Risk Factors for Early Readmission among Veterans

James J. Holloway, M.D., Sharon Vanderbrug Medendorp, and Judith Bromberg

This study was undertaken to identify demographic, clinical, and social risk factors for early readmission in the veteran population. Readmissions within 30 days of discharge were considered "early." A randomly selected 50 percent sample of 6,317 veterans discharged consecutively from one Department of Veterans Affairs medical center (VAMC) was used to build a logistic regression model for early readmission. Of these patients, 22 percent had early readmissions. The adjusted odds ratios (OR) of greatest magnitude for early readmission ($p < .05$) *were associated with discharge from a geriatrics/intermediate care bed (OR = 2.75 relative to medical ward), discharge diagnosis of a chronic disease (OR = 2.03–2.67 relative to acute or self-limiting disorders), and two or more surgical procedures performed during the index admission (OR = 1.87 relative to no surgery). Increasing distance from the VA hospital and increasing age also added readmission risk (OR = 1.18 and 1.10, respectively). Length of stay and the social risk factors of marital status and place of disposition were not sufficiently predictive to enter the model. The model was validated successfully on the second 50 percent sample of patients. We conclude that clinical and demographic factors are more predictive of early readmission than are social factors. Early readmission models could be used to improve VA discharge planning and to focus quality*

This research was supported by the Department of Veterans Affairs. Opinions expressed are the authors' own and do not necessarily reflect those of the Department of Veterans Affairs.

Address correspondence and reprint requests to James J. Holloway, M.D., M.A., Associate Chief of Staff for Ambulatory Care (11C), Veterans Affairs Lakeside Medical Center, 333 East Huron Street, Chicago, IL 60611. At the time this research was completed, Dr. Holloway was a staff physician in the Department of Internal Medicine, Ambulatory Care Section, at the Department of Veterans Affairs Medical Center (VAMC) in Ann Arbor, MI. Sharon Vanderbrug Medendorp, M.P.H. and Judith Bromberg, Ph.D. were Statisticians in Health Services Research and Development at the Ann Arbor VAMC.

assurance and utilization review efforts on providers whose early readmission rates exceed those predicted by the models.

Readmissions shortly following discharge from a hospital are of interest for two principal reasons. First, high-cost users of medical care are characterized by a pattern of repeated admissions (Schroeder, Showstack, and Roberts 1979; Zook and Moore 1980). Anderson and Steinberg (1985) found that almost one-fourth of Medicare inpatient expenditures are for readmissions that occur within 60 days of discharge. Second, readmissions may serve as a marker for premature discharge or other quality-of-care problems (Riley and Lubitz 1986). The Health Care Financing Administration requires that state peer review organizations review the records of prospective payment system (PPS) patients who are readmitted within 15 days of discharge, in order to determine whether the readmission is a consequence of premature discharge or another quality-of-care defect (Dept. of Health and Human Services 1985).

Readmissions are of particular interest to the Department of Veterans Affairs (VA) for several reasons. First, other investigators have found that hospital recidivism rates are higher for veterans than for other groups (Zook and Moore 1980; Zook, Savickis, and Moore 1980). The effect of readmissions on VA medical costs, therefore, may be greater than their effect on private sector costs. Second, in contrast to broader measures of utilization or quality, readmissions represent a readily identifiable, specific item that can be addressed during discharge planning and utilization review. Third, the risk of readmission may be increased by VA's recent switch to a prospective resource allocation system based on diagnosis-related groups (DRGs). Such a system creates incentives to unbundle care by rehospitalizing patients rather than treating them during a single stay. Pressures to reduce the length of stay under prospective reimbursement may also result in premature discharge, followed by readmission.

Many factors can contribute to readmission risk. Possible risk factors include demographic characteristics such as age; clinical factors such as diagnosis and severity of illness; social characteristics such as place of residence, access to care, and marital status; and provider characteristics such as type of hospital and practice patterns. From a policy perspective, the relative importance of these factors in determining readmission risk is significant. If severity of illness and demographic characteristics are most important, zealous efforts to prevent readmissions may be harmful. However, if social factors or provider characteristics dominate, clinically acceptable and less expensive alternatives to readmission might be developed. Furthermore, the use of readmission data to monitor quality of care depends on the development of accurate statistical models for predicting expected readmission rates for a facility, to which the facility's actual readmission rate may be compared.

Prior work on the relative importance of possible risk factors for readmission is sparse and has been focused on clinical characteristics of selected patients (Stanton, Jenkins, Goldstein, et al. 1985; Smith, Norton, and McDonald 1985), or on the Medicare population (Riley and Lubitz 1986; Anderson and Steinberg 1985; Fethke, Smith, and Johnson 1986; Holloway, Thomas, and Shapiro 1988). Factors documented to be associated with increased readmission risk include increased age (Riley and Lubitz 1986; Smith, Norton, and McDonald 1985; Anderson and Steinberg 1985); the presence of chronic disease (Anderson and Steinberg 1985; Holloway, Thomas, and Shapiro 1988); increased severity of illness during the index admission (Stanton, Jenkins, Goldstein, et al. 1985; Smith, Norton, and McDonald 1985; Fethke, Smith and Johnson 1986); poor self-reported health status (Holloway, Thomas, and Shapiro 1988); male sex (Anderson and Steinberg 1985; Fethke, Smith, and Johnson 1986); white race (Anderson and Steinberg 1985); number of emergency room visits prior to the index admission (Smith, Norton, and McDonald 1985); number of discharges in the 60 days prior to the index admission (Anderson and Steinberg 1985); admission during which no surgery was performed (Anderson and Steinberg 1985); possession of supplemental Medicaid coverage (Smith, Norton, and McDonald 1985); index hospitalization in a small or rural hospital (Anderson and Steinberg 1985); widowhood (Fethke, Smith, and Johnson 1986); and low scores on a life satisfaction index (Fethke, Smith, and Johnson 1986). These studies of readmission employed different time-to-readmission definitions, studied widely varying populations, used a variety of study designs, and examined different risk factors. Severity of illness during the index hospitalization is the one factor that was associated with readmission whenever it was explicitly considered. These results therefore complement those of Horn et al. (1983, 1986), Gonnella, Hornbrook, and Louis (1984), and Conklin et al. (1984), who have demonstrated that resource use during a particular hospitalization varies with severity of illness.

However, previous readmission research conducted in nonveteran populations may not be generalizable to the veteran population. The sex ratio and age structure of the veteran population are different from those of the general population, because males are differentially selected for military service and because the bulk of veterans eligible for VA care now were in their late teens and early twenties during World War II and the Korean War. Even after adjusting for age and sex, there may be severity-of-illness or social factors that differ between veterans and nonveterans. Since the extent of any such differences is unknown, it is important to examine readmissions in a population of veterans.

The purpose of this study was twofold. First, we wished to estimate the frequency of readmissions in a population of veterans. Second, we wished to determine the relative importance of hypothesized demographic, clinical, and social risk factors for readmission in this population. We were specifically concerned with predicting early readmissions, which were defined as those occurring within 30 days of discharge. The selection of a time-to-readmission period is arbitrary, especially for a population afflicted with chronic diseases. The 60-day period examined by Anderson and Steinberg (1985) and by Holloway, Thomas, and Shapiro (1988) for Medicare beneficiaries had special meaning for the Medicare population, since 60 days was the length of a Medicare benefit period at the time these studies were conducted. So long as a readmission occurred during the same benefit period as the index admission, only one deductible was paid by the beneficiary (Berman, Weeks, and Kukla 1986). No analogous period exists for veterans. Other researchers have selected time-to-readmission periods of 30 days (Riley and Lubitz 1986); 6 weeks (Fethke, Smith, and Johnson 1986); 6 months (Stanton, Jenkins, Goldstein, et al. 1985; Fethke, Smith, and Johnson 1986); 1 year (Fethke, Smith, and Johnson 1986; Zook, Savickis, and Moore 1980); and 1, 2, 5, and 10 years (Zook, Savickis, and Moore 1980). Because we think that most of the readmissions preventable through better discharge planning or reflective of other quality-of-care defects will occur within one month of discharge, a 30-day time-to-readmission period was selected for study.

METHODS

We defined an early readmission, therefore, as one that occurs within 30 days of discharge. We developed two logistic regression models that related the probability of early readmission to a number of hypothesized demographic, clinical, and social risk factors. The unit of analysis was the individual patient. The outcome event for the first model was early readmission for any reason (any readmission), while that for the second model was early readmission with a primary discharge diagnosis fitting within the same DRG as that for the veteran's preceding admission (same DRG readmission).

Data for the analysis were obtained from the VA patient treatment file (PTF) (Dept. of Health and Human Services 1985). The PTF contains detailed information from each discharge for all veterans who have been inpatients in any VA facility or who have been inpatients in private hospitals at VA expense. Dates of admission and discharge and whether an admission represents an interhospital transfer are included in the PTF. Demographic information in the file includes age, sex, race, period of military service (war or peacetime), and county of residence. Extensive clinical information is contained in the PTF, including length of stay, ICD-9-CM codes for all surgical procedures performed, DRG in which the primary diagnosis was classified, number of operations and other procedures performed during the hospitalization, and disposition status (transferred to another hospital, discharged alive, or died while hospitalized). Information on social characteristics includes marital status, whether or not the veteran was ever a prisoner of war, place to which the patient was discharged (such as a nursing home or domiciliary), and the veteran's disability status. Disability status is categorized according to whether the veteran has a compensable service-connected disability in conjunction with whether care for this disability was received or not during a particular hospitalization. Since all discharges are coded into the PTF, this file can be used to track all hospitalizations in VA facilities and all hospitalizations in private hospitals for which VA pays. However, the PTF does not contain information pertaining to discharges from non-VA facilities when a party other than VA pays for the hospitalization.

SAMPLE DEFINITION, SELECTION, AND EXCLUSIONS

The population selected for study comprised all 6,704 veterans discharged from the internal medicine, surgery, intermediate care (geriatrics or nursing home care unit), or neurology services of a tertiary care VA medical center between January 1, 1981 and December 31, 1982. Patients admitted to the psychiatry service were excluded because the disease classification system used in the model is based on DRGs. Previous research has demonstrated that psychiatric DRGs often bear little relation to severity of illness or resource consumption (Frank and Love 1986; Light, Phipps, Piper, et al. 1986), so a classification system based on DRG assignment would lack face validity for psychiatric patients. Separate data bases were constructed for the endpoints of same-DRG early readmission and for any early readmission.

Each admission is associated with a unique PTF record, so subjects with multiple admissions have several PTF records. For each PTF record during the period of observation, the subject's readmission status 30 days after discharge was determined and appended to the admission record, thereby creating an augmented record that included readmission status. Readmissions that were in fact transfers from another hospital were not counted as readmissions. Subjects were classified as having sustained an early readmission if any of their augmented PTF records showed a readmission within 30 days of discharge. A single record for each subject was designated as the index admission and was used to ascertain the presence or absence of postulated risk factors. All index admissions were to the Ann Arbor VA Medical Center.

For patients with one or more early readmissions, the augmented PTF record with the shortest time to readmission was selected as the index admission. For subjects with one or more PTF records, none of which represented early readmissions, the selection process was more complex. All of these latter subjects' records with an admission date during the first 30 days of the study period or a discharge date during the last 30 days were excluded from the study sample. Such records could actually have represented readmissions within 30 days of a discharge that occurred before the observation period began or could have represented index admissions for which subsequent early readmissions could not have been detected. All subjects whose only hospitalization during the observation period had an admission date during the first month of the period or a discharge date during the last month of the period were thereby excluded, to prevent errors of misclassification. Subjects with multiple admissions were included in the study sample and counted as not readmitted if they failed to meet the criterion for early readmission, and if they had at least one PTF record with admission and discharge dates outside of their respective exclusionary periods. For these subjects, the first eligible PTF record in the series of multiple records was selected as the index admission. A person whose only admission date was during the last 30 days of the observation period, but who was not discharged by the end of this period, was automatically excluded from the study population. Because the PTF was searched by discharge date, no record would have been located for such a subject. This was desirable, since the fact of readmission following such a discharge could not be ascertained. The net effect of these exclusionary criteria was to generate a sample of nonreadmitted subjects, all of whom were at risk for detectable readmissions throughout the study period.

The preceding criteria excluded 387 subjects (5.7 percent of the population). A total of 6,317 subjects—for whom the fact of early readmission could be established with certainty—remained in the study sample. Adjustment for VA admissions that terminated in death or interhospital transfer was accomplished by including type of disposition in all regression models. These adjustments were necessary, because subjects who died were not at risk for early readmission and those who were transferred were at risk for readmission at some unknown time.

SPECIFICATION OF HYPOTHESIZED RISK FACTORS

Hypothesized demographic, social, and clinical risk factors for early readmission are displayed in Table 1. Age and location were entered as ordinal variables and length of stay was entered as a continuous variable. All other hypothesized risk factors are specified in categorical form, using the categories listed in Table 1.

The final clinical variable considered in the analysis is a six-level readmission risk classification. This risk classification system differs in important ways from those developed by Horn et al. (1986, 1983) and Gonnella, Hornbook, and Louis (1984). The latter authors attempted to refine DRGs by incorporating severity of illness adjustments that reduce within-DRG heterogeneity with respect to resource consumption. Our classification takes DRGs in their present form and groups them into a small number of categories that are specifically designed to predict readmission risk. The classification system is based on a combination of previously published work (Zook, Savickis, and Moore 1980) and clinical judgment. The clinical factors employed include chronicity of disease, whether or not the illness is curable, typical time intervals between serious exacerbations of disease, significant comorbidities, and age. Assignments of DRGs to levels of the readmission risk classification were made prior to data analysis while blinded to the readmission status of subjects.

Two factors were most important when deciding at which level of the classification system to place a DRG. The first factor was the expected natural history of illnesses comprising the DRG. Acute, self-limited, and curable illnesses were placed in lower-risk categories, while chronic, progressive diseases were placed in higher-risk categories. The second important factor was the typical time interval between

Table 1: Variables Considered in the Analysis

Variable	*Levels for Categorical Variables*	*Total Sample Size*	*Description*
Demographic Factors			
Age	<35	724	
	35–44	550	
	45–54	1054	
	55–64	2448	
	65–74	766	
	75–84	189	
	85≥	152	
Location of residence	Reference county	588	County with admitting VA medical center
	Close	3643	Close to reference county
	Medium	1237	Moderately far from reference county
	Far	686	Far from reference county
			(Note: distance increments followed an approximate interval scale.)
Sex	Male	6201	
	Female	115	
Beneficiary category	Post-Vietnam	202	Period of military service
	Vietnam	334	
	Peacetime	614	
	WWII/Korea	3550	
	WWI/Spanish	1242	
	Active/Other	217	
VA auspices	No	393	
	Yes	5732	Whether or not patient was to receive any further care under VA auspices

Social Factors			
Marital status	Never married	627	
	Married	3631	
	Separated or divorced	1493	
	Widowed	475	
	Unknown	90	
Place of disposition	Another hospital	230	Place of residence following discharge
	Nursing home/Domiciliary	232	
	Community or penal institution	28	
	Independent living	5594	
Compensation/Pension status	Service connected/Treated	220	Treated for a 10% service-connected disability
	Service connected/Not treated	2231	Have 10% service-connected disability but treated for a different condition during index hospitalization
	Not service connected	3771	
	Not a veteran	93	
Clinical Factors			
Length of stay		Mean = 12.82	Length of hospital stay in days
Bed section	Medicine	2555	Inpatient service at time of discharge
	Surgery	3248	
	Neurology	414	
	Intermediate care	88	
Hospital status	Bed occupant	6314	Hospital status at time of discharge
	Authorized absence	0	
	Unauthorized absence	2	
Spinal cord injury	No	6262	
	Yes	54	
Type of disposition	Regular	5857	Adjustment for deaths and interhospital transfers
	Non-bed care	0	
	Irregular or transfer	321	
	Death	138	

Continued

Table 1: Continued

Variable	*Levels for Categorical Variables*	*Total Sample Size*	*Description*
Number of surgeries	None	3286	Number of surgeries during the index admission
	One	2693	
	Two ≥	337	
*Readmission Risk Classification**	Very low	2922	Examples: acute viral illnesses, most injuries
	Low	910	Examples: uncomplicated peptic ulcer without surgery, age >69; kidney stone, without surgery or complication
	Medium low	801	Examples: kidney stone without surgery with comorbidity and/or complication; uncomplicated diabetes (over 35 years of age), diseases of the digestive system with major bowel surgery, most malignancies with surgery
	Medium	1191	Examples: heart failure, angina without surgery or catheterization; chronic obstructive lung disease; diabetes (<36 years old); peripheral vascular disease
	High	245	Examples: malignancies without surgery, unspecified alcoholism
	Very high	247	Examples: severe anemias, common complications of alcoholism (cirrhosis, pancreatitis, organic brain syndrome)

*A complete list of DRGs assigned to each level of the readmission risk classification is provided in the appendix.

severe exacerbations of nonacute diseases. Chronic diseases associated with shorter time intervals between exacerbations were assigned to higher levels of the classification system, in correspondence with their greater predicted risk of readmission. The placement of disorders that are similar with respect to these two characteristics was influenced by the presence of comorbidities or complications. Since many DRGs are constructed on the basis of age over 70, or the presence of comorbidities or complications, or both, age became an incidental part of the readmission risk classification. However, the motivation behind assigning a DRG to a higher level in the classification system was usually the presence of comorbidities or complications, rather than age. Examples of conditions classified into each level of the readmission risk classification are provided in Table 1, and a complete listing of DRGs placed into each level of this classification system is provided in the appendix.

The reference level for the readmission risk classification was labeled very low and included DRGs that contain acute medical conditions for which the risk of readmission was thought to be very small. Examples of DRGs assigned to this level include 6 (carpal tunnel release), 18 (peripheral nerve disorder), 67 (epiglottitis without surgery), 166 (uncomplicated appendectomy), 222 (musculoskeletal disease with knee surgery, without complication), 300 and 301 (endocrine disease other than diabetes, without surgery), and 80 (infections/inflammation of the respiratory system without comorbidity or complication). The reference level, therefore, included acute curable conditions (epiglottitis, appendicitis, and respiratory infections); some chronic conditions for which a major uncomplicated palliative procedure was performed (carpal tunnel release, knee surgery); and chronic conditions for which outpatient management usually was successful (endocrine diseases other than diabetes).

The intermediate categories in the classification contained a wide spectrum of disease, with discrimination between classification levels often based on the presence of comorbidities. For example, while DRG 80 (respiratory infections, uncomplicated) was placed in the very low category, DRG 79 (respiratory infections with complications/comorbidity) was placed in the low category; while the DRG for uncomplicated appendectomies (166) was placed in the very low category, complicated appendectomies (DRG 164) were placed in the low category. Chronic illnesses that were considered relatively unlikely to require readmission in 30 days also were placed in intermediate levels. Examples of these include peptic ulcer without surgery, age over 69 (DRG 177) and uncomplicated kidney stone surgery (DRG 324), which were placed into the low category, and kidney stone with complication or comorbidity (DRG 323), which was placed at the medium/low level. Many malignancies for which surgery was performed also were placed at the medium/low level (DRGs 146–150). Diabetes without surgery, age over 35 (DRG 294) was placed at the medium/low level. Diabetes without surgery, age under 36 (DRG 295) was placed at the next higher level of the classification system, because it includes more of the relatively complex cases of juvenile onset diabetes.

The next level of the risk classification system, which was labeled medium, contained many chronic diseases. Examples include diabetes in those under 36 (DRG 295), heart failure without surgery (DRG 127), peripheral vascular disease without surgery (DRG 131), chronic obstructive pulmonary disease without surgery (DRG 88), angina without cardiac catheterization (DRG 140), uncomplicated lymphomas and myeloproliferative disorders (DRG 404, 407, 408, 414), and chemotherapy (DRG 410).

The high-risk level consisted primarily of malignancies without surgery (DRGs 16, 11, 64, 172, 173); malignancies of the lung with surgery (DRG 75); malignancies of the pancreas and hepato-biliary systems (DRGs 199–203); and complicated leukemias, lymphomas, and myeloproliferative disorders (DRGs 400, 401, 403, 405, 406). While it could be argued that the latter three conditions belong in a higher level of the classification system, one must remember that many malignant disorders of the blood in the veteran population are of the chronic variety, for which a diagnostic admission is followed by successful outpatient treatment.

Alcoholism and its effects have been shown to be more prevalent among high-cost users of care (Zook and Moore 1980), and alcohol-related gastric intestinal disease has been associated with repeated hospitalizations (Zook, Savickis, and Moore 1980). Alcohol-related disease spans a wide spectrum of severity. Our sample did not include subjects admitted only for inpatient substance abuse treatment, since the service is provided by our psychiatry department, whose admissions were excluded from our analysis. All of the subjects in our sample, therefore, were admitted for acute alcohol intoxication, alcohol detoxification, minor/major alcohol-related complications, or all three. Therefore, unspecified alcohol dependence (DRG 236) was assigned to the high level of the readmission risk classification. Because they represent an even more severe part of the spectrum of alcoholism, DRGs 202 (cirrhosis), 204 (pancreatitis), and 433 and 438 (substance-induced organic mental disorders) were assigned to the highest level of the readmission risk classification: very high.

Other diagnoses placed at the very high level of the readmission risk classification include renal failure (DRGs 316, 317), which others have shown to be highly associated with repeated hospitalization (Zook, Savickis, and Moore 1980); extensive burns that were not transferred (DRG 457); and disorders of the blood cells, coagulation system, and blood-forming or immune organs (DRGs 392–399). Blood disorders, in general, have been associated with repeated hospitalizations (Zook, Savickis, and Moore 1980), and anemia has been associated with an increased risk of unplanned readmission (Smith, Norton, and McDonald 1985). Anemias that determine DRG assignment are likely to be the severe variety that require repeated transfusions (and for which patients were commonly admitted during the study period). For these reasons, DRGs 392–399 were placed at the very high level of the readmission risk classification.

STATISTICAL ANALYSIS

The stepwise logistic regression models were constructed using the BMDP program LR (Logistic Regression). A 50 percent random sample was selected to be used as a data base for developing the statistical models. The remaining half of the sample was reserved to validate the models.

The statistical modeling process involved several steps. In the first step, the association between each hypothesized risk factor and the outcome was assessed using a chi-square statistic. Variables with chi-square statistics less than one were excluded. This screening process was necessary to keep the list of hypothesized risk factors to a manageable size. The remaining variables were subjected to stepwise multiple logistic regression. The criterion for entry of an hypothesized risk factor into the final model was statistical significance at the $p < .05$ level. Next, the fit of the model was assessed by the Hosmer chi-square goodness-of-fit statistic (Hosmer and Lemeshow 1980). Finally, an attempt was made to validate each model by applying to the validation data base the model that had been built using the development data. The following features of the model were assessed in the validation data base: the stability of the coefficients estimated from the development data, the statistical significance of these coefficients, and the value of the Hosmer chi-square test statistic for the model.

RESULTS

The distribution of hypothesized demographic, clinical, and social risk factors in our sample of 6,317 veterans discharged from the Ann Arbor VA Medical Center is displayed in Table 1. When the outcome was any early readmission, 22 percent of veterans had early readmissions; when the outcome was restricted to same-DRG early readmissions, 8 percent of veterans had early readmissions. Approximately 97 percent of the readmissions were to the Ann Arbor VAMC, at which all patients in the study initially received care. The remaining 3 percent represented readmissions to other Great Lakes Region Department of Veterans Affairs medical centers.

PREDICTIVE MODEL: ANY EARLY READMISSION

The logistic regression model for any early readmission was built using data from the 2,970 of 3,159 patients in the development data base for whom complete patient treatment file data were available. Variables entered the logistic regression model for any readmission in the following order: location, number of surgical procedures, compensation and pension status, readmission risk class, bed section of discharge, and age. The Hosmer chi-square statistic for the model in the validation data was 1.98 (p = .981). The estimated coefficients of the model and their associated adjusted odds ratios (OR) for both the original and the validation data bases are displayed in Table 2. With the exception of those for compensation/pension status, the coefficients are similar for both data bases.

The adjusted ORs of greatest magnitude for early readmission were associated with the clinical risk factors of discharge from an intermediate care ward (OR = 2.75 relative to medical ward) and a clinical diagnosis placing the patient into the highest level of the readmission risk classification (OR = 2.67 relative to acute disorders). The readmission risk classification showed a consistent trend of increasing odds ratios in both the development and validation data bases, with most chronic conditions being associated with odds ratios of two or more. The performance of surgery was associated with an increased risk of early readmission. This was evidenced by the OR of 1.87 for two or more surgical procedures performed during an index admission and that of 1.48 for discharge from a surgical service. Increasing distance of county of residence from the Ann Arbor VAMC, at which 97 percent of all readmissions occurred, was associated with an increased probability of early readmission. Each increment of the location variable was associated with an 18 percent increase in the risk of early readmission.

The relationship between compensation and pension status and early readmission is not clear from our results. Individual coefficients for the levels of this variable differ considerably between the development and validation data bases, and attain statistical significance only in the validation data base. One must therefore be cautious about drawing inferences regarding the relationship between compensation and pension status and the probability of early readmission.

Hypothesized risk factors noteworthy for their failure to be selected for entry into the model included sex, marital status, category of beneficiary (period of military service), length of hospital stay, presence of spinal cord injury, number of diagnoses, number of nonoperative procedures performed, and place of disposition (nursing home or other facility as opposed to independent living).

PREDICTIVE MODEL: SAME-DRG EARLY READMISSION

The logistic regression model for same-DRG early readmission was built using data from the 2,985 of 3,159 persons in the development data base for whom complete PTF data were available. The following variables entered the stepwise logistic regression model: location, readmission risk classification, and category of beneficiary. The Hosmer chi-square statistic for the model in the development data was 5.16 (p = .74).

However, this model could not be validated successfully. When stepwise logistic regression was performed on the validation data, different variables entered the model and the coefficients of others changed in sign, magnitude, or both. Since the coefficients of the same-DRG early readmission model were unstable, they are uninterpretable and we do not report them.

DISCUSSION

Improvements in discharge planning and outpatient care potentially could reduce the number of veterans who are readmitted shortly after being discharged from a VA hospital. Given limited resources, such preventive efforts should be concentrated on those veterans who are at greatest risk for early readmission. In addition, models of risk factors for early readmission might improve the efforts of quality assurance personnel, who could concentrate their efforts on facilities, services, or

Table 2: Logistic Regression Model for Any Readmission

	Original Data Set		*Validation Data Set*	
Risk Factor	*Coefficient Estimate*	*Adjusted Odds Ratio*	*Coefficient Estimate*	*Adjusted Odds Ratio*
Location†	0.1687	1.18	0.2061*	1.23
Age†	0.0847	1.10	0.0917*	1.10
Number of Surgeries				
None	—	—	—	—
One	0.1648	1.18	0.2218	1.25
Two ≥	0.6261*	1.87	0.6153*	1.85
Comp/Pension Status				
SC disability, treated	—	—	—	—
SC disability, not treated	0.5088‡	1.66	1.1945*	3.30
No disability	0.0068	1.01	0.6738*	1.96
Nonveteran	-1.3059	0.27	-0.4705	.62
Readmission Risk Classification				
Very Low	—	—	—	—
Low	0.2947*	1.34	0.2556	1.29

Medium Low	0.5987*	1.82	0.3432*	1.41
Medium	0.7072*	2.03	0.4170*	1.52
High	0.7900*	2.20	0.6840*	1.98
Very high	0.9820*	2.67	0.8143*	2.26
Bed Section				
Medical	—	—	—	—
Intermediate	1.0121*	2.75	1.124*	3.07
Neurology	0.1440*	1.16	0.0877	1.09
Surgery	0.3912*	1.48	0.2572	1.29

*Statistical significance at $p \leq .05$.

† Ordinal variable.

‡ In the original data set, the statistical significance of the coefficient of "service-connected (SC) disability—not treated for" dropped just below the $p = .05$ level after other variables were added to the model. However, the X^2 statistic for the joint effect of all levels of the compensation/pension variable was associated with a $p = .15$, causing this variable to remain in the model.

providers that had excess early readmission rates for their level of risk. Therefore, we used PTF data to construct and validate a statistical model that identifies veterans at high risk for early readmission. An early readmission was defined as any admission to a Great Lakes Region VA facility that occurred within 30 days of discharge from the VA medical center at which all initial admissions occurred.

Our principal conclusion is that clinical factors and, to a lesser extent, demographic factors are the dominant predictors of early readmission among veterans discharged from our tertiary care VA medical center. A readmission risk classification, which stratifies DRGs for our population by chronicity of disease and anticipated readmission risk based on the natural history of major diagnoses comprising each DRG, is highly predictive of early readmission. This classification system should be distinguished from previous efforts at modifying DRGs through severity-of-illness adjustments (Horn et al. 1986; Horn, Sharkey, and Bertram 1983; Gonnella, Hornbook, and Louis 1984; Conklin et al. 1984). Unlike these previous efforts, we were not as concerned with the severity of illness during a particular hospitalization as with the short- and long-term natural history of illnesses within DRGs. Severity adjustments to DRGs may be important from the standpoint of resource allocation for particular hospitalizations; however, other factors, such as the natural history of disease, may be more predictive of early readmission or other measures of resource consumption that extend beyond a particular hospital stay. To cite a clinical example, one might compare a 45-year-old male admitted with appendicitis with a 55-year-old male admitted with a moderate exacerbation of asthma and emphysema. The patient with appendicitis probably will consume more resources during his hospital stay than the asthmatic. However, if surgical treatment and antibiotics are effective, he may be less subject to early readmission or repeated hospitalization than the asthmatic. The natural history of treated appendicitis is usually cure by surgery, while asthmatic attacks recur. We did not examine whether a severity of illness for a particular hospitalization was predictive of early readmission. Previous data showing increased readmission risk for patients with longer lengths of stay (Riley and Lubitz 1986; Stanton, Jenkins, Goldstein, et al. 1985), increased symptoms (Stanton, Jenkins, Goldstein, et al. 1985), or laboratory abnormalities (Smith, Norton, and McDonald 1985) suggests such a relationship, but does not demonstrate one conclusively. Further research is needed to ascertain whether severity of illness during a particular hospitalization, systems such as our readmission risk classification, or some combination of these instruments is most predictive of early readmission risk.

We were unable to demonstrate any relationship between early readmission and length of stay. Previous research has demonstrated that longer lengths of stay are associated with higher readmission risk in non-VA populations undergoing surgery (Riley and Lubitz 1986; Stanton, Jenkins, Goldstein, et al. 1985). Our study did not address the issue of whether length of stay is a risk factor for readmission in specific categories of patients, but rather examined the influence of length of stay on readmission risk for the entire discharged population. The most important question concerning length of stay is whether premature discharge increases the risk of early readmission. Unfortunately, this question cannot be answered using data bases such as the PTF, which do not allow one to identify premature discharges. Only research that relates early readmissions to a patient's readiness for discharge, based on utilization review criteria, can address the important issue of whether premature discharge increases the risk of early readmission.

The finding that discharge from an intermediate care ward was highly predictive of early readmission must be reconciled with our failure to find any increased readmission risk among patients released to nursing homes. This apparent paradox is not related to lack of statistical power, for standard power tables (Cohen 1977) showed that our study had a power in excess of 90 percent to detect a relative risk of as low as 2.0 for discharge to a nursing home, relative to discharge to independent living. The most likely explanation for the paradox is that patients discharged from intermediate care wards are different from those released to nursing homes. Approximately one-half the beds in the intermediate care ward of the hospital where this study was performed are reserved for patients with a potential for rehabilitation. Physicians may rehospitalize such patients more aggressively than they would rehospitalize chronic patients whose principal need is caretaking. In other settings, many patients with rehabilitation potential would be released to community nursing homes, rather than to an inhouse geriatrics unit. Therefore, our findings regarding the readmission risk of patients released to nursing homes may not be generalizable to facilities without intermediate care units.

Other negative findings are also noteworthy. Neither spinal cord injury, sex, beneficiary category, marital status, number of diagnoses, nor number of nonsurgical procedures was significantly associated with readmission risk, after adjustment for factors that entered the model. It is unlikely that these are false negative results. Assuming a Type I error of .05, the power of our study to detect relative risks of 1.5–2.0 consistently exceeded 90 percent, except for spinal cord injury, for which a relative risk of 3.0 could be detected with the same power (Cohen 1977). Other studies have found increased readmission rates for spinal cord injury patients (Zook and Moore 1980; Zook, Savickis, and Moore 1980) and for widowed persons (Fethke, Smith, and Johnson 1986; Lewis 1984). However, these studies were conducted in different populations than the one we studied. Zook et al. (1980) and Zook, Savickis, and Moore (1980) examined readmissions among patients referred to a VA spinal cord hospital, rather than in a population initially admitted to an acute care VA hospital. Fethke, Smith, and Johnson (1986) studied readmissions among Medicare beneficiaries over the age of 70, and Lewis examined the discharge rates of patients in private hospitals (1984). Therefore, we interpret the discrepancies between the results of our study and previous research as evidence that readmission risk factors differ among populations.

Further support for the concept that readmission risk factors differ among populations is provided by comparing our results with those of Anderson and Steinberg (1985). The latter authors found that surgery during the index admission reduced the risk of readmission among Medicare beneficiaries. In contrast, we found that surgery increased the risk of subsequent early readmission, especially if two or more operations were performed. Although these studies used different times-to-readmission as endpoints, the most likely explanation for the above discrepancy is that different populations of patients were examined in the two studies.

The above discussion illustrates that early readmission models developed in one population may not be applicable in another. The model that we have developed probably is generalizable to tertiary care VA medical centers with similar patient populations, physician practice patterns, and facilities. However, it may not apply to smaller, non-university-affiliated VA medical centers.

POLICY IMPLICATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The DRG-based resource allocation system provides no incentives for an individual VA medical center to undertake programs to reduce early readmissions. In fact, VA medical centers that were successful in reducing early readmissions could be penalized under this system. Resources would be expended to reduce early readmissions, and the resulting decrease in inpatient volume would adversely influence subsequent resource allocation. However, special resource allocations could be provided to VA medical centers that develop successful preventive programs, in order to mitigate reductions in future financial support caused by reductions in inpatient workload.

One purpose of our research was to identify weaknesses in social support for veterans, the correction of which might prevent unnecessary early readmissions. However, the only social factor of clear importance was alcoholism and its complications. These findings support similar evidence on the relative unimportance of social factors as predictors of readmission risk for Medicare beneficiaries (Holloway, Thomas, and Shapiro 1988). Nonetheless, adverse social factors may increase the risk of early readmission for two reasons. First, the PTF does not allow evaluation of all pertinent social risk factors. For example, no data in the PTF define the adequacy of family support systems or the ability of patients to care for themselves. Therefore, researchers interested in identifying social support deficiencies that contribute to readmission risk must gather data prospectively or through retrospective medical record reviews. Second, our failure to demonstrate statistical significance for hypothesized social risk factors may simply reflect the successful operation of existing social service and discharge planning support systems. In other words, social risk factors will not be detected if existing social services compensate for them. Our data should not be construed as evidence that funding for social services can be reduced without increasing readmission rates.

The unexpected finding that increasing distance between a patient's residence and the VAMC was associated with a higher risk of early readmission needs to be investigated. If patients from distant communities are more severely ill than local patients (due to referral patterns), then more careful attention to the predischarge clinical status of high-risk patients may reduce the incidence of early readmissions. If severity of illness does not differ between these two patient groups, the association between distance and readmission may be due to failure by veterans who reside far from the VA medical center to obtain appropriate medical care in their hometowns. Better coordination of follow-up care by the discharging VA medical center might then be effective in eliminating some unnecessary early readmissions.

The prominent risk that clinical factors play in determining early readmission risk is important for several reasons. First, algorithms that monitor early readmissions to identify either excess utilization or deficiencies in the quality of care should incorporate adjustments based on validated clinical risk factors for early readmission. Further research is needed to determine whether the risk factors we have identified are important for other VA medical centers, especially those not affiliated with major universities. Failure to do so may result in quality problems being identified where none truly exist, or in undue pressure to avoid readmissions.

Second, programs for the prevention of early readmissions should distinguish between avoidable and necessary readmissions. In a population characterized by the presence of chronic illness with intermittent exacerbations, some early readmissions are unavoidable. In addition, those who design preventive programs may wish to concentrate their efforts on particular diagnoses or groups of related diagnoses. Our results do not suggest any broad-based, widely applicable approaches to reducing early readmissions that are likely to be effective. This contention is supported by the results of a recently reported randomized trial of a multifaceted postdischarge intervention in a nonveteran population, which failed to demonstrate a statistically significant reduction in nonelective readmissions among members of the intervention group (Smith et al. 1988). Close cooperation with physicians might identify specific medical conditions where alterations in practice patterns could reduce preventable readmissions without jeopardizing patient welfare. Such an effort would be facilitated by the development of statistical models that predict readmission risk for patients with particular diagnoses, or those whose hospital stays are classified into specific DRGs.

Information pertaining to documented risk factors for early readmission should be incorporated into the design of preventive programs. Such programs should focus on veterans now known to be at high risk for early readmission, such as those with discharge diagnoses that place them at higher levels of our readmission risk classification, those who undergo multiple surgical procedures, those who reside at greater distances from a tertiary care center where they are hospitalized, and those who are discharged from intermediate care wards. Finally, the clinical value and cost effectiveness of programs designed to prevent early readmissions should be assessed in the veteran population, preferably through a random clinical trial. Although such a trial in a nonveteran population demonstrated lower inpatient costs for high-risk subjects who received intensive postdischarge care (Weinberger et al. 1988), similar data are lacking for the veteran population.

APPENDIX

Complete Listing of Readmission Risk Categories

Risk Category	DRGs Included in Category
Very Low	2, 6, 9, 18, 19, 20, 21, 25-27, 29-33, 37-48, 50-63, 66-74, 80, 81, 84, 90, 91, 94, 95, 102, 119, 123, 144, 145, 158, 160, 162, 163, 165-171, 178, 183-190, 196, 198, 201, 206-208, 211-213, 216, 219, 220, 222, 224, 225, 227-229, 232-235, 237, 241-256, 261, 262, 265-270, 276, 278-284, 289, 290, 293, 297, 298, 300, 301, 305, 307, 309, 310, 311-315, 321, 322, 325-333, 337, 339-345, 349-352, 354, 355, 358-362, 364, 365, 368, 369, 370-378, 380, 381, 383-385, 390, 421-425, 427, 431, 432, 440, 443-448, 450, 451, 455, 459, 460, 464, 466, 467, 468-470
Low	3-5, 8, 13, 17, 22-24, 28, 34, 36, 65, 79, 83, 100, 101, 116-118, 120, 128, 134, 135, 151, 156, 157, 159, 161, 164, 175-177, 181, 182, 192, 194, 195, 200, 205, 209, 215, 218, 221, 223, 226, 231, 236, 238, 240, 257-260, 277, 291, 292, 296, 299, 301, 306, 308, 320, 324, 335, 336, 348, 356, 363, 379, 388, 391, 409, 417, 426, 428, 439, 441, 449, 454, 458, 462, 463, 152, 153, 461
Medium Low	1, 7, 16, 78, 85, 86, 98, 99, 104-107, 109, 125, 126, 133, 136, 139, 141-143, 146, 147, 148-150, 155, 179, 180, 193, 197, 210, 214, 217, 230, 271-273, 286, 288, 294, 323, 347, 382, 387, 415, 418, 420, 429, 430, 434, 435, 442, 453, 108
Medium	12, 14, 15, 49, 76, 77, 82, 87-89, 92, 93, 96, 97, 103, 110, 111-115, 121, 122, 124, 127, 129-132, 137, 138, 140, 154, 174, 191, 263, 264, 275, 285, 287, 295, 302, 303, 319, 334, 338, 357, 386, 389, 402, 404, 407, 408, 410, 414, 416, 419, 437, 452, 465, 411, 412
High	10, 11, 64, 75, 172, 173, 199, 203, 239, 274, 318, 346, 353, 366, 367, 400, 401, 403, 405, 406, 413, 436
Very High	202, 204, 316, 317, 392-399, 433, 438, 456, 457

REFERENCES

Anderson, G. F., and E. P. Steinberg. "Predicting Hospital Readmissions in the Medicare Population." *Inquiry* 22, no. 3 (1985):251-58.

Berman, M. J., L. E. Weeks, and S. F. Kukla. *The Financial Management of*

Hospitals, 6th edition. Ann Arbor, MI: Health Administration Press, 1986.

Cohen, J. *Statistical Power Analysis for the Social Services*, revised edition. New York: Academic Press, 1977.

Conklin, J. E., D. Louis, J. Liebermann, and J. Meinberg. "Refinements to Diagnosis-Related Groups Based on Severity of Illness and Age." *Final Report*. Contract no. HMS 100-82-0038, 1984.

Department of Health and Human Services. *Health Care Financing Administration*. Publication no. 19, Transmittal no. IM 85-2, March 1985.

Fethke, C. C., I. M. Smith, and N. Johnson. " 'Risk' Factors Affecting Readmission of the Elderly into the Health Care System." *Medical Care* 24, no. 5 (1986):429-37.

Frank, R. G., and J. R. Love. "Per Case Prospective Payment for Psychiatric Inpatients: An Assessment and Alternatives." *Journal of Health Policy, Politics and Law* 11, no. 1 (1986):83-96.

Gonnella, J. S., M. C. Hornbook, and O. Z. Louis. "Staging of Disease: A Case-Mix Measurement." *Journal of the American Medical Association* 251, no. 5 (1984):637-44.

Health Services Research and Development Program, Ann Arbor Veterans Administration Medical Center. *Patient Treatment File: OSIRIS III Codebook*. October 1983.

Holloway, J. J., J. W. Thomas, and L. Shapiro. "Clinical and Sociodemographic Risk Factors for Readmission of Medicare Beneficiaries." *Health Care Financing Review* 10, no. 1 (1988):27-36.

Horn, S. D., R. A. Horn, P. D. Sharkey, and A. F. Chambers. "Severity of Illness Within DRGs: Homogeneity Study." *Medical Care* 24, no. 3 (1986):226-35.

Horn, S. D., P. D. Sharkey, and D. Bertram. "Measuring Severity of Illness. Homogeneous Case-Mix Groups." *Medical Care* 21, no. 1 (1983):14-30.

Hosmer, D., and S. Lemeshow. "Goodness-of-Fit Tests for the Multiple Logistic Regression Model." *Communication in Statistics—Part A: Theory and Methods* A9, no. 10 (1980):1943-.

Lewis, W. F. "Marital Status and Its Relation to the Use of Short-Stay Hospitals and Nursing Homes." *Public Health Reports* 99, no. 4 (1984):415-24.

Light, D. W., E. J. Phipps, P. O. Piper, D. J. Rissmiller, J. W. Mobilo, and W. F. Ranerri. "Finding Psychiatric Diagnosis-Related Groups That Work: A Call for Research." *American Journal of Psychiatry* 143 (1986):622-24.

Riley, G., and J. Lubitz. "Outcomes of Surgery in the Medicare Aged Population: Rehospitalization After Surgery." *Health Care Financing Review* 8, no. 1 (1986):23-34.

Schroeder, S. A., J. A. Showstack, and H. E. Roberts. "Frequency and Clinical Description of High-Cost Patients in 17 Acute-Care Hospitals." *New England Journal of Medicine* 300, no. 23 (1979):1306-09.

Smith, D. M., J. A. Norton, and C. J. McDonald. "Nonelective Readmissions of Medical Patients." *Journal of Chronic Disease* 38, no. 3 (1985):213-24.

Smith, D. M., M. Weinberger, B. P. Katz, and P. S. Moore. "Postdischarge Care and Readmissions." *Medical Care* 26, no. 7 (1988):699-708.

Stanton, B. A., D. C. Jenkins, R. L. Goldstein, T. J. Vander Salm, M. D.

Klein, and R. A. Aucoin. "Hospital Readmissions Among Survivors Six Months after Myocardial Revascularization." *Journal of the American Medical Association* 253, no. 24 (1985):3568–73.

Weinberger, M., D. M. Smith, B. P. Katz, and P. S. Moore. "The Cost-Effectiveness of Intensive Postdischarge Care: A Randomized Trial." *Medical Care* 26, no. 11 (1988):1092–1102.

Zook, C. J., and F. D. Moore. "High-Cost Users of Medical Care." *New England Journal of Medicine* 302, no. 18 (1980):996–1002.

Zook, C. J., S. F. Savickis, and F. D. Moore. "Repeated Hospitalizations for the Same Disease: A Multiplier of National Health Care Costs." *Milbank Memorial Fund Quarterly (Health and Society)* 58, no. 3 (1980):454–71.