



Management Brief: Central MN Health Network (CMHN) Risk Assessment Instrument V25.9

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Objectives:

1. Provide a basic overview of the Central MN Health Network Risk Assessment Instrument.

Overview

This document describes the development of a risk assessment instrument designed to predict future healthcare spending for Central MN Health Network (CMHN) patients. The CMHN risk assessment instrument predicts future spending within the CentraCare Health system with a high degree of accuracy (R Squared = 25.9%, Mean Absolute Error = 118%, Area Under the Curve = 86.2%). The CMHN risk instrument provides a method for ranking patients by risk level so that the effectiveness of interventions can be maximized.

Effective management of patient healthcare spending requires a method for ranking patients with regards to their need for care. This is especially true as payors push providers toward the provision of value based care. The differences between patients in demand for healthcare spending are very large. For example, the 20% of CentraCare Health (CCH) patients with the highest cost of healthcare in FY2016 generated 94% of the CCH healthcare costs to payors. If the patients with the highest potential for generating high-costs could be identified in advance, it is possible that their costs of care could be reduced through increased efforts to manage their care more cost effectively.

The problem, up until now, has been that CCH has not had an accurate method of ranking its patient's healthcare spending risk. The current healthcare risk assessment methodologies available to CCH have had very low predictive accuracies (See Appendix A). It would be possible to buy risk assessment instruments to correct this deficit, but the initial bid from one vendor has been relatively high. For example, it would cost \$214,000 per year to purchase a license to use the Johns Hopkins Adjusted Clinical Groups (ACG) risk assessment instrument with 250,000 CCH patients. That cost would expand if other organizations in the CMHN were to adopt the John Hopkins ACG system. Aside from the cost, the accuracy of the ACG risk assessment instrument with CCH's IHP population suggests that the ACG system is not highly predictive of CCH patient cost of care (See Appendix A: ACG R Squared = 5.9%).

Given this situation, it seemed that it would be advantageous to pursue an effort to develop an in-house risk assessment instrument for CCH and the related CMHN organizations that are tied into its Epic Electronic Health Records (EHR) system. The initial results from the attempts to produce an in-house healthcare spending risk assessment instrument indicate that it is possible to develop an in-house risk assessment instrument that is as good (or better) at predicting future healthcare costs as the best commercial risk assessment instruments. This instrument has been named the Central MN Health Network (CMHN) Risk Assessment Instrument.

The CMHN Risk Assessment Instrument is undergoing a process of continual adjustment and improvement. Therefore, a version naming system is being used. The current version name of V25.9 is derived from the R Squared value for the latest major revision of the instrument. The V25.9 comes from the current R Squared value for this version of 25.9%. This level of accuracy is comparable to the top commercial risk assessment instruments (See Appendix A), and is gradually improving. For example, as of this writing, the accuracy of the CMHN risk assessment instrument has crept up to 26%. Given this state of flux, version names will only be changed as major changes are made.

A Basic Overview of the CMHN Risk Assessment Instrument V25.9

The CMHN risk assessment system is a hybrid risk assessment model that is built using a multivariate linear regression formula. The current CMHN risk model uses a total of 479 different predictor variables to predict the average predicted amount that the patient will spend over the next 12 months. The 479 variables are collected from the Epic Electronic Health Record (EHR) data for each patient. The CMHN model is called a “hybrid” model because the predictors include a combination of demographics, social indicators, lab results, previous spending, previous diagnoses, and previous procedures. The raw Epic variables are manipulated and transformed in many ways to create statistically significant predictors. The 479 resulting predictors are put into a linear regression model that creates a weight for each predictor that is then used to calculate a risk score for each patient. The risk score is correlated at $r = .509$ with spending in the next 12 months, with translates to an R Squared (Explained Variation) of 25.9%.

Model Development

There is a basic challenge in developing in-house healthcare spending risk assessment instruments because the methodology used in constructing commercial risk assessment systems tends to be a closely guarded secret. For example, the John Hopkins ACG system has been under development for over 30 years, and even after multiple articles have been written about the ACG system, the exact mechanisms used with the ACG system are not published. Therefore, one can only guess at the inner workings of commercial instruments such as the ACG.

While this presents a challenge, this challenge is not insurmountable. A broad healthcare literature exists that indicates which factors tend to be predictive of poor health. For example, we know that heavy tobacco use is a predictor of healthcare spending. We also know that health declines with age. In addition, there are several preexisting conditions such as diabetes that indicate poor health. These and other predictors can be included in a linear regression model predicting high health costs in the next 12 months. As more information is collected about the potential risk factors, the accuracy of the risk prediction increases. The accumulation of predictors is the process that was used to create the CMHN risk assessment instrument.

The basic elements used in the CMHN risk assessment instrument are listed below.

Measurement Class	Detail
Demographics	Age by 10-year range Gender Marital Status
Lab Results	Highest Systolic Blood Pressure Highest A1C Level Last Body Mass Index Highest Cholesterol Level
Prior Spending	Spending from the previous 5 years
Social	Max Drinks per Week History of Tobacco Use
Hierarchical Condition Classification (HCC)	A merged set of 148 CMS and HHS HCCs
ICD Clinical Classification System (CCS)	Number of diagnoses in each of 254 CCS
Berenson-Eggers Type of Service (BETOS)	Number of Types of Service performed
Interactions and Combinations	Products and sums of the variables

Assessing the Accuracy of the CMHN Risk Assessment Instrument

The basic process involved in creating the CMHN risk instrument is outlined in the CMHN Risk Assessment Instrument Technical Manual. The current document, the CMHN Management Brief, will highlight some of the metrics used to assess the accuracy of the CMHN risk assessment instrument. The validation process has focused on three metrics. These are 1) R Squared or Percent of Explained Variance, 2) Mean Absolute Error (MAE), and 3) Area Under the Curve (AUC) for the Receiver Operating Characteristic (ROC) curve.

External Validation Study

Milliman was contracted to provide an independent validation of the accuracy of the CMHN risk assessment instrument. In their December 15, 2017 report, Milliman reported the following. The benchmark comparisons shown are drawn from the 2016 Society of Actuaries (SOA) article “Accuracy of Claims-Based Risk Scoring Models.”

FIGURE 1: PERFORMANCE METRICS		
Metric	CentraCare	Benchmark Range
R ²	25.9%	9.1% - 20.7%
Mean Absolute Error	118.1%	96.4% - 109.2%
Positive Predictive Value for Top 5%	34.6%	N/A*
Area Under the Curve for Top 1%	86.2%	83.3% - 87.7%

* This metric was not provided in the SOA study, but we believe it is informative.

R Squared or Percent of Explained Variance

One of the measures of the accuracy of a healthcare risk assessment instruments is a statistic called R Squared. R Squared provides a measure of the total variance explained by the risk assessment instrument. For example, as shown in Appendix A, the R Squared value for the Epic General Risk Score with CentraCare patients was around 6%, and the R Squared values for some of the best commercial risk assessment instruments approach 25%.

The current V25.9 revision of the CMHN healthcare spending risk assessment model predicts spending in the next 12 months with an R Squared of 25.9%. This level of explained variance is much higher than anything currently available to CentraCare, and it provides a level of accuracy that is higher than commercially available risk assessment systems. Furthermore, the accuracy of the CMHN risk assessment could be enhanced by the addition of additional measures.

Mean Absolute Error (MAE)

The mean absolute error is another popular measure for healthcare risk assessment instruments. Some of the commercially available risk adjustment instruments achieve MAE levels in the 91.2% to 109.2% range. (See Appendix A or page 19 of the article by Hileman, G., & Steele, S., 2016 listed in the references). The instruments achieving this level of accuracy tend to be using claims based data, which is more complete than the data available in Epic, which only includes data generated within the CentraCare system. The V25.9 CMHN model has a MAE of 118%. This could be interpreted as indicating that the predicted CentraCare spend tends to be within 1.18 means of the true value. The mean amount spent on healthcare in the CentraCare system for the average CentraCare patient in 2016 was about \$2,600. Therefore, the amount spent

predicted by the CMHN risk score is within an average of about (plus or minus) \$3,100 of the actual value.

Area Under the Curve (AUC) for the Receiver Operating Characteristic (ROC) Curve

A third measure that is used to evaluate the accuracy of healthcare spending risk assessment instruments is the Area Under the ROC curve, or AUC. Commercial risk assessment instruments achieve AUC values of 81.2 to 88.1 when predicting whether a patient falls into the top 1% of spenders (See page 46 the article by Hileman, G., & Steele, S., 2016 listed in the references). The CMHN risk score predicted the top 1% of spenders with an AUC of 86.2. The ROC curve for the CMHN V25.9 risk assessment instrument is shown in Appendix B.

Conclusion

The V25.9 CMHN risk assessment instrument is a tool that provides an estimate of future spending at accuracy levels comparable to or better than the top commercial risk assessment instruments. It has several advantages over commercial risk assessment instruments.

- First, it is essentially free. The only costs associated with this instrument are employee time associated with development and implementation, and any costs required to integrate this instrument into Epic.
- The second advantage is that the inner workings are known. The instrument can be improved and modified, and future versions can be developed for specific applications. For example, an ACO version could be developed that was optimized for ACO patients. In addition, versions could be developed for other applications, such as predicting ED visits. With an “open source” risk assessment instrument, such as the CMHN risk assessment instrument, the additional costs to add improvements or additional functionality are relatively low.
- Finally, the CMHN risk assessment instrument works with readily available Epic data and does not require additional input from outside the system. Therefore, risk scores can be developed for all CMHN patients.

Given these advantages, it is suggested that the CMHN risk assessment instrument be adopted for use by CMHN providers.

Limitations

A method is needed for full integration of the CMHN risk assessment system into Epic. As it is, the CMHN risk assessment instrument can be used as a “back end” tool for generating reports or patient registries. Without some type of integration method, it will be difficult to use in a clinical setting. It could be integrated into ClikView or SlicerDicer with little effort, but this method of distribution requires an extra effort on the part of providers if they want to access the CMHN risk score as they work with the patient.

References

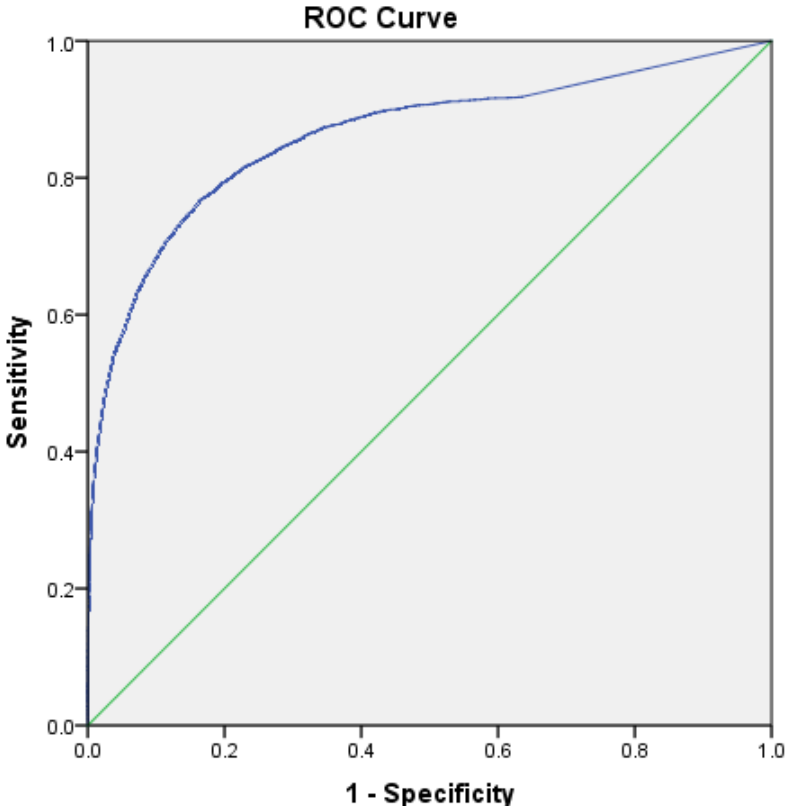
Hileman, G., & Steele, S. (2016). Accuracy of Claims-Based Risk Scoring Models. Technical report. Society of Actuaries. <https://www.soa.org/Files/Research/research-2016-accuracy-claims-based-risk-scoring-models.pdf>

Appendix A: Comparison of Prospective Risk Score Accuracies

The following data was obtained from two sources. The items in black were collected from a report of risk score accuracies generated by the society of actuaries (Hileman & Steele, 2016). The most predictive risk assessment instruments use prior cost as a predictor of future cost. Diagnosis only models tend to be less accurate. The accuracy estimates listed in red were collected from CCH, ACO, and IHP data. The accuracy levels for risk assessment instruments currently available to CentraCare are toward the bottom of the list. These values were generated by using risk scores from 2015 to predict spending in 2016. The R Squared value for the CMHN risk assessment instrument is higher than the commercial scores. The accuracy estimate was generated by taking risk at the end of FY2015 and using it to predict spending in FY2016. The Mean Absolute Error (MAE) is higher than claims based risk assessment instruments, but this might be expected since the EHR data is not as complete as claims data. The AUC for predicting patients in the top 1% of spenders is comparable with the AUCs of commercial risk assessment instruments.

Risk Assessment Instrument	Type	R Squared	MAE	AUC
CMHN Risk Assessment Instrument	Hybrid	25.9%	118%	86.2%
MARA	Prior Cost	24.8%	91.8%	87.9%
DxCG	Prior Cost	23.8%	98.9%	88.1%
Truven	Diagnosis Only	20.7%	96.4%	87.7%
MARA	Diagnosis Only	20.1%	91.8%	87.9%
Impact Pro	Diagnosis Only	18.9%	98.2%	87.1%
DxCG	Diagnosis Only	18.6%	91.2%	87.4%
John Hopkins ACG System	Prior Cost	17.8%	97.6%	87.1%
Wakely	Diagnosis Only	17.0%	97.1%	86.4%
John Hopkins ACG System	Diagnosis Only	16.2%	96.7%	86.3%
SCIO	Prior Cost	15.1%	95.8%	84.2%
CMS-HCC with Central MN ACO	Diagnosis Only	11.7%		
CDPS	Diagnosis Only	9.1%	109%	83.8%
Count of CMS-HCCs	Diagnosis Only	8.0% to 8.5%		
ACG with CCH IHP Population	Diagnosis Only	5.9%		
Epic General Risk Score	Diagnosis Only	3.6% to 6.3%		
CMS-HCC with Central MN ACO	Diagnosis Only	4.8%		

Appendix B: ROC Curve



Diagonal segments are produced by ties.