Technical
White Paper

Risk estimation, stratification, and adjustment

Approaches to consider for measuring patient risk and estimating provider performance

Watson Health™

IBM

Contents

Introduction

Many news stories have recently covered the debate about evaluating educator performance, in particular the challenge of accounting for the mix of students in each classroom. Similarly, one of the most important problems in healthcare informatics is to create a fair way to measure and compensate for the risk of patients attributed to each provider. Because both "fair" and "risk" are difficult to precisely define, it is not surprising that risk measurement, risk adjustment, and risk stratification are still unsolved problems.

Though it may seem impersonal to create a formula for measuring something as complex as patient risk or provider quality, computer algorithms are just about the only rigorous, scalable, and sustainable way to measure patient risk and estimate provider performance. A number of approaches to estimating risk have been designed and refined over the past few decades that can help improve quality and decrease cost of healthcare. It is expected that continued model development coupled with advances in information collection and sharing will lead to marked improvements in the coming years.

Risk estimation

Details of the various risk estimation methodologies are important to consider. A few key choices are made by each of the algorithms:

- the type of data used
  - claims, clinical, administrative, …
- the longitudinality of data
  - one encounter, one month, one year, …
- the type of risk being quantified
  - cost, probability of readmission, …

Various trade-offs can be made within each of these factors, depending on the data available and the use case of the risk model. For example, a Diagnosis Related Group (DRG) is computed using the information on a single inpatient claim, while Hierarchical Condition Category (HCC) is computed by CMS using all patient diagnoses in the previous calendar year. In general, the broader the view of a patient's records that are taken into account, the more specific the risk profile that can be generated.

Because making useful comparisons between providers, practices, or hospitals is necessary now, Watson Health is both providing current innovative risk measurement practices and working to develop the next-generation risk models and adjustment methodologies.

Watson Health selected the Hierarchical Condition Categories (HCC) algorithm from CMS as a basis for the first generation of internal risk measurement and risk adjustment methodologies. In addition to the fact that this methodology is applied to Medicare patients for payment purposes, it calculates a risk score using all diagnoses recorded for a patient over an entire year. This year-long perspective, in addition to the patient's age and sex, gives a more detailed view of a patient's risk than what can be gleaned from any one encounter or episode of care.

HCC and IBM Explorys EPM Application Suite

The HCC algorithm was designed to assign per member per month (PMPM) premiums based on data from the previous year's claims. All diagnoses that are recorded on claims during the reference window are inputted into the HCC algorithm. The algorithm groups ICD codes into 70 categories of the most relevant conditions for payment purposes. HCCs and demographic factors are fed into a regression model to assign a cost weight, with the average cost weight of one for the CMS population.

The methodology of the HCC algorithms is to combine risk evaluated on demographics and diagnoses, including some interaction terms like diabetes mellitus (DM) and congestive heart failure (CHF). For example, an 82 year old female with diagnoses that map to the HCC groups for congestive heart failure, diabetes, and decubitus ulcer would receive a score that is the sum of terms for each of those three groups, one for a DM*CHF interaction, and a final term for age/gender as shown in Table 1.

HCC	Coefficient
congestive heart failure	0.346
diabetes without complication	0.127
decubitus ulcer of skin	1.165
interaction: DM*CHF	0.150
female 80 - 84	0.525
total score	2.313

Table 1: Example of HCC scores

The risk scores calculated in this way helps enable new functionality in the Enterprise Performance Management (EPM) applications that run atop the IBM® Explorys Platform. Registries can be created to stratify patients in registries and quality measures, if the more traditional stratification accomplished by creating registries for diabetes, heart disease, lung disease, and mental illness (which should identify a strong majority of patients with high utilization) is insufficient. The advantage of an HCC risk score is that it can account for comorbidities, avoiding searching for patients across multiple registries.

A patient's HCCs and the associated risk scores also help enable advanced analytics, such as predictive models and risk adjustment methodologies. For example, the HCC categories have been used to develop models for risk of admission due to heart failure or chronic obstructive pulmonary disease that meet or exceed the performance of Agency for Healthcare Research and Quality (AHRQ) models, allowing for evaluation of the risk adjusted measures for heart failure admission (ACO 9) and COPD admission (ACO 10).

Next visit	Last Framingham Risk Score observation date[1]	Last Framingham Risk Score observation value	First 2012 HCC cost weight calculated value	Last 2013 HCC cost weight calculated value	Last Charlson Deyo Risk index risk score date[2]	Last Charlson Deyo Risk index risk score value	Last heart failure diagnosis date
	12/13/2012	16	8.536	6.152	01/01/2013	12	10/11/2012
08/22/2013	07/24/2103	6	8.427	4.311	01/01/2013	9	06/29/2013
	09/14/2012	16	7.819	5.482	01/01/2013	9	08/27/2012
08/19/2013	08/05/2013	2	7.600	2.707	01/01/2013	7	08/05/2013
	11/05/2012	20	6.946	2.510	01/01/2013	6	11/05/2012

Figure 1: Example of risk scores in IBM® Explorys EPM: Registry

Since the grouping and weights published by CMS were designed for the Medicare population, some additional steps must still be completed to calculate HCC scores for the general population. The analytics team at Watson Health is currently developing extensions to modify the hierarchy, such as creating an HCC for pregnancy, which is not covered in the CMS implementation. New demographic weights must also be derived that apply the general population. The analysis and validation steps must be combined with a clinical review of these algorithmic extensions and newly computed weights.

The Department of Health and Human Services (HHS) has created models for the healthcare exchanges in the Affordable Care Act. This HHS HCC 2014 algorithm uses a similar methodology as the CMS HCC algorithm, in which each patient's age, gender, and diagnoses are used to estimate overall risk for each metal tier: platinum, gold, silver, bronze, and catastrophic level coverage.

Multiple versions of the HHS algorithm exist for the metal tiers of available insurance plans: platinum, gold, silver, bronze, and catastrophic. The HHS HCC algorithm will be used as the risk adjustment engine for computing net-zero payment transfers between health plans, based upon average risk of patients in each plan.

IBM Explorys Risk Grouper (ERG)

To improve upon the predictive power of the HCC models, Watson Health has developed and integrated a proprietary risk model into the IBM Explorys EPM Application Suite. In some respects, the IBM Explorys Risk Grouper is similar to other risk models available as it risk stratifies a population based on utilization and that it can be calculated based on administrative data sets. Because ERG can be used to calculate both prospective and concurrent utilization for commercial and Medicare populations, it can be used for both Commercial ACOs and in CMS MSSPs to place groups of patients into risk bins and allocate scarce resources for care management.

When compared to other available risk models, the performance of the ERG model is differentiable from alternative solutions as ERG models have been built using more breadth and depth of data (more than 1500 variables)[3] – many are not typically incorporated into alternative solutions. In addition to demographic and diagnosis information, procedure and medication records for each patient are used when available.

The ERG performs exceptionally well with high predictive power for concurrent risk analyses in Medicare (R^2=74.2) and Commercial (R^2=60.2) populations as well as prospective risk analyses in Medicare (R^2=30.0) and Commercial (R2=28) populations.[4] Because of this exceptional performance, the IBM Explorys EPM Application Suite incorporates the ERG into quality and performance measurement, measures and registries for risk stratification, and into provider and practice variation reporting.

While similar, there are important differences between the concurrent and prospective models. The concurrent model uses available clinical and demographic data to estimate costs for the same time period, but is used for measurement and comparison purposes because the costs have already occurred. A prospective model is a predictive model that gives a forecast for costs at some future time, and is used to manage risk, resources, and populations.

To understand this difference in practice, consider an example of a patient with a diagnosis of chronic kidney disease (CKD). A concurrent model may predict an impact in the costs for that same year, but a prospective model may show an even larger impact in costs for the following year because of the risk of worsening into end stage renal disease (ESRD). In the opposite direction, a child birth on a patient record could impact a concurrent model, but not a prospective model for cost.

Both models are estimates for cost, given the available data, and trained on measured correlations between factors being considered. However, all else being equal, a concurrent model can have more accuracy than a prospective model because forecasting tends to be a more challenging problem.

A few use cases for a concurrent model are: adjusting patient panel size for acuity, investigating factors that influence patient outcomes, and comparing provider efficiency. Use cases for a prospective model include: budgeting and resource allocation and evaluating shared risk or value based contracts.

LACE readmission risk model

The LACE (length of stay, admission source, comorbidities, and emergency room visits) model evaluates the risk of readmission for recently discharged patients from the hospital.

Item	Score
L: Length of stay	
One day	+1
Two days	+2
Three days	+3
Four or more days	+4
A: Admission Source	
Admitted from ED	+1
C: Comorbidities (with ICD-9 codes)	
CHF (402)	+2
Myocardial infarction (412)	+1
Vascular (414, 415, 416, 440, 441)	+1
DM with complications (249, 250)	+1
Respiratory disease (490, 491, 492)	+2
Mild liver disease (570, 571)	+2
Severe liver disease (572)	+3
Tumor (140-239)	+2
Dementia(290-299)	+3
Connective tissue disease (710)	+3
AIDS (042)	+4
E: Emergency Room Visits In Past 6 Months	
One ED visit	+1
Two ED visits	+2
Three ED visits	+3
Four or more ED visits	+4
Total Score	L + A + C + E

Table 2: Details of scoring for LACE model

The LACE model includes scores from each term in the acronym. Organizations may score the model differently; Table 2 provides one scoring mechanism implemented in the IBM Explorys Platform. Each inpatient admission record in the IBM® Explorys Data Grid will have an associated LACE score, which can be used to stratify patients most in need of follow up services when discharged from the hospital.

Additional risk solutions

In 2012, Watson Health went live with its first risk-adjusted measures, leveraging the commercial APR-DRG grouper software developed by 3M. This approach to risk evaluation and adjustment within the IBM® Explorys EPM: Measure application is offered to organizations with the necessary licenses.

Since then, many other risk measurement algorithms have also been implemented in the IBM Explorys Platform and are available in the IBM Explorys EPM Application Suite, such as the registry shown in Figure 1. These models include:

- Framingham 10-year Heart Failure Risk Score[5]
- Charlson Deyo Comorbidity Index[6]
- Elixhauser Comorbidity Index[7]
- CMS Yale readmission risk models[8]
- A variety of customized risk models

Other groupers and risk models will be added to the technology stack as needed, including commercial models, client-defined risk models, and models created or enhanced by the curated data in the IBM Explorys Data Grid.

Concept	Accumulated Value
more than 2 hospitalizations in 1 year	+5
more than 3 ED visits in 1 year	+5
diabetes diagnosis	+2
heart failure diagnosis	+2
hypertension diagnosis	+1

Table 3: Example of a simple risk model

Simple risk models, such as the simple model described in Table 3, can be implemented within the IBM Explorys EPM Suite very quickly. However, more time and effort may be necessary to complete more complicated models or integrate commercial software for the first time.

References

1. Evaluation of CMS-HCC Risk Adjustment Model[9]
2. Risk Adjustment Using the CMS-HCC Model[10]
3. HCC Calculator[11]
4. Yale All-Cause Unplanned Readmission Measure[12]
5. Society of Actuaries Comparative Analysis[13]

About IBM Watson Health

In April 2015, IBM launched IBM Watson Health and the Watson Health Cloud platform. The new unit will work with doctors, researchers and insurers to help them innovate by surfacing insights from the massive amount of personal health data being created and shared daily. The Watson Health Cloud can mask patient identities and allow for information to be shared and combined with a dynamic and constantly growing aggregated view of clinical, research and social health data.

For more information on IBM Watson Health, visit: ibm.com/watsonhealth.

Footnotes

1. Framingham Heart Study, Hard Coronary Heart Disease (10-year risk); (based on The Adult Treatment Panel III, JAMA. 2001); A project of the National Heart, Blood, and Lung Institute and Boston University; 2015; https://www.framinghamheartstudy.org/risk-functions/coronary-heart-disease/hard-10-year-risk.php

2 Deyo RA1, Cherkin DC, Ciol MA; Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases; J Clin Epidemiol. 1992 Jun;45(6):613-9; http://www.ncbi.nlm.nih.gov/pubmed/1607900

3 IBM Explorys Risk Model whitepaper, "Evaluation of Explorys' Risk Adjustment and Predictive Models"; Yi, Rong, PhD, Dec. 20, 2013, http://www-01.ibm.com/common/ssi/cgi-bin/ssialias?subtype=WH&infotype=SA&htmlfid=HPW03023USEN&attachment=HPW03023USEN.PDF

4 Ibid, 2015.

5 Framingham Heart Study, op. ct.; 2015; https://www.framinghamheartstudy.org

6 Deyo RA1, Cherkin DC, Ciol MA; Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases; J Clin Epidemiol. 1992 Jun;45(6):613-9. http://www.ncbi.nlm.nih.gov/pubmed/1607900

7 Elixhauser A1, Steiner C, Harris DR, Coffey RM; Comorbidity Measures for use with Administrative Data; Med Care. 1998 Jan;36(1):8-27. http://czresearch.com/dropbox/Elixhauser_MedCare_1998v36p8.pdf

8 Yale Hospital-Wide (All-Condition) 30 - Day Risk-Standardized Readmission Measure, Draft Measure Methodology Report, 8/10/2011, https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/downloads/MMSHospital-WideAll-ConditionReadmissionRate.pdf

9 Pope, G.C., MS, Kautler, J., PhD, Ingber, M.J., PhD, Freeman, S., MS, Sekar, R., BA, Newhart, C., MA; Evaluation of the CMS-HCC Risk Adjustment Model; The Centers for Medicare & Medicaid Services' Office of Research, Development, and Information (ORDI); Project Number 0209853.006; March 2011; https://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/downloads/evaluation_risk_adj_model_2011.pdf

10 Pope, G.C., MS, Kautter, J., PhD, Randall, P.E., PhD, Ash, A.S., PhD, Ayanian, J.Z., MD, MPP, Iezzoni, L.I., MD, MSc, Ingber, M.J., PhD, Levy, J.M., PhD, Robst, J., PhD; Risk Adjustment of Medicare Capitation Payments Using the CMS-HCC Model; Health Care Fiancing Review/Summer 2004/Volume 25, Number 4; https://www.cms.gov/Research-Statistics-Data-and-Systems/Research/HealthCareFinancingReview/downloads/04summerpg119.pdf

11 HCC Calculator; HCC University; Scan Health Plan; 2008; http://www.hccuniversity.com/hcc-university/risk-score-calculator/

12 Yale Hospital-Wide (All-Condition) 30 -Day Risk-Standardized Readmission Measure, op. cit., 8/10/2011..

13 Winkelman, R., Mehmud, S., A Comparative Analysis of Claims-Based Tools for Health Risk Assessment; Society of Actuaries; 4/20/2007; https://www.soa.org/research/research-projects/health/hlth-risk-assement.aspx,

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Produced in the United States of America
June 2016

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HPW03031-USEN-02

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