

[f]The hospital's ownership/control category was obtained from the AHA Annual Survey of Hospitals and includes categories for government non-federal (public), private not-for-profit (voluntary) and private investor-owned (proprietary). Hospitals in different ownership/control categories tend to have different missions and different responses to government regulations and policies.

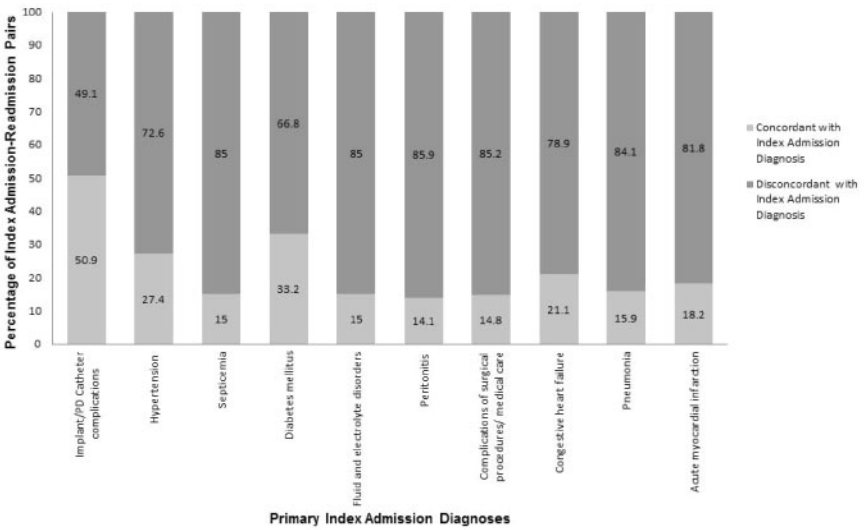


**Fig. 3.** Concordance between index admission diagnosis and readmission diagnosis. The dark gray bars represent the percentage of readmissions with the same diagnosis as index admission, while the light gray bars represent the percentage of readmission with different diagnosis as index admission per diagnosis category.

**Table 2.** aORs for predictors of readmissions in PD patients

| | aOR (95% CI) | P |
|---|---|---|
| Patient characteristics | | |
| Age in years | | |
| 18–34 | Referent | |
| 35–49 | 1.35 (1.09–1.68) | 0.006 |
| 50–64 | 1.08 (0.90–1.30) | 0.37 |
| ≥65 | 1.06 (0.92–1.21) | 0.41 |
| Gender | | |
| Male | Referent | |
| Female | 1.27 (1.12–1.44) | <0.001 |
| Comorbidities | | |
| Liver disease | 1.39 (1.07–1.81) | 0.01 |
| Peripheral vascular disease | 1.33 (1.14–1.56) | <0.001 |
| Depression | 1.22 (1.00–1.48) | 0.04 |
| Chronic pulmonary disease | 1.14 (0.96–1.36) | 0.13 |
| Pulmonary circulation disorder | 0.78 (0.53–1.13) | 0.19 |
| Congestive heart failure | 1.07 (0.92–1.24) | 0.34 |
| Diabetes mellitus | 1.06 (0.92–1.22) | 0.37 |
| Drug abuse | 1.14 (0.72–1.81) | 0.56 |
| AIDS | 1.13 (0.58–2.21) | 0.71 |
| Hypertension | 1.02 (0.88–1.17) | 0.78 |
| Alcohol abuse | 0.99 (0.91–1.09) | 0.90 |
| Median household income category for patient's ZIP code[a] | | |
| 0–25th percentile | Referent | |
| 26–50th percentile | 0.97 (0.81–1.16) | 0.79 |
| 51–75th percentile | 1.03 (0.89–1.20) | 0.63 |
| 76–100th percentile | 0.96 (0.81–1.15) | 0.73 |
| Index admission characteristics | | |
| Admission source[b] | | |
| Non-emergency department | 0.83 (0.68–1.01) | 0.07 |
| Emergency department | Referent | |
| Admission type | | |
| Non-elective | 1.16 (0.87–1.53) | 0.3 |
| Elective | Referent | |
| APR-DRG severity scale[c] | | |
| Minor loss of function | Referent | |
| Moderate loss of function | 1.89 (1.03–3.45) | 0.04 |
| Major loss of function | 1.83 (1.01–3.31) | 0.04 |
| Extreme loss of function | 1.52 (0.82–2.82) | 0.17 |
| Length of stay in days | | |
| <2 | Referent | |
| 3–4 | 1.05 (0.88–1.25) | 0.54 |
| 5–6 | 1.28 (1.04–1.57) | 0.01 |
| ≥7 | 1.2 (1.00–1.43) | 0.04 |
| Primary payer type | | |
| Medicare | 1.17 (0.92–1.50) | 0.18 |
| Medicaid | Referent | |
| Private | 0.84 (0.64–1.10) | 0.21 |
| Self-pay or no charge or others | 0.99 (0.61–1.60) | 0.980 |
| Discharge disposition | | |
| Routine | Referent | |
| Short-term hospital | 1.23 (0.76–1.99) | 0.38 |
| Nursing facility | 1.05 (0.84–1.31) | 0.63 |
| Home health care | 1.31 (1.15–1.50) | <0.001 |
| Against medical advice | 1.24 (0.78–1.98) | 0.35 |
| Hospital characteristics | | |
| Hospital bed size[d] | | |
| Small | 1.03 (0.82–1.30) | 0.77 |
| Medium | 1.00 (0.86–1.16) | 0.98 |
| Large | Referent | |
| Hospital type[e] | | |
| Metropolitan non-teaching | 1.00 (0.88–1.13) | 0.98 |
| Metropolitan teaching | Referent | |
| Non-metropolitan hospital | 0.66 (0.27–1.63) | 0.37 |
| Hospital control[f] | | |
| Government, non-federal | Referent | |
| Private, not-for-profit | 1.03 (0.86–1.22) | 0.72 |
| Private, for-profit | 1.04 (0.81–1.33) | 0.74 |
| Hospital urban–rural designation | | |
| Large metropolitan (serving at least 1 million residents) | Referent | |
| Small metropolitan (<1 million residents) | 0.87 (0.77–0.99) | 0.036 |
| Micropolitan areas (<10 000 residents) | 0.97 (0.36–2.61) | 0.95 |

[a–f]Footnotes as in Table 1.

complications of surgical procedure/medical care and pneumonia. Several independent predictors of readmission were also identified, including female gender, age of 35–49 years, comorbidities of liver disease, peripheral vascular disease and depression, and discharge home with home health care.

The readmission rate in PD patients we report in this cohort is similar to readmission rates reported by others, 19.8% in infection-related hospitalizations and 25% in children, and significantly lower than what is reported for HD patients (37%) [1, 11]. We suspect that the lower rate of admission and readmission in PD compared with HD is due to inherent differences in patients who chose PD as a modality. As PD is predominately done at home with only monthly visits to healthcare providers, patients who choose PD are likely more independent, healthier and have more social support. Furthermore, given that prior data demonstrate that PD patients are most likely to be admitted for infectious causes, it is reasonable that 3 of the top 10 diagnoses for admission were for infection-related hospitalizations: sepsis, peritonitis and pneumonia [1, 12].

Among the top 10 reasons for index admission, over three-quarters of readmissions were for a different CCS diagnosis. As the CCS groups are broad, mutually exclusive categories, those that are categorized as discordant are likely to be for truly different reasons. While dialysis units are going to be penalized for excessive hospital readmissions, this finding is suggestive that in a majority of cases readmissions may not be preventable and that the high readmission rate of this population is due to the complexity of care of the multi-morbid PD patient. However, further research with more granular data is needed to truly determine if this finding holds true.

A surprising finding was that there was no difference in age between the admissions with readmissions and those without readmission. Studies in other populations have found that generally those of the youngest age group had higher rates of readmission compared with other age groups [13, 14]. Additionally, a recent paper found that younger age was predictive of ED use in ESRD patients [15]. We did find that female gender and multiple comorbidities were higher in admissions with readmissions, and that these were also predictors for 30-day unplanned readmissions on multivariate analysis. Of note, while the prevalence of CHF was higher in patient with readmissions, CHF was not an independent predictor of readmission in our model. The latter is surprising as CHF readmission in the Medicare population is noted to be 21.9% and is a quality improvement measure that has been tracked by CMS for years [16]. We speculate that this

might be related to the better fluid management achieved with daily PD [17].

While nearly a quarter of hospitalizations with readmissions were originally discharged home with home health care, we found that discharge to home health care was associated with a 31% increase in odds for readmission. A potential explanation is that these patients had multiple complex comorbidities and/or insufficient social support to maintain care at home compared with those who were discharged routinely. Those patients who were discharged to nursing facilities had additional monitoring that likely impacted the odds of readmission. This may be particularly important in PD patients since this is a renal replacement modality that is done predominantly at home by the patient or patient caregivers. Unfortunately, we currently do not have sufficiently granular data to explore this finding further; however, our results are hypothesis-generating and may be of interest for future research.

Depression was also significantly more prevalent in hospitalizations with readmissions and was a significant predictor of readmission in our model. This highlights the psychosocial aspect of unplanned readmissions and that targeted interventions directed toward PD patients with depression may be of significant benefit. Prior studies demonstrate that depression as screened by a physician is associated with double the rate of death or hospitalization in HD patients; however, few studies have evaluated this association in PD patients [18]. Furthermore, depression is often underdiagnosed in the ESRD population, and even when diagnosed, less than a quarter of patients receive treatment [19]. In fact, even the CMS recognizes the importance of depression, as they are now mandating in outpatient dialysis units the screening and reporting of an action plan for patients who screen positive for depression as part of CMS Quality Improvement Project Measures from 2015.

Our findings suggest the need for effective interventions to screen and effectively treat depression in PD patients. While the new CMS screening requirement is a major step, improvement of access to mental health services also needs to occur. Several studies have found that collaborative care with mental health services improves both short-term and long-term outcomes, including a decrease in utilizations of health care services [20, 21].

Our study has several limitations. First, as the NRD is an administrative database, the classification of diagnosis is done using diagnosis codes, and therefore we may have misclassified some admissions. However, the use of administrative data is widely accepted in tracking outcomes of ESRD patients [1]. Furthermore, we used the CCS schema to classify diagnosis into clinically meaningful categories, and thus the misclassification may not be clinically relevant. As the NRD is a deidentified database, it does not include important patient factors such as dialysis vintage, dialysis adequacy, laboratory results or race. However, as the NRD is a large, nationally representative database, we believe our results are broadly applicable to the US ESRD PD population, including patients who have private insurance.

In conclusion, this study identifies a high readmission rate in ESRD patients on PD and describes the top 10 reasons for admissions. Furthermore, we find that over three-quarters of readmissions were for different reasons than index admission. Lastly, we demonstrate that several patient-related factors are associated with increased odds of readmission. While CMS has taken steps to reduce readmissions by instituting penalties to dialysis units, effective targeted interventions are needed. Improved screening and treatment of depression may potentially be effective at reducing readmissions; however, further studies are necessary to determine the efficacy of such interventions.

## Supplementary data

Supplementary data are available online at http://ckj.oxfordjournals.org.

## Funding

L.C. is supported in part by the National Institute of Health (5T32DK007757 – 18). B.F is supported in part by the American Heart Association (16MCPRP31030016). R.F is supported in part by the National Institute of Health (1TL1TR001434). G.N. is supported in part by the National Institute of Health (1K23DK107908-01A1).

## Conflict of Interest Statement

The results presented in this paper have not been published previously in whole or part, except in abstract format.

## References

1. United States Renal Data System. 2015 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2015
2. Centers for Medicare and Medicaid Services. Report for the Standardized Readmission Ratio. June 2014. https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/ESRDQIP/Downloads/MeasureMethodologyReportfortheProposedSRRMeasure.pdf (3 October 2016, date last accessed)
3. NRD Overview. Healthcare Cost and Utilization Project (HCUP). December 2015. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/nrdoverview.jsp (2 October 2016, date last accessed)
4. Tong L, Erdmann C, Daldalian M *et al*. Comparison of predictive modeling approaches for 30-day all-cause non-elective readmission risk. *BMC Med Res Methodol* 2016; 16: 26
5. HCUP CCS. Healthcare Cost and Utilization Project (HCUP). May 2016. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp (3 October 2016, date last accessed)
6. Baram D, Daroowalla F, Garcia R *et al*. Use of the all patient refined-diagnosis related group (APR-DRG) risk of mortality score as a severity adjustor in the medical ICU. *Clin Med Circ Respirat Pulm Med* 2008; 2: 19–25
7. Friedman B. Hospital inpatient costs for adults with multiple chronic conditions. *Med Care Res Rev* 2006; 63: 327–346
8. Rockhill B, Newman B, Weinberg C. Use and misuse of population attributable fractions. *American Journal of Public Health* 1998; 88: 15–19
9. Glance LG, Kellermann AL, Osler TM *et al*. Hospital readmission after noncardiac surgery. *JAMA Surg* 2014; 149: 439
10. Spiegelman D, Hertzmark E, Wand HC. Point and interval estimates of partial population attributable risks in cohort studies: examples and software. *Cancer Causes Control* 2007; 18: 571–579
11. Laurin LP, Harrak H, Elftouh N *et al*. Outcomes of infection-related hospitalization according to dialysis modality. *Clin J Am Soc Nephrol* 2015; 10: 817–824
12. Fried L, Abidi S, Bernardini J *et al*. Hospitalization in peritoneal dialysis patients. *Am J Kidney Dis* 1999; 33: 927–933
13. Emons MF, Bae JP, Hoogwerf BJ *et al*. Risk factors for 30-day readmission following hypoglycemia-related emergency room and inpatient admissions. *BMJ Open Diabetes Res Care* 2016; 4: e000160

14. Ranasinghe I, Wang Y, Dharmarajan K *et al*. Readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia among young and middle-aged adults: a retrospective observational cohort study. *PLoS Med* 2014; 11: doi: 10.1371/journal.pmed.1001737
15. Lovasik BP, Zhang R, Hockenberry JM *et al*. Emergency department use and hospital admissions among patients with end-stage renal disease in the United States. *JAMA Intern Med* 2016; 176: 1563
16. CMS Outcomes Measures. https://www.cms.gov/medicare/quality-initiatives-patient-assessment-instruments/hospitalqualityinits/outcomemeasures.html (5 October 2015, date last accessed)
17. François K, Ronco C, Bargman JM. Peritoneal dialysis for chronic congestive heart failure. *Blood Purif* 2015; 40: 45–52
18. Hedayati SS, Bosworth HB, Briley LP *et al*. Death or hospitalization of patients on chronic hemodialysis is associated with a physician-based diagnosis of depression. *Kidney Int* 2008; 74: 930–936
19. Hedayati S, Yalamanchili V, Finkelstein F. A practical approach to the treatment of depression in patients with chronic kidney disease and end-stage renal disease. *Kidney Int* 2012; 81: 247–255
20. Gilbody S, Bower P, Fletcher J *et al*. Collaborative care for depression: a cumulative meta-analysis and review of longer-term outcomes. *Arch Intern Med* 2006; 166: 2314–2321
21. van der Feltz-Cornelis CM, Van Os TWDP, Van Marwijk HWJ *et al*. Effect of psychiatric consultation models in primary care. A systematic review and meta-analysis of randomized clinical trials. *J Psychosom Res* 2010; 68: 521–533