# An Electronic Medical Record-Derived Real-Time Assessment Scale for Hospital Readmission in the Elderly

Ariba Khan, MBBS, MPH; Michael L. Malone, MD; Patti Pagel, MSN, RN; Marsha Vollbrecht, MS, CSW, NHA; Dennis J. Baumgardner, MD

## ABSTRACT

**Objective:** "Readmission risk score," a 20-point, 4-dimensional tool, is generated from the electronic medical record. This study was performed to evaluate the ability of the readmission risk score to predict 30-day readmissions among older hospitalized patients.

**Methods:** A retrospective study was conducted utilizing data from the electronic medical record. Using a cutoff value of 7, the readmission score sensitivity was 61%, specificity was 22%, positive predictive value 12%, negative predictive value 77%. The positive and negative likelihood ratios were 0.8 and 1.8, respectively.

**Conclusion:** The readmission risk score was associated with 30-day readmissions (median score of readmitted vs not readmitted patients was 8 vs 5; $P = 0.001$), and it may be better at identifying those who are not at risk for readmission.

## BACKGROUND

Despite significant improvement in care, hospital readmission rates have not declined.[1] Approximately one-fifth of Medicare beneficiaries are readmitted within 30 days of discharge, costing $17.4 billion in 2004.[2] The discharge process is often complex. Older patients may experience multiple transfers after discharge from hospital; eg, from hospital to nursing home to home. Only 61% are limited to a single transfer after their hospital care.[3]

Risk factors for readmission[4-6] and strategies to reduce the risk are well known[7-9] (Table 1). Previous efforts to develop a tool using routine inpatient data have been moderately effective.[10,11] To our knowledge, there is no successful and reliable real-time tool developed to predict readmission at the bedside. It is important for health care workers to know patients at risk of rehospitalization to address the risk.

The Acute Care for Elders Tracker (ACE Tracker)[12] is a real-time report electronic resource that summarizes information from the electronic medical record (EMR) of patients 65 years and older. This report requires no additional evaluations of the patient by the health care team. (See Figure 1 for data queried.) This study was performed to test the effectiveness of the readmission risk score and to answer the question, "Can a real-time readmission risk score embedded in the EMR predict 30-day readmissions among patients 65 years and older"?

## METHODS

The readmission risk score is generated real-time from the EMR. The score ranges from 0 to 20 based on the presence or absence of risk factors noted in Table 1. The variables were chosen based on previous research. An extensive literature search was performed that included all OVID databases (Medline and EBM reviews from 1950 to present), CINAHL, AgeInfo, Ageline, and Google Scholar. A team of clinicians including a physician, nurse, and social worker reviewed the quality of the papers and commented on the relevance of the variables. A number of evidence-based predictors were not captured in the EMR and could not be incorporated in the readmission risk score. The final variables were chosen based on availability in the EMR, previous research[13,14] and team clinical experience (Table 2). The readmission risk score is noted on the ACE Tracker (Figure 1).

Evaluation of the readmission risk score utilized data from the EMR (Cerner Corp, North Kansas City, Missouri). Ten of the 13 hospitals were included in this study due to availability of the ACE Tracker and the EMR at those hospitals. The size

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**Author Affiliations:** Senior Services Program, Aurora Health Care, Milwaukee, Wis (Khan, Malone, Pagel, Vollbrecht); University of Wisconsin School of Medicine and Public Health, Madison, Wis (Khan, Malone, Baumgardner); Center for Urban Population Health, Milwaukee, Wis (Khan, Baumgardner); Department of Family Medicine, Aurora UW Medical Group (Baumgardner).

**Corresponding Author:** Ariba Khan, MBBS, MPH, Aurora Health Care, 1020 N 12th St, Ste 4180, Milwaukee, WI 53233; phone 414.219.7300; fax 414.219.5100; e-mail ariba.khan@aurora.org.

**Table 1.** Risk Factors for Hospital Readmissions

| |
|---|
| **Socioeconomic factors** |
| Age |
| Gender |
| Self-reported Race/Ethnicity |
| Self-reported Household Income |
| Education |
| Insurance Status |
| Having a Regular Physician |
| Activities of Daily Living Score |
| Admit from Skilled Nursing Facility |
| Lives Alone |
| Education Barriers |
| **Admitting Diagnoses** |
| Congestive Heart Failure |
| Psychosis |
| Other Vascular Surgeries |
| Chronic Obstructive Pulmonary Disease |
| Pneumonia |
| Gastrointestinal Problems |
| **Health Conditions** |
| Self-rated General Health |
| Heart Disease |
| Prior Stroke |
| Cancer |
| Diabetes |
| Visual Impairment |
| Congestive Heart Failure |
| Chronic Obstructive Pulmonary Disease |
| Diabetes Mellitus |
| Chronic Skin Ulcers/Pressure Ulcers |
| Cirrhosis |
| Leukemia |
| Peripheral Vascular Disease |
| Metastatic Cancer |
| Malnutrition |
| Acute Respiratory Failure |
| Rheumatoid Arthritis |
| Chronic Kidney Disease |
| End-of-Life Care |
| Depression |
| Polypharmacy |
| Hypertension |
| Rhematoid Arthritis |
| Pulmonary Embolism |
| **Health Care Utilization** |
| Number of Hospital Admissions |
| Length of Stay of Current Hospital Admission |

**Table 2.** Components of the Electronic Medical Record with Weighted Points Used to Compile the Rehospitalization Risk Score

| | |
|---|---|
| **Admitting Diagnosis: Maximum Score** | **5** |
| Congestive Heart Failure | 5 |
| Psychosis | 5 |
| Other Vascular Surgeries | 3 |
| Chronic Obstructive Pulmonary Disease | 3 |
| Pneumonia | 1 |
| Gastrointestinal Problems | 1 |
| **Hospital Utilization: Maximum Score** | **4** |
| One Hospital Admission in Prior 6 Months | 1 |
| Two or More Hospitalizations in Prior 6 Months | 2 |
| Current Length of Hospital Stay 6-9 Days | 1 |
| Current Length of Hospital Stay ≥10 Days | 2 |
| **Comorbidities: Maximum Score** | **6** |
| Congestive Heart Failure | 1 |
| Chronic Obstructive Pulmonary Disease | 1 |
| Diabetes Mellitus | 1 |
| Shortness of Breath | 1 |
| Chronic Skin Ulcers/Pressure Ulcers | 1 |
| Cirrhosis | 1 |
| Leukemia | 1 |
| Peripheral Vascular Disease | 1 |
| Stroke/Cerebrovascular Accident | 1 |
| Metastatic Cancer | 1 |
| Malnutrition | 1 |
| Acute Respiratory Failure | 1 |
| Rheumatoid Arthritis | 1 |
| Hypertension | 1 |
| **Socioeconomic Factors: Maximum Score** | **5** |
| Activities of Daily Living Score[18] ≤6 of 12 | 1 |
| Medicaid Insurance | 1 |
| Admit from Skilled Nursing Facility | 1 |
| Lives Alone | 1 |
| Education Barriers | 1 |

of the included hospitals varied from small to large tertiary care hospitals (5 hospitals were licensed to a capacity in the range of 65 to 100 beds; 4 hospitals had a bed capacity in the range of 101 to 400; and 1 hospital had a capacity of more than 400 beds).

Index hospitalization was defined as inpatients 65 years and older admitted to the hospital on the ACE Tracker on a single day, January 26, 2011. A single day was chosen as a uniform point in time of the assessment of older hospitalized patients. The validity of the EMR has been previously described.[12] To ensure that the tool was as close to "real life" as possible, patients were included regardless of admission to the intensive care unit, the presence or absence of psychiatric diagnosis, and discharge to inpatient rehabiliation. Patients were excluded if the index hospitalization was an observation stay or if death occurred in the hospital. The study was approved by the Aurora Institutional Review Board.

## Primary Outcome

The primary outcome was readmission to any of the hospitals included in the study within 30 days of discharge from the index hospitalization. Admissions to rehabilitation units, transfers from 1 hospital to another hospital, inpatient

| PATIENT ROOM/BED | AGE | LENGTH OF STAY | HISTORY OF DEMENTIA | CAM | NUMBER OF MEDS | BEERS | MORSE | HX OF FALLS | BED REST | P/T | O/T | RES | ADL | CATH | PRESS ULCER | WOUND CARE | BRADEN SCALE | ALBUMIN | SOCIAL SERVICES | ADVANCE DIRECTIVES | READMISSION RISK SCORE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Patient A* | 76 | 2 | N | N | 13 | N | 60 | Y | N | Y | Y | N | 8 | Y | Y | Y | 17 | ND | Y | N | 7 |
| *Patient B* | 74 | 1 | Y | N | 7 | N | 50 | Y | Y | N | N | N | 6 | Y | Y | Y | 9 | 2.9 | N | Y | 12 |
| *Patient C* | 78 | 12 | Y | Y | 10 | Y | 50 | Y | N | Y | Y | N | 7 | N | N | Y | 14 | 3.9 | Y | Y | 9 |
| *Patient D* | 72 | 1 | N | N | 5 | N | 50 | N | N | N | N | N | 12 | N | N | N | 15 | ND | N | N | 2 |
| *Patient E* | 91 | 6 | Y | N | 8 | N | 60* | N | N | Y | Y | N | 6* | N | N | N | 14 | ND | Y | N | 10 |
| *Patient F* | 78 | 1 | N | N | 7 | N | 70 | Y | Y | N | N | N | 6 | Y | N | N | 16 | ND | N | N | 5 |
| *Patient G* | 75 | 1 | N | N | 0 | N | 45 | N | N | Y | Y | N | 12 | N | N | N | 14 | 4.3 | N | N | 3 |
| *Patient H* | 93 | 1 | Y | N | 12 | N | 65 | Y | N | Y | Y | N | 6 | N | N | N | 15 | ND | Y | Y | 5 |
| *Patient I* | 91 | 1 | Y | N | 1 | N | 95 | Y | N | Y | Y | N | 7 | N | N | N | 12 | 3.5 | N | Y | 2 |
| *Patient J* | 74 | 5 | N | N | 20 | N | 45 | Y | N | Y | Y | N | 7 | Y | Y | Y | 12* | ND | Y | Y | 12 |
| *Patient K* | 72 | 6 | N | Y | 14 | N | 20 | N | N | Y | Y | N | 8 | N | N | N | 17 | 3.2 | Y | Y | 4 |
| *Patient L* | 83 | 3 | N | Y | 12 | N | 80* | Y | Y | Y | Y | N | 8 | Y | N | N | 12 | 2.3 | N | Y | 4 |
| Patients Totals | | | 5 | 3 | 11 | 1 | | 8 | 3 | 9 | 9 | 0 | | 5 | 3 | 4 | | | 6 | 7 | |

**Figure 1.** Components of the electronic medical record with weighted points used to compile the rehospitalization risk score.
Abbreviations: CAM, confusion assessment method; meds, medications; Beers, "beers" high-risk medications; Morse, Morse fall score; P/T, physical therapy; O/T, Occupational therapy; RES, restraints; ADL, activities of daily living; Cath, urinary catheter.
Asterisk represents a decline in morse score as compared to admission

**Table 3:** Readmission Risk Score Properties at Varying Cut-off Points

| Readmission Risk Score | Sensitivity | Specificity | Positive Predictive Value | Negative Predictive Value | Positive Likelihood Ratio | Negative Likelihood Ratio | 30-day Readmission |
|---|---|---|---|---|---|---|---|
| ≥4 points | 97% | 28% | 19% | 98% | 1.4 | 0.1 | 19% |
| ≥7 points | 58% | 63% | 21% | 90% | 1.6 | 0.7 | 21% |
| ≥9 points | 42% | 81% | 27% | 89% | 2.2 | 0.7 | 27% |

hospice and elective outpatient procedures were not considered readmissions.

### Statistical Analysis

Sensitivity, specificity, positive and negative predictive values of the risk score, and likelihood ratios were generated for all cut-off values. Median risk score of patients readmitted and not readmitted were compared using the Mann-Whitney test with the assistance of MINITAB software (Minitab, State College, Pennsylvania).

## RESULTS

Two hundred seventy-two patients 65 years and older were admitted to 10 of 13 hospitals and 30 medical-surgical units on January 26, 2011. Forty-five were excluded because of observation status (30), inpatient death (3), and missing data (12); 227 patients were included in the study. Average age was 79 years (65 to 99 years); 57% were females; average length of stay 8 was days (1 to 56 days); average hospital stay on January 26, 2011, was 4 days (0 to 28 days). The overall 30-day readmission rate was 15%.

The distribution of readmission risk score among hospitalized patients is shown in Figure 2. Forty-one percent had a value score of 7 or more. At this cutoff value, sensitivity was 61%, specificity 22%, positive predictive value 12%, negative predictive value 77% (Table 3). The positive and negative likelihood ratios were 0.8 and 1.8. Higher readmission risk scores were correlated with readmission (median score of readmitted vs not readmitted patients 8 vs 5; $P = 0.001$).

Sensitivity, specificity, and positive and negative predictive values were calculated for all possible cut-off points. A few representative cut-off values are presented in Table 3.

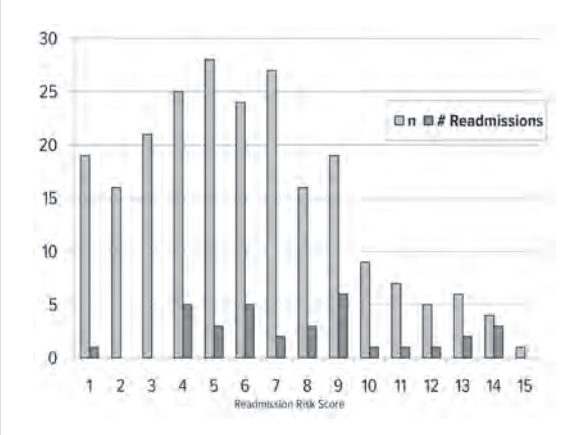


**Figure 2.** Distribution of readmission risk score and rate of readmission among 227 older patients at 10 Aurora hospitals.

## DISCUSSION

### Potential Implications

In a future with financial disincentives for readmissions[15] it will be important for hospitals to deploy models designed to reduce the rate of readmissions. Readmissions are a quality indicator available to the public.[16] At the individual patient level, unnecessary readmission is an inconvenience that may be avoidable.

Those at high risk for readmission could receive general and targeted interventions to mitigate their risk and to optimize the use of post-acute resources. The low positive predictive value and high negative predictive value of the readmission risk score may allow the health care team to safely identify patients who are at low risk for readmission. This may allow targeting of resources to create interventions for the high-risk patients. Low-risk patients may benefit from general interventions to help them manage their illness and coordinate care. Health systems may be able to safely exclude this group of patients from higher-cost interventions such as home nurse visits.

### Limitations

This risk score may be generalizable only to patients cared for at hospitals with an EMR that captures variables specific to the hospitalized elderly; eg, activities of daily living score and education barriers. We may have underestimated readmission rates due to lack of data capture on patients readmitted to a different health care system. Most of the fields that we captured were on admission; any missing or new information did not have any effect on the risk score. Finally, the variables that determine the readmission risk score were determined based on prior research, clinical experience, and availability in EMR.

### Future Direction

A recent systematic review[17] noted that currently available readmission risk prediction models perform poorly. Furthermore, models of patient-level factors (such as medical comorbidities, demographics and clinical variables) are better able to predict mortality than readmissions. Broader social and environmental factors may be better able to predict readmissions. The authors have an opportunity to improve the readmission risk score by further exploring patient care data that includes functional status, and social and environmental factors not included in prior studies. Future efforts will need to address the problems identified with the tool and will need to link the score to interventions to help mitigate the risk. A well-validated readmission risk score could be made available to providers outside of the hospital, the site where most of the effort occurs to prevent rehospitalization. Finally, studies will be needed to demonstrate that using a risk score could improve outcomes or reduce costs.

## CONCLUSION

The readmission risk score correlates with 30-day readmission. The readmission risk score may be better at identifying those who are not at risk for readmission. Software tools automatically built into the EMR may help health care workers define populations who are and who are not at risk for hospital readmission.

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## REFERENCES

**1.** Bueno H, Ross JS, Wang Y, et al. Trends in length of stay and short-term outcomes among Medicare patients hospitalized for heart failure, 1993-2006. *JAMA.* 2010;303(21):2141-2147.

**2.** Jencks SF, Williams MV, Coleman EA. Rehospitalization among patients in the Medicare Fee-for-Service Program. *N Engl J Med.* 2009;360:1418-1428.

**3.** Coleman EA, Min SJ, Chomiak A, Kramer AM. Posthospital care transitions: patterns, complications, and risk identification. *Health Serv Res.* 2004;39(5):1449-1165.

**4.** Smith DM, Giobbie-Hurder A, Weinberger M, et al. Predicting non-elective hospital readmissions: a multi-site study. *J Clin Epidemiol.* 2000; 53(11):1113-1118.

**5.** Smith DM, Katz B, Huster GA, Fitzgerald JF, Martin DK, Freedman JA. Risk factors for nonelective hospital readmissions. *J Gen Intern Med.* 1996;11:762-764.

**6.** Shalchi Z, Saso S, Li HK, Rowlandson E, Tennant RC. Factors influencing hospital readmission rates after acute medical treatment. *Clin Med.* 2009;9(5):426-430.

**7.** Jack BW, Chetty VK, Anthony D, et al. A reengineered hospital discharge program to decrease rehospitalization. *Ann Intern Med.* 2009;150(3):178-187.

**8.** Coleman EA, Parry C, Chalmers S, Min SJ. The care transitions intervention: results of a randomized trial. *Arch Intern Med.* 2006;166(17):1822-1828.

**9.** Naylor M, Keating SA. Transitional care. *Am J Nurs.* 2008;108(9 Suppl):58-63.

**10.** Billings J, Dixon J, Mijanovich T, Wennberg D. Case finding for patients at risk of readmission to hospital: development of algorithm to identify high risk patients. *BMJ.* 2006;333(7563):327.

**11.** Donnan PT, Dorward DWT, Mutch B, Morris AD: Development and validation of a model for predicting emergency admissions of the next year (PEONY): a UK historical cohort study. *Arch Intern Med.* 2008;168(13):1416-1422.

**12.** Malone ML, Volbrecht M, Stephenson J, Burke L, Pagel P, Goodwin G. Acute Care for Elders (ACE) Tracker and E-geriatrician: methods to disseminate ACE concepts to hospital with no geriatricians on staff. *J Am Geriatr Soc.* 2010;58(1):161-167.

**13.** Arbaje AI, Wolff JL, Yu Q, Powe NR, Anderson GF, Boult C. Postdischarge environmental and socioeconomic factors and the likelihood of early hospital readmissions among community-dwelling Medicare beneficiaries. *Gerontologist.* 2008;48(4):495-504.

**14.** Silverstein MD, Huanying Q, Mercer Q, Fong J, Haydar Z. Risk factors for 30-day hospital readmission in patients >=65 years of age. *Proc (Baylor Univ Med Cent).* 2008;21(4):363-372.

**15.** Medicare Payment Advisory Commission. Promoting greater efficiency in medicine. Report to Congress, June 2007. http://www.medpac.gov/documents/Jun07_EntireReport.pdf. Accessed May 11, 2012.

**16.** Ashton CM, Kuykendall DH, Johnson ML, Wray NP, Wu L. The association between quality of inpatient care and early readmission. *Ann Intern Med.* 1995;122(6):415-421.

**17.** Kansagara D, Englander H, Salanitro A, Kagen D, et al. Risk prediction models for hospital readmission: a systematic review. *JAMA.* 2011;306(15):1688-1698.

**18.** Morse JM. *Preventing Patient Falls.* Thousand Oaks, CA: SAGE Publications, 1997.

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