

# Risk Prediction Models for Hospital Readmissions

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# Introduction

The healthcare expenditure in the United States, per capita and as a percentage share of GDP, is considerably higher than most developed nations and is estimated to increase by over 65% over the next decade. The Patient Protection and Affordable Care Act (ACA) has changed reimbursement models from fee-for-service to outcome-based hence healthcare service providers need to improve service delivery, manage risks and patient engagement.

## **Hospital Readmission Reduction Program (HRRP)**

Mandated by the ACA, the HRRP is a payment penalty program designed to reduce Medicare fee-for-service (FFS) hospital readmission rates for conditions that account for expensive, high-volume admissions and frequent readmissions.

Centers for Medicare and Medicaid Services (CMS) reduces a hospital's Medicare payments for all patients if it has a higher-than-expected 30-day readmission rate for patients with specific clinical conditions. As of FY 2015, the HRRP includes readmission measures for heart attack, heart failure, pneumonia, chronic obstructive pulmonary disease (COPD) and total hip and knee replacements.

## **Analytics Opportunity**

Annual hospital readmissions for 2012 were 19% accounting for \$25 billions in healthcare expenditure. A mere one percent reduction could prevent ~\$250 million in unnecessary expenses. Moreover 2,592 hospitals, in the year 2015, will be penalized for exhibiting more than expected readmissions, losing a combined \$420 Million.

Hospitals have been implementing measures to prevent avoidable readmission cases by providing medication on discharge, making a follow-up plan before discharge, providing home-care on wheels among other measures. But these methods tend to be cost-intensive and often do not provide a justifiable return on investments.

Instead, predictive models could be used to identify patients at risk of readmissions either at the time of admission or during their treatment or at discharge to help target and provide extra care to such patients. This could reduce readmission rates across the board and assist hospitals in avoiding CMS-levied payment penalties.

In this paper we share a systematic review & recommendations of various modelling techniques employed to predict readmission risk for 5 conditions (PN, CHF, AMI...) as laid out by the ACA.



# Data requirements

Patient's socio-economic data along with individual electronic medical records, medical correspondences, hospital finance department details, nurse notes, physician logs, procedural details can be used to understand quality of care, patient's medical history and living standards as inputs for the model.

Variables that demonstrate demographic and social characteristics, length of stay for index admission, procedures, number of admissions in last year, comorbidity index etc. can also be included during model development. Given below is an illustrative list of possible variables that could be used –

<b>Demographic</b>	- Age, gender, race/ethnicity
<b>Social health determinants</b>	- Income, insurance status
<b>Prior service utilizations</b>	- hospitalizations, length of stay
<b>Underlying health status</b>	- Mental illness, diagnosis, number at admission, General anesthesia, Hemodialysis
<b>Procedural arterial line</b>	- Central venous catheterization, Endotracheal intubation, Tracheostomy, Nasogastric tube, Foley catheterization, Draining tubes
<b>Therapeutical</b>	- Chemotherapeutic agents, Systemic Glucocorticosteroids, Stress ulcer prophylaxes, Non-steroid anti-inflammatory drugs, ...



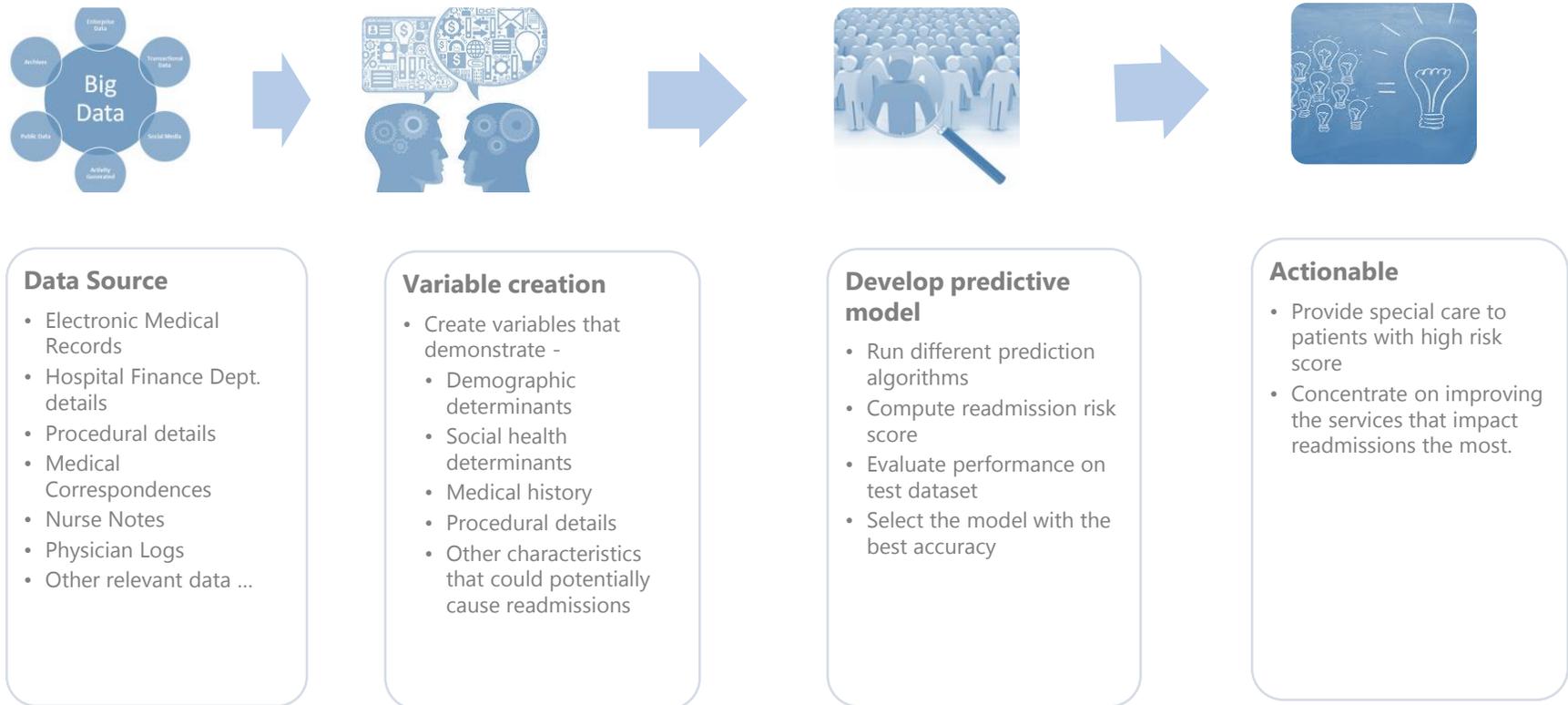
# Modelling Techniques

Several prediction techniques have been explored to evaluate and model patient readmission risk. Given below is a brief description of some of the most popular modeling techniques used for developing patient readmission risk models and discuss the implications of their implementation.

- Logistic Regression - Majority of the models created for the prediction of hospital readmissions have employed logistic regression. These models tend to be high on specificity but low on sensitivity in presence of limited variables. Increasing the variable count can improve efficiency but that makes the models more difficult to implement for practical purposes.
- Random Forest - The random forest algorithm can identify additional variables that are associated with readmissions beyond those found through regression analysis. It can work with all kinds of predictor variables and offers complex classifications and can handle non-linear and conditional relationships in data better than other techniques.
- Support Vector Machines (SVM) - SVMs aim at maximizing the margins between data-points and a hyperplane used to separate two classes. The hospital readmission data is not linearly separable. SVM maps the data into a higher dimensional space (infinite) which helps in separating the data points more effectively.
- Neural Networks/Deep learning - Deep learning models tend to be the most difficult to manage due to the large number of model parameters. These models have the greatest potential to boost predictive accuracy in statistical approaches to predicting early readmission.



# Approach and Recommendations



Depending on the settings and the population being studied, different methods could be opted for. An interesting observation is that models that address a specific patient population or condition tend to perform better than prediction models that are generic and cater to the entire population. This suggests that models should be developed to predict readmissions for a particular subgroup (i.e. one of the five conditions CMS uses to assess penalties). Such directed models can run into power issues if the sample size is limited in which case a generic model that fits the heterogeneous population can prove beneficial. Logistic Regression and Neural Networks have proved highly efficient in predicting Hospital Acquired Infections (HAIs) but not for overall readmissions. Diagnosis-Related groups (DRGs) are used to partition patients into homogenous subgroups for the purpose of comparing methods, however, there may be significant improvement to overall accuracy by a more careful approach to patient stratification.



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