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# Prehemodialysis Care by Dietitians and First-Year Mortality After Initiation of Hemodialysis

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## Abstract

**Background—**Since January 2002, Medicare has provided payment for medical nutrition therapy for patients with chronic kidney disease. Few patients receive dietary counseling before end-stage renal disease (ESRD) onset; whether such counseling is associated with improved outcomes is unknown.

**Study design—**Retrospective cohort analysis.

**Setting and participants—**Patients who initiated hemodialysis June 1, 2005-May 31, 2007, in the US, for whom predialysis dietitian care was reported on the Centers for Medicare & Medicaid Services Medical Evidence Report.

**Predictor—**Dietitian care before ESRD onset.

**Outcome—**Time to death.

**Measurements—**Propensity score for dietitian care calculated using logistic regression; Cox regression analysis used to compare time to death by predialysis dietitian care overall and stratified by tertiles of propensity score, adjusting for baseline characteristics.

**Results—**Most patients (88%) received no dietitian care; 9% received dietitian care for ≤ 12 months, and 3% received dietitian care for > 12 months before dialysis initiation (total $n$ = 156,440). Predialysis dietitian care was independently associated with higher albumin and lower total cholesterol at dialysis initiation. There was evidence of an independent association between predialysis dietitian care for > 12 months and decreased mortality during the first year on dialysis for the second tertile of propensity score. Adjusted mortality hazards ratios (95% confidence

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interval) were 1.16 (0.44–3.09; $P = 0.8$), 0.81 (0.71–0.93; $P = 0.002$), and 0.93 (0.86–1.01; $P = 0.1$) in the first, second, and third tertiles of propensity score, respectively.

**Limitations—**Information on dietitian care was missing from 18.6% of Medical Evidence Reports, and has low sensitivity; including only incident dialysis patients precluded evaluation of an association between dietitian care and CKD progression; observational design allowed possibility of residual confounding.

**Conclusions—**Our study suggests an independent association between predialysis dietitian care for > 12 months and lower mortality during the first year on dialysis.

### Index words

Dietitian care; end-stage renal disease; hemodialysis

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The number of individuals with end-stage renal disease (ESRD) requiring dialysis is rapidly growing.[1] Morbidity and mortality rates are exceedingly high for patients with ESRD, especially during the first year on dialysis.[2] Protein-energy malnutrition due to low protein and caloric intake develops during the course of chronic kidney disease (CKD) and is associated with adverse outcomes. In addition, patients with CKD develop hyperphosphatemia and hyperkalemia due to decreased renal ability to excrete phosphorus and potassium, and these conditions can be managed by dietary changes. The National Kidney Foundation developed Kidney Disease Outcomes Quality Initiative (KDOQI) evidence-based guidelines that recommend routine monitoring of nutritional status at 1- to 3-month intervals for patients with glomerular filtration rate (GFR) less than 30 mL/min/1.73 $m^2$ (CKD Stages 4–5) and every 6 to 12 months for patients with GFR 30 to 60 mL/min/ 1.73$m^2$ (CKD Stage 3).[3] Although the guidelines do not explicitly recommend that evaluation and management be performed by a registered dietitian, they state that “a registered dietitian, trained and experienced in CKD nutrition, is best qualified to carry out these tasks.”[3] Since January 2002, Medicare has provided payment for medical nutrition therapy for patients with GFR 15–50 mL/min/1.73$m^2$ or within 6 months after kidney transplant. Despite these measures, only 10.5% of patients who initiated dialysis in 2005 had received dietary counseling before starting ESRD therapy.[4] Whether dietary counseling for CKD patients is associated with improved patient outcomes remains unknown. To address this knowledge gap, we tested the hypothesis that dietary counseling before ESRD onset is independently associated with lower 1-year mortality among incident hemodialysis patients.

## Methods

### Study Participants

All patients aged 20 years and older who initiated hemodialysis between June 1, 2005, and May 31, 2007, resided in the United States, District of Columbia, Puerto Rico, or the Territories, had valid information on the Centers for Medicare & Medicaid Services (CMS) Medical Evidence Report (form CMS-2728), and maintained stable renal replacement modality for the first 60 days after dialysis initiation ($n = 192,307$) were identified in the US Renal Data System incident cohort files. Patients whose dietitian care status was missing or unknown ($n = 35,867$) were excluded, leaving 156,440 patients in the analytical cohort.

### Data Source

The CMS ESRD Medical Evidence Report was the source of data for the reported analysis. Providers complete this form for all patients within 45 days of renal replacement therapy initiation irrespective of the patient's insurance coverage. All information is reported to the best of the patients' nephrologists' knowledge.

Pre-ESRD dietitian care status was determined based on question 18c of the Medical Evidence Report: "Prior to ESRD therapy, was patient under care of kidney dietitian?" Dietitian care categories were implied as follows: if "no" was checked, no dietitian care; if "yes" and "> 12 months" were checked, dietitian care for ≥ 12 months; if "yes" was checked and "> 12 months" was not checked, dietitian care for 0–12 months.

### Validation of Dietitian Care

Dietitian care responses (yes/no) on the Medical Evidence Report were validated in the patient cohort aged 67 years and older who initiated hemodialysis between June 1, 2005, and May 31, 2007, and had Medicare as their primary source of health insurance continuously in the 2 years before dialysis initiation. Outpatient claims with provider specialty code 71 (dietitian care) over 2 years preceding hemodialysis initiation were used to define dietitian care.

### Follow-up and Outcomes

Patients were followed for 12 months (365 days) from the first dialysis date. Censoring was performed at the end of follow-up (12 months). The primary outcome of the analysis was time to death. Death information was obtained from the Death Notification (form CMS-2746); this information has been shown to be accurate in 99.5% of cases.[5]

### Covariates

Age, sex, race, body mass index (BMI), smoking history, alcohol use, drug dependence, cause of ESRD, functional status (inability to ambulate, inability to transfer, assistance with activities of daily living, institutionalization, employment at the time of ESRD onset), comorbid conditions (atherosclerotic heart disease, congestive heart failure, history of cerebrovascular accident, peripheral vascular disease, hypertension, diabetes mellitus, chronic obstructive pulmonary disease, cancer), predialysis nephrology care, hemoglobin, albumin, and dialysis access at the time of dialysis initiation were obtained from the Medical Evidence Report. Hemoglobin and albumin values were obtained within 45 days before the first dialysis treatment. Whether albumin was measured by bromcresol purple dye-binding assay or by bromcresol green dye-binding assay was specified on the form.

### Statistical Analysis

We calculated propensity scores using a logistic regression model, with predialysis dietitian follow-up (yes versus no) as the outcome studied. To build the propensity score model, we used patient characteristics and several covariate interactions. Baseline characteristics and interaction terms that were retained in the final model are listed in Table S1 (available online

at www.ajkd.org). Model fit and predictive power were assessed using the *c*-statistic; *c*-statistic for the model was 0.809.

Baseline characteristics are presented across dietitian care strata (yes/no) within tertiles of propensity score and compared using ANOVA for normally distributed continuous variables, the Kruscal-Wallis test for non-normally distributed continuous variables, and the chi-square test for categorical variables. Linear regression analyses with adjustment for propensity score of dietitian care before dialysis initiation were performed to identify independent associations with serum albumin, total cholesterol, hemoglobin A1c, weight, and BMI at dialysis initiation. Albumin measured by bromcresol purple dye-binding assay was converted to albumin measured by bromcresol green dye-binding assay by the following formula: $Alb_{BCG} = 0.55 + Alb_{BCP}$.[6] Kaplan-Meier curves of cumulative mortality for groups by dietitian care status were plotted and compared using the log rank test. Cox regression analysis was used to compare survival times, adjusting for baseline socio-demographic characteristics; smoking, alcohol and drug use; functional status parameters; and comorbid conditions as collected on form CMS-2728 in the total cohort and for tertiles of propensity score. All analyses were performed using 9.1 SAS software. Estimated *P*-values are reported without adjustment for making multiple comparisons.

## Results

### Study Population

Of 192,307 patients, dietitian care status before hemodialysis initiation was known for 156,440, who were included in the analysis. The 35,867 patients who were excluded because of missing or unknown dietary care status before dialysis initiation were older, less likely to be white, to have reported comorbid conditions, to be employed, or to have private insurance, and more likely to be institutionalized than patients whose predialysis dietitian care status was reported.

### Validation of Dietitian Care

Of patients who initiated dialysis between June 1, 2005, and May 31, 2007, 54,019 were aged ≥ 67 years and had Medicare as their primary source of health insurance continuously in the 2 years preceding hemodialysis initiation. There were 1094 outpatient Medicare claims for dietitian services over 2 years before dialysis initiation; using Medicare claims as the gold standard, sensitivity of form CMS-2728 dietitian care responses was 38% and specificity was 89%.

### Baseline Patient Characteristics

Of the 156,440 patients included in the analytical cohort, 65% were white, 30% were African American, 44% were women, 46% had ESRD secondary to diabetes, and 25% had private insurance (Table 1). Most patients (88%) received no dietitian care before dialysis initiation, 9% received dietitian care for 12 months or less, and 3% received dietitian care for longer than 12 months before dialysis initiation. The cohort primarily consisted of elderly patients; mean age was 63 ± 15 years and 27% were aged 75 years or older. Patients who received dietitian care for longer than 12 months were slightly older (64.2 ± 14.2 versus 63.3

± 15.2 years), less likely to be African American (25% versus 30%), more likely to be male (60% versus 55%), more likely to have a reported history of heart disease (30% versus 24%), less likely to need help with activities of daily living (9% versus 12%), less likely to be institutionalized (5% versus 8%), more likely to be employed (13% versus 10%), and more likely to have private insurance (30% versus 25%) than patients who did not receive predialysis dietitian care (Table S2). Dietitian care was strongly tied to predialysis nephrology care: 97% of patients who received dietitian care for longer than 12 months before dialysis initiation also received nephrologist care for longer than 12 months. Baseline characteristics of patients with and without dietitian care were well balanced when stratified by tertiles of the propensity score (Table 1).

### Dietitian Follow-up and Nutritional Parameters at Dialysis Start

Predialysis dietitian care was independently associated with higher albumin and lower total cholesterol at dialysis initiation (Table 2). Predialysis dietitian care for 0–12 months was associated with lower weight and BMI, and predialysis dietitian care for > 12 months was associated with higher weight but not BMI. There was no association between predialysis dietitian care and hemoglobin A1c (Table 2).

### Dietitian Follow-up and First-Year Mortality on Dialysis

During mean follow-up of 9.9 months, 38,687 patients died (24.7%).

The *c*-statistic of the logistic regression model to estimate the likelihood of predialysis dietitian care for each patient (propensity score) indicated good predictive ability ($c$ = 0.809). In the analysis stratified by tertiles of the propensity score, after adjustment for multiple covariates, there was a significant 19% relative risk reduction for death among patients with > 12 months dietitian care in the second tertile of propensity score (hazard ratio [HR] 0.81, 95% confidence interval [CI], 0.71–0.93; $P$ = 0.002; Table 3). In the third tertile of propensity score, there appeared to be an association of predialysis dietitian care > 12 months and lower first-year mortality (HR, 0.93; 95% CI 0.86–1.01), but this association did not reach significance ($P$ = 0.1). There was no evidence of an association between predialysis dietitian care > 12 months and first-year mortality (HR, 1.16; 95% CI, 0.44–3.09; $P$ = 0.8) for the first tertile of propensity score. There was no evidence of independent associations between dietitian care < 12 months and mortality in any of the three propensity score strata (Table 3).

The conventional multivariate Cox model revealed a small-in-magnitude but statistically significant association between predialysis nephrology care and survival on dialysis: HRs (95% CI) were 0.95 (0.91–0.99) for dietitian care for 0–12 months and 0.85 (0.79–0.91) for dietitian care for > 12 months, compared with no predialysis dietitian care. After adjustment for predialysis nephrology care, the magnitude of the effect decreased and the association was no longer significant (Table S3). In the cohort limited to patients who received nephrology care, adjusted HRs (95% CI) of death associated with dietitian care were 1.01 (0.97–1.06) for dietitian care for 0–12 months and 0.91 (0.85–0.98) for dietitian care for > 12 months compared with no dietician care ($P$ = 0.01) (Table S3).

## Discussion

In a nationally representative cohort of incident dialysis patients, we found an association between predialysis dietitian care and higher albumin and lower total cholesterol at dialysis initiation, and our results suggest an independent association between predialysis dietitian care > 12 months and improved survival during the first year on dialysis. Our study is the first epidemiologic study to assess the association between predialysis dietitian care and laboratory and clinical outcomes on dialysis. Unfortunately, we report a very low rate of predialysis dietitian care in the United States.

Presence of protein-energy malnutrition, which is associated with increased morbidity and mortality, has long been recognized in a large proportion of maintenance hemodialysis patients.[7] Dietitian counseling can potentially improve nutrition for patients with CKD through recommendations for adequate protein and caloric intake and nutritional supplements as needed, resulting in better nourishment in the incident dialysis population. In addition, dietitian care can influence outcomes for patients with kidney disease by managing hyperphosphatemia and hyperkalemia, two other CKD complications associated with poor outcomes. A small cohort of CKD patients with estimated GFR less than 25 mL/min/1.73 $m^2$ received nutritional counseling from a renal dietitian on at least three occasions over six months; patients were counseled on dietary intake of 0.8 to 1 g/kg/day protein intake and energy intake to achieve BMI of 20 to 25 $kg/m^2$, and dietary supplements were prescribed if needed. Following the intervention, none of the patients showed decline; two patients showed improvement on the Subjective Global Assessment Scale, and all maintained stable weight, biochemical markers, and anthropometric measures, factors expected to worsen based on historic controls and review of the literature.[8] A retrospective study of maintenance hemodialysis patients showed that when renal dieticians implemented standardized nutrition guidelines, there was a decrease in the proportion of patients with malnutrition as measured by the Subjective Global Assessment Scale (from 14% at baseline to 3% after two years), increased dietary energy and protein intake, decreased serum phosphate, and stable serum albumin, potassium, and dry weight.[9] More frequent contact with a dietitian might also be more beneficial for patients with kidney disease.[10] Unfortunately, studies that address this question have been small and retrospective.

Dietitian care can influence patient outcomes by improving biomarkers known to be associated with morbidity and mortality in patients with kidney disease. We found that predialysis dietitian care was independently associated in a graded manner with a higher likelihood of normoalbuminemia at dialysis initiation. Hypoalbuminemia is strongly associated with mortality in hemodialysis patients; in a seminal retrospective study of 13,473 dialysis patients, the odds ratios (95% CI) for death were 1.48 (1.37–1.59) for serum albumin concentrations of 3.5 to 3.9 g/dL, 3.13 (2.87–3.41) for concentrations of 3.0 to 3.4 g/dL, 7.08 (6.12–8.19) for concentrations of 2.5 to 2.9 g/dL, and 12.8 (9.62–16.97) for serum albumin < 2.5 gm/dL after adjustment for age, sex, race, and cause of ESRD.[11] Although serum albumin has traditionally been used as a marker of nutrition, its value as an index of nutrition has more recently been questioned because of the association of hypoalbuminemia with inflammation and illness.[12]

Results of randomized controlled trials that tested the effect of nutritional supplements and dietary counseling on serum albumin in patients with CKD have been inconsistent, but most favor counseling to dietary supplements.[13–15] The largest trial of nutritional interventions in those receiving hemodialysis ($n = 180$), randomized patients with low albumin to intervention that involved identifying specific nutritional barriers and addressing those barriers, compared with usual care. Barriers comprised limited knowledge, poor appetite, lack of needed help with shopping or cooking, suboptimal fluid intake, inadequate dialysis dose, depression, trouble chewing or swallowing, gastrointestinal symptoms, and acidosis. After 12 months, albumin levels increased more for patients who received the intervention than for control patients (+0.21 versus +0.06 g/dL; $P < 0.01$), as did energy intake (+4.1 versus −0.6 kcal/d/kg; $P < 0.001$) and protein intake (+0.13 versus −0.06 g/d/kg; $P < 0.001$). The intervention appeared to be specifically effective for barriers related to poor nutritional knowledge.[15] Results of these studies support an important role of dietary counseling in maintaining nutritional health in patients with kidney disease. Despite this indirect evidence, no randomized controlled trials to date have tested the hypothesis that dietitian care improves clinical outcomes in patients with CKD.

Dietitian care also plays a role in the management of two other complications of CKD associated with poor outcomes: hyperphosphatemia and hyperkalemia. High serum phosphorus has been associated with increased all-cause and cardiovascular mortality in patients with kidney disease.[16] Dietary education may be successful in improving phosphorus knowledge and control of hyperphosphatemia in dialysis patients.[10;17;18] Prior research suggests that dietary counseling is an effective intervention for control of hyperphosphatemia, but unfortunately we lacked the data on parameters of bone metabolism, including phosphorus, at dialysis initiation to test the hypothesis that predialysis dietitian care is associated with lower phosphorus levels and better control of hyperparathyroidism at dialysis initiation.

We observed an independent association between longer predialysis dietitian care and lower mortality on dialysis among patients in the second tertile of propensity score, and there appeared to be an association among patients in the third tertile, albeit not at the level of significance. We found no evidence of an association among patients in the first tertile, but this tertile included few patients with predialysis nephrology care and few events, creating unstable estimates of effect size. One can speculate that dietitian care before dialysis initiation is most likely to alter outcomes for patients with more favorable functional and socio-demographic profiles, who are more likely to comply with dietary recommendations. Compared with the other tertiles, prevalence of inability to ambulate, inability to transfer, and need for help with activities with daily living was higher for patients in the first tertile of propensity score for dietitian care, and more of these patients were institutionalized and fewer were employed.

Validation revealed low sensitivity but adequate specificity of Medical Evidence Report answers by providers compared with Medicare claims data. This finding should be taken with caution because our “gold standard,” Medicare claims for dietitian care, might have its own limitations; dietary education can be obtained during hospitalizations and as part of multidisciplinary renal education sessions, and this will not be reflected in outpatient

Medicare claims. However, low sensitivity of dietitian care as determined by Medical Evidence Report answers might have resulted in our study being under-powered.

This study, performed in a large national cohort of incident dialysis patients, is the first epidemiologic study to test the hypothesis that predialysis dietitian care is associated with improved outcomes in patients with CKD. Despite its strengths, the study has several additional limitations. Information on dietitian care, as reported by patients' physicians on the Medical Evidence Report (form CMS-2728) was missing from 18.6% of forms. Information on content of care and number of interactions is also not available. Because our cohort included only incident dialysis patients, we were unable to evaluate an association between dietitian care and progression of CKD. Given the observational design of our study, we cannot eliminate the possibility of residual confounding. Randomized controlled trials of predialysis dietitian care are warranted to evaluate the effectiveness of dietary counseling in improving clinical outcomes. Until such trials are conducted, the question of independent benefit of dietitian care before dialysis initiation will remain.

In conclusion, this study suggests an independent association between dietitian care for longer than 12 months before dialysis initiation and lower mortality during the first year of dialysis. Further research that explores the association between duration, frequency, and content of dietitian care in CKD and outcomes, and ways to make dietary counseling part of routine pre-ESRD care, is urgently needed.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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**Table 1**

Baseline Characteristics by Presence of Dietitian Care Stratified by Tertiles of Propensity Score

| | | Tertile 1 | | Tertile 2 | | Tertile 3 | |
|---|---|---|---|---|---|---|---|
| **Baseline Characteristics** | **All** | **No Dietitian Care** | **Dietitian Care** | **No Dietitian Care** | **Dietitian Care** | **No Dietitian Care** | **Dietitian Care** |
| *No.* | 156,440 | 53,313 | 305 | 46,799 | 4,689 | 38,088 | 13,246 |
| Age | 63.4 ± 15.2 | 62.6 ± 15.7 | 64.3 ± 15.5 | 63.2 ± 15.2 | 63.5 ± 14.4 | 64.6 ± 14.5 | 63.9 ± 14.4 |
| Race | | | | | | | |
| White | 102,187 (65) | 33,516 (63) | 199 (65) | 30,233 (65) | 3,130 (67) | 26,093 (69) | 9,016 (68) |
| African American | 46,501 (30) | 17,628 (33) | 91 (30) | 14,504 (31) | 1,388 (30) | 9,695 (26) | 3,195 (24) |
| Asian | 5,819 (4) | 1,584 (3) | 10 (3) | 1,452 (3) | 129 (3) | 1,830 (5) | 814 (6) |
| Native American | 1,723 (1.1) | 498 (0.9) | 5 (2) | 547 (1.2) | 39 (0.8) | 435 (1.1) | 199 (1.5) |
| Other | 210 (0.1) | 87 (0.2) | 0 | 63 (0.1) | 3 (0.1) | 35 (0.1) | 22 (0.2) |
| Sex | | | | | | | |
| Men | 87,164 (56) | 29,405 (55) | 194 (64) | 25,829 (55) | 2,634 (56) | 21,281 (56) | 7,821 (59) |
| Women | 69,276 (44) | 23,908 (45) | 111 (36) | 20,970 (45) | 2,055 (44) | 16,807 (44) | 5,425 (41) |
| Cause of ESRD | | | | | | | |
| Diabetes | 72,513 (46) | 21,336 (40) | 137 (45) | 22,195 (47) | 2,294 (49) | 19,683 (52) | 6,868 (52) |
| Hypertension | 43,485 (28) | 16,246 (31) | 91 (30) | 13,245 (28) | 1,362 (29) | 9,478 (25) | 3,063 (23) |
| GN | 10,457 (7) | 3,119 (6) | 16 (5) | 2,984 (6) | 313 (7) | 2,917 (8) | 1,108 (8) |
| Other | 29,985 (19) | 12,612 (24) | 61 (20) | 8,375 (18) | 720 (15) | 6,010 (16) | 2,207 (17) |
| Comorbid conditions | | | | | | | |
| ASHD | 37,868 (24) | 11,616 (22) | 74 (24) | 10,185 (22) | 1,098 (23) | 10,772 (28) | 4,123 (31) |
| CHF | 56,543 (36) | 19,855 (37) | 145 (48) | 16,307 (35) | 1,634 (35) | 13,746 (36) | 4,856 (37) |
| PVD | 24,883 (16) | 7,696 (14) | 57 (19) | 6,911 (15) | 719 (15) | 6,786 (18) | 2,714 (21) |
| CVA/TIA | 16,411 (11) | 5,605 (11) | 31 (10) | 4,860 (10) | 483 (10) | 3,968 (10) | 1,464 (11) |
| Diabetes | 83,431 (53) | 26,266 (49) | 173 (57) | 25,205 (54) | 2,622 (56) | 21,718 (57) | 7,447 (56) |
| Hypertension | 132,041 (84) | 45,488 (85) | 239 (78) | 38,071 (81) | 4,072 (87) | 32,865 (86) | 11,306 (85) |
| COPD | 15,003 (10) | 5,585 (11) | 40 (13) | 4,500 (10) | 434 (9) | 3,339 (9) | 1,105 (8) |
| Cancer | 12,264 (8) | 4,443 (8) | 22 (7) | 3,624 (8) | 339 (7) | 2,893 (8) | 943 (7) |
| Functional status | | | | | | | |

| | | Tertile 1 | | Tertile 2 | | Tertile 3 | |
|---|---|---|---|---|---|---|---|
| **Baseline Characteristics** | **All** | **No Dietitian Care** | **Dietitian Care** | **No Dietitian Care** | **Dietitian Care** | **No Dietitian Care** | **Dietitian Care** |
| Unable to ambulate | 11,690 (8) | 5,079 (10) | 30 (10) | 3,316 (7) | 257 (6) | 2,250 (6) | 758 (6) |
| Unable to transfer | 5,392 (4) | 2,537 (5) | 15 (5) | 1,530 (3) | 115 (3) | 877 (2) | 318 (2) |
| Help with ADL | 18,157 (12) | 7,552 (14) | 47 (15) | 5,345 (11) | 458 (10) | 3,587 (9) | 1,168 (9) |
| Institutionalized | 12,158 (8) | 5,667 (11) | 37 (12) | 3,428 (7) | 277 (6) | 2,015 (5) | 734 (6) |
| Employed | 15,224 (10) | 4,601 (9) | 22 (7) | 4,394 (9) | 463 (10) | 4,181 (11) | 1,563 (12) |
| Alcohol use | 2,607 (2) | 1,347 (3) | 3 (1) | 729 (2) | 51 (1) | 346 (0.9) | 131 (1) |
| Smoking | 10,340 (7) | 4,245 (8) | 17 (6) | 3,319 (7) | 355 (8) | 1,820 (5) | 584 (4) |
| Drug use | 2,501 (2) | 1,327 (3) | 2 (0.7) | 704 (1.5) | 68 (1.5) | 279 (0.7) | 121 (0.9) |
| BMI ($kg/m^2$) | 28.6 ± 7.7 | 28.1 ± 7.7 | 28.2 ± 7.9 | 28.8 ± 7.8 | 29.0 ± 7.9 | 28.9 ± 7.6 | 28.7 ± 7.5 |
| Hemoglobin (g/dL) | 10.1 ± 1.7 | 9.7 ± 1.7 | 10.2 ± 1.8 | 10.0 ± 1.7 | 10.2 ± 1.6 | 10.4 ± 1.6 | 10.5 ± 1.7 |
| Hb ≥ 11g/dL | 40,666 (26) | 10,572 (20) | 90 (30) | 11,330 (24) | 1,244 (27) | 12,731 (33) | 4,699 (35) |
| Albumin ≥ 4.0 g/dL * | 14,628 (9) | 3,064 (6) | 27 (9) | 4,259 (9) | 513 (11) | 4,839 (13) | 1,926 (15) |
| eGFR (mL/min/1.73m2) | 10.4 ± 4.8 | 10.1 ± 5.1 | 10.0 ± 4.6 | 10.6 ± 4.9 | 10.7 ± 4.7 | 10.6 ± 4.5 | 10.6 ± 4.5 |
| EPO use | 49,845 (32) | 348 (0.7) | 115 (38) | 3,607 (8) | 196 (4) | 33,522 (88) | 12,057 (91) |
| Nephrology care | | | | | | | |
| None | 60,634 (39) | 52,229 (98) | 93 (31) | 8,229 (18) | 81 (2) | 2 (0) | 0 |
| 0–12 mo | 55,839 (36) | 540 (1) | 143 (47) | 23,419 (50) | 2,998 (64) | 21,301 (56) | 7,438 (56) |
| > 12 mo | 36,645 (23) | 227 (0.4) | 65 (21) | 12,198 (26) | 1,564 (33) | 16,783 (44) | 5,808 (44) |
| Unknown | 3,321 (2) | 317 (0.6) | 4 (1.3) | 2,952 (6) | 46 (1) | 2 (0) | 0 |
| Access at initiation | | | | | | | |
| AVF | 21,150 (14) | 141 (0.3) | 28 (9) | 5,176 (11) | 603 (13) | 10,729 (28) | 4,473 (34) |
| AVG | 7,120 (5) | 126 (0.2) | 10 (3) | 2,710 (6) | 210 (5) | 3,032 (8) | 1,032 (8) |
| Catheter | 127,158 (81) | 52,764 (99) | 265 (87) | 38,595 (83) | 3,800 (81) | 24,116 (63) | 7,618 (58) |
| Other | 949 (0.6) | 267 (0.5) | 1 (0.3) | 300 (0.6) | 71 (2) | 198 (0.5) | 112 (0.9) |
| AVF maturing | 27,945 (18) | 7,095 (13) | 49 (16) | 9,108 (20) | 1,035 (22) | 7,952 (21) | 2,706 (20) |
| AVG maturing | 6,459 (4) | 1,825 (3) | 16 (5) | 2,001 (4) | 258 (6) | 1,691 (4) | 668 (5) |
| Medical coverage at initiation | | | | | | | |
| Private | 39,673 (25) | 11,404 (21) | 79 (26) | 12,158 (26) | 1,286 (27) | 10,998 (29) | 3,748 (28) |

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| | | Tertile 1 | | Tertile 2 | | Tertile 3 | |
|---|---|---|---|---|---|---|---|
| **Baseline Characteristics** | **All** | **No Dietitian Care** | **Dietitian Care** | **No Dietitian Care** | **Dietitian Care** | **No Dietitian Care** | **Dietitian Care** |
| Medicare only | 28,847 (18) | 10,239 (19) | 52 (17) | 8,815 (19) | 930 (20) | 6,651 (18) | 2,160 (16) |
| Medicaid only | 17,547 (11) | 6,790 (13) | 35 (12) | 5,974 (13) | 522 (11) | 3,136 (8) | 1,090 (8) |
| Medicare/Medicaid | 20,421 (13) | 7,310 (14) | 42 (14) | 6,628 (14) | 602 (13) | 4,411 (12) | 1,428 (11) |
| VA | 1,406 (0.9) | 331 (0.6) | 5 (2) | 124 (0.3) | 3 (0.1) | 506 (1.3) | 437 (3) |
| Other | 36,332 (23) | 10,558 (20) | 73 (24) | 10,250 (22) | 1,045 (22) | 10,705 (28) | 3,701 (28) |
| None | 12,214 (8) | 6,681 (13) | 19 (6) | 2,850 (6) | 301 (6) | 1,681 (4) | 682 (5) |

ADL, activities of daily living; ASHD, atherosclerotic heart disease; AVF, arteriovenous fistula; AVG, arteriovenous graft; BMI, body mass index; CHF congestive heart failure; COPD, chronic obstructive pulmonary disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; eGFR, estimated glomerular filtration rate; EPO, erythropoietin; ESRD, end-stage renal disease; GN, glomerulonephritis; PVD, peripheral vascular disease; VA, Veterans Administration; Hb, hemoglobin.

*Note:* Values are *number* (%) or mean ± standard deviation unless otherwise indicated. Conversion factors for units: albumin and hemoglobin in g/dL to g/L, x10; eGFR in mL/min/1.73 m2 to mL/s/1.73 m2, x0.01667.

*Albumin measured by bromcresol purple dye-binding assay was converted to albumin measured by bromcresol green dye-binding assay by the following formula: $Alb_{BCG} = 0.55 + Alb_{BCP}$.

**Table 2**

Associations of Pre-Dialysis Dietitian Care with Nutritional Markers at Dialysis Initiation*

| | Albumin† | | Total Cholesterol | | Hemoglobin A1c | | Weight | | BMI | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dietitian Care** | **Parameter Estimate** | ***P*** | **Parameter Estimate** | ***P*** | **Parameter Estimate** | ***P*** | **Parameter Estimate** | ***P*** | **Parameter Estimate** | ***P*** |
| None | Ref | -- | Ref | -- | Ref | -- | Ref | -- | Ref | -- |
| 0–12 mo | 0.00 | 0.9 | −1.68 | 0.08 | 0.04 | 0.7 | −0.94 | < 0.001 | −0.16 | 0.04 |
| > 12 mo | 0.12 | < 0.001 | −4.42 | 0.002 | −0.20 | 0.3 | 0.96 | 0.005 | 0.15 | 0.2 |

BMI, body mass index; ref, reference

*Linear regression model adjusted for propensity score for dietitian care.

†Albumin measured by bromcresol purple dye-binding assay was converted to albumin measured by bromcresol green dye-binding assay by the following formula: $Alb_{BCG} = 0.55 + Alb_{BCP}$.

**Table 3**

Dietitian Care Before Dialysis Initiation and Risk of Death in First Year on Dialysis Stratified by Tertile of Propensity Score of Dietitian Care

| | Tertile 1 | | Tertile 2 | | Tertile3 | |
|---|---|---|---|---|---|---|
| **Dietitian Care** | **HR (95% CI)** | ***P*** | **HR (95% CI)** | ***P*** | **HR (95% CI)** | ***P*** |
| **Minimally adjusted model** * | | | | | | |
| None | 1.00 (reference) | | 1.00 (reference) | | 1.00 (reference) | |
| 0–12 mo | 1.26 (1.03–1.55) | 0.03 | 0.92 (0.86–0.99) | 0.02 | 1.02 (0.97–1.07) | 0.6 |
| > 12 mo | 0.94 (0.61–1.46) | 0.8 | 0.74 (0.65–0.85) | < 0.001 | 0.81 (0.75–0.88) | < 0.001 |
| **Fully adjusted model** † | | | | | | |
| None | 1.00 (reference) | | 1.00 (reference) | | 1.00 (reference) | |
| 0–12 mo | 1.08 (0.74–1.59) | 0.7 | 0.97 (0.90–1.04) | 0.4 | 1.01 (0.96–1.06) | 0.7 |
| >12 mo | 1.16 (0.44–3.09) | 0.8 | 0.81 (0.71–0.93) | 0.002 | 0.93 (0.86–1.01) | 0.1 |

CI, confidence interval; HR, hazard ratio.

*Cox proportional hazards model adjusted for age, sex, and race.

†Cox proportional hazards model adjusted for age, sex, race, smoking, alcohol use, drug dependence, cause of end-stage renal disease, functional status (inability to ambulate or transfer, assistance with activities of daily living, institutionalization, employment at the time of end-stage renal disease onset), comorbid conditions (history of atherosclerotic heart disease, congestive heart failure, cerebrovascular accident, peripheral vascular disease, hypertension, diabetes, chronic obstructive pulmonary disease, cancer), hemoglobin at dialysis initiation, vascular access at dialysis initiation, predialysis erythropoietin use, insurance at the time of dialysis initiation.