The Medicare end-stage renal disease (ESRD) program costs more than $2 billion a year. Costs per treatment vary significantly across hemodialysis facilities, yet the relationship of these cost differentials to case mix and outcomes is uncertain. This study analyzed treatment variations in 527 chronic hemodialysis patients dialyzing in four freestanding and three hospital-based facilities. Results indicated that patients receiving care in the hospital-based units received a more costly routine dialysis treatment as well as more intensive nursing care during the treatment process than did patients in freestanding units. Policy and clinical implications of the findings are discussed.

Variations in the Hemodialysis Treatment Process

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Variations in treatment processes and their effects on patient outcomes and the costs of care are currently of high interest to health policy researchers and clinicians. Variations may be appropriate if they are due to differences in the needs of individual patients and if the various patterns of care are close in terms of effectiveness and efficiency. However, previous studies have repeatedly demonstrated that practice style vari-

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ations alone account for many of the differences observed in care of patients with similar conditions (Brook et al., 1984; Wennberg, 1984; Wennberg & Gittelsohn, 1982).

Treatment variations have important cost implications. Variations in nursing resource allocations to diagnostically similar patients have cost implications as well. This article explores the relationships between practice patterns, clinical and sociodemographic characteristics of hemodialysis patients, and outcomes of care.

THE PROBLEM

The United States Medicare program has been paying for the treatment of individuals with end-stage renal disease (ESRD) since 1973. These renal patients represent high-cost beneficiaries because of the resource-intensive hemodialysis and transplant procedures required as well as the chronic nature of the condition and its treatment. Patients receive center hemodialysis treatments in either hospital-based outpatient units or freestanding (independent) units. Although Medicare payment rates per treatment are higher on average for patients dialyzing in hospital-based units, there is no standard adjustment for possible case mix differences between the two types of units. Hospital-based units have been arguing for years that they are dialyzing a more complex and severely ill case mix than the freestanding units. The freestanding units counter that the higher costs experienced by hospital-based units are instead the result of inefficient practices rather than patient mix differences.

REVIEW OF LITERATURE

Several studies have attempted to determine whether case mix differences exist across the different types of hemodialysis units. Most of these studies were limited by lack of detailed patient data, and many used patient care outcomes or medical treatment processes as proxies for case mix. Few if any examined the relationships between case mix measures and treatment patterns or costs.

An early study, reported by Hampers and Hager (1979), concluded that patients did *not* differ with respect to medical risk factors, that for-profit units dialyzed patients more intensively (a greater number of hours per week), and that functional status was the same across the units. Eggers (1982) reported that hospital-based units might have a more complex case mix because they had lower survival rates, longer hospital episodes, higher hospitalization rates, more diabetics, and more newly initiated patients. Plough and his colleagues (Plough, Shwartz, & Salem, 1984; Plough, Shwartz, Salem, Weller, & Ferguson, 1985) used cluster analysis to estimate the probability of death in the first year of treatment and over the course of treatment. They concluded that hospital-based units may be taking care of a more severe case mix because these units had more patients in the highest severity groupings and higher death rates within each severity grouping. Representatives of the freestanding units argued that Plough et al.'s results only demonstrated higher mortality rates in hospital-based units after controlling for severity differences, and therefore might only indicate lower quality of care in those units (Lowrie & Hampers, 1984; Tell, 1984).

Jones et al. (1986) analyzed a onetime Health Care Financing Administration patient inventory and corresponding unit audit and found significantly higher costs in the hospital-based units. Factors associated with the higher costs were higher overhead allocations, higher average salaries per full-time-equivalent employee, more employees per treatment, and a higher percentage of patients with an unknown or "other" renal diagnosis. Case mix differences did exist between the two types of units but were not shown to be related to the higher costs of hospital-based units. The data did not allow an examination of whether higher costs were associated with better outcomes.

PURPOSE OF STUDY

This article presents the results of a study that attempted to measure hemodialysis practice pattern differences across the freestanding and hospital-based units using methods developed to measure both routine and nonroutine care processes occurring during the hemodialysis treatment process. The study also explored whether specific sociodemographic and clinical factors were associated with resource use variations.

METHOD

SAMPLE

The sample consisted of 527 patients dialyzing in seven different hemodialysis units in one geographic region of a Southern state. Of these patients, 240 were from four free-standing units and 287 were from three hospital-based units. These patients constituted the entire population of chronic patients dialyzing for more than 3 months' time within these units. The units were selected on the basis of (a) medical and nursing director willingness to participate in the study and (b) accessibility by the study researchers.

MEASURES

Standard Hemodialysis Process

The first approach to measuring resource use per hemodialysis treatment was to identify the standard or routine hemodialysis treatment being delivered to patients within the two dialysis settings. Data collected for each patient included the number of treatments and number of hours of treatment per week, type of artificial kidney, type of dialysate delivery system, number of medications prescribed during treatments and number of nondialysis medications, and reuse of the artificial kidney.

Nonstandard Hemodialysis Treatment

The second approach to measuring resource use during hemodialysis treatments was to monitor the occurrence of unusual or nonroutine interventions delivered to patients over a 3-month period. Interviews were held with practicing hemodialysis staff nurses, unit educators, and a clinical nurse specialist for the purpose of identifying the range of nonroutine interventions or unusual events that could occur during hemodialysis treatment and would thus generate additional nursing time and medical supply requirements. A list of these hemodialysis "intensity events" was generated and added to the data collection instrument. A record was kept of each time an event of this type occurred over a 3-month time period.

Because the identified intensity events ranged in levels of seriousness and predicted resource requirements, a method was devised to attach incremental cost estimates to each event so that additional resource requirements could be estimated for each patient. Four expert nephrology nurses (two hemodialysis unit directors, one hemodialysis unit in-service educator, and one nephrology nurse specialist) were asked to provide estimates of the number of minutes it would take an experienced registered nurse to respond to each intensity event and what medical supplies would be required. Each nurse expert provided an estimate of the minimum and the maximum requirements per intensity event.

Unit price lists were obtained from the nurse experts, who also supplied information on current hourly nurse wage rates within their units. Average supply costs for each item were calculated, as were average nurse salary costs per hour. These figures were then applied to the low and high estimates of additional nursing time and supply requirements per intensity event and then multiplied by the number of times that each event occurred over the 3-month monitoring period for each patient. The result was an imputed standard cost or price per event that was used to estimate additional resources consumed by each patient experiencing unusual events during hemodialysis treatments. Although this method does not reflect actual costs incurred by the individual units or patient, it eliminates the problem of differing supply and wage costs across units. The resources intensity variables and imputed costs are shown in Table 1.

PROCEDURE

Information collected on each patient included sociodemographic characteristics, treatment characteristics, clinical variables, such as primary diagnosis and comorbidities, and outcomes. Data were obtained from review of medical records and unit treatment flow charts and were collected by staff hemodialysis nurses who were reimbursed for their efforts. The

Table 1
Resource Consumption Measurement Using Hemodialysis Intensity Events

	Nursing minutes		Labor costs (in dollars)		Supply costs (in dollars)	
Intensity event	Low	High	Low	High	Low	High
Gastrointestinal bleeding	30	60	5.76	11.53	1.32	72.06
Nose bleeding	5	60	0.96	11.53	6.74	7.57
Access site bleeding	5	60	0.96	11.53	0.30	10.30
Clotted kidney	10	30	1.92	5.76	12.07	12.25
Clotted lines	10	20	1.92	3.84	2.44	2.44
Vasopressor	5	10	0.96	1.92	11.57	11.57
Blood expander	5	10	0.96	1.92	2.17	2.17
Saline infusion	5	10	0.96	1.92	2.00	2.00
Nonresponsiveness	30	60	5.77	11.53	2.56	2.56
Agitation	60	60	11.53	11.53	6.29	12.19
Noncooperation	15	30	2.88	5.77	0.00	0.00
Partial code	20	60	3.84	11.53	8.08	8.08
Full code	60	120	11.53	23.06	55.76	55.76
Severe cramping	5	30	0.96	5.76	1.16	12.19
Blood pressures	2	5	0.38	0.96	0.00	0.00
Temperatures	1	3	0.19	0.58	0.21	0.21
Chest pain	15	30	2.88	5.77	0.11	2.26
Severe hiccups	5	15	0.96	2.88	10.77	10.77
Antibiotic therapy	10	60	1.92	11.53	9.29	70.79
Rhythm strip	5	15	0.96	2.88	1.68	1.68
Minor dressing	5	15	0.96	2.88	0.39	0.44
Major dressing	5	20	0.96	3.84	1.65	3.07
Oxygen therapy	5	30	0.96	5.77	1.08	1.08
Restraints	5	30	0.96	5.77	5.06	5.06
Blood draws	5	5	0.96	0.96	0.13	0.84
Cultures	5	5	0.96	0.96	0.71	0.71
Access clotting	10	20	1.92	3.84	2.39	2.39
Needle insertion	5	30	0.96	5.77	1.97	1.97
Dislodged needles	10	15	1.92	2.88	1.64	1.64
Persistent nausea and vomiting	15	45	2.88	8.65	10.41	10.41
Transfusions	15	60	2.88	11.53	76.49	111.49
Seizures	15	60	2.88	11.53	20.82	20.82
Isolation	10	45	1.92	8.65	1.15	1.15

information collected was available in the same form across all the units in the study. Extensive training sessions were held at each site by a research associate who was also an experienced hemodialysis nurse. In addition, each site had a study coordinator who assigned patients to nurse data collectors and reviewed data collection forms for completeness and accuracy.

RESULTS

DEMOGRAPHICS

The sample was 67% Black and 41.5% male. More than half of the patients demonstrated a relatively low educational level, with 59.2% having less than a high school education. A substantial number were married (43.4%), but the majority were either single, divorced, or widowed. Half of the patients owned their own home; the other half either rented or lived with other people, including a small percentage who were in nursing homes. Whereas a substantial portion of the sample was receiving Medicaid benefits (40.4%), a slightly higher percentage reported having additional private health insurance. A very small percentage of the patients worked, and only 58% were judged able to carry on normal activity or to do active work, findings that may in part be related to the fact that 31.8% of the sample was over the age of 65 years.

Table 2 shows the distribution of sociodemographic characteristics across the two types of hemodialysis units. There are several significant differences in characteristics of the patients being dialyzed, with the hospital-based units taking care of a lower sociodemographic group in general.

STANDARD HEMODIALYSIS TREATMENT PATTERNS

As seen in Table 3, there were significant variations in routine treatment patterns across the two types of hemodialysis units. Patients in the freestanding units dialyzed a greater number of hours per week on average than did those in the hospital-based units. They were also prescribed more nondialysis medications, although the number of different medications administered during hemodialysis treatments was essentially the same across the units. Patients dialyzing in the hospital-based units more often had an external access device, perhaps indicating more problems maintaining their circula-

Table 2
Comparison of Patient Demographic Information, by Type of Hemodialysis Facility (in percentages)

Variable	Freestanding unit	Hospital-based unit
Race*		
White	45.8	18.6
Black	52.1	80.0
Other	2.1	1.3
Sex		
Male	41.4	41.5
Female	58.6	58.5
Education		
College graduate	7.7	9.2
Some college	10.7	9.9
High school graduate	25.3	18.8
Less than high school	56.2	62.1
Marital status		
Single	10.5	15.2
Divorced	19.8	20.9
Married	48.1	39.5
Widowed	21.4	24.3
Living arrangement*		
Homeowner	59.3	44.7
Renting	22.1	29.4
Other	18.6	26.0
Financial status*		
Medicaid	35.2	44.7
Health insurance	43.8	28.6
Mean number in household*	2.5	2.8

*$p < .05$.

tory access, although the mean number of accesses per patient was the same across the units. Results indicated that patients in the hospital-based units were more likely to receive a more individualized treatment process, with more frequent use of special artificial kidneys (coil or flat plate), special dialysate solutions (usually bicarbonate rather than acetate), and an individualized rather than centralized dialysate delivery system. In addition, patients in the hospital-based units were less likely to experience reuse of their dialyzers. Although the study was unable to ascertain the actual costs of the standard

Table 3
Distribution of Treatment Characteristics, by Type of Facility

Variable	Freestanding unit	Hospital-based unit
Schedules		
Hours per week**	10.7	10.1
Number of treatments per week	2.9	2.8
Drug routine		
Number of routine medications*	4.7	4.5
Number of dialysis medications	1.4	1.6
Percentage access type**		
Internal	96.6	86.5
External	3.4	12.8
Other	0.0	0.7
Percentage artificial kidney type**		
Hollow fiber	93.3	84.5
Flat plate	6.7	15.5
Percentage delivery system used**		
Central	55.4	2.1
Individual	44.6	97.7
Percentage special dialysate used**	3.8	25.3
Percentage dialyzer reuse**	90.4	41.9

*$p < .05$; **$p < .01$.

dialysis treatments within each unit, it seems logical that a more individualized treatment process with less reuse of the artificial kidney, the single most expensive item associated with the treatment, would generate higher costs per patient per treatment.

NONSTANDARD HEMODIALYSIS COSTS PER TREATMENT

Patients dialyzing in hospital-based units experienced a significantly higher number of intensity events (mean = 42.2) than did those in the freestanding units (mean = 25.5). Patients in hospital-based units had more instances of clotted artificial kidneys and blood lines, blood expander infusions, nonroutine saline infusions, severe muscle cramps with treatment, and nonroutine blood pressure and temperature measurements. Patients in the freestanding units experienced persistent nausea and vomiting significantly more often. Again, the patients in the hospital-based units appeared to be experiencing a more resource-intensive dialysis treatment. The next phase of the analysis focused on identifying patient sociodemographic and clinical characteristics that had a significant association with the incremental resource requirements of chronic hemodialysis patients.

MULTIVARIATE ANALYSIS

Several ordinary least squares regression models were estimated for the dependent variable total incremental treatment costs. The first model included clinical independent variables, the second model added sociodemographic characteristics, and the third model added standard treatment process variables.

The first model for incremental treatment costs was significant and explained 21.6% of the variation in these costs. Each additional "other" comorbid condition was associated with $58.43 in incremental treatment costs over the 3-month monitoring period. This comorbid list included acute and chronic lung disease, hematologic disorders, bone osteodystrophy, arthritis, and nonrenal malignancies. Each time that a patient did not appear for a scheduled hemodialysis treatment was associated with $49.51 in incremental costs. One of the primary renal diagnoses, other renal diagnosis (usually either congenital anomaly or posttraumatic acute tubular necrosis), was associated with $415.51 in incremental treatment costs. The primary renal diagnosis of diabetes mellitus did not achieve statistical significance. Positive hepatitis antigen, which requires dedicated machines and strict isolation procedures, was associated with $333.84 in additional treatment costs.

Two physiologic variables were statistically significant in this model. Each unit percentage increase in hematocrit levels (reflecting less severe anemia) was associated with $18.28 in lower incremental costs, whereas each 1 mEq increase in serum potassium levels was associated with $91.91 in additional treatment costs. Residual urine formation capability was associated with lower incremental costs, as were increasing patient age and length of time receiving chronic hemodialysis treatments. Increasing number of accesses was associated with significantly higher incremental treatment costs. A different model specification that used specific comorbid conditions rather than grouped comorbids revealed that other cardiovascular conditions ($215), hepatitis ($303), systemic infection ($265), and lung disease ($172) had significant, positive associations with incremental treatment costs.

When sociodemographic variables were added, one additional variable achieved statistical significance: Being a Medicaid recipient was associated with $170.79 in incremental treatment costs. Interestingly, treatment history and number of no-shows for scheduled treatment were no longer statistically significant in this model. The explained variance increased slightly to 23.01%.

Several standard treatment variables achieved statistical significance when added to the model. Each additional medication prescribed for administration during hemodialysis treatments was associated with $83.46 in incremental treatment costs. Each additional hour of hemodialysis treatment per week was associated with $44.45 in additional costs, and reuse of the artificial kidney was associated with $115.63 in incremental treatment costs over the 3-month monitoring period. The explained variance improved to 28.1%. These results are shown in Table 4.

RELATIONSHIP BETWEEN TREATMENT PROCESSES AND OUTCOMES

Of much interest to patients, clinicians, and policymakers is whether treatment variations are associated with differences in patient care outcomes. In this analysis, bivariate techniques did not reveal a significant difference across the two types of units in the occurrence of death nor in the rate or days of hospitalization. Thus the noted differences in treatment style by type of unit did not appear to make a difference in these two clinical outcomes measured over a relatively short period of time (6 months).

DISCUSSION

The end-stage renal disease program has been subjected to several reductions in reimbursement rates per treatment (Maxwell & Sapolsky, 1987). These lower reimbursement levels

Table 4
Regression Results for Total Incremental Costs Using Grouped Comorbid Conditions: Significant Variables Only

Variable	Coefficient 1[a]		Coefficient 2[b]		Coefficient 3[c]	
"Other" comorbid conditions	58.43	(.02)	57.49	(.02)	—	
Patient age	−5.23	(.02)	−5.16	(.03)	−4.93	(.03)
Treatment history	−1.76	(.04)	—		−2.06	(.02)
Accesses	48.51	(.01)	43.41	(.02)	38.92	(.04)
No-shows	49.51	(.03)	—		48.26	(.03)
Potassium	91.91	(.03)	101.89	(.00)	78.49	(.02)
Hematocrit	−18.28	(.00)	−18.83	(.00)	−19.18	(.00)
"Other" renal diagnosis	415.31	(.01)	399.49	(.01)	413.53	(.01)
Positive hepatitis antigen	333.84	(.04)	373.41	(.02)	427.82	(.01)
Residual urine formation	−112.40	(.04)	−113.85	(.04)	—	
Medicaid	—		170.79	(.00)	116.69	(.04)
Routine dialysis medications	—		—		83.46	(.00)
Treatment hours per week	—		—		44.45	(.00)
Dialyzer reuse	—		—		115.63	(.05)
R^2	.2164		.2301		.2809	

Note. Number in parentheses is significance level.
a. Model with clinical variables only.
b. Model with clinical and sociodemographic variables.
c. Model with clinical, sociodemographic, and treatment variables.

are of concern to patient and clinical groups because of their potential for reducing the quality of care delivered (Maxwell & Sapolsky, 1987). Most concerns have focused on the practice of dialyzer reuse and shorter treatment sessions, but there is also a fear that reducing staffing levels and lower skill mix of caregivers will also compromise the hemodialysis process (Palmer, 1982).

This study explored variations in standard treatment processes across hemodialysis units and whether variations are related to differences in outcomes. The proprietary freestanding units were providing a less costly treatment process, with multiple-time reuse of dialyzers, a centralized dialysate delivery system, and infrequent use of special dialyzers or solutions.

Patients in freestanding units, however, received the same average number of medications and, perhaps because of the centralized treatment process, were dialyzed a significantly higher number of hours per week.

The analysis detected several significant associations between the standard treatment process and incremental resource use. First, although patients were receiving a customized hemodialysis treatment in the hospital-based units, they experienced a significantly greater number of intensity events/complications during treatments. They might be less stable than those dialyzing in freestanding units, or it is possible that the nurses are demonstrating divergent care practices for patients with similar conditions. Williams (1981), for example, found that nurses used the same level of intensity of intervention regardless of the cause or depth of a hypotensive crisis, whereas few nurses used the same intervention measures for patients with the same pathology or for a particular patient having repeated episodes of hypotension.

More hours of treatment per week, more medications, and dialyzer reuse were all associated with higher incremental costs. Lowrie, Laird, Parker, and Sargent (1981) noted that short-term dialysis duration contributed to patient morbidity. However, previous research found no negative outcomes as a result of dialyzer reuse (Pollak, Kant, Parnell, & Levin, 1984). These results suggest that reuse of dialyzers may reduce the cost of a standard hemodialysis treatment but at the same time lead to higher incremental treatment costs due to greater patient instability.

The study found that increasing patient age was associated with significantly lower incremental treatment costs. These findings argue against using age as a proxy for severity of illness or as a rationing criteria for access to hemodialysis therapy. Although their survival rates are lower (Prowant et al., 1983; Vollmer, Wahl, & Blagg, 1983), older patients may actually do better and be less costly patients to treat while alive and dialyzing (Chester, Rakowski, Argy, Giacalone, & Schreiner, 1979; Cohen, Comty, & Shapiro, 1970).

Access history may be a reflection of patient compliance as well as an indication of circulatory status and longevity on hemodialysis. As pointed out by Lowrie and Hampers (1984), circulatory access problems and compliance would be much better indicators of additional resource requirements by chronic hemodialysis patients than would the use of age or death rates within the units.

The relationship between Medicaid status and incremental treatment costs is interesting. Part of the association appears to be related to patient treatment history and noncompliance. It is possible that Medicaid may have been functioning as a proxy for socioeconomic status in general and was reflecting sociological, environmental, cultural, and psychological conditions pertinent to these very-low-income patients. Socioeconomic factors have been implicated in other studies of outcomes in ESRD patients (Garcia-Garcia et al., 1985; Health Care Financing Administration, 1987).

IMPLICATIONS

The study results have several implications for nursing practice. In general, nurses should examine more closely selected interventions applied during hemodialysis treatments and their impact on both costs and patient care outcomes. Similar to medical practice patterns, there appears to be significant variation in nursing practice, with resulting cost differences but with suggested minimal influence on patient outcomes. There is a need to identify the most cost-effective care delivery patterns in this cost-constrained environment.

Also identified were areas for targeted interventions. Closer monitoring of patients with lung problems, hematologic disorders, bone osteodystrophy, arthritis, and cancer might avoid some incremental costs. More intensive counseling programs might need to be instituted for the patients who skip scheduled treatments. The large incremental costs associated with hepatitis support more widespread administration of Hepatovax, a vaccine effective in preventing the occurrence of hepatitis.

Nursing staff should monitor serum potassium levels very closely, provide intensive educational and counseling sessions for reducing dietary intake, and refer problem patients to the nutritionist. Drug intervention might also be required. More intensive educational sessions for access maintenance might need to be provided to patients, family, and staff members, especially staff outside the hemodialysis unit. The results indicate that patients treated with Hu-EPO (synthetic erythropoietin) may experience a more stable and less expensive hemodialysis treatment due to their improved anemia. Nurses should expect younger, shorter-term ESRD patients to experience a more unstable dialysis process than the older, more long-term patients.

The role of socioeconomic status needs to be further explored, preferably in a sample with patients from a broader range of social stratum. Besides the implied factor of noncompliance, other possible associated factors include chronic nutritional deficiencies, environmental stress, and lack of financial resources to purchase the required medications, dietary supplements, and transportation services.

Another finding requiring further study is the positive association between reuse of the kidney and incremental treatment costs. Although past studies noted no association between reuse and morbidity (hospitalization) rates, none examined whether reuse has an influence on the actual hemodialysis process. The study results reported here suggest that the reuse patient experiences more instability and nursing interventions during treatment compared to the nonreuse patient. A more targeted study that focuses on this relationship is needed. The addition of other outcomes would also be helpful. A more intensive style of nursing care might not influence morbidity or mortality, but it could have an effect on patient health status, functional status, and quality of life.

The findings of this study have limited generalizability because of the nature of the sample, which contained a much higher proportion of Blacks and smaller percentage of males than are found in the national hemodialysis sample. The patients in the present sample also were less educated and from a lower socioeconomic stratum than is the general hemodialysis population. Another limitation is the absence of reliability testing of the data collected by the staff nurses, although efforts were made to provide adequate training and reinforcement to ensure conformity across the units and individual participants.

Despite these shortcomings, the results provide needed preliminary information about the variability in treatment processes across the hemodialysis units and the relationships between clinical and sociodemographic characteristics of patients and resource use during hemodialysis treatments. This analysis needs to be repeated on a more representative sample of patients from additional geographic areas of the country. Independent data abstractors should be trained and reliability and validity tests conducted on the acquired data.

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