Clinical and sociodemographic risk factors for readmission of Medicare beneficiaries

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In a random sample of Medicare beneficiaries, multiple logistic regression was used to examine clinical, sociodemographic, and insurance coverage risk factors for readmission within 60 days of discharge. The patients most likely to be readmitted were those with poor health status or with chronic diseases and those who had not had surgery. Age, marital status, living situation, and having insurance to supplement Medicare were not independently predictive of readmission risk. The dominant roles of health status, diagnosis, and surgery as predictors of readmission provide evidence that risk-adjusted readmission rates can be equitably used for quality of care studies.

Introduction

It is important to identify factors that predispose Medicare beneficiaries to readmission following a hospitalization, for at least two reasons. First, almost one-fourth of Medicare inpatient expenditures are for readmissions that occur within 60 days of discharge (Anderson and Steinberg, 1984). If even a small fraction of such readmissions are unnecessary, successful preventive efforts could be associated with substantial savings for the Medicare Trust Fund. The description of factors that predispose patients to readmission may assist in the identification of truly unnecessary readmissions and improve the efficiency of intervention efforts.

Second, readmission might indicate poor quality of care during the prior hospitalization (Riley and Lubitz, 1986; Roos et al., 1986; Zook, Savickis, and Moore, 1980). This may be true especially for readmissions that occur in relatively close proximity to the preceding discharge. Because of this concern, the Health Care Financing Administration (HCFA) now requires that peer review organizations (PRO's) examine the records of all Medicare patients who are readmitted within 15 days of discharge (Health Care Financing Administration, 1988). With such a procedure, readmission serves as a flag to identify individual cases for which the presence of quality problems (e.g., premature discharge) is considered more likely; judgments about quality are then based on detailed review of the medical care process. Information on readmissions also may be useful as a basis for inferring quality differences among hospitals (as well as among physicians or other types of providers). For example, if a particular hospital experiences readmissions at a rate that is significantly higher than those for other similar institutions, that hospital's higher rate may be a result of poorer quality of care. However, final judgments on quality must be supported by detailed peer review of the medical care process.

Before variations in readmission rates can be attributed to quality differences, alternative explanations must be excluded. For example, hospitals serving populations characterized as having poorer than average health status and more limited access to both ambulatory care and community support services might be expected to experience rates of readmission that are higher than those of other institutions. Thus, when examining readmission rates, clinical, demographic, and social attributes that could legitimately affect observed rate differences must be identified, and then these factors must be measured and controlled in the analysis. The first step in this process, referred to as "risk adjusting," (Blumberg, 1986) is to develop an appropriate readmission risk-prediction model.

The purpose of this article is to evaluate patient sociodemographic and clinical characteristics that appear likely to constitute risk factors for readmission. We present the results of an analysis of readmissions occurring in a sample of Medicare beneficiaries who were hospitalized in Michigan during the period January 1982 through June 1983. Only those readmissions occurring within 60 days of the preceding discharge are included in the definition of readmission used for this study. Identification of risk characteristics is expected to be useful both for designing strategies to reduce avoidable readmissions and for utilizing readmission rate data in quality of care studies.

Background

Previous research has identified several beneficiary characteristics that are associated with higher likelihoods of readmission. In a study of Medicare beneficiaries, using the same 60-day time interval to define readmission, Anderson and Steinberg (1985) found higher readmission rates for males, persons living in rural areas, persons covered by Medicaid, those eligible for Medicare by virtue of disability, and those admitted for chronic diseases. Lower rates were observed for surgery patients. Other researchers (Fethke, Smith, and Johnson, 1986; Riley and Lubitz, 1986; Zook and Moore, 1980; Gooding and Jette,

1985; and Victor and Vetter, 1985) have also found clinical factors of diagnosis and chronic comorbidities to be important predictors of readmissions. Higher readmission rates for males have also been observed by Fethke, Smith, and Johnson (1986) and Gooding and Jette (1985).

In the study reported here, we were able to include most of the variables that have been examined by previous researchers. In addition, we considered the relationship between readmissions and insurance to supplement Medicare ("medigap"), as well as that between readmission and health status. The purpose of medigap insurance is to pay Medicare deductibles and copayments. As a result, by reducing out-of-pocket costs, having medigap policies might lead beneficiaries to be more willing to be readmitted. It has been assumed that patients with poor health status are more likely to require readmission. Because, in previous studies of readmissions, simple direct measures of health status have not been available, researchers have had to rely on indicators such as diagnosis, age, and sex. For the study reported here, two types of self-reported health status measures were included: perceived health status and functional health status.

As with the study reported by Fethke, Smith, and Johnson (1986), we examined relationships between early readmission and social characteristics, including marital status, living situation, and place of residence. Knowledge of the relative importance of such risk factors may promote the improvement of intervention programs implemented through hospital social service departments or community health agencies. Although the sample size of the Fethke, Smith, and Johnson (1986) study limited the generalizability of their conclusions, our larger sample produced more definitive results.

Methods

Characterization of readmissions

Two conceptually different models of readmissions were investigated for this study. The first, which is similar to models used by other researchers, identifies risk factors associated with readmission for any reason ("readmission" model). For the second model, we exclude from the data those readmissions that appear, based on principal diagnosis, to be unavoidable or nondiscretionary. For the cases that remain, patients' physicians are assumed to have had relatively greater discretion in the decision to hospitalize; thus, we refer to this as the "discretionary readmission" model.

Although discretionary readmissions are not necessarily synonymous with unnecessary readmissions, the discretionary category, by definition, includes most admissions that would be identified as unnecessary through standard utilization review procedures. Therefore, the study of discretionary readmissions, using existing claims and survey data, may provide useful clues to the risk

factors for unnecessary readmissions, which otherwise can be identified only through detailed review of individual medical records.

If identified risk factors are found not to differ between the readmission and the discretionary readmission models, two explanations are likely. One possibility is that risk factors in fact are the same for the two types of readmissions. Alternatively, failure to identify differences may be the result of lack of specificity in our classification of readmissions. Because, as described below, we classify readmissions as discretionary or nondiscretionary on the basis of principal diagnosis, failure to show differences in risk factors may indicate that the principal diagnosis does not provide sufficient information for such a dichotomy. In either case, for future studies of readmissions, negative results would suggest that classifying the data base in this fashion would not be fruitful.

Classification of cases as discretionary or nondiscretionary was performed prior to data analysis using the principal diagnoses listed in the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) for the readmissions. A nondiscretionary diagnosis was defined as one for which accepted standards of care usually mandate admission. Examples include acute myocardial infarction, acute stroke, and septicemia. Readmissions with a principal diagnosis of cancer, during which major surgery was performed, also were deemed nondiscretionary. All other readmissions were classified as discretionary.[1] In this context, "discretionary" does not always mean "unnecessary," but rather indicates that the necessity for admission cannot be determined from the principal diagnosis alone, without reviewing individual medical records to ascertain the severity of illness and associated comorbidities. Examples of discretionary diagnoses include chronic obstructive lung disease, diabetes, acute alcohol intoxication, congestive heart failure, and acute cystitis. Although admissions classified as nondiscretionary almost certainly included both necessary and unnecessary admissions, we lacked the access to medical records required to determine with certainty if particular hospital stays for discretionary diagnoses were absolutely necessary.

The distinction between nondiscretionary and discretionary diagnoses can be clarified by considering the examples of acute myocardial infarction and congestive heart failure. Because modern standards of care in the United States require hospitalization for acute myocardial infarction, this was considered a nondiscretionary diagnosis. In contrast, congestive heart failure can sometimes be managed on an outpatient basis, depending on the severity of illness. Given the widespread variations in practice patterns observed for physicians (Wennberg, 1984), it is likely that a detailed review of the medical records of patients hospitalized for congestive heart failure would reveal that some patients absolutely required

[1]Tables of diagnosis codes classified for this study as discretionary or nondiscretionary are available from the authors upon request.

hospital care, while others could have been expected to respond to more intense outpatient treatment. Because the optimal location of care depends heavily on the severity of illness and associated comorbidities, heart failure was classified as a discretionary diagnosis.

Data

Data from three sources were merged to create the data base used in the analysis. Data on health status, medigap coverage, and sociodemographic characteristics were obtained through a mail survey conducted at the end of 1982. Questionnaires were mailed to 3,000 randomly selected Michigan Medicare beneficiaries. After dropping beneficiaries who had died, could not be reached by mail or phone, or were unable to respond because of mental disability, 2,123, or 81.2 percent of the remaining beneficiaries, responded to the questionnaire. The initial data base for the analysis reported here consisted of the 665 of these 2,123 respondents who had one or more hospitalizations between January 1, 1982 and June 30, 1983. Data on hospital admissions and clinical risk factors for this period came from the claims files of the Medicare intermediary/carrier for Michigan. Finally, data pertaining to Medicaid coverage of beneficiaries during 1982 and 1983 were obtained from the Michigan Department of Social Services. Detailed results of the mail survey and the relationships between beneficiary health status and health care costs are published elsewhere (Thomas and Lichtenstein, 1986a and 1986b).

To assess health status, the mail survey included items pertaining to perceived health status, functional health status, and the type and number of chronic illnesses with which a subject was afflicted. Among the 23 chronic illnesses included in the survey were high blood pressure, arthritis, bronchitis or lung trouble, heart trouble or angina, cancer, diabetes, and epilepsy. To evaluate perceived health status, subjects were asked: "Compared to other persons your age, would you say your health is excellent, good, fair, or poor?" For purposes of the analysis reported here, perceived health status responses are divided into three categories: excellent/good, fair, and poor.

Functional health status was measured using a series of 11 items, 6 of which pertained to the subject's ability to perform activities of daily living (ADL), such as getting dressed or eating without help. The ADL scale employed in this analysis is a modified version of Katz's Index of Activities of Daily Living (Katz et al., 1963), as used by Branch et al. (1981) and Jette and Branch (1981). The remaining five functional health status items came from the Rosow-Breslau Functional Health Scale, which deals with instrumental activities of daily living (IADL) (Rosow and Breslau, 1966).

Items on the IADL scale are more difficult to perform than those on the ADL scale and include activities such as walking one-half of a mile or climbing stairs to the second floor of a building. The ADL scale, IADL scale, and the combined 11-item ADL-IADL scale have each been shown to form Guttman scales (Thomas and Lichtenstein, 1986a). For purposes of the analysis reported here, responses to the functional health items were grouped into two three-level functional health status scales, one for the ADL scale and another for the IADL scale. These groupings were necessitated by the small number of negative responses to some of the questions.

Data on sociodemographic characteristics of respondents also were gathered through the survey. Subjects were asked if they were married, widowed, divorced/separated, or never married; if they lived alone or with someone else; if they lived with a relative; what kind of housing they lived in; and how many years of school they had completed. For the analysis reported here, some of these sociodemographic variables were considered dichotomous. Marital status was divided into the categories married and unmarried. Type of housing was divided into the categories independent and dependent. Persons who lived in a private house, apartment, rooming house, or hotel were classified as independent; those who lived in a rest home, nursing home convalescent center, or hospital were classified as dependent.

Claims files obtained from the Medicare intermediary included admission dates, discharge dates, and ICD-9-CM codes for diagnoses treated and procedures or operations performed. With these data, two variables hypothesized as clinical risk factors for readmission were developed. The first variable identified whether or not a major surgical procedure was performed during the patient's first hospital stay. Major surgical procedures, including such operations as appendectomies and total knee replacements, require resources that are available only on an inpatient basis. Major diagnostic procedures, such as cardiac catheterization and endoscopy, were not considered surgical procedures.

To construct the second clinical variable, each discharge was classified into a diagnosis-related group (DRG), using its assigned ICD-9-CM code and the MEDPAR Grouper. DRG's were then classified into three categories, reflecting the chronicity and hypothesized readmission risk of the associated illnesses. Assuming that readmission risk is inversely related to the typical time interval between exacerbations of a disease, hypothesized readmission risk for a DRG was based on the natural history of the illnesses commonly included in the DRG.

The "chronic DRG's" category includes DRG's containing chronic illnesses characterized by relatively short time intervals between exacerbations. DRG's assigned to the "intermediate" group cover a spectrum of acute and chronic disorders. For the chronic conditions in this group, the anticipated time between exacerbations was judged greater than that for conditions assigned to the chronic DRG's group. The third category, "acute DRG's," includes DRG's for acute or self-limited disorders and serves as the reference level for readmission risk. This three-level

classification represents a simplification of six-level taxonomy that has previously been shown to predict readmission risk for patients in a Veterans' Administration hospital (Holloway, Medendorp, and Bromberg, to be published). The complete classification is available from the authors upon request.

Examples of DRG's placed into the chronic DRG's category include DRG 88 (chronic obstructive pulmonary disease without surgery), DRG 127 (heart failure without surgery), DRG 140 (angina without surgery), DRG's 11, 16, 64, 172, and 173 (malignancies without surgery), DRG's 400-408 (leukemias, lymphomas, and myeloproliferative disorders), DRG 202 (cirrhosis), DRG 204 (pancreatitis), and DRG's 433-438 (substance-induced organic mental disorders). Examples of acute DRG's include DRG 6 (carpal tunnel release), DRG 67 (epiglottitis without surgery), DRG 80 (uncomplicated respiratory infections), and DRG 166 (uncomplicated appendectomy). The intermediate group includes DRG 177 (peptic ulcer disease without surgery), DRG's 146-150 (includes some malignancies for which surgery was performed), and DRG 294 (diabetes without surgery, age over 35).

Derivation of study sample

The study sample was derived by merging the survey with hospital utilization data. All 665 survey respondents who had been hospitalized during the study period (January 1982-June 1983) constituted the basic units of analysis. For each such patient, one index hospital record was used to identify hypothesized clinical risk factors for readmission, thereby preventing the sample from being biased toward the inclusion of subjects with multiple hospitalizations. Index hospitalizations were selected by a sequential method, described below, which assured that a patient was actually at risk for readmission following discharge and that all readmissions were identified.

The study sample was initially drawn by selecting all subjects who had been hospitalized at any time during the study period. Survey respondents who reported hospitalizations outside of Michigan were then excluded, as claims data pertaining to such hospital stays were not available. Next, a complete record for each hospitalization was created by appending to its claim record the admission date of the subject's next hospitalization, if any. Seven admissions that occurred within 1 day of discharge were assumed to represent interhospital transfers and therefore were not counted as readmissions. Although some of these 24-hour readmissions may not have been transfers, it is likely that subjects truly readmitted within 1 day of release are similar to those readmitted just beyond this cutoff. Therefore, their exclusion would not bias the data as much as would the inclusion of patients actually transferred between hospitals, who are clearly different from those who were discharged.

We applied additional exclusionary criteria to prevent misclassification bias. Subjects who died during their only admission were excluded, as they were never at risk for readmission. Subjects whose only hospitalization occurred during the first or last 60 days of the study period also were excluded, because our data did not permit the identification of all admissions that occurred within 60 days in both time directions from such a hospitalization. Had we not applied the latter exclusionary criterion, we could have mistakenly classified as nonreadmitted those subjects who actually were readmitted, but whose initial hospitalization or readmission occurred outside the timeframe of our data base. After the application of all exclusions, the list of 665 beneficiaries with one or more admissions was truncated to a study sample of 546 subjects, all of whom were at risk for readmission and whose readmissions could be identified with certainty.

For each of the 546 subjects, we selected one admission to serve as the index hospitalization. For subjects with only one readmission within 60 days of discharge, the hospital stay immediately preceding this readmission was selected as the index hospitalization. For subjects with two or more readmissions during the study period, the hospital stay closest to its associated readmission was selected as the index hospitalization. For subjects with a single admission, this admission was selected as the index admission. For subjects with multiple hospitalizations, of which none qualified as readmissions by our 60-day definition, the index admission was selected randomly from among all admissions. As a result of the above process, the readmission data base consisted of individual subjects, of whom none were counted more than once and all of whom were at risk for readmissions that could be identified with our Michigan claims data.

Analytic methods

The BMDP stepwise logistic regression program LR was used to build separate predictive models for readmission and discretionary readmission. Except for age and number of chronic medical conditions, which were specified in ordinal form, all independent variables considered in the analysis were specified in categorical form. Each level of a categorical variable was considered by the statistical program to be a unique risk factor. The significance level required for a risk factor to enter either model was $p < .10$, with a $p > .15$ required to remove a previously entered variable. Neither model was subjected to split-sample validation, as the resultant sample sizes would have been too small. However, the appropriateness of the logistic model and the fit of the final model to the study sample data were assessed by the Brown and Hosmer chi-square statistics.

Table 1

Number and percent of subjects in study, by candidate variables: Michigan, January 1982–July 1983

Variable	Number	Percent readmitted	P-value, univariate association[1]	Variable	Number	Percent readmitted	P-value, univariate association[1]
Age				**DRG category**			
65-74 years	227	28	.77	**for index stay**			
75-84 years	223	26		Acute	171	15	<.001
85 years or over	94	29		Intermediate	164	32	
				Chronic	211	34	
Sex							
Male	239	29	.52	**Surgery during**			
Female	307	26		**index stay**			
				Yes	232	19	<.001
Marital status				No	314	34	
Married	265	25	.26				
Unmarried	280	30		**Number of chronic**			
				medical conditions			
Education				0	47	26	.02
Some college	94	28	.71	1-2	164	23	
12th grade	127	27		3-6	209	23	
8th grade	239	26		7 or more	62	42	
Less than 8th grade	73	33					
				IADL category			
Living situation				High	140	19	.006
With relative	319	26	.34	Medium	231	27	
With other	47	36		Low	195	35	
Live alone	177	28					
				ADL category			
Housing[2]				High	448	25	.13
Independent	414	27	.31	Medium	68	35	
Dependent	132	31		Low	30	40	
Perceived				**Supplemental**			
health status				**insurance**			
Excellent/good	226	21	<.001	Medigap only	396	24	.06
Fair	218	25		None	84	33	
Poor	102	47		Medicaid	44	36	

[1]P-values are those for the chi-square statistic for the two-way tables of each risk factor versus readmission status.
[2]Dependent means residing in a nursing home, rest home, or hospital other than the admitting facility. Independent means residing in a private home or apartment.

NOTES: DRG is diagnosis-related group. ADL is activities of daily living. IADL is instrumental activities of daily living.

SOURCE: University of Michigan, School of Public Health: Data from the study, A Health Status Measure for Adjusting the Health Maintenance Organization Capitation Rates of Medicare Beneficiaries, Health Care Financing Grant No. 18-P-98179/5-01, Ann Arbor, Mich., 1982-84.

Results

Of the 546 subjects, 150 or 27 percent were readmitted within 60 days of discharge; 117 subjects (21 percent) experienced a discretionary readmission within this period. Candidate variables for the stepwise logistic regression models are displayed in Table 1, along with their frequency distributions and univariate associations with readmission. Age, sex, marital status, educational attainment, and living arrangement (alone versus with relatives; independent versus dependent) were not significantly associated with readmission risk (Table 1). The risk factors most highly associated with readmission were poor self-perceived health status, diagnosis in intermediate or chronic DRG category, lack of surgery during the index stay, affliction with seven or more chronic medical conditions, and low IADL score (Table 1). Medium and low ADL scores, as well as lack of medigap insurance, were associated with readmission risk, but with p-values between .05 and .1.

In addition to the variables listed in Table 1, the following interaction terms were included among the candidate variables for the model: surgery and acute DRG's, surgery and intermediate DRG's; surgery and poor health; poor health and acute DRG's, poor health and intermediate DRG's.

The strong association between perceived health status and readmission requires that the relationship between perceived health status and other potential measures of health be examined. Evidence that perceived health status is related to biological health is provided by the reported prevalence of selected chronic diseases among patients with varying levels of perceived health status (Table 2). Statistically significant increases in the proportions of subjects with hypertension, heart disease, cancer, and diabetes are apparent as perceived health status declines. Subjects with fair or poor health status were especially likely to suffer from multiple chronic conditions.

Turning to an examination of functional health status, we found that patients with impaired functional status were much more likely than those with high ADL or IADL scores to report poor or fair

perceived health status (Table 3). Although these results were expected, they document that perceived health status bears a close relationship to both the burden of chronic illness and functional impairment.

Results of the logistic regressions for predicting both readmission and discretionary readmission are displayed in Table 4. The statistically insignificant probability values for the Brown and Hosmer chi-square statistics for both models suggest that logistic regression is appropriate for modeling the data and that the models displayed in Table 4 fit the data well.

The principal risk factors for readmission were health status perceived as poor and an index admission classified into a chronic DRG, both of

Table 2

Percent of subjects with chronic disease in each level of self-perceived health status, by number and type of disease: Michigan, January 1982-July 1983

Chronic disease	Excellent/good	Fair	Poor	P-value
	Percent with chronic disease			
Heart disease	19	3	34	[1].001
Cancer	6	10	17	[1].006
Diabetes	9	13	21	[1].01
Total number of chronic diseases:				
0	14	7	6	[2].001
1-2	43	29	21	
3-6	39	49	42	
7 or more	4	14	31	

[1]Each P-value represents the level of significance for a contingency table of level of health status versus presence or absence of a particular disease. For the sake of clarity, only the percentages of subjects with each illness are recorded.
[2]This P-value represents the significance level for the contingency table of level of health status versus number of chronic conditions.

SOURCE: University of Michigan, School of Public Health: Data from the study, A Health Status Measure for Adjusting the Health Maintenance Organization Capitation Rates of Medicare Beneficiaries, Health Care Financing Grant No. 18-P-98179/5-01, Ann Arbor, Mich., 1982-84.

Table 3

Percent of subjects in self-perceived health status categories, by functional health status: Michigan, January 1982-July 1983

Functional health status	Self-perceived health status			
	Excellent or good	Fair	Poor	P-value
ADL scale	Percent			
High	8	42	10	[1]<.001
Medium	19	27	54	
Low	3	33	64	
IADL scale				
High	74	25	1	[1]<.001
Medium	42	46	12	
Low	16	43	41	

[1]P-value for the contingency table of functional health status scale versus perceived health status level.

NOTES: ADL is activities of daily living. IADL is instrumental activities of daily living.

SOURCE: University of Michigan, School of Public Health: Data from the study, A Health Status Measure for Adjusting the Health Maintenance Organization Capitation Rates of Medicare Beneficiaries, Health Care Financing Grant No. 18-P-98179/5-01, Ann Arbor, Mich., 1982-84.

which displayed adjusted odds ratios of 2.6 relative to their reference levels. The adjusted odds ratio for surgery during the index admission was 0.7, demonstrating that surgery during the index admission tends to lower the risk of readmission. However, the odds ratio for the first-order interaction between surgery and chronic DRG's was 1.6, indicating that subjects with index admissions included in chronic DRG's who also underwent surgery were at increased risk for readmission.

The results of the discretionary readmission model were similar to those of the readmission model. The two most important risk factors were an index admission classified into a chronic DRG, with an adjusted odds ratio of 3.3, and poor perceived health status, with an odds ratio of 3.0. As was the case for the readmission model, surgery during the index admission generally appeared to reduce discretionary readmission risk, with an odds ratio of 0.8 relative to no surgery. Likewise, surgery performed during an admission for one of the chronic DRG's increased the risk of discretionary readmission, with an odds ratio for the interaction between surgery and chronic DRG's of 2.5.

Two additional first-order interaction terms entered the discretionary readmission model. The odds ratio of 1.8 for the interaction between surgery and intermediate DRG's implies that surgery performed

Table 4

Coefficients and adjusted odds ratios for readmission and discretionary readmission models, by variables entered in the models

Variable	Readmission		Discretionary readmission	
	Coefficient	Adjusted odds ratio	Coefficient	Adjusted odds ratio
Intercept	-.4633	—	-.6681	—
Poor health status	[2].9711	2.1	[2].1130	3.0
Chronic DRG's	.9516	2.6	[2]1.1995	3.3
Intermediate DRG's	[3].7944	2.2	[2].9468	2.6
Surgery	[4]-.3797	.7	[3]-.2259	.8
Interaction terms:[1]				
Surgery and chronic DRG's	[4].4381	1.6	[3].9314	2.5
Surgery and intermediate DRG's	—	—	[5].5840	1.8
Poor health and chronic DRG's	—	—	[5].4338	1.5
Goodness-of-fit statistics:				
Hosmer χ^2	p = .47		p = .71	
Brown χ^2	p = .68		p = .99	

[1]These terms represent the interaction effects between surgery and DRG category and between poor perceived health status and DRG category.
[2]Significant at p < .001 level.
[3]Significant at p < .01 level.
[4]Significant at p < .1 level.
[5]Significant at p < .05 level.

NOTE: DRG is diagnosis-related group.

SOURCE: University of Michigan, School of Public Health: Data from the study, A Health Status Measure for Adjusting the Health Maintenance Organization Capitation Rates of Medicare Beneficiaries, Health Care Financing Grant No. 18-P-98179/5-01, Ann Arbor, Mich., 1982-84.

during an admission for any nonacute condition increases the risk of discretionary readmission. The odds ratio of 1.5 for the interaction between poor perceived health status and chronic DRG's implies that subjects with poor health status who are admitted for chronic diseases have a greater risk of discretionary readmission.

Several hypothesized risk factors proved not to be independently predictive of readmission risk in either analysis. After adjustment for risk factors that entered the models, neither age, sex, marital status, education, living situation, residence in a nursing home or other community facility, number of chronic medical conditions, functional health status as measured by ADL or IADL score, nor possession of insurance to supplement Medicare was associated with readmission risk at the $p < .1$ level of significance. The failure of some variables that displayed univariate associations with readmission (IADL score, ADL score, number of chronic conditions) to enter the logistic model probably reflects their strong associations with perceived health status (Tables 2 and 3). The failure of insurance coverage to enter implies that it is not an important predictor of readmission, after adjustment for health status, DRG category, and surgery, despite its moderate univariate association with readmission. The failure of social factors, including living arrangements, to enter the models simply reflects their weak associations with readmission (Table 1).

To determine the level of confidence that can be placed in our negative results (Freiman et al., 1978), standard tables were used to estimate the power of our study to detect true odds ratios of 2.0 and 1.5 for postulated risk factors that did not enter the models, assuming a Type I error rate of .05 (Cohen, 1977). For most factors, including living arrangement, marital status, and possession of insurance coverage to supplement Medicare, the power of the study to detect odds ratios of 2.0 or more consistently exceeded 0.9, while the power to detect odds ratios of 1.5 ranged between 0.6 and .75. For lower IADL scores, the power was approximately .75 for a true odds ratio of 2.0, and 0.5 for a true odds ratio of 1.5. Therefore, hypothesized risk factors that failed to enter our models probably do not appreciably and independently influence readmission risk.

Discussion and conclusion

Consistent with findings reported by other researchers, results from this sample of Medicare beneficiaries indicate that clinical factors (chronic disease, surgery, and health status perceived as poor) dominate the prediction of readmission risk. Social and demographic factors are relatively unimportant as independent predictors, even when only discretionary readmissions are examined.

The influence of chronic and disabling illness on readmission rates has been observed by Zook and Moore (1980), Anderson and Steinberg (1984), Gooding and Jette (1985), Victor and Vetter (1985),

and Fethke, Smith, and Johnson (1986). Thus, the relatively high adjusted odds ratios observed for both poor perceived health status and chronic DRG's confirm these previously reported results. Although the generally negative association between surgery during the index hospitalization and readmission risk supports previous findings (Anderson and Steinberg, 1984), our examination of interaction terms showed this association to be more complex than previously reported. For the sample of Medicare beneficiaries included in this study, index admissions that involve surgery and are classified into chronic DRG's were associated with increased readmission risk.

Our finding that readmission rates are not significantly related to patient age is consistent with results reported by Gooding and Jette (1985), Graham and Livesley (1983), and Fethke, Smith, and Johnson (1986). Also consistent with previously reported results is the absence of a relationship between readmission risk and either education (Fethke, Smith, and Johnson, 1986) or living situation (Victor and Vetter, 1985; Fethke, Smith, and Johnson, 1986). Unlike other studies (Anderson and Steinberg, 1984; Fethke, Smith, and Johnson, 1986; Gooding and Jette, 1985), in which males were found to have higher readmission rates, we did not find gender to be an important predictor. Furthermore, although Anderson and Steinberg (1984) found eligibility for Medicaid to be a predictor of readmission, neither Medicaid nor medigap insurance coverage proved significant in our analyses. It appears likely that the combined strengths of diagnosis, surgery, and perceived health status subsume any independent effects of gender, social situation, living arrangement, or insurance on readmission risk.

We anticipate that these findings will prove useful to hospitals attempting to reduce unnecessary readmissions. The results emphasize the importance of focusing on clinical characteristics (chronic diseases, medical admissions, surgery performed on patients with chronic diseases) to identify patients who are at greater risk for both readmission and discretionary readmission. Such identification may enable medical management during the hospitalization and following discharge to be oriented toward preventing unnecessary rehospitalization. For example, prior to discharge, high-risk patients might be provided more rehabilitation therapy and more intensive education on controlling diet and maintaining medication regimens. More attention might be given to high-risk patients' post-discharge placements and access to home care services, as well as to improved coordination with patients' primary care providers (Gooding and Jette, 1985).

The relative unimportance of social characteristics as predictors of readmission is particularly important for efforts to use readmission data in hospital quality of care studies. To infer hospital quality differences based on differences in readmission rates, it is necessary to adjust readmission data to reflect the relevant characteristics of an institution's patient population. Typically this is done by using an

appropriate risk model to calculate each hospital's expected readmission rate. The expected rate is then compared with the hospital's actual rate (Blumberg, 1986). Because data on patient social characteristics (e.g., living arrangements, education) are less likely to be available in standard record systems, risk models that incorporate such factors could not be widely applied. However, the findings presented above indicate that clinical, rather than social, variables are the primary predictors of readmission.

As data on most of the clinical characteristics associated with readmission risk are readily available in patients' medical records and discharge abstracts, the use of risk models in studies of early readmissions appears to be practical. This conclusion must be qualified, because information on perceived health status, which was an important independent predictor of readmission, is not currently included in patients' records. However, because of the usefulness of health status information, for example for predicting Medicare costs (Thomas and Lichtenstein, 1986a), it is possible that such data will become a standard part of patients' medical or Medicare administrative records.

Usefulness of discretionary early readmissions

One of the objectives of this study was to determine if a separate analysis focusing on discretionary readmission would produce results different from those obtained when all readmissions were analyzed. The data do not provide a clear answer to this question. The set of significant risk factors identified in the analysis of readmission includes, with the exception of two interaction terms, the same variables yielded by the discretionary readmission analysis.

Nevertheless, two aspects of the results presented in Table 4 suggest that the discretionary/nondiscretionary dichotomy might be useful. As indicated by the Hosmer and Brown chi-square statistics, the models are able to achieve a better fit to the discretionary readmission data than to the readmission data. The associations between predictors and readmission are also stronger for discretionary readmission, as measured by their adjusted odds ratios. Furthermore, additional significant variables, one representing the interaction between surgery and intermediate DRG's and another representing the interaction between poor health status and chronic DRG's, were identified only with the discretionary readmissions analysis. Although not definitive, these results suggest that focusing on discretionary readmission may be advantageous for utilization control purposes, and that further efforts toward refining the definition of discretionary readmissions are justified.

Health status as a predictor

When interpreting the relatively high adjusted odds ratio for the variable of health status perceived as poor, it must be recognized that the survey used to assess perceived health status was administered during the interval over which readmissions were occurring, rather than at the beginning of this interval. It is possible, therefore, that beneficiaries' perceptions of health status might have been influenced by their prior hospitalization experiences, including readmissions; i.e., health status perceived as poor might reflect, rather than predict, readmissions. Although a previously reported analysis of the health status items on the questionnaire showed these measures to be quite stable over a 12-month period (Lichtenstein and Thomas, 1987), prospective studies in which health status information is collected prior to the index admission will be needed to confirm the usefulness of perceived health status as a predictor of readmission risk.

The greater predictive strength of perceived health status, compared with that of functional health status, is interesting, as the functional health measure has been shown in other studies to be superior for explaining variations in Medicare beneficiaries' annual health care costs (Thomas and Lichtenstein, 1986a). Perceived health status is a more global measure than functional health status, because it reflects patients' attitudes and emotional characteristics, as well as the influence of comorbidities, on patients' physical functioning. Thus, because of its broader scope, perceived health status may provide a better measure of patients' physiologic reserve (Knaus and Wagner, 1987), which influences the rate and outcome of the recovery process.

Additional issues for future research

Although our results demonstrate that the logistic regression models fit the data that were used to construct them, sample size limitations prevented us from internally validating the models using techniques such as split-sample analysis. However, the validity of our models is supported by their similarity to previously developed models, when candidate variables that were common to each of the studies are examined (e.g., Anderson and Steinberg, 1985; Fethke, Smith, and Johnson, 1986; Holloway, Medendorp, and Bromberg, to be published). In particular, the three-level classification of DRG's, which was previously shown to predict readmission to a Veterans Administration hospital (Holloway, Medendorp, and Bromberg, to be published), was also highly predictive of readmission for the Medicare beneficiaries included in this study. Additional studies, preferably prospective in design, will be required to validate conclusively the readmission risk factors identified by our analysis, as well as to better define diagnostic groups for the study of readmissions.

The fact that similar risk factors were observed for readmission of veterans within 30 days of discharge (Holloway, Medendorp, and Bromberg, to be published) and for Medicare beneficiaries within 60 days of discharge suggests little variability of readmission risk factors with the discharge-readmission interval. A more detailed study

of the relationship between readmission risk factors and discharge-readmission time interval would obviously be useful, as one would expect earlier, rather than later, readmissions to be more highly associated with premature discharge. However, a sample size larger than that for the current study is necessary to meaningfully address this important issue, especially for readmissions occurring in fewer than 30 days.

The type of readmission model best suited for screening medical records to identify those that should be further reviewed may vary according to the intended use of the readmission data. For utilization review purposes, a discretionary readmission model, with discretionary readmission being narrowly defined, may be more suitable than models that predict the risk of any readmission. However, for purposes of quality monitoring, a readmission definition that approaches the concept of unplanned or unscheduled readmission may be most useful (Smith, Norton, and McDonald, 1985; Phillips et al., 1987). This could be accomplished with standard discharge abstract data by identifying and excluding from the definition of readmission those readmissions that are legitimately linked to a diagnosis treated during the previous stay by the performance of a procedure requiring hospitalization (Gertman and Lowenstein, 1984).

Important and as yet unaddressed issues pertaining to the use of readmission models for the purpose of quality monitoring include the sensitivity and specificity of various discharge-readmission time intervals for the identification of premature discharges, as well as the variability, if any, of readmission risk factors with this time span.

Our findings concerning the relative insignificance of social characteristics as predictors of early readmission are, as noted above, generally consistent with results obtained in other studies. However, such findings conflict with the strongly held beliefs and anecdotal evidence of many physicians and hospital discharge planners. Additional research, involving prospective collection of data on patients' home environments and access to post-discharge support services, will be required to clarify the precise role played by social and environmental conditions in the determination of readmission risk.

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