

# Instability on Hospital Discharge and the Risk of Adverse Outcomes in Patients With Pneumonia

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**Background:** Investigating claims that patients are being sent home from the hospital “quicker and sicker” requires a way of objectively measuring appropriateness of hospital discharge.

**Objective:** To define and validate a simple, usable measure of clinical stability on discharge for patients with community-acquired pneumonia.

**Methods:** Information on daily vital signs and clinical status was collected in a prospective, multicenter, observational cohort study. Unstable factors in the 24 hours prior to discharge were temperature greater than 37.8°C, heart rate greater than 100/min, respiratory rate greater than 24/min, systolic blood pressure lower than 90 mm Hg, oxygen saturation lower than 90%, inability to maintain oral intake, and abnormal mental status. Outcomes were deaths, readmissions, and failure to return to usual activities within 30 days of discharge.

**Results:** Of the 680 patients, 19.1% left the hospital with 1 or more instabilities. Overall, 10.5% of patients with no instabilities on discharge died or were readmitted compared with 13.7% of those with 1 instability and 46.2% of those with 2 or more instabilities ( $P < .003$ ). Instability on discharge ( $\geq 1$  unstable factor) was associated with higher risk-adjusted rates of death or readmission (odds ratio [OR], 1.6; 95% confidence interval [CI], 1.0-2.8) and failure to return to usual activities (OR, 1.5; 95% CI, 1.0-2.4). Patients with 2 or more instabilities had a 5-fold greater risk-adjusted odds of death or readmission (OR, 5.4; 95% CI, 1.6-18.4).

**Conclusions:** Instability on discharge is associated with adverse clinical outcomes. Pneumonia guidelines and pathways should include objective criteria for judging stability on discharge to ensure that efforts to shorten length of stay do not jeopardize patient safety.

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OVER THE past 15 years, hospital length of stay has fallen dramatically. Studies assessing the impact of the prospective payment system on hospital care of Medicare beneficiaries in the 1980s indicated that this shortening length of stay was accompanied by a 43% relative increase in patients being sent home clinically unstable with unresolved medical issues.<sup>1,2</sup> This was worrisome because Medicare beneficiaries who were discharged unstable had a 60% greater odds of death.<sup>2</sup> This has been called the “quicker and sicker” phenomenon. The widespread diffusion of managed care throughout the 1990s has resulted in even more dramatic declines in the length of stay for many common conditions, including pneumonia.<sup>3</sup> With patients needing to be sicker than ever to justify admission and the duration of hospital stays becoming even shorter, many providers, patients, and policy makers have expressed concern that

patients are being sent home quicker and sicker than ever.<sup>4-8</sup>

Investigating these claims in an unbiased fashion requires a way of objectively measuring appropriateness of hospital discharge. In general, federal and state legislative and regulatory approaches have focused on the duration of hospital stay.<sup>6</sup> Unfortunately, since the landmark RAND study in the early 1990s,<sup>2</sup> there have been few, if any, clinical indicators proposed that empirically assess readiness for hospital discharge. The RAND measure of instability on discharge, which was developed in the 1980s, has the limitations of not including some factors that are now considered core vital signs (such as oxygen saturation), while including others that are no longer thought to have major clinical significance (eg, premature ventricular contractions).

In a previous study, we developed a pneumonia-specific measure of clinical stability that was based on a smaller number of key clinical variables, included key

## SUBJECTS AND METHODS

### STUDY POPULATION AND SITES

The present study was part of the Pneumonia Patient Outcomes Research Team (PORT) cohort study (a prospective, multicenter, observational study of outcomes in hospitalized and ambulatory patients with community-acquired pneumonia). Complete details about the Pneumonia PORT cohort study have been described previously.<sup>12,15</sup> Study inclusion criteria were (1) age 18 years or older, (2) symptoms of acute pneumonia, and (3) radiographic evidence of pneumonia. Patients were excluded if they were human immunodeficiency virus positive or had been hospitalized within 10 days.

As part of a substudy on all hospitalized patients enrolled in the Pneumonia PORT cohort study, detailed daily inpatient data were collected during 2 consecutive sampling periods. During period 1 (October 15, 1991, through May 14, 1993), medical record review was done on consecutive low-risk patients (<4% predicted risk of death). During period 2 (May 15, 1993, through March 31, 1994), medical record review was done on all consecutive hospitalized patients regardless of mortality risk. This strategy captured 680 patients who were discharged alive from the overall Pneumonia PORT cohort study of 1343 inpatients. Because we oversampled low-risk patients during period 1, the 680 patients in the detailed daily assessment cohort we report on in the present study were younger (mean age, 61 vs 74 years) and had lower predicted 30-day mortality (2% vs 6%) than patients in the overall Pneumonia PORT study who did not have daily medical record review. The mortality rates for all inpatients enrolled during study periods 1 and 2 (prior to exclusion of high risk cases in period 1) were the same (7% vs 6%). There were no differences in the mortality rates for patients entered in the 2 sampling periods when we stratified by admission mortality risk class as defined by the Pneumonia Severity Index (PSI), a multivariable logistic model of short-term mortality described below.<sup>15</sup>

The participating inpatient sites (and number of patients enrolled) were the University of Pittsburgh Medical Center and St Francis Medical Center, Pittsburgh, Pa (214 and 59, respectively); the Massachusetts General Hospital, Boston (243); and the Victoria General Hospital, Halifax, Nova Scotia (164). The study was conducted from October 15, 1991, through March 31, 1994, and was approved by the institutional review board of all participating institutions.

### BASELINE DATA, DAILY MEASUREMENTS, AND DEFINITIONS OF STABILITY

Information on sociodemographic characteristics, initial pneumonia severity, comorbid conditions, vital signs, mental status, ability to eat, physical examination findings, laboratory results, and chest radiography findings was collected on admission. Pneumonia severity was assessed using the PSI, which is a well-validated, disease severity classification using a 20-variable composite score based on age, sex, nursing home residence, 5 comorbid illnesses, vital signs on admission, mental status, and 7 laboratory and chest radiography findings from presentation.<sup>15</sup> Class I patients have the least severe disease, and class V patients, the most

severe disease. The PSI has been shown to be a robust predictor of a full range of 30-day outcomes including mortality, readmissions, and return to usual activities.<sup>12,15-18</sup>

The highest temperature, heart rate, and respiratory rate and the lowest systolic blood pressure, oxygen saturation, and PaO<sub>2</sub> of each hospital day was abstracted from the medical record. Nearly all temperatures on the hospital ward were measured orally. The patient's mental status and ability to eat each day were also recorded. A patient was considered to be stable on discharge if their temperature, heart rate, respiratory rate, systolic blood pressure, oxygenation, ability to eat, and mental status were all stable in the 24-hour period prior to discharge.<sup>9</sup> Stable values for vital signs were selected prior to analysis based on the clinical literature and common clinical practice.<sup>2,10</sup> The stability cut point for temperature was 37.8°C or lower; heart rate, 100/min or lower; systolic blood pressure, 90 mm Hg or higher; and respiratory rate, 24/min or lower.

Oxygenation was considered stable if the oxygen saturation rate was 90% or higher or the PaO<sub>2</sub> was 60 mm Hg or higher and a patient was not receiving mechanical ventilation or supplemental oxygen by face mask. We did not know the oxygen flow rate for patients who received supplemental oxygen by nasal prongs. Therefore, we regarded these patients to have stable oxygenation if they had an oxygen saturation rate of 95% or higher. If oxygenation was not measured on a given day, the value of the most recent assessment was used. The mean last day that oxygen saturation was measured was 6.4 days. Patients who used home oxygen prior to admission were not considered to have unstable oxygenation on discharge.

Mental status was considered stable if the patient was either normal or, for those with chronic dementia, back to baseline. Patients who were able to eat (or resumed long-term tube feeding) were counted as having stable eating status. The number of instabilities on discharge was defined as the number of vital sign and clinical status factors that did not meet the above criteria in the 24 hours prior to leaving the hospital.

### CLINICAL OUTCOMES

All patients received a standard telephone follow-up call 30 days after discharge to ascertain survival, readmissions, and return to their usual activities. Any death or readmission within 30 days of discharge was considered a major event. Patients who died after being readmitted were only counted as having 1 major event. We constructed this composite outcome because we believed that either adverse outcome could be a marker of a patient being sent home prior to being clinically ready.

### STATISTICAL ANALYSES

Means±SDs are presented for normal data and medians with interquartile ranges (IQRs) for nonnormal data. We used logistic regression to examine the association between the number of instabilities on discharge and the risk of death, readmission, major events, and failure to return to usual activities within 30 days of hospital discharge. Candidate variables entered into the multivariable models were PSI score, do not resuscitate (DNR)

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status, number of comorbid conditions, presence of chronic obstructive pulmonary disease, use of home oxygen, discharge to a skilled nursing home facility, discharge against medical advice, and receipt of posthospital home health services. Covariates that were significant at the 2-tailed level of  $P < .05$  were retained in the final multivariable models. All other analyses also used 2-tailed significance levels of  $P < .05$  and were conducted with SAS statistical software (version 6.12; SAS Institute, Cary, NC). Using the Kaplan-Meier and Cox proportional hazards methods, we found similar associations between instabilities on discharge and the time to death, readmission, or failure to return to usual activities within 30 days as those produced by the primary logistic regression models we report herein. The sensitivity, specificity, positive predictive value, and negative predictive value of 2 definitions of instability on discharge to identify death or readmission within 30 days were calculated in the standard fashion.<sup>19</sup>

variables such as oxygenation, and used vital sign cut points that more closely corresponded to traditional thresholds than the original RAND criteria (eg, heart rate is stable if  $\leq 100/\text{min}$  vs RAND cut point of  $< 130/\text{min}$ ).<sup>2,9,10</sup> Our definition of clinical stability was based on temperature, heart rate, blood pressure, respiratory rate, oxygenation, mental status, and ability to maintain oral intake. These factors have been identified by physicians as important for deciding when to switch from intravenous to oral antibiotics<sup>10</sup> and how to judge appropriateness for hospital discharge.<sup>11</sup> Once someone with pneumonia was stable according to this disease-specific definition of stability, the risk of serious clinical deterioration during the rest of their hospital stay was 1% or less, even in the sickest subgroup of patients.<sup>9</sup>

From a patient safety perspective, it is equally important to assess the relationship between stability on discharge and posthospital outcomes. Among patients with pneumonia, the rates of death, readmission, and delayed return to usual activities in the 30 days after leaving the hospital are substantial.<sup>12-14</sup> The specific aims of the present study were to (1) describe rates and types of instability on discharge, (2) examine associations between instability on discharge and a range of posthospital outcomes, and (3) determine if instability on discharge influences the risk of adverse events even after adjusting for other important prognostic factors and potential confounders. Our hypothesis was that the greater the number of instabilities on discharge, the greater the risk of adverse outcomes following discharge.

## RESULTS

### PATIENT CHARACTERISTICS

Characteristics of the study subjects are summarized in **Table 1**. The patients' mean age was  $57.9 \pm 19.3$  years (range, 18-101 years). Half (352) of the sample were women. According to the PSI score on admission, 70%

of patients were low-risk cases (class I-III), 20% were moderate risk (class IV), and 8%, high risk (class V). One quarter (165) of patients had 1 major comorbid illness, and half (345) had 2 or more.

### VITAL SIGNS ON DISCHARGE AND RATES OF INSTABILITY

The mean length of hospital stay was  $9.2 \pm 8.9$  days (median, 7 days; IQR, 5-10 days). The mean length of stay ranged from 7.7 to 11.3 days among the 4 sites. The mean vital sign measures on discharge were a temperature of  $36.7^\circ\text{C} \pm 0.60^\circ\text{C}$ , a heart rate of  $82.4/\text{min} \pm 12.39/\text{min}$ , a respiratory rate of  $20.8/\text{min} \pm 3.3/\text{min}$ , a systolic blood pressure of  $121.6 \text{ mm Hg} \pm 19.0 \text{ mm Hg}$ , and an oxygen saturation rate of  $93.6\% \pm 4.7\%$ . The incidence of unstable vital signs on discharge ranged from 1% for a systolic blood pressure of 90 mm Hg or lower to 5.9% for an oxygen saturation rate of 90% or lower (**Table 2**). Mental status and ability to maintain oral intake were both abnormal in fewer than 2% of patients.

Overall, 130 patients (19%) had 1 or more instabilities on discharge. Among the 117 patients with 1 instability on discharge, the most common abnormalities were oxygenation (32%), respiratory rate (16%), heart rate (16%), temperature (15%), mental status (8%), eating status (7%), and systolic blood pressure (4%). Twelve patients had 2 instabilities on discharge, and 1 patient had 3 abnormalities. Among patients with more than 1 instability on discharge, no specific combination of abnormalities dominated. There were no differences in rates of instability on discharge among the 4 study sites (range, 18.9%-20.6%).

### OUTCOMES

In the 30 days after discharge, 23 patients (3.4%) died; the median time to death was 18 days (IQR, 8-24 days). Sixty-seven patients were readmitted within 30 days (9.9% readmission rate); the median time of readmission was 10 days (IQR, 4-16 days). Overall, 80 patients died or were readmitted within 30 days of discharge (major adverse events rate, 11.8%). Ten patients died after readmission to the hospital. Patients admitted from a nursing home accounted for 15.0% of major events. We had data on return to usual activities for 641 patients. Overall, 223 patients (32.8%) did not return to their usual activities within 30 days of discharge.

### UNIVARIABLE ASSOCIATIONS BETWEEN INSTABILITY ON DISCHARGE AND OUTCOMES

The greater the number of instabilities on discharge, the greater the risk of death, readmissions, major events, and failure to return to usual activities ( $P < .05$  for all) (**Figure**). For example, 10.5% of patients with no instabilities on discharge died or were readmitted within 30 days compared with 13.7% of those with 1 instability and 46.2% of those with 2 or more instabilities ( $P = .003$ ). When we considered patients with any instabilities on discharge as unstable, we found that those who left the hospital prior to reaching stability had higher rates of death (odds ratio [OR], 2.8; 95% confidence interval [CI], 1.2-

**Table 1. Characteristics of 680 Patients Hospitalized With Community-Acquired Pneumonia\***

Sociodemographic Characteristics	
Age, y	
18-44	202 (30)
45-64	179 (26)
≥65	299 (44)
Female sex	349 (51)
White race	564 (83)
Type of insurance	
Medicare/private	412 (61)
Medicaid	75 (11)
Canadian medical insurance	155 (23)
Uninsured	35 (5)
Married	292 (43)
Education (>high school)	256 (38)
Admitted from nursing home	60 (9)
Clinical Characteristics	
Comorbidities on presentation	
Chronic obstructive pulmonary disease	143 (21)
Coronary artery disease	133 (20)
Diabetes mellitus	90 (13)
Congestive heart failure	78 (11)
Asthma	64 (9)
Cerebrovascular disease	61 (9)
Renal insufficiency	54 (8)
Active cancer	36 (5)
Liver disease	12 (2)
Severity of illness on admission†	
Risk class I	148 (22)
Risk class II	187 (28)
Risk class III	151 (22)
Risk class IV	138 (20)
Risk class V	56 (8)

\*Data are number (percentage) of patients. Data on insurance status were missing for 3 patients, education for 10 patients, and marital status for 1 patient.

†Severity of illness was assessed using the Pneumonia Severity Index. Class I patients have the lowest severity and mortality risk, and class V the highest severity and risk.

6.7;  $P = .02$ ), readmission (OR, 1.6; 95% CI, 0.9-2.9;  $P = .09$ ), major events (OR, 1.8; 95% CI, 1.0-3.0;  $P = .04$ ), and failure to return to usual activities (OR, 1.7; 95% CI, 1.1-2.6;  $P = .009$ ) within 30 days (**Table 3**).

Compared with patients with no instabilities on discharge, those with 1 unstable factor had modestly increased odds of death or readmission (OR, 1.4; 95% CI, 0.8-2.5) and not returning to usual activities (OR, 1.6; 95% CI, 1.1-2.5) (Table 3). In contrast, having 2 or more instabilities on discharge increased the risk of major events (death or readmission) 7-fold (OR, 7.4; 95% CI, 2.4-22.8), with a trend toward doubling the chance of not returning to usual activities (OR, 2.5; 95% CI, 0.8-8.3). We also found a similar relationship between instabilities on discharge and risk of adverse outcomes at 7 and 14 days when complications are most likely to be purely pneumonia related (data not shown).

#### MULTIVARIABLE ASSOCIATIONS BETWEEN INSTABILITY ON DISCHARGE AND OUTCOMES

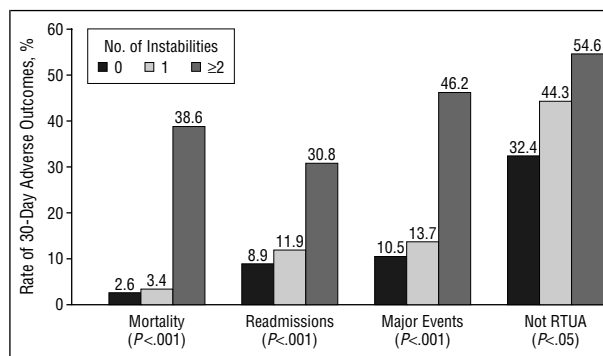
The number of instabilities on discharge remained significantly associated with posthospital outcomes even

**Table 2. Frequency of Unstable Vital Sign and Clinical Status Factors on Discharge\***

Temperature >37.8°C	23 (3%)
Respiratory rate >24/min	26 (4%)
Heart rate >100/min	24 (4%)
Systolic blood pressure ≤90 mm Hg	7 (1%)
Oxygen saturation <90%†	40 (6%)
Altered mental status	11 (2%)
Inability to maintain oral intake	13 (2%)
No. of unstable factors per patient	
0	550 (81%)
1	117 (17%)
≥2	13 (2%)

\*Data are number (percentage) of patients (N = 680).

†Hypoxemia defined as an oxygen saturation rate lower than 90% or a  $P_{aO_2}$  lower than 60 mm Hg.



Number of instabilities on discharge and rates of 30-day adverse outcomes. Major events were defined as death or readmission within 30 days of discharge. Not RTUA indicates not returned to usual activities within 30 days of discharge.

after controlling for other important prognostic factors and potential confounders including: the admission PSI score and DNR status. Patients with any instabilities on discharge had higher risk-adjusted rates of major events (OR, 1.6; 95% CI, 1.0-2.8;  $P < .05$ ) and failure to return to usual activities (OR, 1.5; 95% CI, 1.0-2.4;  $P = .04$ ) within 30 days (Table 3). Those persons with 2 or more instabilities on discharge experienced dramatically higher risk-adjusted rates of death (OR, 14.1; 95% CI, 3.1-69.0), readmission (OR, 3.5; 95% CI, 1.0-12.4), and total major events (OR, 5.4; 95% CI, 1.6-18.4). Forcing other potentially important clinical variables such as the presence of chronic obstructive pulmonary disease or use of home oxygen therapy into the multivariable model did not alter our findings.

We also performed a series of stratified analyses to assess whether certain subgroups might be more sensitive to the hazards related to clinical instability. Among the 54 patients (7.9%) who were DNR, 24.1% were discharged prior to reaching stability compared with 18.7% who were not DNR ( $P = .33$ ). Analyses that stratified by DNR status revealed that instability on discharge was associated with higher risk of poor outcomes in all subgroups. Similarly, instability on discharge increased the risk of major events across the PSI risk strata.



**Table 3. Effects of Instability on Discharge on Unadjusted and Risk-Adjusted 30-Day Outcomes\***

Outcome	Definition of Disability on Discharge (N = 680)				P Value‡
	Any†	0	1	≥2	
Death					<.001
Unadjusted	2.8 (1.2-6.7)	1.0	1.4 (0.4-4.2)	23.9 (6.9-82.4)	
Adjusted	2.1 (0.8-5.4)	1.0	1.1 (0.3-3.5)	14.1 (3.1-69.0)	
Readmission					.02
Unadjusted	1.6 (0.9-2.9)	1.0	1.4 (0.7-2.6)	4.5 (1.4-15.3)	
Adjusted	1.5 (0.8-2.7)	1.0	1.3 (0.7-2.5)	3.5 (1.0-12.4)	
Major event					.003
Unadjusted	1.8 (1.0-3.0)	1.0	1.4 (0.8-2.5)	7.4 (2.4-22.8)	
Adjusted	1.6 (1.0-2.8)	1.0	1.3 (0.7-2.4)	5.4 (1.6-18.4)	
Failure to return to usual activities					.007
Unadjusted	1.7 (1.1-2.6)	1.0	1.6 (1.1-2.5)	2.5 (0.8-8.3)	
Adjusted	1.5 (1.0-2.4)	1.0	1.5 (1.0-2.4)	1.6 (0.4-6.1)	

\*Data are odds ratio (95% confidence interval) unless otherwise specified. Adjusted odds ratios control for Pneumonia Severity Index (age, sex, nursing home residence, comorbidities, initial laboratory values, and vital signs) and do-not-resuscitate status. Model fit for the multivariate models were c = 0.88 for death, c = 0.66 for readmission, c = 0.70 for major event, and c = 0.67 for failure to return to usual activities.

†Any means 1 or more instabilities on discharge.

‡According to Cochran-Mantel-Haenszel test for trend comparing the outcomes of patients with 0, 1, and 2 or more instabilities on discharge.

**Table 4. Sensitivity, Specificity, and Predictive Values of 2 Different Definitions of Instability on Discharge to Detect Major Adverse Events Within 30 Days of Discharge\***

Definition of Instability on Discharge	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
≥ 1	27.5 (24.1-30.9)	82.0 (79.1-84.9)	16.9 (14.1-19.7)	89.4 (87.1-91.7)
≥ 2	7.5 (5.6-9.4)	98.8 (98.0-99.6)	46.1 (42.4-49.8)	88.9 (86.5-91.3)

\*Data are percentage (95% confidence interval).

One of our secondary hypotheses was that patients who were unstable on discharge would be more likely to be sent to a monitored setting such as a skilled nursing facility and be spared adverse consequences compared with patients returning home. The greater the number of instabilities a patient had on discharge, the more likely they were to be discharged to a skilled nursing facility (10.5% of patients with no instabilities on discharge, 14.9% of those with 1 instability on discharge, and 41.7% of those with 2 or more instabilities on discharge were institutionalized;  $P = .007$ ). However, instability on discharge remained a significant predictor of risk-adjusted rates of death, readmissions, major events, and failure to return to usual activities even after stratifying by discharge to a skilled nursing facility ( $P < .05$  for all). Nor were the adverse outcomes of instability on discharge mitigated among patients sent home with visiting nurse services compared with those who went home alone.

We found no significant relationship between hospital length of stay and instability on discharge. For example, the median length of stay was 7 days (IQR, 5-10 days) in those with no instabilities, 8 days (IQR, 6-11 days) for those with 1 instability, and 6 days (IQR, 5-9 days) for patients with 2 or more instabilities ( $P = .19$ ); the median length of stay was 8 days (IQR, 6-11 days) among patients with 1 or more instabilities ( $P = .28$ ). Nor were there any associations between the natural logarithm of length of stay (or stays shorter than 4 days) and instability on discharge.

#### TEST OPERATING CHARACTERISTICS OF INSTABILITY ON DISCHARGE

From a clinical perspective, individual physicians or medical groups may want to use a specific definition of instability to help gauge appropriateness for hospital discharge. In this respect, the instability criteria may be considered a type of diagnostic test for future adverse events. The sensitivity, specificity, and predictive values of the 2 definitions of instability are displayed in **Table 4**. Instability defined as any abnormalities ( $\geq 1$ ) was more sensitive than the more extreme definition of 2 or more abnormalities (27.5% vs 7.5%), but less specific (83.1% vs 98.8%). To put the prognostic value of the instability information in context, knowing that a patient had 2 or more instabilities on discharge was a better predictor of the risk of death or readmission (positive predictive value, 46.1%) than knowing that they were DNR (positive predictive value, 35.1%) or in the highest pneumonia risk group (PSI class V) on admission (positive predictive value, 28.6%).

The negative predictive value of the instability information was 89% for both definitions. There were 58 patients who were discharged with no instabilities but who went on to die or be readmitted within 30 days. These patients had a worse initial prognosis than the overall cohort. Half of these patients had moderate- or high-risk pneumonia on admission (50.0%), 24.1% were DNR, and 19.3% were discharged to a nursing home. They had similar socioeconomic status as the overall group.

In this multicenter, prospective cohort study, nearly 1 in 5 patients with pneumonia left the hospital with 1 or more unstable vital sign or clinical status factor. Leaving the hospital prior to becoming stable had important clinical consequences because the greater the number of instabilities, the greater the risk of death or readmission and failure to return to usual activities. Patients with any one of 7 unstable factors on discharge had a 60% increased odds of death or readmission and a 50% increased odds of not returning to their usual activities in the 30 days after discharge, even after adjusting for other important prognostic factors and potential confounders. Among the small group of patients with 2 or more unstable factors on discharge, the risk of major adverse events increased 5-fold.

We deliberately defined stability in a clinically simple manner based on vital signs, oxygenation, ability to eat, and mental status. All of these factors are measured in everyday practice and have been identified by physicians as very important in deciding the readiness to switch to oral antibiotics and appropriateness for hospital discharge.<sup>11</sup> We have previously shown that once a patient is stable by these criteria, the risk of serious clinical deterioration during the index hospitalization was 1% or less, even in the sickest subgroup of patients.<sup>9</sup> It is now clear that the same criteria are strongly associated with a range of important medical outcomes following discharge. Instability on discharge remained an important marker of posthospital adverse outcomes even after adjusting for pneumonia severity, comorbid illness burden, DNR status, and discharge location. The instability criteria outlined herein can help a clinician or case manager to quickly ascertain if a given patient is safe for discharge (in the absence of extenuating medical or social circumstances).

Which of the 2 instability criteria modeled in our study is to be recommended? Unfortunately, we have no easy answer to this question. The more conservative definition ( $\geq 1$  instability) identified more patients at risk for doing poorly (but at a higher false-positive rate) compared with the less conservative definition ( $\geq 2$  instabilities) in which the opposite was true. There was no doubt that patients with 2 or more instabilities had extremely high rates of poor outcomes and should not be discharged in the absence of extenuating circumstances. Individual clinicians will need to decide for themselves if just 1 instability on discharge is an absolute reason for continued hospitalization, since the associated increased risk of adverse events was more modest. Though we weighed all instabilities equally to facilitate feasibility and use in real world practice, findings from additional analyses suggest that inability to eat and hypotension, though uncommon, were more serious single indicators of the risk of adverse events. All of the other factors had relatively similar prognostic weights.

Our definition of stability differed from the one used in the original RAND study of instability on discharge in several ways.<sup>2</sup> The criteria we used were disease specific (eg, oxygenation), had fewer elements, and were based on vital sign cut points closer to traditional values

for stability (eg, heart rate  $\leq 100/\text{min}$  vs  $\leq 130/\text{min}$ ).<sup>10</sup> However, despite the differences in methodology, time, and patient population studied, Koscoff and colleagues<sup>2</sup> also reported an association of similar magnitude between instability on discharge and short-term mortality. As expected, the more extreme cut points (eg, temperature  $>38.4^\circ\text{C}$  or heart rate  $>130/\text{min}$ ), which were used in the original RAND study, have greater specificity for predicting adverse events, though with the trade-off of lower sensitivity.

Our study had several strengths such as its multicenter, prospective nature; clinically simple definition of stability; focus on both fatal and nonfatal outcomes; and use of well-validated, disease-specific risk adjustment tools. Some limitations are worth noting. Because this was an observational study, we cannot unambiguously infer causality. We do not know what would have happened if patients we identified as unstable on discharge had stayed in the hospital longer instead of being sent home. However, we do know from previous work that most patients will stabilize over time.<sup>9</sup> There may have been some patients who were sent home prior to attaining stability because the physician and patient desired intentionally less aggressive care. This was one of the reasons why we controlled for DNR status. While we observed a trend toward patients who were DNR being more likely to be discharged unstable, instability on discharge exposed all patients to increased risk of poor outcomes regardless of advanced directive status.

Because we did not have data on all vital signs in the 24 hours prior to discharge, it is possible that some of the patients we identified as unstable may have had 1 set of stable vital signs on discharge. However, we knew the most abnormal value of the day, such as the highest temperature, which usually factors heavily into medical decision making. In any event, any abnormalities in the 24 hours prior to discharge increased the risk of adverse outcomes. Finally, our data reflect the medical practice from 1991 to 1994, when there was considerably less pressure to shorten length of stay. We expect that rates of instability on discharge are likely to be higher today, which would only strengthen the importance of our findings.

## CONCLUSIONS

Physicians should be aware that instability in the 24 hours prior to discharge increases the risk of poor posthospital outcomes. At a minimum, patients with 1 instability on discharge should have close outpatient follow-up and appropriate patient education about warning signs and symptoms that merit urgent medical attention. Persons with 2 or more instabilities should almost certainly remain in the hospital for continued treatment and observation in the absence of extenuating circumstances. From a policy standpoint, pneumonia practice guidelines and critical pathways should include objective criteria for judging stability on discharge to ensure that efforts to reduce length of stay do not jeopardize patient safety. Our findings may also have implications for quality measurement and improvement efforts. The 2 main national quality indicators for pneumonia care focus primarily on initial management (antibiotic selection and time to first dose

of antibiotics).<sup>20-22</sup> Our data would support including the proportion of patients discharged prior to attaining clinical stability as a complementary patient safety indicator with which to compare provider or health plan performance and stimulate quality improvement initiatives.

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