

Risk prediction models for hospital readmission: a systematic review

Devan Kansagara MD, MCR
David Kagen MD
Honora Englander MD
Amanda Salanitro MD

VA HSR&D Cyber Seminar
12/16/2011

POLL QUESTION 1

- What is your interest in this topic?
 - A. I am involved in implementing a transitional care intervention
 - B. I am involved in using readmission rates as a quality metric
 - C. I am a researcher interested in studying readmission risk prediction
 - D. I am just curious

Outline

- ESP program overview
- Why the interest in readmission prediction
 - Risk-standardized readmission rates and quality reporting
 - Clinical application
- Summary of systematic review methods and findings
 - Overview of 3 specific models
- Reasons for poor performance
- Lessons learned

Evidence-based Synthesis Program (ESP)

Disclosure

This report is based on research conducted by the Evidence-based Synthesis Program (ESP) Center located at the Portland VA Medical Center, Portland, OR funded by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Health Services Research and Development. The findings and conclusions in this document are those of the author(s) who are responsible for its contents; the findings and conclusions do not necessarily represent the views of the Department of Veterans Affairs or the United States government. Therefore, no statement in this article should be construed as an official position of the Department of Veterans Affairs. No investigators have any affiliations or financial involvement (e.g., employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties) that conflict with material presented in the report.

Evidence-based Synthesis Program (ESP)

VA Evidence-based Synthesis (ESP) Program Overview

- Sponsored by VA Office of R&D and HSR&D.
- Established to provide timely and accurate syntheses/reviews of healthcare topics identified by VA clinicians, managers and policy-makers, as they work to improve the health and healthcare of Veterans.
- Builds on staff and expertise already in place at the Evidence-based Practice Centers (EPC) designated by AHRQ. Four of these EPCs are also ESP Centers:
 - Durham VA Medical Center; VA Greater Los Angeles Health Care System; Portland VA Medical Center; and Minneapolis VA Medical Center.

Evidence-based Synthesis Program (ESP)

- Provides evidence syntheses on important clinical practice topics relevant to Veterans, and these reports help:
 - develop clinical policies informed by evidence,
 - the implementation of effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures, and
 - guide the direction for future research to address gaps in clinical knowledge.
- Broad topic nomination process – e.g. VACO, VISNs, field – facilitated by ESP Coordinating Center (Portland) through online process:

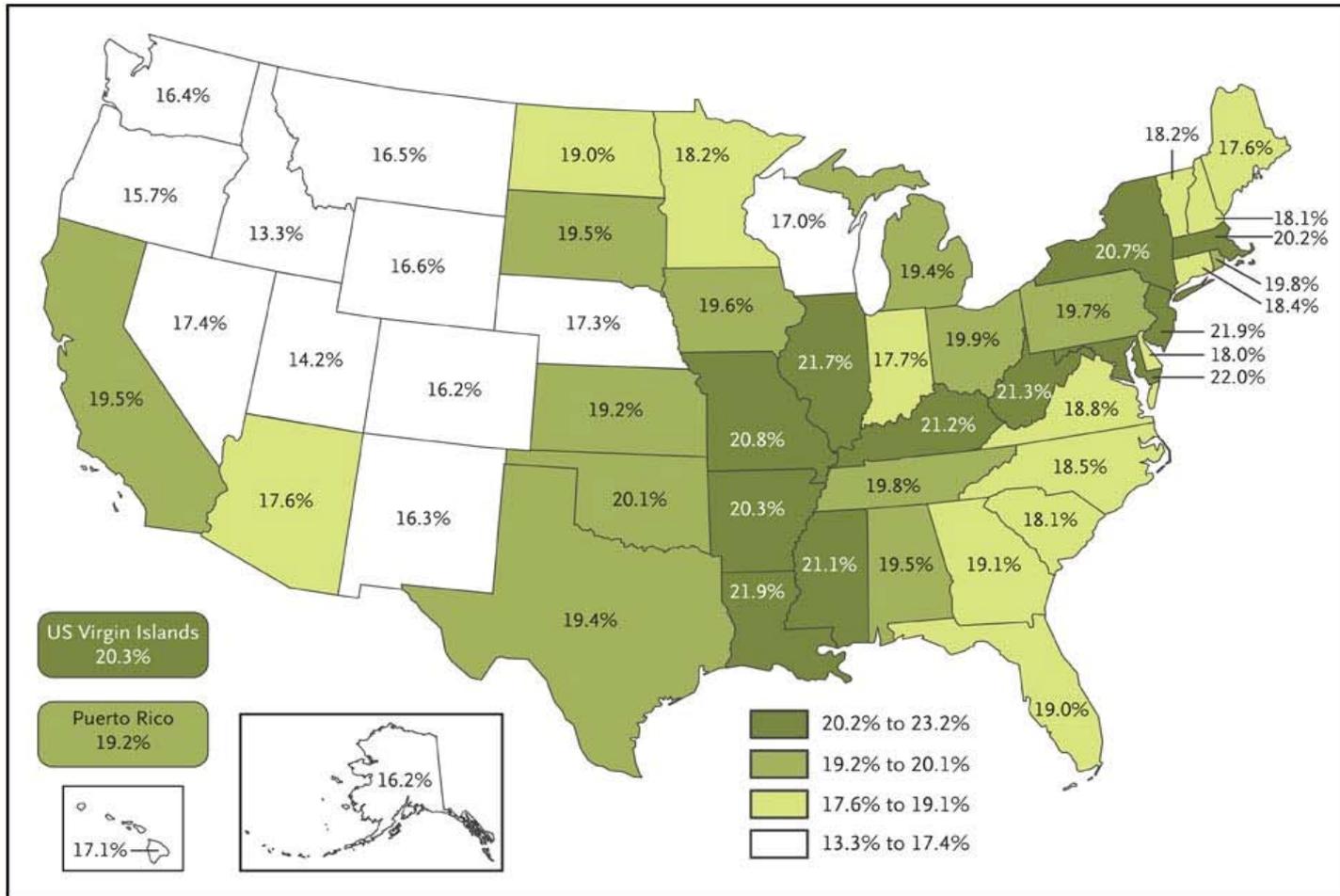
<http://www.hsrd.research.va.gov/publications/esp/TopicNomination.cfm>

Outline

- ESP program overview
- Why the interest in readmission prediction
 - Risk-standardized readmission rates and quality reporting
 - Clinical application
- Summary of systematic review methods and findings
 - Overview of 3 specific models
- Reasons for poor performance
- Lessons learned

Readmissions are common and costly

Medicare rehospitalization within 30 Days after Hospital Discharge: \$17.4 Billion



30 Day readmission rates in VA and non-VA hospitals are similar

| | CHF | AMI | Pneumonia |
|------------------|-------|-------|-----------|
| VA hospitals | 25.2% | 20.6% | 19.2% |
| Non-VA hospitals | 24.8% | 19.9% | 18.4% |

Source: Kaiser Health News, Sep 2011, based on data from www.hospitalcompare.hhs.gov

“Hospital readmissions are frequent and costly events which...can be reduced by systemic changes to the health care system, including improved transition planning, quick follow-up care, and persistent treatment of chronic illnesses.”

Reasons for interest

- Risk-standardized readmission rates have become a quality metric
 - Public reporting
 - Financial penalties
- Identify high-risk patients for intervention

POLL QUESTION 2

- Do you think hospitals should be publicly compared on the basis of 30 day readmission rates?
 - A. Yes
 - B. No
 - C. Don't know/not sure

Rationale for Risk-standardization

Hospital A

Mid-sized in affluent suburb

Patients

- Few comorbidities
- Younger
- Insured

System

- Good access to outpatient care
- Track record of care coordination

Hospital B

Urban tertiary care center

Patients

- Multiple comorbidities
- Complex illness
- Uninsured

System

- Limited access to outpatient care
- Limited peri-discharge services

Is it fair to compare hospitals A and B?

Adjust for patient case-mix

Adjust for patient case-mix

Hospital A

Mid-sized in affluent suburb

Patients

- Few comorbidities
- Younger
- Insured

System

- Good access to outpatient care
- Track record of care coordination

Hospital B

Urban tertiary care center

Patients

- Multiple comorbidities
- Complex illness
- Uninsured

System

- Limited access to outpatient care
- Limited peri-discharge services

Targets for change

The diagram illustrates the differences between Hospital A and Hospital B. Hospital A is a mid-sized hospital in an affluent suburb, characterized by patients with few comorbidities, younger ages, and insurance, and a system with good outpatient access and care coordination. Hospital B is an urban tertiary care center with patients having multiple comorbidities, complex illnesses, and being uninsured, and a system with limited outpatient access and peri-discharge services. Two blue arrows point from the 'Targets for change' text to the System sections of both hospitals, indicating areas for improvement or adjustment.

Calculation of Risk-Standardized Readmission Rates (RSRR)

- Conceptually: compares a hospital's performance, given its case mix, with the average hospital's performance, given the same case mix

Number of 30-day readmissions **predicted**
based on the hospital's performance with its
observed case mix

x

U.S. national
readmission rate

Number of 30-day readmissions **expected**
based on the nation's performance with that
hospital's case mix

Home

Manage Your Health

Medicare Basics

Resource Locator

Help & Support

Help

For Consumers

For Professionals

Medicare.gov Hospital Compare Home

Hospital Compare

Where do you want to find a hospital?

Search Information

Location - ZIP Code or City, State

e.g. 10009 or New York, NY

Search type [?]

- General
- Medical Conditions
- Surgical Procedures

Find Hospitals



Hospital Spotlight

Click on the new Patient Safety Tab during your hospital search to see new information **Hospital Acquired Conditions and Serious Complications and Deaths.**

In January, Medicare will report new measures for heart attack care and surgical care. Also, for the first time, we will be reporting information on central line infections from the **Centers for Disease Control's National Healthcare Safety Network.**

You can now visit **Medicare's Hospital Value Based Purchasing Program** page and learn more about future measures.

Readmission: Who Is Counted?

- Patients age 65 or older
- Enrolled in traditional fee-for-service Medicare
- Enrolled for at least 1 year
- Discharged alive from acute care hospital
- Did not leave against medical advice (AMA)
- Principal diagnosis:
 - Acute myocardial infarction (AMI)
 - Congestive heart failure (CHF)
 - Pneumonia

Penalty for High Readmission Rates

- CMS penalty begins in FY 2013
 - Payment cuts if risk-standardized readmission rates for AMI, CHF, or pneumonia are in the worst quartile
- Max penalty: 1% of total reimbursement
 - Increases to 2% in FY 2014, 3% in FY 2015
- Additional diagnoses to be added (likely):
 - Chronic obstructive pulmonary disease, coronary artery bypass surgery, peripheral vascular disease

POLL QUESTION 3

- Do you think hospitals should be financially penalized for high readmission rates?
 - A. Yes
 - B. No
 - C. Don't know/not sure

Reasons for interest

- Readmissions as a quality metric
 - Hospital comparison based on risk-standardized rates
 - Public reporting
 - Financial penalties
- Identify high-risk patients for intervention

Transitional care

“a set of actions designed to ensure the coordination and continuity of health care as patients transfer between different locations or different levels of care”

The Care Transitions Intervention

Preparing Patients and Caregivers to Participate in Care Delivered Across Settings: The Care Transitions Intervention

Eric A. Coleman, MD, MPH,*¹ Jodi D. Smith, ND, GNP,* Janet C. Frank, DrPH,¹ Sung-Joon Min, AM,* Carla Parry, PhD, MSW,* and Andrew M. Kramer, MD*¹

OBJECTIVES: To test whether an intervention designed to encourage older patients and their caregivers to assert a more active role during care transitions can reduce rehospitalization rates.

DESIGN: Quasi-experimental design whereby subjects receiving the intervention (n = 158) were compared with control subjects derived from administrative data (n = 1,253).

SETTING: A large integrated delivery system in Colorado.

PARTICIPANTS: Community-dwelling adults aged 65 and older admitted to the study hospital with one of nine selected conditions.

INTERVENTION: Intervention subjects received tools to promote cross-site communication, encouragement to take a more active role in their care and assert their preferences, and continuity across settings and guidance from a transition coach.

patients at risk for transitions who are not acutely ill. *J Am Geriatr Soc* 52:1817-1825, 2004.

Key words: care transition; care coordination; self-management; chronic illness

Older adults moving between different healthcare settings are particularly vulnerable to receiving fragmented care.^{1,2} Healthcare delivery is ostensibly divided into discrete loci of care that often function in isolation of one another. Financial, regulatory, and professional barriers serve to further reinforce these silos of care such that care coordination across settings is often lacking.³⁻⁵ When practitioners in different settings operate independently with no common care plan, older patients may be adversely affect-



Better Outcomes for Older
through Safe Transitions



State Action on
Avoidable
Rehospitalizations

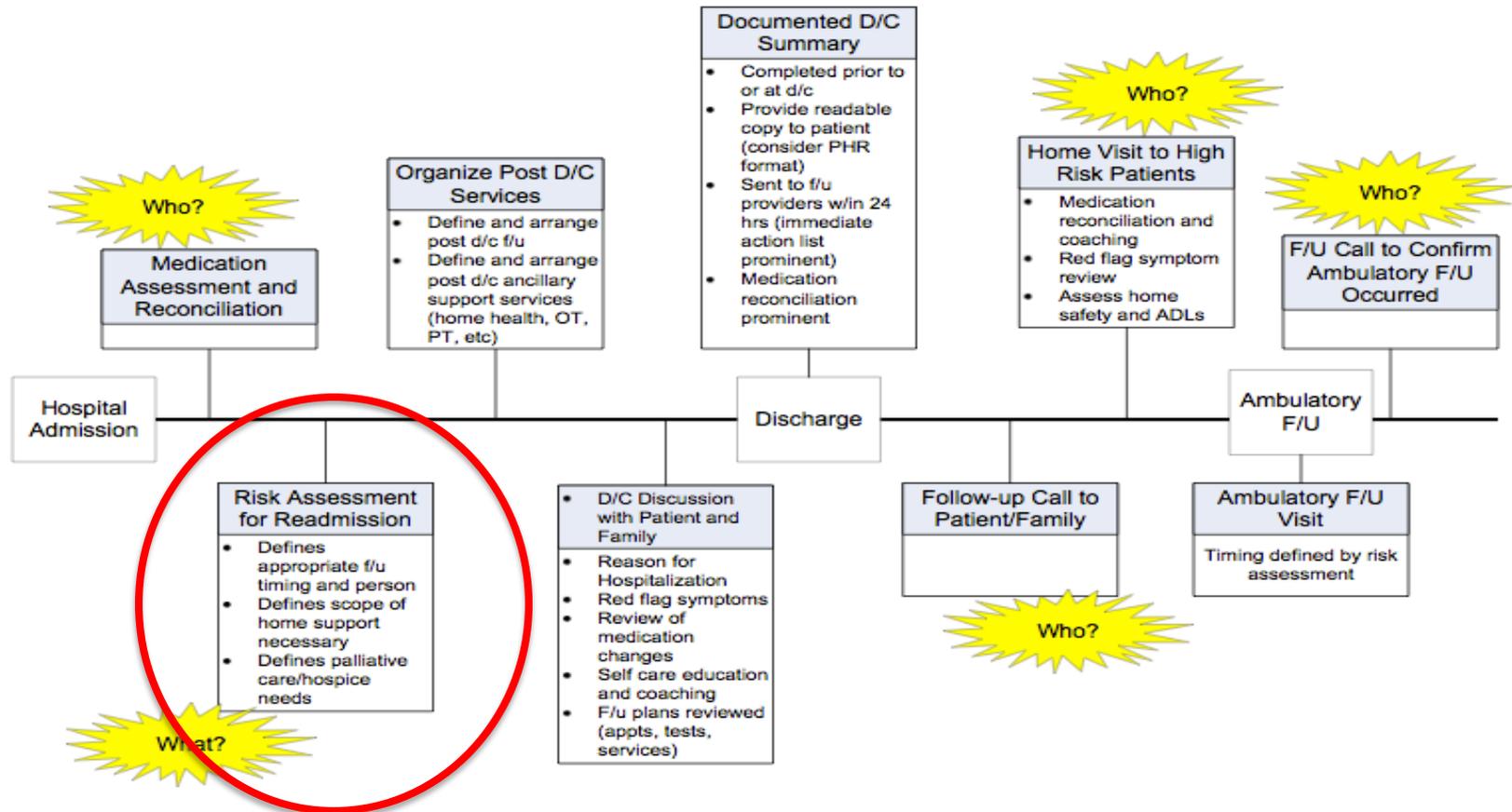


An initiative of The Commonwealth Fund & the Institute for Healthcare Improvement

POLL QUESTION 4

- Is there a transitional care program at your facility?
 - A. Yes
 - IF YES, how are patients identified for the intervention?
 - 1) based on disease (CHF, COPD)
 - 2) clinician referral
 - 3) risk assessment model
 - 4) don't know
 - B. No
 - C. Don't know/not sure

Clinical application



Characteristics of ideal models

- Hospital comparison
 - Reliable data that is easily obtained
 - Deployable in large populations
 - Use variables clinically related to and validated in target population
 - Good predictive value
- Clinical application
 - Provide data before discharge
 - Discriminate very high from very low risk patients
 - Not overly complex
 - Adapted to settings and populations in which use is intended

Risk Prediction Models for Hospital Readmission

A Systematic Review

Objective:

Synthesize the available literature on validated readmission risk prediction models, describe their performance, and assess their suitability for clinical or administrative use.

METHODS

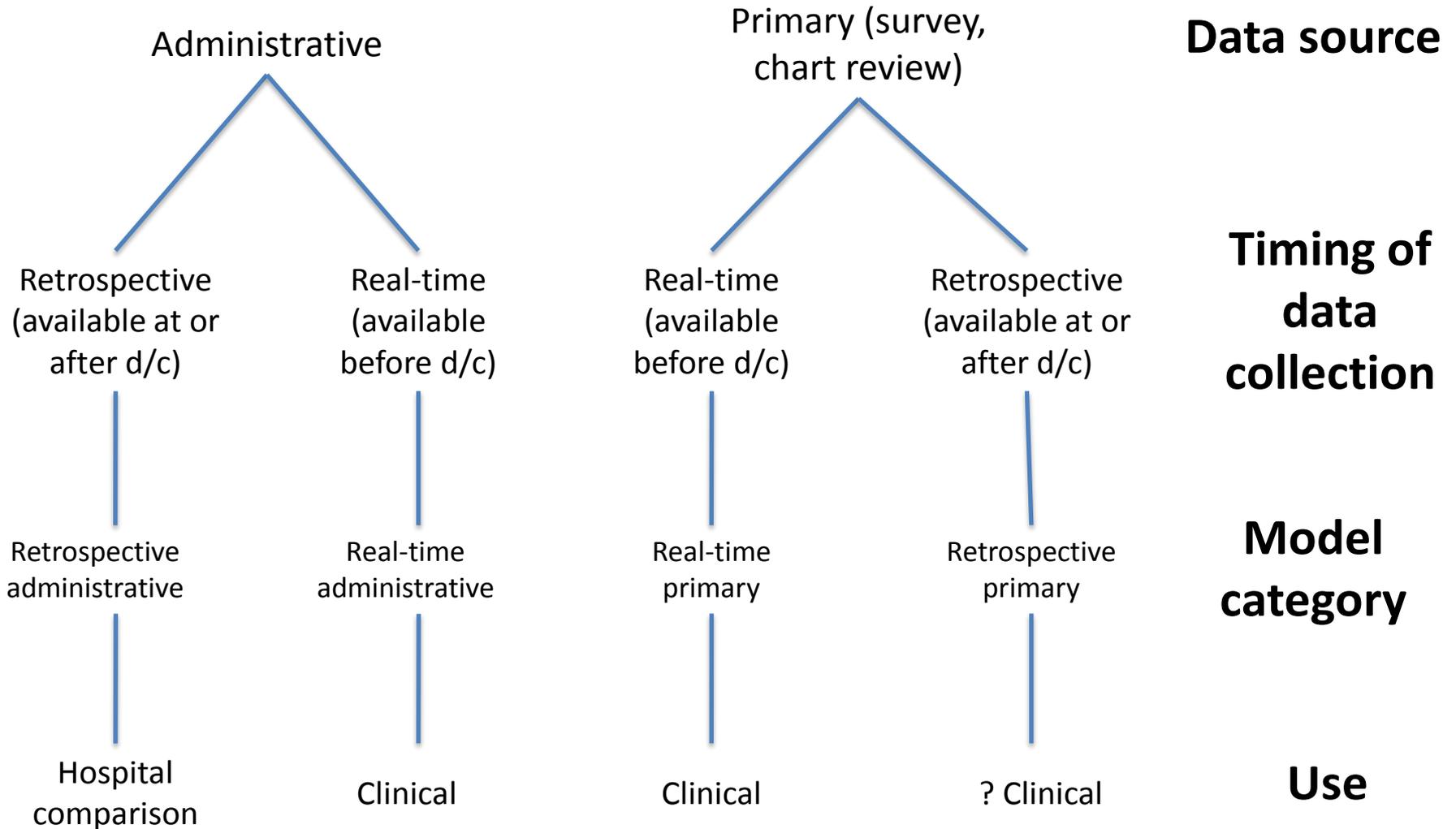
Search

- MEDLINE, CINAHL, and the Cochrane Library
 - database inception through March 2011
 - EMBASE through August 2011

Inclusion and exclusion

- Inclusion
 - Studies of statistical models to predict hospital readmission risk
 - Medical population
 - Validated models
- Exclusion
 - Non-medical population (pediatric, surgical, psychiatric, obstetric)
 - Non-english language
 - Studies in developing nations

Model characterization



Assessing model performance

- Discrimination
 - C-statistic measures model's ability to discriminate between those who get readmitted and those who don't
 - C-stat of 0.7 means a model will correctly sort high- and low-risk pair of patients 70% of the time
 - Range 0.5 (no better than chance) to 1.0 (perfect)
 - C-stat 0.5- 0.7 → poor
 - 0.7-0.8 → acceptable/modest
 - >0.8 → good

Assessing model performance

- Calibration
 - degree to which predicted rates are similar to those observed in the population
 - we report the range of observed readmission rates from the predicted lowest to highest risk groupings

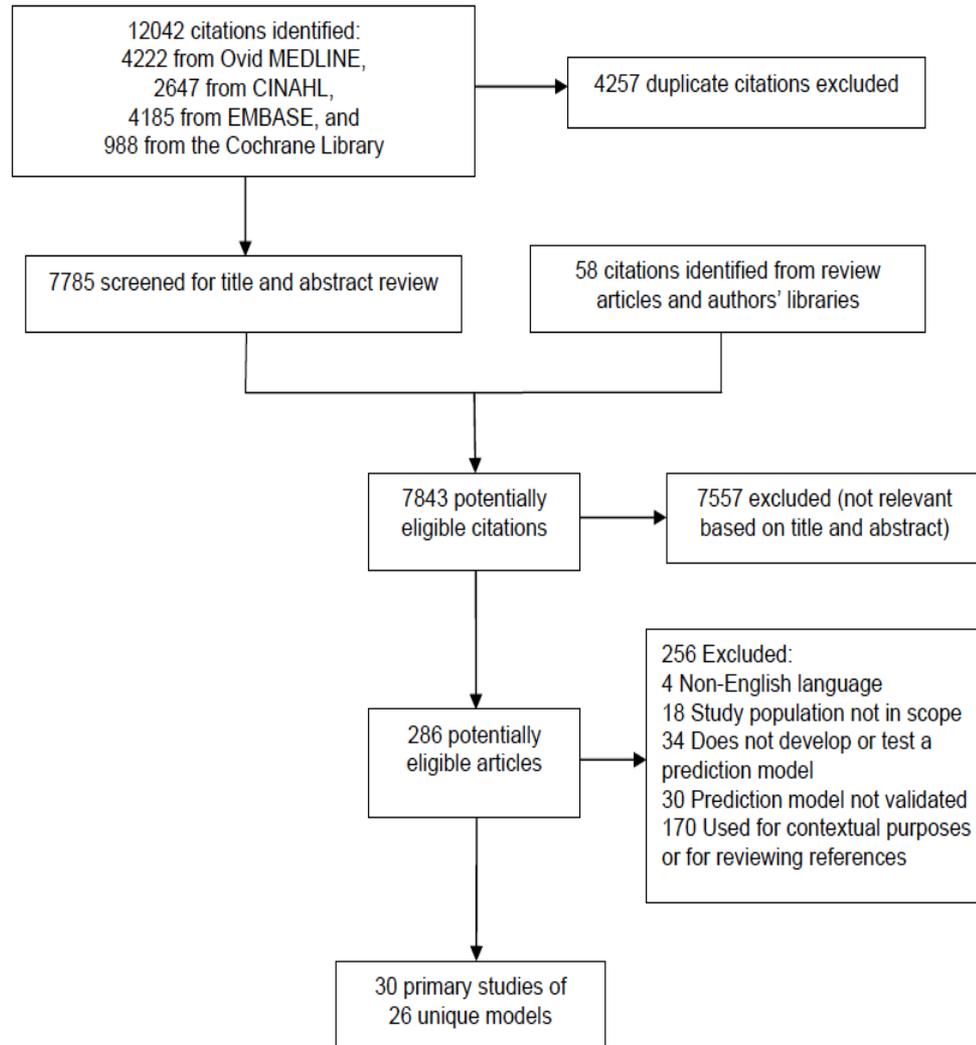
Methodologic assessment

- cohort definition
- follow-up
- adequacy of prognostic and outcome variable measurement
- validation method

RESULTS

Risk Prediction Models for Hospital Readmission

A Systematic Review



Findings

- 14 retrospective administrative data models
- 4 real-time primary data models
- 3 real-time administrative data models
- 5 retrospective primary data models
- Only 1 model specifically evaluated preventable readmissions
- 30 day readmission most common outcome

Retrospective administrative data models (hospital comparison models)

- 9 of these tested in large US populations
 - C-stat 0.55-0.65
 - 3 of these were CMS models (CHF, AMI, pneumonia)
 - C-stat 0.60-0.63
- 3 better performing models (c-stat > 0.70) developed in Europe or Australia

Clinical models

- 3 used real-time administrative data
 - C-stat 0.69-0.72
- 4 used primary data available before hospital discharge
 - C-stat 0.53-0.61
- 5 used primary data available at or after discharge
 - C-stat 0.66-0.83

Calibration

- Though model discrimination was often poor, high- and low-risk scores were associated with clinically meaningful gradient of readmission rate

Examples of 3 different types of models

- Retrospective Administrative Data
- Real-time Administrative Data
- Primary Data collected in Real-Time

Model Using Retrospective Administrative Data: CMS CHF model

- 30 day readmits
- Comorbidities from Medicare claims data:
 - index admission and 12 months before index admission
- 37 variables: age, gender, CV variables and comorbidities
- C-Stat 0.60
- Observed readmission rates from lowest to highest decile of predicted risk: 15.0 - 37.0%

Model using Real-time Administrative Data

- 30-day readmits among pts with CHF
- Single urban US center
- Real-time EMR data
 - Social: # address changes, marital status, SES, anxiety/depression
 - Behavioral: cocaine, missed clinic visits
 - Utilization: prior admissions, ED presentation time
- C-stat 0.72 (0.70-0.75)
- Observed readmission rates from lowest to highest quintile of predicted risk: 12.2 – 45.7%

Model using Primary Data collected in Real-Time

- 4-year all-cause readmission
- Medicare, age ≥ 70 in 1984
- 8 factors:
 - Age, sex, self-rated health, informal caregiver, coronary disease, diabetes, hospital admission within past year, ≥ 6 visits within past year
- C-Stat 0.61
- Observed readmission rates from lowest to highest halves of predicted risk: 26.1 – 41.8%

Studies that compared models within a population

- 6 studies compared different models within the same population
- In 2 of these instances, addition of social determinants and functional status variables improved performance

Amarasingham, 2010
Coleman, 2004

Use of Variables

| Variable considered | Included in final model (n) | Evaluated, not included (n) | Variable not considered (n)* |
|--|-----------------------------|-----------------------------|------------------------------|
| Medical dx or comorbidity index | 24 | 0 | 3 |
| Prior hospitalization | 14 | 1 | 10 |
| SES/ income/ employment | 5 | 7 | 10 |
| Education | 0 | 4 | 17 |
| Caregiver availability/ social support | 2 | 1 | 19 |
| Access to care | 5 | 2 | 14 |

*6 studies did not report candidate variables

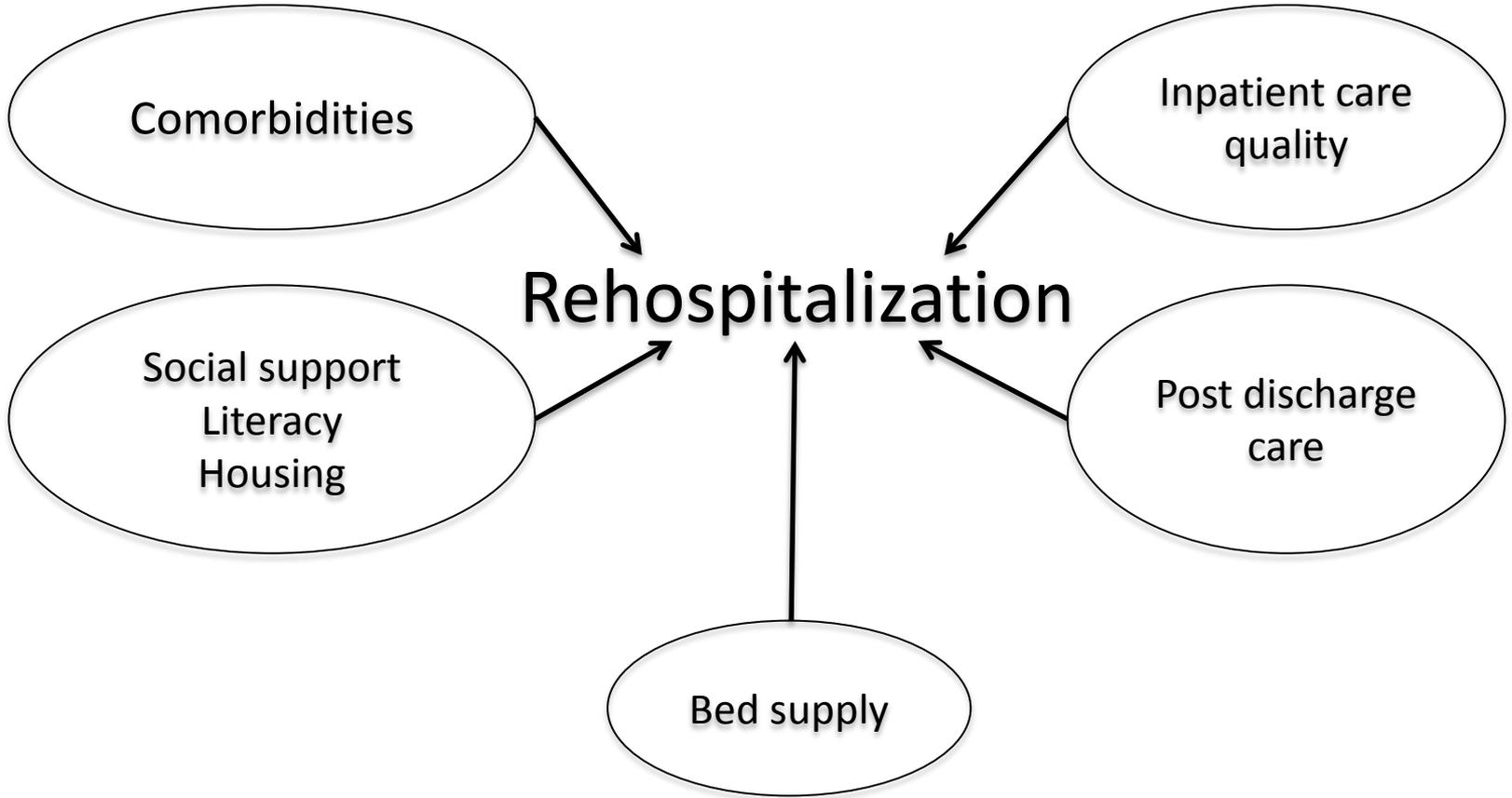
POLL QUESTION 5

- Based on your own observations at your facility, which of the following contributes often to preventable readmissions (can choose more than one answer)?
 - A. Lack of access to timely outpatient follow-up
 - B. Poor quality of inpatient care
 - C. Lack of patient self-management training
 - D. Lack of access to palliative care/hospice services
 - E. Patient factors (lack of social support, compliance, mental health/substance abuse issues)

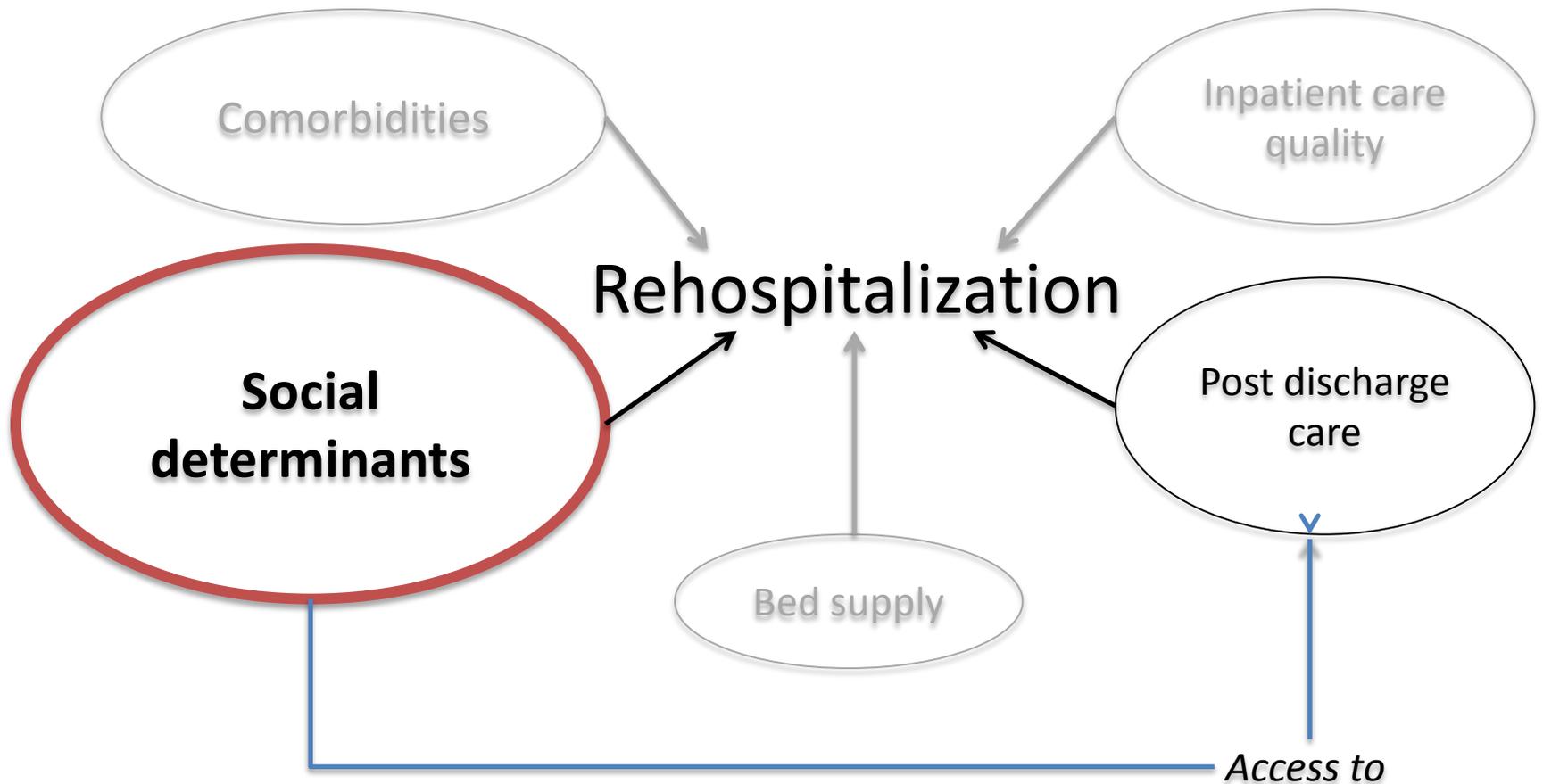
DISCUSSION

Why have most models created to date had difficulty in predicting readmission risk?

Readmissions: it's complicated



Social determinants and readmission risk



Social determinants and readmission risk

- Most commonly included
 - Diagnoses or comorbidity index
 - Prior hospital utilization
 - Age, sex, race/ethnicity

Social determinants—less commonly utilized

- Illness severity
- Mental health and substance use
- Overall health and function
- Socioeconomic status
- Social support
- Access to care
- Health literacy, numeracy
- Self-management skills

BOOST – 8Ps

- Problem meds (insulin, warfarin, digoxin, ASA)
- Psychological (depression)
- Principal Dx (CA, DM, COPD, CHF, CVA)
- Polypharmacy (> 5 meds)
- Poor health literacy (can't teach back)
- Patient support lacking
- Prior hospitalizations (last 12 months)
- Palliative care

Project RED

- No formal model
- Risk factors:
 - Depressive symptoms
 - Limited health literacy
 - Frequent hospital admissions
 - Unstable housing
 - Substance abuse

Summary

- Readmission risk prediction models have been developed for hospital comparison and clinical intervention purposes
- Most models in both categories perform poorly
- Most models have relied on comorbidity and utilization data
- Few models have examined social determinant variables

IMPLICATIONS

Implication 1

Broad-based comparisons of risk-standardized rates, especially when tied to reimbursement, may be problematic and could be associated with unintended consequences

Which hospitals have the highest readmission rates?

Table 4. Odds of Being in the Worst Quartile of Heart Failure Readmission Rates, by Select Characteristics

| Hospital Characteristics | Risk-Adjusted OR* (95% CI) | P Value | Fully Adjusted OR† (95% CI) | P Value |
|---------------------------------|----------------------------|---------|-----------------------------|---------|
| Ownership | | | | |
| Public | 2.1 (1.8, 2.5) | <0.001 | 1.5 (1.2, 1.8) | <0.001 |
| For-profit | 1.5 (1.3, 1.8) | <0.001 | 1.9 (1.5, 2.4) | <0.001 |
| Nonprofit | 1.0 | Ref | 1.0 | Ref |
| Median county income | | | | |
| Lowest quartile | 2.9 (2.4, 3.5) | <0.001 | 1.2 (1.0, 1.6) | 0.10 |
| 2nd quartile | 1.5 (1.3, 1.9) | <0.001 | 0.8 (0.7, 1.0) | 0.12 |
| 3rd quartile | 1.1 (0.9, 1.3) | 0.51 | 0.8 (0.6, 1.0) | 0.05 |
| Highest quartile | 1.0 | Ref | 1.0 | Ref |
| Cardiac services | | | | |
| None | 5.0 (4.0, 6.2) | <0.001 | 3.0 (2.2, 4.1) | <0.001 |
| Partial | 2.0 (1.6, 2.6) | <0.001 | 1.7 (1.3, 2.3) | <0.001 |
| Full | 1.0 | Ref | 1.0 | Ref |
| Nurse-to-census ratio | | | | |
| Lowest quartile (fewest nurses) | 2.0 (1.7, 2.4) | <0.001 | 2.4 (2.0, 3.0) | <0.001 |
| 2nd quartile | 0.9 (0.8, 1.1) | 0.40 | 1.4 (1.1, 1.7) | 0.005 |
| 3rd quartile | 0.6 (0.5, 0.8) | <0.001 | 0.9 (0.7, 1.1) | 0.39 |
| Highest quartile (most nurses) | 1.0 | Ref | 1.0 | Ref |
| Hospital size | | | | |
| Small | 3.8 (2.9, 5.0) | <0.001 | 2.3 (1.5, 3.5) | <0.001 |
| Medium | 1.5 (1.2, 2.0) | 0.003 | 1.4 (0.9, 2.0) | 0.10 |
| Large | 1.0 | Ref | 1.0 | Ref |

Implication 2

For clinical purposes, the perfect does not have to be the enemy of the good. Even modest incremental knowledge of risk can improve the cost-effectiveness of interventions.

Implication 3

Match the model to intended use

- Models designed for measuring quality are probably not well suited for clinical use and vice versa.
- Think carefully about the local population to which it is being applied.

Implication 4

Given the lack of an existing risk prediction standard, incorporate clinically informative variables in your risk assessment that would not otherwise be captured.

- Housing status
- Access to care
- Health literacy
- Substance abuse

Implication 5

Think about workflow and feasibility of data collection when adapting risk assessment tools

- Avoid overly complex models that impede workflow
- Data must be easily available in real-time
 - ? Incorporate into EMR
 - Simple surveys

Implication 6

We do not know how many readmissions are preventable. Think about using additional metrics to measure peri-discharge care.

Can we make improvements in an already-integrated system?

| | CHF | AMI | Pneumonia |
|------------------|-------|-------|-----------|
| VA hospitals | 25.2% | 20.6% | 19.2% |
| Non-VA hospitals | 24.8% | 19.9% | 18.4% |

Source: Kaiser Health News, Sep 2011, based on data from www.hospitalcompare.hhs.gov

Evidence-based Synthesis Program (ESP)

Questions?

If you have further questions,
feel free to contact:

Devan Kansagara, MD MCR
kansagar@ohsu.edu

The full report and cyberseminar presentation is available on the ESP website:

<http://www.hsrd.research.va.gov/publications/esp/>

| | | | | |
|------------|---------|---|---|---|
| 12/13/2011 | 12:00pm | Risk Prediction Models for Hospital Readmission | Spotlight on Evidence-based Synthesis Program | Englander, Honora Kagen, David Kansagara, Devan Amanda Salanitro |
|------------|---------|---|---|---|

VA Uses readmission rates on the IPEC Links Dashboard. Are these readmission rates based on the models with the .6 C statistic?

No, I believe these are unadjusted rates, though VA did participate in the hospital compare initiative and these data are risk-standardized rates using the same CMS methodology we discussed.

Can you discuss the reliability of the LACE readmission tool?

The LACE index measures Length of stay, Acuity of admission, Comorbidity (Charleson index), and prior Emergency room use. Its C-stat was 0.68 which is not great, but better than many other models. However, this was only tested in Canada across a broad group of patients who were not that ill. Baseline readmission rates were only about 7%. Also, since measure includes LOS, requires waiting until d/c to calculate it. (van Walraven, CMAJ, 2010)

There's been a lot of focus on model fit (e.g. C-stat). Assuming that some of the most major predictors of 30-day readmission are system-factors such as care transition practices, are standard assessments of model fit too strict?

Agree – model discrimination as measured by the c-stat is only one way of evaluating these models. As we discussed, it is almost certainly the case that the exclusion (by design) of system-level factors from many model s reduces their performance. The question then becomes how good is good enough – the answer probably depends on what the model is being used for and the consequences of model use. As we said, there are lots of considerations in terms of using models clinically – the c-stat is only one small piece of this. Thinking about population of interest, other patient factors that have high face validity (social determinant issues), ease of use and so forth all need to be considered. The perfect does not have to be the enemy of the good. On the other hand, the potential negative unintended consequences of using poorly performing models for risk standardization if these risk-standardized rates are used for financial penalty purposes need to at least be considered.

Predictions either account for hospital specific fixed or random effects and so are meant to essentially use the characteristics of the hospital itself to predict the probability of readmission.

Yes, when CMS calculates its RSRR as rate predicted for a given hospital/rate expected for average hospital with same case mix, it is both adjusting for patient case mix and taking into account a hospital's baseline readmission risk. "The predicted number of readmissions (technically called a shrinkage estimate) is calculated by adding the hospital-specific intercept, representing baseline readmission risk, to the sum of the estimated regression coefficients applied to the patient characteristics in the hospital, and after transformation, summing over all patients in the hospital."

| | | | | |
|------------|---------|---|---|---|
| 12/13/2011 | 12:00pm | Risk Prediction Models for Hospital Readmission | Spotlight on Evidence-based Synthesis Program | Englander, Honora Kagen, David Kansagara, Devan Amanda Salanitro |
|------------|---------|---|---|---|

Did you have any information on models that speak to Non-medical populations: Mental Health? Especially since the depressive symptoms and MH and substance abuse continues to surface during these discussions.

No – we didn't examine models in non-medical populations.

Comment: The expected values are essentially the predictions gathered from a "reference" facility, that is those from a model which does not use random or fixed effects to predict the probability of readmission.

"Operationally, we obtained the expected number of readmissions for each hospital by regressing the risk factors on readmission using all hospitals in our sample, applying the subsequent estimated regression coefficients to the patient characteristics observed in the hospital, adding the average of the hospital-specific intercepts, and after transformation, summing over all patients in the hospital to get a count."

Did you look at readmissions from skilled nursing facility?

No, not explicitly – many models would have included patients readmitted from home or a SNF.

An individual may be hospitalized more than once, would then they be entered twice into the model? Was there accounting of the nesting?

Typically, patients would not be counted more than once – they would either have a readmission within x period or not.

Does any model look at hospitals with a transition of care program?

Some of the larger models would have tested patients that had been part of a hospital with a transitions program, but we're not aware of any models specifically tested in hospitals with transitions programs.

Are there specific biomarkers that predict readmission in cardiac patients?

Ross JS, Archives Int Med, 2008;168(13) is a systematic review of predictors of heart failure readmissions. They looked at both statistical models and the literature on patient predictors (including biomarkers) on CHF readmission.

| | | | | |
|------------|---------|---|---|---|
| 12/13/2011 | 12:00pm | Risk Prediction Models for Hospital Readmission | Spotlight on Evidence-based Synthesis Program | Englander, Honora Kagen, David Kansagara, Devan Amanda Salanitro |
|------------|---------|---|---|---|

What was the purpose of this study? Was it to examine methods or was it to study findings?

“This systematic review was performed to synthesize the available literature on validated readmission risk prediction models, describe their performance, and assess their suitability for clinical or administrative use”