AN ANALYTICAL FRAMEWORK TO REDUCING HOSPITAL READMISSIONS

Descriptive, Predictive, and Prescriptive Analytics

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Outline

1. What is Readmission? Why Readmission is bad?
2. What causes Readmission?
3. What we can do to reduce avoidable Readmission.
4. Analytics in a nutshell: Descriptive, Predictive and Prescriptive.
5. How analytics can help in avoidable Readmission reduction.
Readmission is “an admission to a subsection(d) hospital within 30 days of a discharge from the same or another subsection(d) hospital”

‘Rework’, or a ‘Recall’
Definition

A return hospitalization to a same (or different) care unit within a specific time interval, following a prior admission and discharge.

Taxonomy

Readmission

- Avoidable or Unnecessary
- Planned or Advised

Facts

- Readmission is influenced by *Quality of Care* and patient’s health status (Miller, 2007).
- Section 3025 of the Obamacare established Hospital Readmission Reduction Program (2010)
- Readmission is influenced by *Access to Care* and patient socioeconomic status (Kangovi 2011).
- There is no single solution to address the issues contributing to readmission (Williams 2013).
Hospitalizations account for nearly one-third of the total $2 trillion spent on health care in the United States, and a substantial fraction of which are related to avoidable readmissions.

In 2009, 19.6% of Medicare fee-for-service patients discharged from a hospital were readmitted within 30 days that accounts for $12 billion annually. In comparison to other European countries, the US has the highest readmission rate.

PPACA: about two-thirds (or 2,211) of US hospitals have been penalized a cumulative $280 million (1%) in Medicare funds because of excess readmissions starting Oct. 1, 2012. This is acted for 55 Michigan hospitals in FY 2013 and caused $14 million penalty.
### Cost of Readmission

**Patient Readmission within 30 days, National Statistics 2011, AHRQ**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of index stays</th>
<th>No. of all-cause readmissions</th>
<th>Mean cost per readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestive Heart Failure</td>
<td>818,987</td>
<td>203,253</td>
<td>$13,966</td>
</tr>
<tr>
<td>Septicemia</td>
<td>794,760</td>
<td>164,379</td>
<td>$16,386</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>931,532</td>
<td>145,720</td>
<td>$13,417</td>
</tr>
<tr>
<td>Mood Disorders</td>
<td>894,67</td>
<td>136,491</td>
<td>$7,320</td>
</tr>
<tr>
<td>COPD and Bronchiectasis</td>
<td>626,113</td>
<td>132,271</td>
<td>$11,670</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>494,174</td>
<td>101,192</td>
<td>$11,725</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute Myocardial Infarction</td>
<td>509,756</td>
<td>82,964</td>
<td>$13,821</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conditions received penalty from CMS by **2013**: AMI, CHF, and Pneumonia

Conditions received penalty from CMS by **2015**: COPD, Coronary Artery Bypass, Peripheral Vascular Disease
What Causes Readmission?

**Patient level factors**
- Age
- Health Conditions
- Race
- Medical Coverage

**Medical factors**
- Premature discharge
- Inappropriate treatment
- Inadequate follow up
- Erroneous diagnosis

**Location**
- Hospital
- Geographic Region

30-day readmission rate for Medicare beneficiaries in 2010

An Analytical Framework to Reducing Hospital Readmission
Manage practices and culture of medical facilities and medical neighborhood will affect Readmission rates.

Systematic Interventions through Healthcare Systems Engineering

- Care Coordination and Transition Planning
- Discharge Process Re-Engineering
- Care Access and Quality Improvement
- Patient, Family, and Community Support
Readmission Intervention Roadmap

Admission
- Medication reconciliation
- Risk assessment for readmission

Discharge
- Organize post D/C services
- Document D/C summary

F/U call to patients and family
- Home visit to high risk patients
- F/U call to confirm ambulatory F/U occurred

Ambulatory F/U
- Ambulatory F/U visit

Who

An Analytical Framework to Reducing Hospital Readmission
## Some Intervention Programs

<table>
<thead>
<tr>
<th>Project</th>
<th>Main Intervention</th>
<th>Result</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Effective</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| RED: Re-Engineered Discharge (Jack et al. 2009) | • Follow-up phone-call  
• Post-discharge services  
• Medication reconciliation  
• Patient education plan | • 30% decrease in hospital utilization in 30-day follow-up  
• 34% lower observed costs in RED group due to 32% lower use of hospital resources | • Decrease in both ED and readmissions  
• The method was most effective for patients with high utilization |
| **The Care Transitions Program® (Coleman, 2004)** | • A Personal Transition Coach meets the patient in hospital.  
• The PTC visits patients at their home.  
• The PTC arrange three phone calls within 28 days after discharge. | • Decreased readmission overall:  
30 days = 4%  
90 days = 6%  
180 days = 5%  
• Decreased readmission for same diagnosis:  
30 days = 2%  
90 days = 5%  
180 days = 5% | • Longer time to the next readmission (225 days vs. 217 days, p < 0.001)  
• Use RN, NP, APN as transition coach |
| Transitional Care Model (TCM) (Naylor, 2004) | • A Transitional Care Nurse conducts home visits 24h after discharge helping on patient and family education  
• A TCN accompanies the patient on the first post-discharge visits | • 17% decrease in 180-day readmission rate for the intervention group  
• Significantly fewer number of readmissions at one year for HF elderly (65+) patients. | • Advanced Practice Nurses (APN) provide transitions among care settings |
## Some Intervention Programs

<table>
<thead>
<tr>
<th>Project</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Care North Carolina (2004)</td>
<td>• Coordinate care through developing local networks of PCPs</td>
<td>• 23% cut in Pediatrics asthma hospitalization</td>
<td>• Designed for Medicaid and low-income patients</td>
</tr>
<tr>
<td></td>
<td>• Makes care deliverers responsible for performance</td>
<td>• Diabetes hospitalizations decreased by 9%</td>
<td>• Covered initiatives such as asthma, HF, diabetes, ED, and pharmacy</td>
</tr>
<tr>
<td>Commonwealth Care Alliance Brightwood Clinic (2008)</td>
<td>• Multidisciplinary clinical team model with own authorities</td>
<td>• Unspecified readmission rates</td>
<td>• Intensive resources for highly coordinated teams with close individual outreach and follow-ups</td>
</tr>
<tr>
<td></td>
<td>• Reminders calls for preventive care</td>
<td>• Cost saving of $204 PMPM compared to fee-for-service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Enhanced behavioral health care</td>
<td>• ED utilization decrease from 0.109 visits PMPM to 0.097 visits PMPM.</td>
<td></td>
</tr>
<tr>
<td>Home Healthcare Telemedicine (Naylor, 2004)</td>
<td>• Visit the patient remotely via video 1-3 times per week</td>
<td>• 5% cut in rate of readmission for CHF patients</td>
<td>• Designed for CHF and COPD patients</td>
</tr>
<tr>
<td></td>
<td>• Telemonitor patient blood pressure and pulse oximeter</td>
<td></td>
<td>• Cost of telemedicine unit ($5,500) is less than one hospital admission</td>
</tr>
</tbody>
</table>
## Some Intervention Programs

<table>
<thead>
<tr>
<th>Project</th>
<th>Main Intervention</th>
<th>Result</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Promising but requiring additional data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| BOOST: Better Outcomes for Older adults through Safe Transition (2008) | • General Assessment of Preparedness (GAP) tools  
• Nurse training of ‘teach-back’ process  
• Standard forms and methods to transmit information to PCPs | • 8.5 % cut in all-cause 30-day readmission for patients (70-)  
• 22 % cut in all-cause 30-day readmission for patients (70+) | • Results are from one site (Atlanta Piedmont Hospital)  
• It covers 24 medical facilities in Michigan |
| STAAR: STate Action on Avoidable Readmissions (2009) | • Customized education for patient and caregivers at discharge  
• In-person visit for high-risk patients and phone calls for moderate-risk ones 48h after discharge | • No published results; it launched in 2009 for a 4-year cycle | • It covers states of MA, MI, OH, and WA  
• It conducts real-time patient- and family-centered communications |
| Hospital at Home (Leff et al. 2005) | • Web-based community to share tool kits and best practices  
• Post-discharge medication management, early follow-up, and symptom management | • No results have been published | • Focused on patients (65+) with HF or AMI diagnosis discharges |
What is Risk Adjustment?

The process by which the health status of a population is taken into account when evaluating outcomes of care or setting capitation rates.

Rationale for Risk-Adjustment

<table>
<thead>
<tr>
<th>Hospital A</th>
<th>Hospital B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>System</td>
</tr>
<tr>
<td>- Few</td>
<td>- Good access to</td>
</tr>
<tr>
<td>comorbidities</td>
<td>outpatient care</td>
</tr>
<tr>
<td>- Younger</td>
<td>- Care coordination</td>
</tr>
<tr>
<td>- Insured</td>
<td></td>
</tr>
</tbody>
</table>

Is it Fair to Compare These Hospitals?
How to do Risk Adjustment?

Compare a hospital’s performance, given clinical status of its patients (Case Mix), with the average hospital’s performance, given the same Case Mix.

**Risk-Adjusted Readmission Rate**

Number of 30-day Readmission Predicted Based on the Hospital’s Performance with its Observed Case Mix

Number of 30-day Readmission Expected Based on the Nation’s Performance with that Hospital’s Case Mix

Does this hospital have more or fewer readmission than would be expected from a typical hospital?
Risk-Adjusted Readmission Rates (RARR) are publicly reported on CMS and VA Hospital Compare websites.

**Table:**

<table>
<thead>
<tr>
<th>Hospital Name</th>
<th>Better Than U.S. National Rate (Adjusted readmission is lower than U.S. National Rate)</th>
<th>No Different Than U.S. National Rate (Adjusted readmission is about the same as U.S. National Rate or difference is uncertain)</th>
<th>Worse Than U.S. National Rate (Adjusted readmission is higher than U.S. National Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON MEDICAL CENTER CORPORATION</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>MASSACHUSETTS GENERAL HOSPITAL</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>VA BOSTON HEALTHCARE SYSTEM - JAMAICA PLAIN</td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

The 'total number' of hospitals in the table below is the total number of hospitals that had eligible admissions for this measure. See 30-Day Death and Readmission Measures for additional information about the data collection for the readmission measures.

Out of 4519 in the United States:
- 30 hospitals in the United States were Better than U.S. National Rate
- 2338 hospitals in the United States were No different than U.S. National Rate
- 41 hospitals in the United States were Worse than U.S. National Rate
- 2110 hospitals in the United States did not have enough cases to reliably tell how well they are performing
Risk-Adjusted Readmission Rates (RARR) are publicly reported on CMS and VA Hospital Compare websites.

![VA Hospital Compare](https://www.hospitalcompare.va.gov/apps/Compare/index.asp?state=MI&DiseaseBox=2&Detail=1)

<table>
<thead>
<tr>
<th>Medical Center</th>
<th>Medical Center Rate</th>
<th>Interval Estimate</th>
<th>VA National Rate</th>
<th>Lower Than National VA Rate</th>
<th>Within The National VA Rate</th>
<th>Higher Than National VA Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battle Creek VA Medical Center</td>
<td>20.22%</td>
<td>(15.15%, 26.31%)</td>
<td>20.87%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detroit (John D. Dingell) VA Medical Center</td>
<td>19.1%</td>
<td>(15.34%, 23.52%)</td>
<td>20.87%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron Mountain MI VA Medical Center</td>
<td>17.25%</td>
<td>(12.88%, 22.64%)</td>
<td>20.87%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saginaw VA Medical Center</td>
<td>18.43%</td>
<td>(13.86%, 23.56%)</td>
<td>20.87%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VA Ann Arbor Healthcare System</td>
<td>19.06%</td>
<td>(16.03%, 23.09%)</td>
<td>20.87%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data for the above grid is based on patients that are 65 years old and higher.

Mortality Rates for Congestive Heart Failure Patients at VA Hospitals in Michigan are Compared to the VA National Rate

Congestive Heart Failure mortality rates show you how the 30-day mortality rates from Congestive Heart Failure at the VA hospitals in the state you selected compare to the VA national mortality rate. These comparisons take into account how sick patients were before they were admitted to the VA hospital and differences in death rates that might be due to chance.
Readmission Rate as a Quality Metric

Risk-Adjusted Readmission Rates (RARR) are used for Financial Penalties.

http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html
Current Problems in Readmission Reduction

• Diversity of Medical Facilities, Management Practices, and Cultures. Lack of Comparative Outcome Studies.

• Variations in Readmission Causes (Risk Factors) among Different Healthcare Settings and among Different Patient Population

• Deficiency in Current Risk Prediction Models and Lack of Consensus on Readmission Timeframe.

• Cost and Resources related to Readmission Intervention Programs. Absence of Optimal Mechanism to Allocate Interventions to a Given Patient Population.
Analytics in a Nutshell

Prescriptive Analytics: What we should do?

\[ \max Z = \sum p_i x_i - c_0 Q \]
subject to:
\[ x_i = f(q_i) \times A_i \]
\[ \sum q_i = Q \]
\[ Q \leq Q_{\text{max}} \]
\[ \sum A_i = A_{\text{max}} \]
\[ q_i, x_i \geq 0 \]

Predictive Analytics: Predict what will happen

Descriptive Analytics: Understand what happened in the past.

An Analytical Framework to Reducing Hospital Readmission
Data

4 VA Michigan facilities, FY 2008 to 2012, contained near 4724 records from 1852 patients. 76.8% were readmitted once, 14.8% were readmitted twice, and 8.4% were readmitted 3 times or more.

Patient Factors

Demographics: Gender (Male ~86%), Age (60+ about 76%), Race …
SES: Income, Insurance (Insured about 62%) …
Utilization: Ward, Length of stay…
Risk and comorbidities: Treatment Specialty, Principal Diagnosis, …
War-connected: POW, Radiation status, …
**Descriptive Analytics at Work**

**Ward**

- **DOM** – Mental Health Domiciliary (Offsite)
- **OBS A3N** – Acute Medicine (Observation for <24 hours)
- **A4 NO OB MED** – Acute Medicine (Observation for <24 hours)

**An Analytical Framework to Reducing Hospital Readmission**
Treatment Specialty

1F – Hospice for Acute Care

13 – Cardiac Intensive Care Unit
37 – Domiciliary CHV
51 – OB/GYN
24 – Medicine

An Analytical Framework to Reducing Hospital Readmission
1) Dementia in conditions classified elsewhere with Behavioral disturbance
2) Leiomyoma of uterus
3) Dysphasia causing late effects in cerebrovascular disease
4) Hypovolemia
5) Anemia, Hemolytic, Acquired
6) Bipolar I Disorder, most Recent episode (or current) mixed, Moderate
7) Anemia of other Chronic Disease
8) Infection and inflammatory reaction due to internal joint prosthesis
9) Mechanical complication due to other implant and/or internal device
10) Other postoperative functional disorders
11) Chronic hepatitis C with hepatic coma
12) Other abnormal clinical findings
13) Anemia in Neoplastic Disease
14) Electrolyte and fluid disorders
15) Cardiac dysrhythmia
16) Neutropenia, unspecified
17) Contusion of abdominal wall
18) Seroma complicating a procedure
19) Drug Induced Neutropenia
20) Arteritis
21) Esophagitis, unspecified
22) Acute Venous Embolism and Thrombosis of other Thoracic Veins
23) Unspecified disorder of intestine

An Analytical Framework to Reducing Hospital Readmission
• Understand What Patients Look Like?

• Identify Vulnerable Areas and Wards.

• Pinpoint High Risk Disease Types and Patient Groups.

• Develop Customized Readmission Intervention Approaches.
Predictive Analytics

• Predict Readmission Risk for Individual Patients
• Classify Patients into High, Medium, and Low Risk Groups.

Objective

Develop a Risk Prediction Model that:

1. Can capture the timing of readmission
2. Be able to incorporate patient’s past history of readmission
3. Produce better discriminative results comparing to the literature (c-Statistics > 0.7)
Timing to Readmission for COPD Patients

Days 1-30

Percentage of Readmission, 17.3

Days following Discharge

Percent Not Readmitted

38 days
Predictive Analytics (Goal 1)

Modeling Time to Readmission with Patient Flow Approach

Shams et al., Working paper 2013

Community

High risk of readmission

Low risk of readmission

Continuous-Time Markov Process

Hospital

Time to Readmission

Time from the starting state until absorption in the absorbing state.

An Analytical Framework to Reducing Hospital Readmission
Predictive Analytics (Goal 1)

Inference

The model can be seen as a CTMP with k+r transient state and one absorbing state. The initial probability is $P=(1 \ 0 \ 0 \ \cdots \ 0 \ 0)$ and the transition matrix is given by $\Psi$. If $t$ presents the time to absorption (Readmission Time), we have:

$$f(t) = P \exp(\Psi \lambda) \alpha; \quad \alpha = -\Psi 1 = (0 \ 0 \ \cdots \ \lambda_{hr} \ 0 \ \cdots \ \lambda_{lr})^T$$

$$S(t) = \Pr(T > t) = P \exp(\Psi \lambda) 1$$

The time spent in each phase follows an exponential distribution. Hence, the pdf can be viewed as a mixture of two generalized Erlang distribution ($k$, $k+r$) like:

$$f(t) = pf_k(t) + (1-p)g_{k+r}(t)$$

where $p$ is the probability of being in the high-risk group and can be estimated as

$$p = \frac{\lambda_{hr}}{\lambda_{hr} + \lambda_k}$$
Predictive Analytics (Goal 1)

Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>St. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_1$</td>
<td>0.04</td>
<td>0.003</td>
</tr>
<tr>
<td>$\lambda_2$</td>
<td>3.62</td>
<td>0.12</td>
</tr>
<tr>
<td>$\lambda_3$</td>
<td>5.87</td>
<td>0.23</td>
</tr>
<tr>
<td>$\lambda_4$</td>
<td>1.25</td>
<td>0.05</td>
</tr>
<tr>
<td>$\lambda_{40}$</td>
<td>1.04</td>
<td>0.03</td>
</tr>
<tr>
<td>$\lambda_{50}$</td>
<td>0.07</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Proposal

In order to minimize the classification error between high-risk and low-risk group, we use Bayesian classification argument which yields to the cut-off readmission time where

$$ pf_k(t) = (1 - p) g_r(t) $$

simply where the two corresponding curves intersect

Optimal Time Window = 42 Days
Risk Prediction Model to study the Effects of Patient Factors

Let $h_{ij}$ be the risk of $j^{th}$ readmission for patient $i$ ($j = 1, \ldots, n_i$), then we propose

$$h_{ij}(t|x, z) = h_0(t) \exp(\beta'x_{ij} + z'_{ij}w_{ij})$$

Where $w_{ij}$ accounts for the correlation among patients within a cluster.

Both inter- and intra-patient variability of readmission can be captured ($i$ and $j$ indices).

Results

<table>
<thead>
<tr>
<th>Method</th>
<th>MPSE</th>
<th>$AUC_{ROC}$</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our proposal</td>
<td>2.36</td>
<td>0.84</td>
<td>0.89</td>
<td>0.92</td>
</tr>
<tr>
<td>Logistic R</td>
<td>3.14</td>
<td>0.67</td>
<td>0.82</td>
<td>0.93</td>
</tr>
</tbody>
</table>

MPSE := \frac{1}{n} \sum_{i=1}^{n} (y_i^* - y_{o,i})^2

NPV = \frac{TN}{TN + FN}

PPV = \frac{TP}{TP + FP}
### Association of Patient Factors with 42-day Hazard Ratio

<table>
<thead>
<tr>
<th>Patient Risk Factor</th>
<th>Hazard Ratio (95% CI)</th>
<th>Patient Risk Factor</th>
<th>Hazard Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, 40-60</td>
<td>1 [Reference]</td>
<td>Priority 1, service connected &gt;50%</td>
<td>2.4 (2.1-2.6)</td>
</tr>
<tr>
<td>Age, 65+</td>
<td>1.07 (1.03-1.08)</td>
<td>Priority 2, service connected 30–50%</td>
<td>1.6 (1.4-1.8)</td>
</tr>
<tr>
<td>Sex, Male</td>
<td>1 [Reference]</td>
<td>Priority 3, service connected 20–30%</td>
<td>1.3 (1.1-1.4)</td>
</tr>
<tr>
<td>Sex, Female</td>
<td>0.97 (0.94-0.99)</td>
<td>Priority 4, severely disabling injury</td>
<td>1.8 (1.6-1.9)</td>
</tr>
<tr>
<td>Race, White</td>
<td>1 [Reference]</td>
<td>Priority 5, low income or Medicaid</td>
<td>1.2 (1.1-1.3)</td>
</tr>
<tr>
<td>Race, Black</td>
<td>1.04 (1.02-1.06)</td>
<td>Priority 6, Agent Orange or Gulf War</td>
<td>2.8 (2.6-3)</td>
</tr>
<tr>
<td>Race, Other</td>
<td>0.96 (0.93-0.99)</td>
<td>Priority 7, non-service connected, income below HUD</td>
<td>1.2 (1.1-1.3)</td>
</tr>
<tr>
<td>POW, Yes</td>
<td>1.8 (1.7-2.1)</td>
<td>Priority 8, non-service connected, income above HUD</td>
<td>1 [Reference]</td>
</tr>
<tr>
<td>Radiation Status, Yes</td>
<td>2.6 (2.4-2.8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Prescriptive Analytics

General Framework

Data
Structured + Unstructured

Models

Predictions

Rules

Effects
How Decision will Impact the business

Decisions
What we will do based on these predictions

Application in Readmission

- Individualized Readmission Intervention Programs
- Assign Right Patients to Right Intervention Programs with Resource Constraints
# Analytical Framework for Reducing Hospital Readmission

## Discharge Criteria

### Low Risk Discharge
- Independent in ADL’s
- Caregivers in the home and available to assist
- Lives alone with community support
- Independent with management of chronic diseases
- Adherent to treatment plan
- Able to direct medical care
- Consistently followed by MD/Practioner

### Moderate Risk Discharge
- Lives alone with limited community support
- Requires assistance with medications
- Issues of health literacy
- History of mental illness
- Polypharmacy (greater than 7 meds)
- Requires temporary assistance with IADL’s and ADL’s
- Requires assistance in:
  - Ambulating
  - Transferring
  - Wound Care
  - Management of oxygen and/or nebulizer

*If ≥ 2 then refer to home health agency*

### High Risk Discharge
- Lives alone with no community support
- Lives with family that is not actively involved in care
- Clinically complex
  - (multiple co-morbidities, repeat hospitalizations or ED visits, needs considerable assistance to manage or is unable to manage medical needs independently)
- History of falls
- Acute/chronic wound or pressure ulcer
- Incontinent
- Cognitive impairment
- History of mental illness
- CHF and/or COPD and/or diabetes and/or HIV/AIDS
- End stage condition
- Requires considerable assistance in:
  - Transferring
  - Ambulating
  - Medication management (greater than 7 meds)
  - Management of oxygen and/or nebulizer

*If ≥ 4 then refer to home health agency upon patient admission to hospital*

### Discharge to Community
- Refer to home care services for:
  - Patient received services from home care prior to hospitalization?
    - Yes  No  If Yes, name of agency:
  - Skilled Nursing
    - Observation and assessment
    - Teaching and training
    - Performance of skilled treatment or procedure
    - Management and evaluation of a client care plan
    - Physical, occupational and/or speech therapy
    - Medical social work
    - Home health aide service for personal care and/or therapeutic exercises
    - Telehealth Care Management

*If ≥ 2 then refer to home health agency*

### Other Outpatient Referrals
- Services not provided by home care agencies:
  - Outpatient mental health
  - Medicaid/Public Assistance
  - Social Security Office

This information is provided as guidance and should not be considered to be an all inclusive list of discharge planning options. Providers need to select and/or develop protocols that apply to their specific patient population and region.

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Prescriptive Analytics

Modeling within an Optimization Framework

Assuming $C_j$ be the cost of readmission for disease type $j$, and $C'_{i(j)}$ be the cost of intervention program for patient $i$ having illness $j$, an assignment can be formulated as:

$$\max \sum_j c_j \sum_{i(j)} \left[ 1 - S_{i(j)}(T_j) \right] x_{i(j)}$$

$s.t.$ $\sum_{i(j)} c'_{i(j)} x_{i(j)} \leq B_j \quad \forall j$

Further improvements can be made by making difference between pre- and post-discharge intervention costs (and budgets).
Thanks for your patience

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