Relationship between Clinical Performance Measures and Outcomes among Patients Receiving Long-Term Hemodialysis

Michael V. Rocco, MD, MS; Diane L. Frankenfield, DrPH; Sari D. Hopson, MSPH; and William M. McClellan, MD, MPH

Background: Patients receiving long-term hemodialysis have a yearly mortality rate of 15% to 20%.

Objective: To determine whether attaining clinical performance measures for hemodialysis care is associated with favorable 12-month mortality and hospitalization rates.

Design: Cohort study.

Setting: Outpatient hemodialysis centers in the United States.

Patients: 15 287 patients who were selected from a 5% random sample of patients receiving long-term hemodialysis.

Measurements: The authors used data from the Centers for Medicare & Medicaid Services End-Stage Renal Disease Clinical Performance Measures Project from 1999 and 2000. The clinical performance measure targets were hemoglobin value of 110 g/L or greater; serum albumin value of 40 g/L or greater or 37 g/L or greater (bromcresol green and bromcresol purple laboratory methods, respectively); use of a fistula for vascular access; and measured single-pool Kt/V urea value of 1.2 or greater. The outcome measures were death or hospitalization during 1-year follow-up.

Results: 8364 patients (54.7%) were hospitalized and 3062 (20.0%) died during the 12-month follow-up period. Six percent of patients did not meet any clinical measure targets, 24% met 1 target, 39% met 2 targets, 24% met 3 targets, and 7% met all 4 targets. The unadjusted 12-month hospitalization and mortality rates for these 5 groups were 60%, 60%, 56%, 49%, and 43% ($P < 0.001$) and 29%, 25%, 21%, 14%, and 7% ($P < 0.001$), respectively. The risk for death increased for each additional guideline indicator that was not met: Adjusted hazard ratios were 4.6 (95% CI, 3.3 to 6.4), 3.5 (CI, 2.6 to 4.7), 2.6 (CI, 1.9 to 3.5), and 1.9 (CI, 1.4 to 2.6) for 0, 1, 2, or 3 targets met, respectively, compared with meeting 4 targets (referent). Similarly, the risk for hospitalization increased for each additional guideline indicator that was not met: Adjusted hazard ratios were 1.6 (CI, 1.4 to 1.9), 1.5 (CI, 1.3 to 1.7), 1.3 (CI, 1.1 to 1.5), and 1.1 (CI, 0.98 to 1.3), respectively.

Limitations: It was not possible to determine the roles of severity of illness, other patient factors, or suboptimal care in failure to meet performance measures.

Conclusions: In patients receiving long-term hemodialysis, meeting multiple clinical measure targets is associated with a decrease in hospitalization and mortality rates.

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For author affiliations, see end of text.

Mortality rates among patients with end-stage renal disease (ESRD) in the United States have declined during the past 2 decades despite increases in the age and prevalence of diabetes in this population (1). The improvements in survival are not uniformly distributed across patients with differing durations of long-term dialysis therapy. Mortality rates have declined by 22% during the first 2 years after renal replacement therapy and by 15% during the next 3 years and have actually increased for patients surviving longer than 5 years (1). Despite these improvements in early survival, mortality rates remain quite high among patients with ESRD who are receiving hemodialysis, and 212 of every 1000 patients die annually.

It is important to identify potentially modifiable risk factors for the persistently high mortality rates among U.S. patients with ESRD. The quality of care provided after the onset of renal replacement therapy provides one example of a set of modifiable risk factors. In 1997, the National Kidney Foundation developed quality-of-care indicators as part of the Dialysis Outcomes Quality Initiative (DOQI). These indicators were modified by the Centers for Medicare & Medicaid Services (CMS) ESRD Clinical Performance Measures Project (formerly known as the ESRD Core Indicators Project). Increased adequacy of hemodialysis and control of anemia have been shown to be associated with improved survival and quality of life among patients with ESRD (2–4). During the past decade, there has been a statistically significant improvement in the adequacy of dialysis as measured by Kt/V urea and in anemia management, which was fostered and documented by the CMS Clinical Performance Measures Project (5).

Most studies that have examined the association between the quality of care of patients with ESRD and subsequent risk for death have used single measures of the quality of care provided to patients receiving dialysis (6–13). This approach fails to account for the possibility that achieving certain thresholds for multiple care processes is associated with less hospitalization and improvements in patient survival. We have tested this hypothesis using data from the ESRD Clinical Performance Measures Project to determine the association between hospitalization and mortality rates and meeting multiple guidelines for care delivered to patients receiving chronic hemodialysis.

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Methods

Study Design and Sample Selection

Detailed information about CMS's ESRD Clinical Performance Measures Project has previously been published (5). In brief, a random sample of Medicare-eligible adults receiving in-center hemodialysis stratified by the 18 ESRD Networks is selected each year from a census of patients with ESRD. The ESRD Networks are regional organizations contracted by CMS to perform quality oversight activities to ensure the appropriateness of services and quality of services for patients receiving dialysis. Patients were eligible for inclusion in the sample for each year of the study if they were at least 18 years of age as of 1 October of the previous year (for example, 1 October 1998 for study year 1999), were receiving in-center hemodialysis, and were alive on 31 December of the previous year. Clinical information was obtained on the selected patients for October to December of the year before the patient was chosen for the study. If a patient was randomly selected for more than 1 study year, then only the earlier year in which the patient was included in these samples was used for analytic purposes. For this analysis, data were analyzed for study years 1999 and 2000.

Context

Several intermediate outcomes are used to evaluate care in hemodialysis programs, but the relationship between these measures and patient outcomes is uncertain.

Contribution

The authors studied 4 intermediate outcome measures (anemia, serum albumin level, functioning vascular access, and dialysis adequacy) in a 5% random sample of all U.S. patients receiving long-term hemodialysis. Annual mortality rates in patients who met 0, 1, 2, 3, or 4 quality measures were 29%, 25%, 21%, 14%, and 7%, respectively.

Cautions

This study was unable to determine whether failure to meet an outcome measure was due to patient factors, such as severity of illness, or because of poor-quality care.

Implications

Failure to meet hemodialysis quality measures is associated with increased mortality and hospitalization rates.

—The Editors

Data Collection

In May of each study year, the ESRD Networks sent a 3-page data collection form to approximately 2700 facilities. These facilities selected 1 or more patients for the sample. The median number of patients sampled per center was 2, and the number of patients sampled at an individual dialysis center ranged from 1 to 27; the 25th and 75th percentiles were 1 and 4 patients, respectively. Available patient information included sex, age, race (white, black, Asian or Pacific Islander, Native American or Alaska native, and other or unknown), Hispanic ethnicity, the primary cause of ESRD, and number of years that the patient received dialysis.

In June of each study year, dialysis facility staff abstracted patient data from medical records for October to December of the previous year, including the patient's height, first documented blood urea nitrogen concentration before and after dialysis, weight before and after dialysis, dialysis session length, type of vascular access, hemoglobin value, and serum albumin value (bromcresol green or bromcresol purple laboratory methods). Completed forms were returned to the appropriate ESRD Network office where data were reviewed and entered into a computerized database. The Networks forwarded data to CMS for aggregation and analysis.

Data regarding comorbid conditions were obtained by merging the ESRD Clinical Performance Measures database with data from CMS Form 2728 (Medical Evidence Form). This form provides additional clinical information on each patient at the initiation of dialysis. Specifically, the presence or absence of each of the following conditions was ascertained at the initiation of dialysis: congestive heart failure; ischemic heart disease; coronary artery disease; myocardial infarction; cardiac arrest; cardiac dysrhythmia; pericarditis; cerebrovascular disease, cerebrovascular accident, or transient ischemic attack; peripheral vascular disease; history of hypertension; diabetes mellitus (primary or contributing); diabetes mellitus and current use of insulin; chronic obstructive pulmonary disease; tobacco use (current smoker); malignant neoplasm or cancer; alcohol dependence; drug dependence; HIV-positive status; AIDS; inability to ambulate; and inability to transfer.

Hospitalization information (all-cause hospitalization and ≥1 hospital admission during the follow-up period) was obtained from the U.S. Renal Data System's (USRDS) Hospitalization Standard Analytic File; dates of death, censoring information, and withdrawal from dialysis were obtained from the USRDS's Patients Standard Analytic File. Hospitalizations and dates of death were subsequently linked to the clinical information in the ESRD Clinical Performance Measures data file.

Statistical Analysis

The following intermediate outcomes or clinical measure targets were examined: mean Kt/V urea value of 1.2 or greater, mean hemoglobin value of 110 g/L or greater, use of an arteriovenous fistula for vascular access, and mean serum albumin value of 40 g/L or greater or 37 g/L or greater by the bromcresol green or bromcresol purple laboratory methods, respectively. In calculating mean values for Kt/V urea, hemoglobin, and serum albumin, all available reported data were used. If a value was missing for 1 of the study months, the mean value was calculated by averaging the 2 values over the 3-month study period. If values

Table 1. **Number of Clinical Performance Measures Met according to Patient Demographic Characteristics and Clinical Factors***

Variable	Patients	Clinical Measure Targets Met				
		0	1	2	3	4
Total, *n (%)*	15287 (100)	884 (6)	3684 (24)	5904 (39)	3730 (24)	1085 (7)
Sex, *n (%)*†						
Male	8136 (53)	497 (57)	1750 (48)	2840 (48)	2245 (60)	804 (74)
Female	7131 (47)	381 (43)	1928 (52)	3058 (52)	1485 (40)	279 (26)
Race, *n (%)*†						
White	8020 (52)	440 (50)	1866 (51)	3106 (53)	2025 (54)	583 (54)
Black	5638 (37)	367 (42)	1459 (40)	2195 (37)	1257 (34)	360 (33)
Hispanic ethnicity, *n (%)*†	1829 (12)	88 (10)	372 (11)	693 (12)	511 (14)	165 (16)
Primary cause of end-stage renal disease, *n (%)*						
Diabetes mellitus†	6224 (41)	418 (47)	1633 (44)	2547 (43)	1332 (36)	294 (27)
Hypertension‡	3915 (26)	202 (23)	877 (24)	1542 (26)	985 (26)	309 (28)
Glomerulonephritis†	1874 (12)	91 (10)	394 (11)	618 (10)	571 (15)	200 (18)
Age†						
18–44 y, *n (%)*	2620 (17)	176 (20)	561 (15)	837 (14)	723 (19)	323 (30)
45–64 y, *n (%)*	5829 (38)	386 (44)	1366 (37)	2176 (37)	1454 (39)	447 (41)
≥65 y, *n (%)*	6836 (45)	322 (36)	1755 (48)	2891 (49)	1553 (42)	315 (29)
Mean (SD), *y*†	60.7 (15.3)	58.6 (15.1)	61.8 (15.1)	62.4 (15.0)	59.4 (15.4)	54.5 (16.1)
Median, *y*	62.7	59.2	63.8	64.5	61.0	55.2
Duration of dialysis†						
<0.5 y, *n (%)*	2091 (14)	400 (45)	786 (21)	642 (11)	218 (6)	45 (4)
0.5–0.9 y, *n (%)*	2257 (15)	134 (15)	527 (14)	938 (16)	510 (14)	148 (14)
1.0–1.9 y, *n (%)*	3205 (21)	130 (15)	725 (20)	1266 (22)	830 (22)	254 (23)
≥2.0 y, *n (%)*	7728 (51)	220 (25)	1644 (45)	3056 (52)	2170 (58)	638 (59)
Mean (SD), *y*†	3.3 (3.7)	1.8 (2.9)	2.9 (3.5)	3.3 (3.6)	3.7 (4.0)	4.0 (4.4)
Median, *y*	2.0	0.63	1.7	2.1	2.5	2.4
BMI after dialysis, *kg/m²*						
Mean (SD)†	26.1 (6.4)	28.8 (7.6)	26.5 (7.0)	26.0 (6.2)	25.7 (5.9)	25.2 (5.4)
Median	25.0	27.4	25.1	24.8	24.8	24.3
Comorbid conditions, *n (%)*						
Cardiovascular†§	5512 (36)	365 (41)	1435 (39)	2250 (38)	1203 (32)	259 (24)
Noncardiovascular†‖	2084 (14)	161 (18)	565 (15)	819 (14)	418 (11)	121 (11)

* Clinical measure targets were mean Kt/V urea ≥1.2; mean hemoglobin value ≥110 g/L; use of an arteriovenous fistula for vascular access; and mean serum albumin value ≥40 g/L or ≥37 g/L by the bromcresol green or bromcresol purple laboratory methods, respectively. Percentages may not add up to 100% because of rounding. Subtotals may not equal 15 287 because of missing data. BMI = body mass index.
† Statistically significant differences among groups: $P < 0.001$.
‡ Statistically significant differences among groups: $P = 0.003$.
§ Cardiovascular comorbid conditions included cardiac arrest, congestive heart failure, cardiovascular disease, cardiac dysrhythmia, pericarditis, peripheral vascular disease, ischemic heart disease, and myocardial infarction.
‖ Noncardiovascular comorbid conditions included alcohol or drug dependence, cancer, HIV infection, AIDS, inability to ambulate or transfer, chronic obstructive pulmonary disease, and tobacco use.

were missing for 2 of the 3 months, the available value became the mean value for that patient. For calculating rates of arteriovenous fistula use, patients with missing data were excluded from the denominator. Associations of group classification with the clinical measure targets were tested by the chi-square test, the 2-tailed Student *t*-test, and hierarchical analysis of variance. A 2-tailed *P* value less than 0.01 was considered statistically significant. Racial categorization was restricted to black and white only because of the small numbers of patients in other racial groups. Comorbid conditions were categorized as cardiovascular or noncardiovascular for subsequent analyses. Cardiovascular comorbid conditions included cardiac arrest, congestive heart failure, cerebrovascular disease, cardiac dysrhythmia, pericarditis, peripheral vascular disease, ischemic heart disease, and myocardial infarction. Noncardiovascular comorbid conditions included alcohol dependence, cancer, drug dependence, HIV infection, AIDS, inability to ambulate, inability to transfer, chronic obstructive pulmonary disease, and tobacco use. If a comorbid condition was not indicated on the Medical Evidence Form, then we assumed it was not present for the purposes of this analysis.

To determine whether meeting 1 or more clinical measure targets was associated with hospitalization or death during the 12 months after the end of the study period, separate multivariable Cox proportional hazards modeling was performed. In addition to the number of clinical measure targets that were met, factors that were entered into the models included sex, race (black and white only), Hispanic ethnicity, age, years of dialysis, diabetes mellitus as the cause of ESRD compared with other causes combined, mean body mass index (weight in kilograms divided by the square of the height in meters) after dialysis, and preexisting cardiovascular and noncardiovascular comorbid conditions. Patients were censored at the time of transplantation, when they were switched to peritoneal dialysis, or when they were lost to follow-up for the Cox proportional hazards modeling analyses. All factors were entered simultaneously into the Cox proportional hazards models. Predictors with *P* values less than 0.05 were retained in the final models. Additional analyses were conducted by using Cox modeling in which the quality indicator variables were entered individually as dichotomous variables in 1 set of models and entered as continuous variables in another set of models. **Appendix Table 1** and **Appendix Table 2** (available at www.annals.org) show these results. Secondary analyses were also conducted to examine the potential effects of transplantation or withdrawal from dialysis on the findings derived from the Cox proportional hazards models. The data analyses were conducted by using SPSS, version 10.0 (SPSS, Inc., Chicago, Illinois), and SAS, version 8.02 (SAS, Inc., Cary, North Carolina).

Results

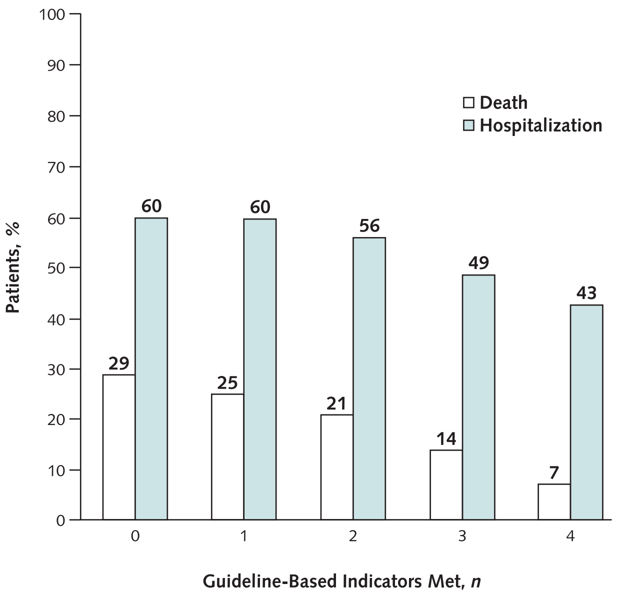
A total of 15 287 patients from 2668 dialysis facilities was included in the sample for analysis. For the 4 clinical measure targets that we examined, 100% of patients had data available to calculate a mean serum albumin value for the 3-month study period. For 98.2% (15 006 of 15 287 patients), a mean hemoglobin value was reported; for 98.0% (14 975 of 15 287 patients), a mean single-pool Kt/V urea value was reported; and for 97.2% (14 853 of 15 287 patients), the type of vascular access was reported. For the Cox proportional hazards modeling analyses, 115 patients were censored because of a switch to peritoneal

Table 2. **Number of Clinical Performance Measures Met according to Selected Intermediate Outcomes***

Clinical Measure	Clinical Measure Targets Met				
	0	1	2	3	4
Adequacy					
Mean Kt/V urea value (SD)†	1.01 (0.17)	1.39 (0.32)	1.50 (0.28)	1.52 (0.25)	1.51 (0.22)
Median Kt/V urea value	1.06	1.38	1.48	1.49	1.47
Mean Kt/V urea value ≥1.2, *n (%)*†	0 (0)	2521 (71)	5248 (90)	3562 (96)	1085 (100)
Vascular access type					
Arteriovenous fistula, *n (%)*†	0 (0)	212 (6)	1015 (18)	1770 (48)	1085 (100)
Arteriovenous graft, *n (%)*†	336 (40)	2094 (59)	3546 (62)	1554 (42)	0 (0)
Catheter, *n (%)*†	502 (60)	1232 (35)	1149 (20)	358 (10)	0 (0)
Anemia					
Mean hemoglobin value (SD), *g/L*†	97 (9)	104 (12)	115 (11)	119 (9)	121 (9)
Median, *g/L*	99	104	115	118	120
Mean hemoglobin value ≥110 g/L, *n (%)*†	0 (0)	714 (20)	4272 (73)	3390 (92)	1085 (100)
Serum albumin value					
Bromcresol green laboratory method					
Mean (SD), *g/L*†	34.4 (4.1)	35.7 (3.9)	37.5 (3.5)	40.3 (4.0)	42.3 (1.9)
Median, *g/L*	35.0	36.3	37.7	40.7	42.0
Bromcresol purple laboratory method					
Mean (SD), *g/L*†	30.0 (4.7)	32.5 (4.1)	35.1 (4.1)	37.8 (4.4)	40.4 (2.7)
Median, *g/L*	31.0	32.7	35.0	38.0	39.7
Mean serum albumin value ≥40 g/L or ≥ 37 g/L by bromcresol green or bromcresol purple laboratory methods, respectively, *n (%)*†	0 (0)	237 (7)	1273 (22)	2468 (67)	1085 (100)
Mean serum albumin value ≥35 g/L or ≥32 g/L by bromcresol green or bromcresol purple laboratory methods, respectively, *n (%)*†‡	452 (52)	2382 (66)	4772 (82)	3474 (94)	1085 (100)

* Clinical measure targets were mean Kt/V urea ≥1.2; mean hemoglobin value ≥110 g/L; use of an arteriovenous fistula for vascular access; and mean serum albumin value ≥40 g/L or ≥37 g/L by the bromcresol green or bromcresol purple laboratory methods, respectively. Continuous variables are displayed as the mean (SD) and median values, and categorical variables are displayed as numbers and percentages of available values.
† Statistically significant differences between groups: $P < 0.001$.
‡ Mean serum albumin values <35 g/L or <32 g/L by the bromcresol green and bromcresol purple laboratory methods, respectively, are defined in the Centers for Medicare & Medicaid Services End-Stage Renal Disease Clinical Performance Measures Project as inadequate for the purpose of the End-Stage Renal Disease Clinical Performance Measures Annual Report and have been shown to be markers for diminished survival.

Figure 1. **One-year mortality rates and percentage of patients hospitalized during a 1-year period based on the number of guideline-based indicators that were met during the preceding year.**



dialysis, and 553 were censored because of transplantation; another 437 were lost to follow-up.

Patients were categorized by the number of clinical measure targets that were met over the 3-month observation period. Six percent of patients did not meet any clinical measure targets, 24% met 1 target, 39% met 2 targets, 24% met 3 targets, and 7% met all 4 clinical measure targets (**Table 1**). Patients who met all clinical measure targets were more likely to be male, of white race, of Hispanic ethnicity, and younger; have hypertension or glomerulonephritis as the cause of ESRD; have a lower body mass index after dialysis; and have received dialysis for more years. They were less likely to have diabetes mellitus as the cause of ESRD and less likely to have cardiovascular or noncardiovascular comorbid conditions ($P < 0.001$ for all except hypertension as the cause of ESRD [$P = 0.003$]).

Table 2 shows the intermediate outcomes for all patients by the number of clinical targets that were met. The mean single-pool Kt/V urea value for all patients in the sample was 1.45 (SD, 0.30), and 17% of patients had a mean Kt/V urea value less than 1.2. The mean hemoglobin value was 113 g/L (SD, 13), and 37% of patients had a hemoglobin value less than 110 g/L. The mean serum albumin values were 37.9 g/L (SD, 4.3) and 35.3 g/L (SD, 5.0) by the bromcresol green laboratory method and the bromcresol purple laboratory method, respectively. Sixty-seven percent of patients had a serum albumin value that was either less than 40 g/L by the bromcresol green laboratory method or less than 37 g/L by the bromcresol purple laboratory method. Twenty-eight percent of patients had an arteriovenous fistula, 51% had an arteriovenous graft, and 22% had a catheter for vascular access during hemodialysis.

A comparison of the guideline-based indicator targets suggests that some targets were more easily achieved than others in all patients. For dialysis adequacy as measured by Kt/V urea, patients who met 2 or more guideline-based indicators had a mean Kt/V urea value of more than 1.50 compared with 1.39 if only 1 guideline-based indicator was met and 1.01 if no guideline-based indicators were met. Similarly, for hemoglobin, patients who met 2 or more guideline-based indicators had a mean hemoglobin value of more than 114 g/L, compared with 104 g/L if only 1 guideline-based indicator was met and 97 g/L if no guideline-based indicators were met. The use of an arteriovenous fistula was a difficult guideline-based indicator to meet because fewer than 50% of patients who met 3 of the guideline-based indicators had an arteriovenous fistula in place. Finally, for serum albumin, there was a consistent increase of 1.0 g/L to 3.0 g/L for each guideline-based indicator that was met, regardless of the method used to measure these values.

Mortality rates and risk for hospitalization decreased with increasing numbers of clinical targets that were met. Unadjusted 1-year mortality rates for patients attaining 0 to all 4 clinical indicators (5 groups) were 29%, 25%, 21%, 14%, and 7% ($P < 0.001$), respectively (**Figure 1**). The percentages of patients who were hospitalized 1 or more times during the 1-year follow-up period in each of these 5 groups were 60%, 60%, 56%, 49%, and 43% ($P < 0.001$), respectively (**Figure 1**).

When multivariate Cox proportional hazards analysis was used, there was a progressive increase in the risk for 12-month mortality and hospitalization rates for each clinical measure that was not met (**Table 3**). The increase in the hazard ratio for death for each additional guideline-based indicator that was not met was 70% to 90%. A Kaplan–Meier plot of mortality rates stratified by the number of guideline indicators that were met shows a marked decline in survival for each additional guideline-based indicator that was not met (**Figure 2**; $P < 0.001$). For hospitalization, the increase in the hazard ratio for hospitalization for each additional guideline-based indicator that was not met was 10% to 30% (**Figure 2**). The findings for the Cox proportional hazards models for death and hospitalization were similar when patients who had transplantation were not censored from the analysis ($n = 553$) and when patients who withdrew from dialysis were excluded from the data analysis ($n = 1751$; data not shown).

Finally, we performed additional data analyses to account for the possibility of death as a competing risk in the hospitalization analysis. This analysis showed no informative censoring of the association between hospitalization and quality of care. In addition, there was a strong gradient

Table 3. **Final Cox Proportional Hazards Models Predicting 12-Month Mortality and Hospitalization Rates***

Variable	Mortality		Hospitalization	
	Adjusted Hazard Ratio (95% CI)	*P* Value	Adjusted Hazard Ratio (95% CI)	*P* Value
Targets met				
0	4.6 (3.3–6.4)	<0.001	1.6 (1.4–1.9)	<0.001
1	3.5 (2.6–4.7)	<0.001	1.5 (1.3–1.7)	<0.001
2	2.6 (1.9–3.5)	<0.001	1.3 (1.1–1.5)	<0.001
3	1.9 (1.4–2.6)	<0.001	1.1 (0.98–1.3)	0.096
4 (referent)	1.0		1.0	
Male sex		NS	0.90 (0.85–0.95)	<0.001
White race	1.5 (1.3–1.6)	<0.001	1.07 (1.00–1.13)	0.035
Hispanic ethnicity	0.71 (0.59–0.84)	<0.001	0.83 (0.75–0.91)	<0.001
Age	1.031 (1.027–1.035)	<0.001	1.006 (1.004–1.008)	<0.001
Duration of dialysis	1.05 (1.02–1.07)	<0.001	1.03 (1.02–1.05)	<0.001
Diabetes mellitus as the cause of end-stage renal disease (versus all other causes combined)	1.5 (1.3–1.6)	<0.001	1.16 (1.10–1.23)	<0.001
BMI after dialysis	0.958 (0.950–0.966)	<0.001	0.989 (0.984–0.993)	<0.001
Cardiovascular comorbid conditions†	1.2 (1.1–1.3)	<0.001	1.15 (1.09–1.22)	<0.001
Noncardiovascular comorbid conditions‡	1.3 (1.1–1.4)	<0.001	1.10 (1.02–1.17)	0.010

* Clinical measure targets were mean Kt/V urea value ≥1.2; mean hemoglobin level ≥110 g/L; use of an arteriovenous fistula for vascular access; and mean serum albumin value ≥40 g/L or ≥37 g/L by bromcresol green and bromcresol purple laboratory methods, respectively. All variables entered into the models are presented in the table. BMI = body mass index; NS = not significant.
† Cardiovascular comorbid conditions included cardiac arrest, congestive heart failure, cardiovascular disease, cardiac dysrhythmia, pericarditis, peripheral vascular disease, ischemic heart disease, and myocardial infarction.
‡ Noncardiovascular comorbid conditions included alcohol or drug dependence, cancer, HIV infection, AIDS, inability to ambulate or transfer, chronic obstructive pulmonary disease, and tobacco use.

of increased risk for hospitalization associated with declining quality of care (data not shown).

Discussion

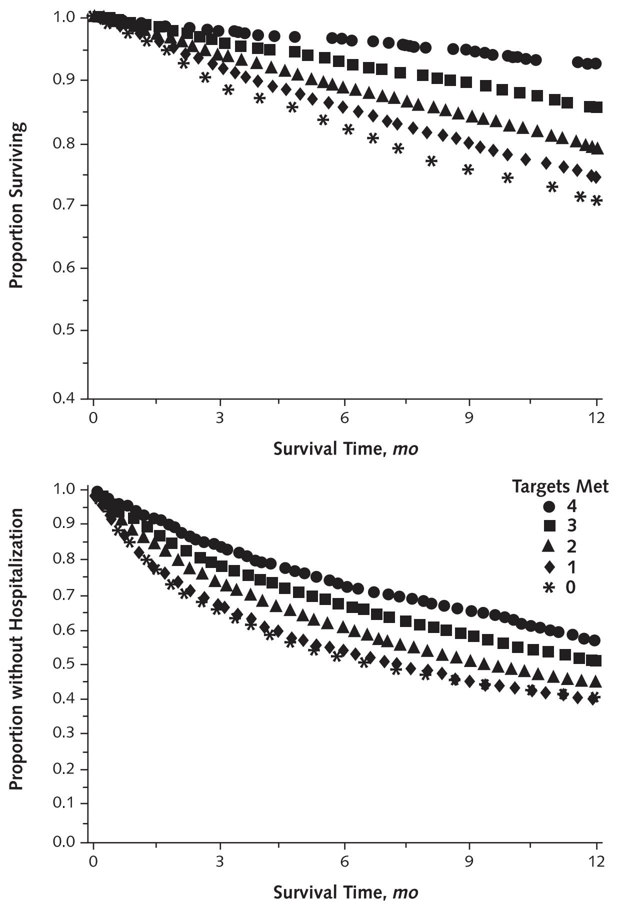
This study shows that there is a relationship between meeting a cumulative number of clinical measures that reach guideline-recommended goals and outcomes of care of patients with ESRD. In this respect, it is important to note that a high proportion (69%) of this nationally representative sample of patients receiving chronic hemodialysis achieved recommended therapeutic targets for 2 or fewer of the quality indicators. This finding had profound implications for subsequent outcomes and was associated with increased risk for hospitalization and death.

The high prevalence of patients who did not meet clinical targets is surprising. Since 1994, the CMS has conducted a national program to improve the care of patients who are receiving dialysis in the United States (5). This program seeks to promote the adoption and use of clinical practice guidelines in the care of such patients. The findings from these annual data collections are used to target facility-specific quality improvement interventions and to monitor trends in the quality of care (14).

Since the inception of this quality improvement program in 1994, we and others have observed substantial improvements in individual variables of care, such that the proportion of patients receiving long-term hemodialysis who meet adequacy targets has improved from 80% in 1998 to 89% in 2002 (14, 15). This improvement is probably due to active interventions to adjust the dialysis prescription. Comparable changes in control of anemia, from 59% to 79%, are probably due to active interventions to adjust the erythropoietin dose and provide intravenous iron as appropriate (14). An increase from 26% to 33% in the presence of a fistula for vascular access (14) is probably due to multiple factors, including timing of referrals to nephrologists and to surgeons for access placement and the types of vascular access that are placed by an individual surgeon. Clearly, this intermediate outcome is influenced by personnel inside and outside the dialysis unit and includes non-nephrology personnel. Although not targeted for quality improvement interventions, serum albumin levels have been monitored and reported by the ESRD Clinical Performance Measures Project. Serum albumin values have not appreciably changed over a 10-year period of observation, which is probably due to the paucity of interventions that have been shown to increase these values and to the influence of comorbid medical conditions on decreasing the synthetic rate of albumin synthesis by the liver (16).

In addition, comorbid medical conditions may make it more difficult to achieve intermediate outcomes for dialysis dose, anemia, and dialysis access in selected patients. For example, a patient with peripheral vascular disease may not have suitable vasculature to create an arteriovenous fistula, and some patients prefer a catheter and will decline to have a fistula placed. A morbidly obese patient may not be able

Figure 2. **Kaplan–Meier survival curve based on the number of guideline-based indicators that were met in the preceding year (*top*) and Kaplan–Meier hospitalization curve based on the number of guideline-based indicators that were met in the preceding year (*bottom*).**



to achieve adequate dialysis because of the large amount of time required for dialysis, and a patient with chronic gastrointestinal bleeding or hematologic conditions, such as sickle-cell anemia or multiple myeloma, may be unable to attain hemoglobin targets. Lack of information of these disease states would lead to a bias away from the null.

Other barriers to meeting intermediate outcomes are socioeconomic and include nonadherence to medical therapy, inability to afford prescription medications, and difficulty arranging transportation for dialysis or clinic appointments. Future iterations of clinical performance measure calculations should consider comorbid conditions and socioeconomic factors that may decrease the patient's likelihood of achieving these intermediate outcomes.

Because of the small number of patients evaluated at each center, it was not possible to determine variability in attaining process measures across ESRD centers. Ascertainment of ESRD center effects would require the collection of data from all patients in a very large number of dialysis centers. The current CMS ESRD Clinical Performance Measures Project obtains data on only a 5% random sample of patients with ESRD, although plans are under way to obtain complete data collection for these intermediate outcomes in the near future.

Because this was not a randomized, controlled clinical trial but a retrospective analysis of a limited set of variables, it is not possible to determine causality, only associations of these variables with the outcomes examined. In addition, it is recognized that comorbid conditions are underreported on the Medical Evidence Form (17) and that information on the severity of such reported comorbid conditions was not available. However, a recent comparison of different comorbidity indices assessing severity of disease did not find improved prognostic power in predicting survival after adding severity grading (18). Finally, we could not determine the roles of severity of illness, other patient factors, or suboptimal care in the failure to meet performance measures.

Despite individual improvements in quality indicator performance, our results show that there is substantial variability among patients with respect to the overall attainment of multiple therapeutic targets. In turn, increasing attainment of multiple therapeutic targets in an individual patient is associated with decreasing risk for hospitalization and death. This observation is consistent with reported studies that have documented an increased risk for death and hospitalization associated with lower levels of dialysis adequacy (4, 7, 8), increasing degrees of anemia (3), lower serum albumin values (4, 9–11), and hemodialysis with vascular access other than an arteriovenous fistula (13). These analyses typically account for the joint influence of various quality indicators on a clinical outcome by treating 1 quality indicator as the intervention of interest and the remaining quality indicators as covariates in a multivariate model. This provides an estimate of the association between an individual quality indicator and the outcome of interest, controlling for other patient characteristics, including other quality-of-care indicators. Our analysis is thus different from previous analyses because we examined the impact of the cumulative attainment of multiple quality indicators on death and hospitalizations in patients with ESRD.

Additional analyses showed that individual quality indicators were associated with reductions in death and hospitalization when these indicators were entered as either dichotomous or continuous variables in the multivariate models (**Appendix Tables 1** and **2**, available at www.annals.org). The association between anemia and adequacy of dialysis with both outcomes was somewhat smaller than for albumin and vascular access, perhaps reflecting the marked reduction in variability and the improved care for anemia and adequacy of dialysis (2). Our observations support the current approach of maintaining the quality-of-care gains over the past decade for adequacy of dialysis and anemia management and incorporating arteriovenous access as a focus for quality improvement. They also underscore the need to develop quality improvement programs targeted at nutrition. Our observations are consistent with an emphasis on the incremental value of exceeding multiple thresholds within individual patients and support the view that meeting additional clinical targets in a specific patient will result in a cumulative benefit of improved morbidity and survival.

We have shown that decreased attainment of multiple therapeutic targets is associated with higher mortality rates and higher hospitalization rates in a dose-dependent manner. This suggests that quality improvement activities might better focus on a particular outcome and seek the joint improvement of the multiple modifiable factors associated with that outcome. This is a testable premise, and one can envision a trial of targeted versus multifactorial quality improvement on outcomes of ESRD care. For example, the Fistula First Project, sponsored by CMS, is designed to increase the percentage of patients receiving long-term hemodialysis in whom an arteriovenous fistula is used. Consideration should be given to new quality improvement projects designed to increase the percentage of patients who meet multiple clinical performance measures.

In conclusion, our data provide confirmatory evidence that clinical performance measures are associated with morbidity and mortality in patients receiving chronic hemodialysis. Although 3 of the 4 clinical performance measures have improved in the past 10 years, there is still room for additional improvement individually in measures of care and in the quality improvement process used to remediate less than optimal outcomes.

From Wake Forest University School of Medicine, Winston-Salem, North Carolina; Centers for Medicare & Medicaid Services, Baltimore, Maryland; and Emory University, Atlanta, Georgia.

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Requests for Single Reprints: Michael V. Rocco, MD, MS, Section on Nephrology, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157-1053; e-mail, mrocco@wfubmc.edu.

Current author addresses are available at www.annals.org.

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Current Author Addresses: Dr. Rocco: Section on Nephrology, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157-1053.
Dr. Frankenfield: Centers for Medicare & Medicaid Services, Office of Clinical Standards and Quality, 7500 Security Boulevard, Mailstop S3-02-01, Baltimore, MD 21244.
Ms. Hopson and Dr. McClellan: Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, GA 30322.

Appendix Table 1. **Binary Model***

Outcome	Risk Factors (Quality-of-Care Indicators)			
	Adequacy of Dialysis (Kt/V Urea Value)	Anemia (Hemoglobin Value)	Arteriovenous Fistula	Albumin Value
Time to death				
β	−0.07691	−0.30404	−0.31379	−0.57087
Hazard ratio (95% CI)	0.926 (0.817 to 1.049)	0.738 (0.672 to 0.810)	0.731 (0.648 to 0.823)	0.565 (0.501 to 0.637)
Time to hospitalization				
β	−0.00271	−0.20173	−0.22647	−0.14269
Hazard ratio (95% CI)	0.997 (0.924 to 1.076)	0.817 (0.771 to 0.867)	0.797 (0.744 to 0.854)	0.867 (0.814 to 0.924)

* Quality-of-care indicators were modeled as either target met (1) or target not met (0). The quality-of-care target was met for each indicator as follows: mean hemoglobin value, ≥110 g/L; adequacy of dialysis, mean Kt/V value ≥1.2; arteriovenous fistula in place (dichotomous variable [yes or no]); and mean albumin value ≥40 g/L or ≥37 g/L by the bromcresol green and bromcresol purple laboratory methods, respectively.

Appendix Table 2. **Standardized Continuous Model***

Outcome	Risk Factors (Quality-of-Care Indicators)			
	Adequacy of Dialysis (Kt/V Urea Value)	Anemia (Hemoglobin Value)	Arteriovenous Fistula	Albumin Value
Time to death				
β	−0.01100	−0.12162	−0.26027	−0.37748
Hazard ratio (95% CI)	0.989 (0.938 to 1.043)	0.885 (0.842 to 0.931)	0.771 (0.679 to 0.876)	0.686 (0.652 to 0.720)
Time to hospitalization				
β	−0.03148	−0.10470	−0.22259	−0.08781
Hazard ratio (95% CI)	0.969 (0.937 to 1.002)	0.901 (0.873 to 0.929)	0.800 (0.743 to 0.863)	0.916 (0.886 to 0.947)

* Quality-of-care indicators were modeled as standardized continuous variables. The quality-of-care target was met for each indicator as follows: mean hemoglobin value, ≥110 g/L; adequacy of dialysis, mean Kt/V urea ≥1.2; arteriovenous fistula in place (dichotomous variable [yes or no]); and mean albumin value ≥40 g/L or ≥37 g/L by the bromcresol green and bromcresol purple laboratory methods, respectively. Models that use standardized covariates provide parameter estimates and hazard ratios that are not contingent on the unit of measure. The standardized value for each quality-of-care indicator is calculated by subtracting the mean value of the indicator from the observed value of the indicator, then dividing this difference by the standard deviation of the indicator.