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# The Marginal Cost of Frailty Among Medicare Patients on Hemodialysis



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**Introduction:** Dialysis patients incur disproportionately high costs compared with other Medicare beneficiaries. Care for frail individuals may be even more costly. We examined the extent to which frailty contributes to higher costs among dialysis patients.

**Methods:** We used ACTIVE/ADIPOSE (A Cohort to Investigate the Value of Exercise/Analyses Designed to Investigate the Paradox of Obesity and Survival in ESRD) enrollees (adult hemodialysis patients evaluated from June 2009 to August 2011) in a retrospective cohort analysis. Individuals using Medicare as the primary payer were included. Fried's frailty phenotype was evaluated at baseline, 12, and 24 months. Costs were derived from linkage with the US Renal Data System (USRDS) and Medicare claims data. We used generalized estimating equations (GEEs) incorporating time-updated frailty and costs to evaluate adjusted point estimates and the marginal cost associated with being frail. We also investigated if frail patients who died during the study incurred higher costs than those who survived.

**Results:** Among 771 enrollees in ACTIVE/ADIPOSE, 425 met inclusion criteria. Mean age was  $56 \pm 13$  years, body mass index (BMI)  $29.2 \pm 7.1$  kg/m<sup>2</sup>, 42.4% were women, and 29.0% were frail at baseline. Over a mean follow-up of 2.3 years, frail individuals incurred 22% (95% confidence interval [CI] 9.6%–35.8%) higher costs compared with nonfrail individuals (\$87,600 per patient per year [pppy], 95% CI 76,800–100,000, vs. \$71,800 pppy, 95% CI 64,800–79,600), the difference was driven primarily by higher inpatient expenditures. The difference between frail and nonfrail patients' inpatient expenditures was even more pronounced among those who died during the study compared with those who survived.

**Conclusions:** Frail dialysis patients incur a significantly higher cost relative to their nonfrail counterparts, primarily driven by higher inpatient costs. Frail patients near end of life incur even higher costs.

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KEYWORDS: costs; dialysis; frailty; USRDS

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Since 1972, millions of patients with end-stage renal disease (ESRD) have been guaranteed Medicare coverage, but the cost of caring for dialysis patients has become a significant and growing burden to the American health care system.<sup>1</sup> Although ESRD beneficiaries make up less than 1% of the Medicare population, expenditures on this group totaled \$35.4 billion in 2016, accounting for roughly 7.2% of total Medicare expenditures.<sup>1</sup> The continued rise in Medicare ESRD spending beyond inflation is driven primarily by the

increase in the number of patients covered,<sup>1</sup> but the aging dialysis population and high prevalence of frailty also could contribute. Frailty is highly prevalent among patients on dialysis and may represent an additional economic burden to the health care system beyond what would be expected based on ESRD alone.<sup>2</sup>

The cost of frailty has been assessed in nondialysis populations, and studies have found that frail individuals incur a higher cost of care relative to their nonfrail counterparts.<sup>2–5</sup> Although these studies are few, they are vital if we are to be able to assess the cost-effectiveness of interventions intended to obviate poor outcomes among frail patients. Given the disproportionate spending on ESRD beneficiaries, assessing the incremental cost of frailty among medically complex dialysis patients and ways to mitigate this cost may be even more pertinent. This study seeks to quantify the

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marginal cost of frailty among a cohort of prevalent dialysis patients by assessing differences in cost to Medicare longitudinally and identifying drivers of this cost difference.

## METHODS

### Study Design

We used data from the ACTIVE/ADIPOSE study, a USRDS Special Study conducted by the Nutrition and Rehabilitation/Quality of Life Special Studies Centers that enrolled 771 prevalent in-center hemodialysis patients from the Atlanta and San Francisco Bay areas between June 2009 and August 2011.<sup>6</sup> Adult patients ( $\geq 18$  years of age) who were English or Spanish speaking, on hemodialysis for at least 3 months, and capable of providing informed consent were enrolled at 14 dialysis centers. Patients were excluded if they were scheduled for living donor kidney transplantation or planning to change to another dialysis center or to peritoneal dialysis within the next 6 months. The study was approved by the institutional review boards at the University of California, San Francisco and Emory University, and all patients provided written informed consent. Patients were followed over the course of 2 years with study visits and assessments at baseline, 12 months, and 24 months.

### Frailty

We used the Fried frailty phenotype, the most widely used frailty measure among dialysis patients.<sup>7</sup> Fried's frailty phenotype classifies individuals meeting 3 or more of the following 5 criteria as frail<sup>8</sup>: weight loss, exhaustion, low physical activity, weakness, and slow gait speed.<sup>6,9</sup> Weight loss was determined by asking individuals if they had more than 10 pounds of unintentional weight loss over the preceding 12 months. Exhaustion was defined as having a positive response to 2 questions regarding endurance and energy from the Center for Epidemiologic Studies Depression questionnaire. Low physical activity was obtained using the modified Minnesota Leisure Time Physical Activity questionnaire. Grip strength was assessed using a handheld dynamometer. Meeting the low gait speed criterion was defined using the faster of two 15-foot walking trials at an individual's usual pace using standard cut-points based on sex and height. Frailty was assessed at baseline and at the 12-month and 24-month follow-up study visits.

### Defining the Time Period of Interest

We defined the time period during which we would collect cost information as the period from the baseline study visit until 12 months after the last measurement of frailty (typically 36 months from baseline study visit). We

only included periods during which patients were enrolled in Medicare Parts A, B, or D with Medicare serving as the primary payer (MPP) to obtain the most comprehensive cost data available. Patients were censored at the time of death, transplant, or loss to follow-up.

### Costs

Costs to Medicare were derived from claims data contained in the Medicare Parts A, B, and D Standard Analysis Files in the USRDS dataset using reported Medicare payment amounts for each claim. Claims were included if the beginning date of service was within the time periods as previously defined. Annual time periods after the date of enrollment were created corresponding to frailty measurements (baseline to 12-month follow-up visit, 12-month to 24-month follow-up visit, 24-month to 36-month end of follow-up, or the last date of frailty evaluation to the date of death, transplantation, or loss to follow-up). Claims were segregated into the appropriate time period by beginning date of service. Costs were inflated to 2017 US dollars by a discount rate of 3% per annum based on the year of service. Costs were then aggregated during the annual time period defined by frailty measurements and converted to average US dollars per patient per year (pppy) using the number of days on MPP for each patient within each annual time period. For individuals who died, received a transplant, or were lost to follow-up, claims were normalized to annual time periods based on the number of days from the last frailty assessment to the date of death, transplant, or loss to follow-up. Periods in which patients were not enrolled in MPP were excluded (i.e., when patients lost or switched coverage from MPP). Individual claims were also identified as contributing to dialysis (outpatient only), inpatient, outpatient (nondialysis), physician, or medication costs based on the claims dataset from which they were derived, or the location code associated with the claim.

### Covariates

Other potential predictors of costs during follow-up included age, race, sex, BMI, and comorbid conditions (diabetes, congestive heart failure, and coronary artery disease). Age, race, and sex were obtained by patient report, and comorbidities were extracted from the USRDS Medical Evidence file (Centers for Medicare and Medicaid Services form 2728) and through chart review at the baseline study visit.

### Statistical Analysis

Comparisons between frail and nonfrail patients were performed using either *t*-tests or Kruskal-Wallis tests for continuous data and  $\chi^2$  tests for categorical data.

To account for the longitudinal nature of our time-varying cost and time-varying frailty measurements, we used a multivariable gamma-distributed GEE model using a log link to assess the association between frailty and total costs over time. GEE models are advantageous over mixed-effect models given our population-level approach with a relaxed distribution assumption for model parameters.<sup>10,11</sup> We used a gamma distribution with a log link given our right-skewed cost distribution and a previous study using similar models.<sup>12</sup> The correlation structure was assumed to be exchangeable for repeated observations. Once the GEE model was fitted to our data, we extracted the marginal percent difference in costs due to frailty from the beta estimate for frail and nonfrail patients. We also estimated the average total cost for frail and nonfrail patients standardized to the average age and BMI of our cohort. A similar model was used to assess differences between frail and nonfrail patients in dialysis costs, outpatient costs, inpatient costs, physician costs, and medication costs to investigate if any of these were drivers for any observed cost differences between frail and nonfrail patients. We performed a sensitivity analysis assuming a zero rate of inflation to assess the impact of inflation on our results. We also performed a sensitivity analysis assessing the subset of individuals who had claims from all 3 Medicare Parts (Parts A, B, and D) to assess if patients having claims for only 1 or 2 parts (i.e., potentially only having coverage for Medicare Parts A and B but not D) may introduce bias.

We also hypothesized that patients who were near end of life (i.e., died during the study) may have contributed more expenditures on average compared with patients who survived and that the higher cost among frail patients might be driven in part by end-of-life care. We evaluated and compared the baseline characteristics of patients who died during the study and those who did not die by using *t*-tests, Kruskal-Wallis tests, and  $\chi^2$  tests, as appropriate. We then investigated the differences in total and specific (e.g., inpatient, outpatient) expenditures between frail and nonfrail patients among those who died and those who survived during the study using a similar GEE model stratified by survival status. We also assessed if there was an interaction between frailty and death during the study with respect to total cost.

Analyses were adjusted for age, sex, BMI, race, and comorbidities (diabetes, coronary artery disease, and congestive heart failure). No patients were missing data on frailty, demographics, or comorbid conditions at baseline. There were 19 patients missing information for frailty at 12 months or 24 months (7 missing at 12 months,

**Table 1.** Baseline characteristics of participants by frailty status

|                                    | Nonfrail    | Frail       | All         | <i>P</i> value |
|------------------------------------|-------------|-------------|-------------|----------------|
| <i>n</i>                           | 300         | 125         | 425         |                |
| Age, yr                            | 54.6 ± 12.8 | 62.0 ± 13.1 | 56.8 ± 13.3 | <0.001         |
| Sex, % female                      | 41.3        | 44.8        | 42.4        | 0.51           |
| Body mass index, kg/m <sup>2</sup> | 29.1 ± 6.8  | 29.3 ± 7.6  | 29.2 ± 7.1  | 0.78           |
| Albumin, mg/dl                     | 4.03 ± 0.33 | 3.87 ± 0.42 | 3.98 ± 0.36 | <0.001         |
| Race, %                            |             |             |             | 0.89           |
| White                              | 14.7        | 16.8        | 15.3        |                |
| Black                              | 77.0        | 72.0        | 75.5        |                |
| Other                              | 8.3         | 11.2        | 9.2         |                |
| Comorbidities, %                   |             |             |             |                |
| Diabetes                           | 40.0        | 58.4        | 45.4        | <0.001         |
| Coronary artery disease            | 6.7         | 10.4        | 7.8         | 0.19           |
| Congestive heart failure           | 14.7        | 19.2        | 16.0        | 0.25           |
| Outcomes                           |             |             |             |                |
| Died in study, <i>n</i> (%)        | 29 (9.7)    | 28 (22.4)   | 57 (13.4)   | <0.001         |

14 missing at 24 months, 2 missing at both assessment time periods, and 5 missing at 12 months but not 24 months). All analyses were performed using Stata, version 14.2 (Stata Corp., College Station, TX).

## RESULTS

### Characteristics of the Cohort

Among 771 patients enrolled in the ACTIVE/ADIPOSE study, 425 patients were identified to have Medicare Part A, Part B, or Part D, or a combination thereof during the study period. Of 425 patients included in the study, 420 patients had Medicare Part A claims during any point of the study period, 422 patients had Medicare Part B claims during any point of the study period, and 347 patients had Medicare Part D claims during any point of the study period.

Patients in our cohort had a mean age of 56 ± 13 years, a mean BMI of 29.2 ± 7.1 kg/m<sup>2</sup>, 42.4% were women, and 75.5% were black (Table 1). A total of 125 patients (29.4%) were considered frail at baseline. In general, frail patients were older, had lower baseline serum albumin concentrations, and were more likely to have diabetes.

### Marginal Cost of Frailty

We found that frail patients incurred 22.0% higher costs compared with their nonfrail counterparts (95% CI: 9.6%–35.8%) (Table 2). Frail patients incurred an average of \$87,600 pppy (95% CI: \$76,800–\$100,000 pppy) in expenditures compared with \$71,800 pppy (95% CI: \$64,800–\$79,600 pppy) for nonfrail patients (costs standardized to average age and BMI of our cohort). This translates to approximately \$15,800 pppy higher expenditures among frail patients compared with nonfrail (95% CI: \$12,000–\$20,400 pppy).

When assessing individual contributions from dialysis, outpatient (nondialysis), inpatient, physician, and

**Table 2.** Adjusted<sup>a</sup> mean point estimates and percentage differences in expenditures between frail and nonfrail patients

|             | Nonfrail<br>×1000 \$/pppy<br>(95% CI) | Frail<br>×1000 \$/pppy<br>(95% CI) | Percentage difference<br>in expenditures<br>(95% CI) |
|-------------|---------------------------------------|------------------------------------|--|
| Total costs | 71.8 (64.8–79.6)                      | 87.6 (76.8–100.0)                  | +22.0% (+9.6 to +35.8)                               |
| Dialysis    | 23.7 (21.8–25.6)                      | 22.0 (19.9–24.4)                   | −7.0% (−14.9 to +1.7)                                |
| Outpatient  | 11.4 (9.9–13.2)                       | 14.3 (12.2–16.6)                   | +24.6% (+7.8 to +44.1)                               |
| Inpatient   | 18.4 (14.4–23.3)                      | 29.9 (22.4–39.9)                   | +62.9% (+27.3 to +108.3)                             |
| Physician   | 9.2 (7.9–10.7)                        | 10.3 (8.6–12.3)                    | +11.9% (−1.8 to +27.6)                               |
| Medication  | 7.8 (6.3–9.6)                         | 8.0 (6.3–10.0)                     | +2.4% (−8.4 to +14.5)                                |

CI, confidence interval.

<sup>a</sup>Adjusted for age, sex, body mass index, race, and comorbidities (diabetes, coronary artery disease, and congestive heart failure).

Point estimates standardized to average age and body mass index of all study participants.

medication claims, we found that frail patients incurred higher outpatient and inpatient costs, but there was no statistically significant difference in dialysis, physician, or medication costs (Table 2). Outpatient and inpatient costs were 24.6% (95% CI: 7.8%–44.1%) higher and 62.9% (95% CI: 27.3%–108.3%) higher, respectively, among frail patients compared with nonfrail patients. Average cost differences of \$2900 pppy and \$11,500 pppy were noted for outpatient and inpatient expenditures, respectively, between frail and nonfrail patients.

In our sensitivity analysis assuming a zero rate of inflation, we observed similarly higher costs incurred by frail patients that remained driven by higher inpatient and outpatient expenditures (data not shown).

In our sensitivity analysis analyzing the 345 patients who had claims for Medicare Parts A, B, and D, we again observed a similar marginal cost of frailty driven by higher inpatient and outpatient expenditures (Supplementary Table 1).

### Marginal Cost of Frailty Among Those Who Survived and Did Not Survive During Follow-up

Overall, 57 patients (13.4%) died during the study period, 28 (49.1%) of whom were frail at baseline. Patients who died were more likely to be older, have lower serum albumin levels, lower serum pre-albumin levels, more likely to have diabetes, and more likely to be frail (Table 3).

Among survivors, frail and nonfrail patients incurred approximately \$74,200 pppy (95% CI: \$65,400–\$84,200 pppy) and \$67,800 pppy (95% CI: \$61,000–\$75,300), respectively. The estimated marginal cost of frailty among these survivors was \$6400 pppy (representing 9.4% higher costs), but the difference was not statistically significant (95% CI: 1.4% lower to 21.6% higher) (Table 4).

Among individuals who died, frail and nonfrail patients incurred approximately \$181,300 pppy (95%

**Table 3.** Baseline characteristics of patients who survived through the study and died during the study

|                                    | Survived    | Died           | All         | P value |
|------------------------------------|-------------|----------------|-------------|---------|
| n (%)                              | 368 (87)    | 57 (13)        | 425         |         |
| Age, yr                            | 56.2 ± 13.3 | 60.7 ± 13.3    | 56.8 ± 13.3 | 0.02    |
| Sex, % female                      | 41.6        | 47.4           | 42.3        | 0.41    |
| Body mass index, kg/m <sup>2</sup> | 29.3 ± 7.1  | 28.5 ± 7.1     | 29.2 ± 7.1  | 0.44    |
| Albumin, mg/dl                     | 4.01 ± 0.34 | 3.85 ± 0.44    | 4.00 ± 0.36 | 0.001   |
| Pre-albumin, mg/dl                 | 29.8 ± 7.2  | 26.1 ± 7.9     | 29.3 ± 7.4  | 0.001   |
| Race, %                            |             |                |             | 0.47    |
| White                              | 14.7        | — <sup>a</sup> | 15.3        |         |
| Black                              | 76.1        | 75.5           | 75.5        |         |
| Other                              | 9.2         | — <sup>a</sup> | 9.2         |         |
| Comorbidities, %                   |             |                |             |         |
| Diabetes                           | 43.5        | 57.9           | 45.4        | 0.04    |
| Coronary artery disease            | 7.6         | — <sup>a</sup> | 7.8         | 0.76    |
| Congestive heart failure           | 15.8        | 17.5           | 16.0        | 0.73    |
| Frail                              | 26.4        | 49.1           | 29.4        | <0.001  |

<sup>a</sup>Percentages suppressed because 1 or more categories contains <11 individuals.

CI: \$131,600–\$240,800 pppy) and \$135,300 pppy (95% CI: \$94,900–\$192,800 pppy), respectively, with costs 34.0% higher on average among the frail patients compared with their nonfrail counterparts (95% CI 2.6%–75.1% higher) (Table 4). We did not find any statistically significant interaction between frailty and death during the study on our total cost outcome (*P* value for interaction = 0.59), suggesting that although cost of care was higher for patients who died, frail patients continued to have higher costs independent of survival.

Interestingly, the types of charges driving the higher cost of care in frail and nonfrail patients differed between survivors and nonsurvivors. Among survivors, we saw statistically significantly higher outpatient expenditures among frail versus their nonfrail counterparts (27.0% higher, 95% CI: 9.2%–47.9% higher), corresponding to an approximately \$3100 pppy difference. Among those who died, we did not see any difference in outpatient expenditures, but we noted that frail patients incurred 60.3% higher inpatient expenditures (95% CI: 7.1%–140.1% higher) with point estimates of \$107,100 pppy and \$66,800 pppy for frail and nonfrail individuals, respectively.

## DISCUSSION

Among our cohort of dialysis patients followed for up to 3 years, we found that frail patients incurred 22% higher costs compared with their nonfrail counterparts. Extrapolating to the overall US hemodialysis population consisting of approximately 458,000 patients<sup>1</sup> with the assumption that our observed prevalence of frailty of approximately 29% extends to the overall hemodialysis population, our study would

**Table 4.** Adjusted<sup>a</sup> mean point estimates and percentage differences in expenditures between frail and nonfrail patients by survival during study period

|                               | Nonfrail<br>×1000 \$/pppy<br>(95% CI) | Frail<br>×1000 \$/pppy<br>(95% CI) | Percentage difference in<br>expenditures between frail<br>and nonfrail (95% CI) |
|-------------------------------|---------------------------------------|------------------------------------|---|
| Survived through study period |                                       |                                    |   |
| Total costs                   | 67.8 (61.0–75.3)                      | 74.2 (65.4–84.2)                   | +9.4% (−1.4 to +21.6)   |
| Dialysis                      | 23.1 (21.2–25.2)                      | 20.9 (18.7–23.4)                   | −9.4% (−18.0 to 0.0)  |
| Outpatient                    | 11.7 (10.0–13.5)                      | 14.8 (12.6–17.4)                   | +27.0% (+9.2 to +47.9)  |
| Inpatient                     | 15.8 (12.3–20.4)                      | 20.6 (15.0–28.3)                   | +30.4% (−1.3 to +72.2)  |
| Physician                     | 8.4 (7.0–10.1)                        | 8.5 (7.0–10.3)                     | +0.8% (−12.3 to +15.9)  |
| Medication                    | 7.9 (6.3–9.9)                         | 7.9 (6.2–10.0)                     | +0.1% (−9.6 to +10.9)   |
| Died during study period      |                                       |                                    |   |
| Total costs                   | 135.3 (94.9–192.8)                    | 181.3 (136.6–240.8)                | +34.0% (+2.6 to +75.1)  |
| Dialysis                      | 31.1 (27.1–35.7)                      | 27.7 (23.1–33.2)                   | −10.9% (−24.5 to +5.2)  |
| Outpatient                    | 7.7 (4.7–12.7)                        | 9.2 (5.7–14.8)                     | +19.8% (−24.6 to +90.4)   |
| Inpatient                     | 66.8 (37.2–120.0)                     | 107.1 (68.0–168.8)                 | +60.3% (+7.1 to +140.1)   |
| Physician                     | 18.9 (13.6–26.2)                      | 23.6 (17.6–31.7)                   | +25.1% (−3.5 to +62.2)  |
| Medication                    | 7.1 (3.5–14.5)                        | 8.0 (4.4–14.7)                     | +12.6% (−38.9 to +107.6)  |

CI, confidence interval.

<sup>a</sup>Adjusted for age, sex, body mass index, race, and comorbidities (diabetes, coronary artery disease, and congestive heart failure).

Point estimates standardized to average age and body mass index of all study participants.

suggest that frailty may be associated with approximately \$2.2 billion in excess US health care expenditures annually. The additional costs incurred by frail patients was largely driven by higher expenditures on inpatient and outpatient services, although inpatient services accounted for a larger proportion of spending compared with outpatient services. In fact, inpatient expenditures incurred by frail hemodialysis patients are estimated to contribute an additional \$1.6 billion annually, whereas outpatient expenditures contribute only an additional \$400 million annually.

Given that frail patients are at higher risk of death, we hypothesized that end-of-life care might account for a substantial amount of the excess costs among frail patients. Indeed, individuals who died incurred more than double the pppy costs compared with individuals

who did not die during follow-up, which may be attributable to more hospitalizations or to more expensive hospitalizations (e.g., with more procedures and intensive care) closer to the end of life. However, there was no statistically significant interaction between frailty and survival status, suggesting that frail patients incurred higher costs independent of survival status. Our analysis suggests that although more money is spent toward the end of life, especially on inpatient care, frail patients remain more expensive even after accounting for these costs.

Although there have been several studies in recent years assessing the cost of frailty, all but 1 study investigated costs within a 12-month period, and none examined the cost of care in a medically complex dialysis population (Table 5<sup>2,3,12–15</sup>). Studies have either investigated costs incurred among community-dwelling adults whose prevalence of frailty ranges from 6% to 13%,<sup>2,3,12–14</sup> or reported peri-surgical costs in a sicker population with a prevalence of frailty of 38.7%.<sup>15</sup> All have shown higher costs among frail individuals regardless of the length of follow-up time or the prevalence of frailty.<sup>2,5,12–15</sup> Compared with these studies, our study highlights the magnitude of Medicare expenditures for the ESRD benefit program (which were at least 3 to 4 times higher among ESRD patients compared with community-dwelling frail elders), the high prevalence of frailty among patients on dialysis, and the association of frailty with higher cost even in this already-high-cost population. The difference in the mean cost of care for frail compared with nonfrail dialysis patients was considerably larger than the difference between frail and nonfrail community-dwelling elders in most studies.

Given the magnitude of health care utilization among patients on dialysis, cost savings may be realized with even small decreases in utilization. Maintaining patients in or returning them to a nonfrail state could potentially save money and decrease mortality.

**Table 5.** Studies comparing cost of frail versus nonfrail patients defined using Fried's frailty phenotype

| Study                                      | Country       | Population   | Frailty prevalence, % | Cost assessment and follow-up period   | Cost difference between frail and nonfrail                             |
|--|---------------|--|-----------------------|--|--|
| Sirven and Rapp, 2016 <sup>13</sup>        | France        | 1284 Community-dwelling elders aged ≥65  | 13.0                  | 12-month ambulatory health care expenditures for 2012                            | EUR 3900 vs. EUR 2629  |
| Bock et al., 2016 <sup>2</sup>             | Germany       | 2598 Community-dwelling adults aged 57–84  | 8.0                   | Self-reported health care use over a retrospective 3 months                      | EUR 3659 (4–5 criteria), EUR 1616 (3 criteria), and EUR 642 (nonfrail) |
| García-Nogueras et al., 2017 <sup>14</sup> | Spain         | 830 Community-dwelling adults age ≥ 70   | 19.3                  | Associated costs related to diagnosis-related group over 1044 days of follow-up  | EUR 2476 vs. EUR 1217  |
| Hajek et al., 2017 <sup>3</sup>            | Germany       | 1636 Community-dwelling adults aged 57–84  | 6.2–12.0              | Self-reported health care use over a retrospective 3 months                      | Cost increase by 54%–101%  |
| Goldfarb et al., 2017 <sup>15</sup>        | Canada        | 235 patients age ≥60 undergoing cardiac surgery in Montreal, Canada                              | 38.7                  | Costs from operation date to date of discharge based on diagnosis-related groups | CAD 32,742 vs. CAD 23,370  |
| Ensrud et al., 2018 <sup>12</sup>          | United States | 2150 community-dwelling women participating in the Study of Osteoporotic Fractures (SOF) year 10 | 19.0                  | 12-months following Year 10 examination in the SOF study                         | USD 10,755 vs. USD 3781  |

Interventions to prevent frailty and improve the health of frail dialysis patients, especially aimed at decreasing rates of hospitalizations, are urgently needed given the rapid rise of health care expenditures. Indeed, cost savings could be higher than we estimated, considering the indirect costs of caring for frail patients, including the cost of caregivers and costs related to the inability to work, which likely far exceed the calculated direct costs of care to the Medicare program.

Our well-defined prospective cohort of patients on dialysis who were followed over the course of 2 years with annual frailty assessments and corresponding Medicare claims data over 3 years is a strength. We used repeated measurements of costs and frailty to avoid dependence on a single determination of frailty during several years of follow-up, which is especially important given that the state of frailty can change and that change in frailty status in turn may affect health care expenditures. A limitation of our study is the modest sample size; however, health care expenditures in our study were similar to national data (approximately \$88,000 ppy),<sup>1</sup> suggesting that our cohort's health care utilization was representative of the population as a whole. We did not assess temporal trends in expenditures, given our rolling enrollment and relatively short follow-up time of 3 years. To partially account for differences in claim year, we adjusted all costs for inflation and performed a sensitivity analysis assuming a zero rate of inflation. Adjusting for inflation did not significantly alter our overall results, suggesting our results are robust. We are also unable to fully account for the transition to the ESRD Prospective Payment System between 2009 and 2011; however, our intent was to analyze direct costs to Medicare (excluding costs incurred by patients), and we anticipate that the claims data continue to reflect payment from Medicare to facilities and providers. Another limitation to this study is that not all patients used MPP for the entire study period, and we extrapolated for patients who switched coverage, lost coverage, or gained coverage within a calendar year. Our focus on patients using MPP was necessary to ensure that we captured all medical claims, which could have affected external validity. However, good alignment of costs in our cohort with costs in the overall US dialysis population<sup>1</sup> and the large percentage of dialysis patients for whom Medicare is the primary payer support the validity of our findings. Last, although we selected covariates that may be confounders to the association between frailty and costs, there may be residual confounding from factors that were not measured or accounted for.

In conclusion, frail patients on dialysis incur significantly higher costs compared with their nonfrail

counterparts over time. The cost difference between frail and nonfrail patients appears to be driven by significantly higher inpatient expenditures, especially among patients who died during study follow-up. Death during follow-up was associated with higher costs for both frail and nonfrail patients compared with those who survived. Improving or maintaining a nonfrail status to decrease hospitalizations may help to decrease Medicare spending.

## DISCLOSURE

All the authors declared no competing interests.

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## AUTHOR CONTRIBUTIONS

Research idea and study design: JS and KLJ; data acquisition: BG, JS; data analysis/interpretation: JS, ES, KLJ; supervision or mentorship: KLJ. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

## SUPPLEMENTARY MATERIAL

[Supplementary File \(PDF\)](#)

**Table S1.** Adjusted mean point estimates and percentage differences in expenditures between frail and nonfrail patients for those who have claims from all 3 Medicare parts (Parts A, B, and D).

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