

## Predicting non-elective hospital readmissions: A multi-site study

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Received 15 January 1999; received in revised form 15 February 2000; accepted 4 March 2000

### Abstract

**Objective:** To determine clinical and patient-centered factors predicting non-elective hospital readmissions. **Design:** Secondary analysis from a randomized clinical trial. Clinical setting. Nine VA medical centers. Participants. Patients discharged from the medical service with diabetes mellitus, congestive heart failure, and/or chronic obstructive pulmonary disease (COPD). Main outcome measurement. Non-elective readmission within 90 days. **Results:** Of 1378 patients discharged, 23.3% were readmitted. After controlling for hospital and intervention status, risk of readmission was increased if the patient had more hospitalizations and emergency room visits in the prior 6 months, higher blood urea nitrogen, lower mental health function, a diagnosis of COPD, and increased satisfaction with access to emergency care assessed on the index hospitalization. **Conclusions:** Both clinical and patient-centered factors identifiable at discharge are related to non-elective readmission. These factors identify high-risk patients and provide guidance for future interventions. The relationship of patient satisfaction measures to readmission deserves further study. © 2000 Elsevier Science Inc. All rights reserved.

**Keywords:** Patient readmission; Hospitalization; Risk factors; Patient discharge; Patient satisfaction

### 1. Introduction

Among hospitalized general medicine patients who are discharged to home, 17–19% experience non-elective readmissions (those for urgent or emergent reasons) within 90 days of discharge [1–3] and these rates are higher (31–50%) for older patients [4,5]. Early readmission may reflect the natural course of disease or poor quality of care [6,7]. In ei-

ther case, strategies to identify and intervene with high-risk patients are essential as health care systems seek to reduce hospital utilization [8]. Nowhere is such knowledge more relevant than in the Veterans Health Administration (VHA) health care system that provides care to older and vulnerable patients at risk for readmission [9,10].

The objective of this study was to identify clinical and patient-centered factors that predict non-elective hospital readmission. Such information may be useful for providing direction for developing interventions to reduce these events. Previous studies of non-elective readmission have used prognostic models to identify risk factors [1,2,4,5,11].

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Several of those risk factors, identified by multivariable analyses, were consistent among reports. Those risk factors were more frequent prior hospitalizations and emergency room (ER) visits [1,4,5], higher blood urea nitrogen (BUN) or serum creatinine levels [1,2,11], higher white blood cell (WBC) counts [1,11], and anemia [1,2,11].

A recent multi-site clinical trial [12] provided an opportunity to extend prior research. The advantages of this database were that it contained data from nine geographically diverse hospitals and included measures of patient-centered variables such as functional status (health-related quality of life) and patient satisfaction (a measure of quality of care). Our hypotheses were that higher functional status and higher patient satisfaction would be independently and inversely related to readmission after adjusting for previously reported risk factors.

## 2. Methods

### 2.1. Study sites and population

This is a secondary analysis of a multi-center randomized, controlled trial of increasing access to primary care for patients hospitalized at nine VA Medical Centers [12]. Sites were chosen for diversity of location and academic affiliation, not on the basis of their readmission rates. Before the investigation began, all the study personnel met to review and standardize the study protocol.

Patients hospitalized on the General Medicine Service were eligible if they had diabetes mellitus, chronic obstructive pulmonary disease (COPD), or congestive heart failure (CHF) documented in the medical record at or before the time of the index admission (not necessarily as the reason for admission). We selected these three diseases because they are prevalent among veterans, patients with these diseases are commonly readmitted, and hospital readmissions to treat these diseases might be reduced if physicians could recognize high-risk patients sufficiently early (at time of discharge) to provide more intensive care before or after discharge.

Patients were excluded if they were: already receiving continuous care at a primary care clinic; receiving dialysis, chemotherapy, or radiation therapy; residing in, or planned to be discharged to a nursing home; admitted only to undergo a procedure; hospitalized to receive terminal care; unable to speak English; if they scored  $\leq 5$  on the Mental Status Questionnaire [13] and had no care giver; or had no telephone access.

### 2.2. Study design

Research assistants at each site screened all patients admitted to the General Medicine Service. Potentially eligible patients were referred to the study nurse, who determined eligibility, obtained informed consent, and collected baseline data. Patients were randomized into one of two groups, control (usual care) or a primary care intervention, and were

then followed for 6 months [12]. The primary care intervention included enhanced access to a primary care nurse and physician.

### 2.3. Baseline variables

Baseline variables included the hospital site, patient demographics, the Medical Outcomes Study short form health survey (SF-36) from which the Physical and Mental Component Summaries were computed [14,15], and 11 subscales of the Patient Satisfaction Questionnaire (PSQ) [16]. We hypothesized that increased physical and mental function and increased patient satisfaction would be related to lower readmission rates. From the medical records, data were obtained on the severity of disease. For diabetes mellitus, severity classes were: (1) on diet or oral agents; (2) on insulin; and (3) with severe end-organ damage irrespective of treatment. For COPD, severity was coded as: (1) presence of COPD without oral steroids or home oxygen; (2) on chronic oral steroids; and (3) on home oxygen with or without oral steroids. For CHF, we used the New York Heart Association classes (I through IV).

In addition, from each local hospital computer (Decentralized Hospital Computing Program, a standardized information system in VA hospitals), we obtained the last laboratory value prior to discharge for BUN, hemoglobin, and WBC. Hospitalizations during the 180 days prior to discharge were obtained from the Patient Treatment File (PTF), a national administrative database containing information on all VA hospitalizations.

### 2.4. Primary outcome variable

The primary outcome variable was time to first non-elective readmission within 90 days of discharge. Elective readmissions were not considered as part of the outcome. Elective readmissions were for non-urgent, scheduled procedures where a delay in the inpatient stay presented no risk to the patient; for example, elective orthopedic surgery, hernia repair, and elective cardiac catheterization. All other readmissions were considered non-elective [11]. Patients who died were censored at the time of death.

We identified readmissions within the VA using the PTF. We chose 90 days as the time period when readmissions are more likely affected by baseline measures. The 90-day interval has also been used in previous reports [1–3] and a plot of readmission frequency over time showed a drop in frequency after 90 days. Information regarding non-VA readmissions came from reports by patients and were verified with their providers. Only readmissions that could be verified by providers were counted. Medical records of VA and non-VA hospitalizations were classified as elective or non-elective by a panel of physicians.

### 2.5. Statistical analysis

The patient was the unit of analysis. Chi-square tests and *t*-tests were used for the bivariate analyses evaluating the

association between candidate variables and readmission. PROC LIFETEST from SAS [17] was used to test the proportional hazards assumption. Participating site showed definite departure from this assumption (log-rank,  $P = 0.0001$ ); so a stratified Cox model was used with site as the stratification variable [18,19]. The SAS procedure PHREG [17] was used to conduct the analysis allowing for stratification by site. The Cox model was initially fit including all candidate predictor variables. A stepwise procedure was then employed using backward elimination. The model routine ceased removing variables when no variable had a significance level greater than 0.05.

Twenty bootstrap samples were run to see what variables would be selected in each of the models. For each sample, stepwise Cox regression analysis was performed with backward elimination using the  $\alpha \geq 0.05$  elimination criterion.

### 3. Results

During the study, 10,129 patients were screened; 3209 met all criteria for eligibility, and 1396 (43.5%) were enrolled. The common reasons for non-enrollment were the patient's decision not to participate (concerned about losing specialists' care) and discharge from the hospital before enrollment was completed. Of those enrolled, 18 died or withdrew from the study before discharge, leaving a cohort of 1378. Of these, 321 (23.3%) were non-electively readmitted within 90 days.

#### 3.1. Bivariate analysis

By bivariate analysis (Table 1), those patients who were readmitted non-electively were older, more likely to be Caucasian, and be unemployed. Readmitted patients had a higher burden of illness as reflected by higher BUN, presence of anemia, and leukocytosis. Those readmitted had more ER visits and hospitalizations in the prior 6 months, and they had a longer stay on the index admission. Lower physical and mental component summary scores (from the SF-36) were also found for those non-electively readmitted indicating a lower functional status for this group. Higher scores on the satisfaction surveys indicate a measure of greater satisfaction. In these bivariate analyses, there were no significant differences in satisfaction scores between those non-electively readmitted and those not, although some P-values were between 0.05 and 0.10. Patients assigned to the intervention (primary care) group were more likely to be readmitted [12]. The percent of patients readmitted varied significantly among the nine sites ranging from 15.3% to 37.3%.

The relationship between disease severity and readmission rates are shown in Table 2. For patients with CHF, readmission rates increased consistently from 23.0% to 34.8% with increasing severity by the New York Heart Association classification. For patients with COPD, readmission rates increased from 27.7% to 38.2% along the three levels of se-

verity distinguished by pharmacologic management and use of oxygen therapy. However, for patients with diabetes mellitus, readmission rates only increased for the subgroup with end organ damage.

#### 3.2. Multivariable analyses

The variables in the final Cox regression model are shown in Table 3. Grouping these variables by the domains from Tables 1 and 2, we found none of the demographic variables to be independent predictors of non-elective readmissions. Of the three laboratory variables obtained at baseline, only a higher BUN level was an independent predictor. In terms of resource utilization, both increased emergency room visits and increased hospitalizations in the prior 6 months predicted future hospitalization.

Two patient-centered variables were significantly and independently related to non-elective readmissions: (1) lower scores on the mental component summary scale (from the SF-36) and (2) higher satisfaction with access to emergency care. Assignment to treatment group (enhanced access to primary care providers) continued to be a significant predictor of readmissions. Of the three disease variables, only COPD increased risk for readmission.

Results of the 20 models in bootstrap analyses showed that hospitalizations in the prior 6 months and the diagnosis of COPD entered all 20 models. Number of ER visits in the prior 6 months and BUN level entered the models 18 and 16 times, respectively. These were followed by treatment group (13 times), satisfaction with access to emergency care (12 times), and mental component summary score (12 times). Thus, there was good consistency between the final model and the bootstrap results.

### 4. Discussion

The high frequency of hospital readmissions with their associated morbidity and costs emphasize the need for identifying high-risk patients and potential interventions targeted to risk factors that might be amenable to change. Clinical trials of interventions without targeting specific risk factors have not been successful in reducing readmission rates [3,12,20,21]. Thus, there is need for more guidance in targeting high-risk patients with specific interventions.

Using a unique database, we were able to identify seven variables that were significantly and independently related to risk of non-elective readmission. Further, these variables were validated by 20 bootstraps of the model. Some of these variables (patient-centered characteristics) have not been previously reported and provide new insights into risk factors for readmission.

Among the risk factors identified, prior health care utilization and disease severity are supported by previous studies in the literature. Specifically, prior emergency room visits and hospitalizations [1,4,5], higher levels of BUN or serum creatinine [1,2,11], and the presence of the diagnosis

Table 1  
Baseline characteristics of patients grouped by non-elective readmission status at 90 days<sup>a</sup>

Characteristics	Not readmitted (n = 1,057)	Nonelectively readmitted (n = 321)	P-Value
<b>Demographic</b>			
Age (years)	61.6 ± 11.1	64.3 ± 10.6	<0.001
Gender (% males)	98.4	98.8	0.643
Race (% white, non-Hispanic)	62.7	72.3	0.002
Marital status (% married)	54.7	54.8	0.963
Education (highest grade completed)	11.2 ± 3.2	10.9 ± 3.1	0.193
Living distance from VAMC (miles)	32.9 ± 34.5	33.7 ± 38.9	0.740
Employment status (% employed)	18.9	10.9	0.001
Service connected (%)	29.6	28.4	0.663
<b>Laboratory variables</b>			
Blood urea nitrogen (mg/dl)	19.8 ± 12.6	25.4 ± 17.6	<0.001
Presence of anemia (Hgb, males <12 G/dl, females <10 G/dl) (%)	22.8	30.8	0.001
Presence of leukocytosis (WBC ≥12,000/cu.mm) (%)	10.6	15.6	0.015
<b>Resource utilization variables</b>			
ER visits in prior 6 months	1.06 ± 1.13	1.43 ± 1.44	<0.001
Hospitalization in prior 6 months (%)	24.4	45.2	0.001
Length of stay on index hospitalization (days)	10.1 ± 9.8	12.7 ± 15.4	0.005
<b>Patient-centered variables</b>			
Physical component summary (SF-36)	32.3 ± 11.1	28.8 ± 9.5	<0.001
Mental component summary (SF-36)	45.4 ± 12.5	43.0 ± 12.7	0.003
<b>Satisfaction scales</b>			
Access to emergency care	3.3 ± 0.7	3.4 ± 0.7	0.092
Ease of reaching care location	3.5 ± 0.8	3.5 ± 0.9	0.994
Access to primary care	3.1 ± 0.9	3.2 ± 0.9	0.302
Continuity of care	2.7 ± 1.0	2.7 ± 1.0	0.904
Technical competence of providers	3.4 ± 0.5	3.4 ± 0.5	0.824
Elimination of unnecessary risks	3.0 ± 0.5	3.0 ± 0.6	0.819
Quality of facilities	3.6 ± 0.7	3.6 ± 0.7	0.318
Prudence with expenses	3.1 ± 0.8	3.1 ± 0.7	0.874
Explanations by providers	3.1 ± 0.8	3.0 ± 0.9	0.069
Consideration shown by providers	3.6 ± 0.6	3.6 ± 0.5	0.583
General satisfaction	3.2 ± 0.7	3.2 ± 0.7	0.939
Assignment to primary care intervention group (%)	47.6	56.4	0.006
Readmission by site (range, %)		15.3–37.3%	0.001

<sup>a</sup>Values are the means and standard deviations or percentages.

of COPD [4] have been previously reported as predictive of subsequent readmission. Our identifying these risk factors lends further support to their importance as predictor variables for non-elective readmission among general medicine patients. In addition, the 23% readmission rate during 90 days after discharge is also consistent with previous reports of high frequencies of non-elective readmissions for patients discharged from the medical service [1–5].

The unique findings in this study are that two patient-centered variables were significantly and independently related to non-elective readmissions even after adjusting for prior health care utilization and disease severity: mental component summary scores from the SF-36 and a patient satisfaction measure. The influence of mental health problems on risk for increased hospitalizations for patients with chronic medical disease is increasingly being recognized as important. Notably, older patients hospitalized with congestive heart failure and depression use more outpatient and inpatient medical services compared to those with congestive heart failure but without depression [22]. Thus, there is support for lower mental health scores being a risk factor for readmission among general medicine patients.

Table 2  
Disease severity and readmission rates

Disease	n	% Readmitted	P-value <sup>a</sup>
<b>Congestive heart failure</b>			
Absent	881	19.9	
NYHA Class I	61	23.0	
NYHA Class II	186	27.4	
NYHA Class III	164	31.1	
NYHA Class IV	86	34.8	0.001
<b>Chronic obstructive pulmonary disease</b>			
Absent	805	19.3	
No oral steroids or home oxygen	434	27.7	
On oral steroids	71	28.2	
On home oxygen with or without oral steroids	68	38.2	0.001
<b>Diabetes mellitus</b>			
Absent	634	27.3	
On diet or oral agents	325	18.8	
On insulin	193	14.5	
With severe end organ damage	226	26.2	0.001

<sup>a</sup>The P-values compare the percent readmitted across all severity groups within a disease.

Table 3  
Model of predictors of non-elective readmission by stepwise Cox regression

Variable	Parameter estimate	Standard error	Chi-square P-value	Risk ratio (95% CI)
Laboratory variables				
BUN	0.012	0.004	0.003	1.012 (1.004, 1.020)
Resource utilization variables				
Number of ER visits in prior 6 months	0.128	0.045	0.004	1.134 (1.041, 1.240)
Hospitalization in prior 6 months	0.617	0.134	0.0001	1.854 (1.425, 2.413)
Patient-centered variables				
Mental component summary (SF-36)	-0.013	0.005	0.011	0.987 (0.977, 0.997)
Satisfaction with access to emergency care	0.202	0.092	0.028	1.223 (1.022, 1.465)
Assignment to primary care intervention group	0.279	0.129	0.031	1.322 (1.027, 1.703)
Disease variables				
COPD	0.287	0.068	0.0001	1.333 (1.166, 1.524)

The other patient-centered risk factor was the patient satisfaction scale that has not been studied as a predictor of outcomes. Increased satisfaction with access to emergency care was associated with increased risk for readmission. Further, the intervention that increased/improved access to primary care resulted in increased patient satisfaction with access to both emergency care and primary care, but also increased readmissions [12]. We interpreted the increased frequency of emergency room visits to be a marker of those patients with unstable or more severe disease states that were not measured in this study. Thus, it appears that improving access to and satisfaction with primary care and emergency care in patients who have more severe disease without a specific intervention for those conditions is not only ineffective, but may increase non-elective readmission rates. Clearly it would be inappropriate to reduce satisfaction with access to emergency care as a method for reducing readmission rates. However, a direction for further research would be to evaluate high-risk patients for specific interventions at discharge, during follow-up care, and during emergency room visits for potential specific interventions for their disease conditions. That is, in order to reduce readmissions, research efforts will need to be directed to specific interventions in improving care when improving access.

Few of the risk factors identified in this study are modifiable, but it is important to review them to see if there are clues for possible interventions. Risk factors of prior health care utilization (e.g., prior hospitalizations and emergency room visits), are easy to obtain for rapidly targeting patients at risk for potential interventions either in a clinical trial or in clinical practice. They likely indicate patients with unstable or more severe disease states. It may be that other domains or other patient characteristics, not measured in this study, will be found to provide a direction for intervention. For example, the association of quality of inpatient care and early readmission has been reported [6,23]. Another unmeasured domain is unmet medical, nursing, and social support needs at discharge. In a previous study, this variable was predictive, but ER visits was not [11]. Thus, prior utilization factors help to easily target patients at risk and provide in-

centive to investigate other factors not measured in this study.

In the domain of disease and disease severity, higher levels of BUN and presence of COPD were significant and independent predictors of readmission. These variables indicate that patients with these specific illness markers are at higher risk. Knowledge of these markers is available at the time of discharge. One direction for finding potential interventions would be to examine the care process for patients with these markers, especially those patients with more frequent prior health care utilization.

Closely related to disease and disease severity is the domain of functional status (e.g., the mental component summary score from the SF-36). This is an important risk factor and it is not routinely assessed in practice. Consideration should be given to a brief screen for this factor at time of discharge. A review of interventions that have had a positive effect on function in this area is another direction for potential interventions to reduce readmission rates.

The findings of this study are limited by the inception cohort consisting of hospitalized veterans which limits application to other populations. However, it is a multi-site study, and many of the predictors for non-elective readmission in this study have been reported in other populations. Another limitation is the breadth of domains of the potential risk factors collected. For example, measures of quality of care [6,23] and unmet medical, nursing, and social support needs [11] were not collected. Finally, two of the risk factors in the model have risk ratios that are close to one, BUN level and mental component summary score. Although their inclusion is justified by the bootstrap analysis, variables with odds ratios close to one may not be consistently found in future studies.

In summary, identification of those factors which best predict readmission provides direction for potential interventions and/or further research for reducing costly readmissions and associated morbidity. This model is unique in finding patient-centered variables, such as mental health status and patient satisfaction, as significant and independent risk factors. Increasing the breadth of domains in future

models to include additional areas may further improve accuracy of prediction and provide more direction for potential interventions.

## Acknowledgments

Other persons participating in the study include the following: Chairperson's office: Maria Horner, M.S.P.H. (project coordinator); Jenny Terrenoire (project coordinator); Patricia Cowper, Ph.D. (health economist); Pauline Lyna, M.P.H. (statistical/programmer); Pamela Landsman, M.P.H. (statistical/programmer); Michael Monger, M.S. (research specialist); Stan Greenberg (programmer); Glenda Kwascha (secretary). Hines VA Cooperative Studies Program Coordinating Center: James Gibbs, Ph.D. (health services researcher); Rintta Lott (project coordinator). Site Participants: Brooklyn, NY: Edward Mack, M.D.; Estelita Anteola, R.N.; Rita Varano; Cincinnati, OH: Virginia Hedger, R.N.; James Schultz; Columbia, SC: Francis Goldstein, M.D.; Grady Allen, R.N.; Jodie Calkins, Ph.D.; Durham, NC: Aileen Ward, R.N.; Marjorie Foy, M.A.; Fresno, CA: Paula Hensley, R.N.; Sandra Pascal, M.S.N.; Kimberli Cox, M.A.; Indianapolis, IN: Terryl Adams, R.N.; Gayle Redmon; Leavenworth, KS: Lynn Carrel, R.N.; Marie Cook; Loma Linda, CA: Elizabeth Wise, R.N.; Nalda Gordon; Joi Carvalho; Philadelphia, PA: Neil Farber, M.D., Terry A. Jacobson, M.D.; Alice Cooney, R.N.; Joan Havey. Data Monitoring Board: Mary Foulkes, Ph.D., Bethesda, MD; Mark Hlatky, M.D., Palo Alto, CA; Thomas Meyer, M.D., Denver, CO; Kristin Nichol, M.D., M.P.H., Minneapolis, MN. Department of Veterans Affairs Headquarters: John Demakis, M.D., Director; Shirley Meehan, M.B.A., Deputy Director, Health Services R&D Service; Ping Huang, Ph.D. (staff assistant) and Joe Gough, M.A. (program manager), Cooperative Studies Program.

Funding source: Health Services Research and Development Service, Cooperative Studies Program and the Career Development Program of the U.S. Department of Veterans Affairs.

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