ASSOCIATION RULES IN HEART FAILURE READMISSION RATES AND PATIENT EXPERIENCE SCORES

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Abstract

Objective: Thirty-day readmission rates are closely monitored in today's healthcare ecosystem to prevent higher-than-average rates in inpatient settings. Excess readmission rates result in decreased reimbursement for healthcare facilities. Additionally, feedback from patients about their hospital experience may indicate areas of improvement for healthcare facilities. This feedback is a national survey that collects data on patient experience through a standardized survey called Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS). The objective of this study is to identify significant patterns between readmission rates and HCAHPS survey data through the application of association rules.

Materials and Methods: Publically accessible HCAHPS survey data and 30-day readmission rates provided by the Centers for Medicare and Medicaid Services (CMS) were utilized for this study. Through the implementation of association rules using SAS Enterprise Miner, significant rules were identified in the data.

Results: Association rules were developed in SAS Enterprise Miner and produced three significant rules associated with high heart failure (HF) readmission as the right-hand rule. The rules indicated that a high pneumonia readmission, a low cleanliness star rating, and a low medication communication star rating were associated with a high readmission rate for heart failure.

Conclusions: The rules provided strong associations between HCAHPS star ratings and determining a high readmission rate for HF. It was interesting to find that pneumonia readmissions exist as well with a high HF readmission. Hospitals should work on improving their star ratings for the HCAHPS domains identified and work on lowering pneumonia readmissions to lower their HF readmissions.

Keywords: hcahps, readmission rate, heart failure, association rules, patient satisfaction

Background and Significance

Hospital Readmission Rates

Coding professionals and health information professionals play a huge role in assuring the appropriate documentation and applying accurate diagnosis codes to properly identify any hospital readmissions. A particular quality of care indicator are 30-day readmission rates. When patients return to a hospital for the same condition within 30 days of their discharge, this brings into question a possible case of inadequate care. With the average length of stay scrutinized in the current healthcare ecosystem, the faster hospitals get the patients out, the less a hospital incurs in costs for providing care to the patient. However, hospitals must still maintain their quality of care while implementing ways to reduce costs. This important indicator is not only monitored internally, but by a major external organization.

The program, designed by the Centers for Medicare and Medicaid Services (CMS) to begin monitoring these high readmission cases, meant hospitals would begin to see a reduction in their reimbursement when readmission volumes are higher than the national average. Identified in the program are six diagnoses that CMS has deemed crucial enough to monitor. The Affordable Care Act initialized monitoring and controlling of healthcare spending toward excessive readmissions on October 1, 2012. The Hospital Readmissions Reduction Program (HRRP) is a Medicare value-based purchasing program that reduces payments to hospitals with excess readmissions.[1] According to CMS, acute myocardial infarction, chronic obstructive pulmonary disease, heart failure (HF), pneumonia, coronary artery bypass graft surgery, and elective primary total hip arthroplasty and/or total knee arthroplasty are the conditions and procedures currently monitored by the program for excess readmissions.[2] These conditions are recognized by CMS to have excess readmissions in the acute, inpatient settings. One of these conditions are identified below as impacting Americans and the readmission to hospitals.

Heart Failure (HF)

This study will specifically look at heart failure readmissions. The focus on heart failure is due to its widespread prevalence in American hospitalizations. Chronic heart failure (CHF) affects over 5 million Americans and accounts for over 1 million hospitalizations annually.[3] In order to predict the risk associated with heart failure readmission, the Readmission After Heart Failure (RAHF) scale was developed.[4]

Subsequently, CHF is the most common indication for admission to the hospital among older adults.[5] The older adult population indicated in the study is the population primarily funded through Medicare. Behavioral factors, such as poor compliance with treatment, frequently contribute to exacerbations of heart failure, a fact suggesting that many admissions could be prevented.[6]

In a study conducted by the Veterans Health Administration, results indicated that two hospitals (2 percent) had a CHF risk-stratified readmission rate (RSRR) worse than the national average, whereas no hospital demonstrated worse-than-average RSRR for AMI or pneumonia.[7] Additionally, the study attempts to combine three years of data indicating hospitals had RSRRs worse than the national average for all three conditions.[8] Another study found that of patients with HF, about 23 percent of them were readmitted or died within 30 days of hospital discharge.[9]

The studies introduced above from the literature review indicate a presence of readmission rate studies due to the impactful nature of HRRP on reimbursement. However, many of these studies were conducted without the use of the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) data for patient feedback on their hospital experience. This allows for further

research into the predictive power of HCAHPS scores on readmission rates for CHF.

As a government payer, Medicare seeks to reduce payment for subpar care. Readmission rates above the average for the nation are penalized.[10] Hospitals will continue to lose money if readmission rates are not lowered. Hospitals in this situation try to implement changes and improve processes to get readmission rates below the national average. To see a reduction, the right change must be implemented.

HCAHPS Surveys

HCAHPS provides scores for domains related to the patient's experience during their stay. HCAHPS are patient-completed surveys that are provided to the patient once they have been discharged. According to CMS, the HCAHPS survey asks discharged patients 27 questions about their recent hospital stay. The survey contains 18 core questions about critical aspects of a patient's hospital experience (e.g., communication with nurses and doctors, the responsiveness of hospital staff, the cleanliness and quietness of the hospital environment, pain management, communication about medicines, discharge information, overall rating of hospital, and would they recommend the hospital).[11]

The HCAHPS scores are a way to gather valuable feedback from the patients on the quality of their hospital stay. This data could assist the healthcare facility in further determining areas of improvement or to boast areas of excellence. As indicated, the survey measures multiple areas, addressing communication, cleanliness, and many more. The HCAHPS survey addresses 10 of these domains in total.

For each domain question, a patient has the option to select an answer from varying degrees. For most of the questions, the available responses are on a scale of "Always," "Usually," or "Sometimes/Never." For the question on whether the patient would recommend the hospital, only responses of "Yes" or "No" are provided. Other domains include binary responses, as well, such as "Agree" or "Disagree."

The survey results are analyzed by the Agency for Healthcare Research and Quality (AHRQ) and provide an overall star rating for the hospital and each domain. This normalizes the varying samples of the hospitals and provides every hospital a 1-5-star rating for each of the 10 domains. The healthcare consumers, healthcare providers, and third-party payers can better understand a star rating when comparing healthcare providers.

HCAHPS scores can provide insight into the quality performance of the hospital. Using star ratings, a hospital could have low star ratings on the quietness or cleanliness domain, which may influence a healthcare consumer's decision to choose that site for a procedure. Other domains identify the healthcare provider's level of engagement with their patients. The star ratings in the domains of nurse communication or communication about medications may indicate high or low engagement

between clinicians and their patients. Overall, star rating and recommendation domains may indicate whether a patient will return to that facility for future procedures or decide to acquire their healthcare needs elsewhere.

Both HCAHPS and readmission rates are publicly available datasets published by CMS, and several studies are utilizing both datasets. The previous studies indicate heart failure readmission rates as an area of study and interest in the healthcare domain. One group attempted to find a link between the HCAHPS responses and readmission rate, and conducted a retrospective analysis using 10 years of HCAHPS and readmissions data. Results indicate that patients who responded after readmission were significantly more dissatisfied with physicians, staff responsiveness, pain control, discharge plan, noise, and cleanliness of the hospital.[12]

Another study, explicitly focused on total hip arthroplasty readmissions and HCAHPS data, reports 30-day readmissions were associated with a significantly lower likelihood of rating the hospital a 9 or 10 out of 10.[13]

A retrospective, cross-sectional study examined the relationship between communication and discharge HCAHPS questions and readmissions at 30 days, specifically at the patient level. In conclusion of their study, six of the eight items analyzed were found to be significantly associated with 30-day readmission, and two of the HCAHPS questions (relating to "help after discharge" and "receiving written information after discharge") had higher top box responses for readmitted patients than non-readmitted patients.[14]

Association Rules

Association rules analyze items or attributes in transactional datasets that are commonly found together. In market basket analysis, association rules can identify which items are frequently purchased together. This data-mining approach can support decision-making to optimize item purchases in a market setting. An example of such an association rule is the statement that 90 percent of transactions that purchase bread and butter also purchase milk. The antecedent of this rule consists of bread and butter, and the consequent consists of milk alone. The number 90 percent is the confidence factor of the rule.[15]

One study sought to use association rules in finding interesting patterns in hospital infection control and public health surveillance data.[16] Association rules utilizing the HCAHPS data and readmission data would identify interesting patterns among the different HCAHPS domain star ratings and readmission rates for hospitals. Each transaction in this dataset is a healthcare provider. In pursuit of finding meaningful and accurate association rules, the study excludes the other conditions and procedures indicated by CMS in the right-hand rule. The target right-hand rule, or consequent, for this study will be a high or low readmission rate for CHF. Left-hand rules, or the antecedent, will

include domain star ratings for the facility from the HCAHPS data, as well as all types of readmissions found in the 30-day readmission dataset. The solution will be built using SAS Enterprise Miner (SAS EM) to develop these association rules.

Materials and Methods

Data Extraction and Collection

HCAHPS data was downloaded from the CMS website for the latest year available. The Readmission rates for hospitals were also downloaded from the same source. The data collection period for the HCAHPS data set was 2017-2018, and the readmission rates dataset had a collection period of 2014-2017, as well. The datasets were available in CSV format and imported into Excel for data preparation and cleanup.

Data Preparation

Since both datasets came from CMS, all records came with an identifier assigned by CMS. This made the process of merging the datasets seamless. The HCAHPS dataset included the following hospital attributes: HCAHPS Measure ID, Provider ID, Hospital Name, Address, City, State, ZIP Code, County Name, Phone Number, HCAHPS Question, HCAHPS Answer Description, Patient Survey Star rating, Patient Survey Star Rating Footnote, HCAHPS Answer Percent, HCAHPS Answer Percent Footnote, HCAHPS Linear Mean Value, Number of Completed Surveys, Number of Completed Surveys Footnote, Survey Response Rate Percent, Survey Response Rate Percent Footnote, Measure Start Date, Measure End Date, and Location.

Attributes from the HCAHPS dataset were removed except for Provider ID, HCAHPS Question, and Patient Survey Star Rating. Additionally, the only rows retained from the dataset were the rows pertaining to the HCAHPS Question that measured “Star Rating” of the domain. After filtering out the other questions, there were 10 rows remaining for each unique Provider ID. The Star Rating for that row was in the Patient Survey Star Rating column. The 5-star rating was further categorized as “high” or “low” to represent a 4- or 5-star rating, or a 1- to 3-star rating, respectively. This created a new derived attribute to represent the star ratings such that Patient Survey Star Rating was no longer required for the dataset.

Utilizing association rules for this study requires all the data to be represented in two columns. The first column indicates the Provider ID, later to be recognized in SAS EM as the ID. The second column will be each unique attribute related to the provider. After preparing the HCAHPS dataset, three columns were retained, one column containing our derived attribute. To utilize this dataset in SAS EM, HCAHPS Question and our derived attribute needed to be concatenated in Excel. While retaining the original data values in the two attributes, a new derived attribute was created. An example of this new attribute is, “Low Discharge Information - Star Rating,” which represents a provider’s star rating for Discharge Information domain between 1 and 3.

A similar process was followed for the Readmission Rate dataset. The dataset began with the following attributes for the Readmission Rate dataset: Hospital Name, Provider ID, State, Measure Name, Number of Discharges, Footnote, Excess Readmission Ratio, Predicted Readmission Rate, Expected Readmission Rate, Number of Readmissions, Start Date, and End Date.

After reviewing the attributes, the only attributes retained were Provider ID, Measure Name, and Excess Readmission Ratio. For the determination of a "high" readmission rate and a "low" readmission rate, the excess readmission ratio was categorized to low or high. Since the ratio represented a comparison of the provider's rate to the national rate, anything above a 1 would be interpreted as a higher-than-average readmission rate. A provider with a number less than 1 would have a lower-than-average readmission rate. A formula was created in Excel to translate values in excess readmission ratio greater than 1 to be high and all else translated to low. This became our new Readmission Rate, and Excess Readmission Ratio was removed from the dataset. Additionally, to create one field from the two (Measure Name and Excess Readmission Ratio), another attribute was created to concatenate the value in each column. An example of this derived field is High READM_30_HF_HRRP, representing a greater-than-average readmission rate than the national rate for heart failure.

When both datasets had been separately cleaned, they were merged into one CSV file. Each Provider ID would include several rows of attributes, including each Domain Star Rating and the Readmission Rate category. The data was now prepared for the SAS EM environment and was imported into the application.

Data Analysis

The File Import node was placed into the workspace. This allowed the file to be imported. The variables of the dataset need to be assigned roles. The Provider ID field was given the role ID, and the attributes column was assigned the Target role. Additionally, the parameters need to be adjusted in the File Import node to indicate transactional data. The Association node was placed on the workspace and ran.

Post-Pruning

With the initial output of rules resulting from the analysis, the right-hand rule of "High READM_30_HF_HRRP" needed to be retained and the rest of the rules filtered out. Once the other rules were removed, to find strong rules from those that remain, the parameters to prune the rules were adjusted. Confidence was set to 60 percent or higher, Support was set to 20 percent or higher, and Lift was set to >1. Three rules remained after post-pruning. Additionally, it was important to identify the statistical significance of each rule. To find out if any of the remaining association rules were significant, the first step was to find the reliability of the rule that was calculated by finding the difference between expected confidence and confidence.

To measure the statistical significance of the rule, a t-test was performed to evaluate the

significance of the difference in expected confidence and confidence, represented as reliability. The three remaining rules after post-pruning were identified as significant according to our t-test statistic. The following association rules remained after post-pruning was completed:

Rule 1Low Cleanliness - Star Rating & High READM_30_PN_HRRP ==> High READM_30_HF_HRRP
Rule 2High READM_30_PN_HRRP ==> High READM_30_HF_HRRP
Rule 3Low Communication About Medicines - Star Rating & High READM_30_PN_HRRP ==> High READM_30_HF_HRRP

Results

As a result of the data-mining process and using association rules, three interesting rules were produced with a high readmission for heart failure as the right-hand rule. Two of the rules were three-item rules, and one of the rules a two-item rule. All three rules contained high readmission for pneumonia in the left-hand rule. The three rules are explained below.

Rule 1 indicates that if there was a low cleanliness star rating and a higher than the national average readmission rate for pneumonia, it is associated with a high readmission rate for heart failure. A low cleanliness rating indicates that the cleanliness domain was scored below a 4-star rating. This domain primarily covers the aspects of care related to how clean a patient felt the room was during their stay. In the study by Siddiqui, et al. (2018) above, they found that patients who were readmitted were dissatisfied with cleanliness, among other domains.

Rule 3 suggests that if a hospital has a low star rating for communication about medicines and a high readmission for pneumonia cases, then a high readmission rate for heart failure followed. Patients who have come into the hospital with heart failure tend to go home with some type of medication. The common ones are ACE inhibitors, beta-blockers, digoxin, and diuretics. When low communication star ratings are assigned, patients are indicating that they were either not shown how to take their medications or feel there was enough explanation about their medications. When a patient does not follow medication instructions regularly, it may lead to poor management of their heart failure condition at home. This can lead to a readmission to the hospital because the patient may have not been following their prescribed medication regiment appropriately. This low rating, along with a high pneumonia readmission, also associates with a high HF readmission.

Rule 2 is explained, as it exists in Rule 1 and 3. The rule states that if the hospital has a high pneumonia readmission, then a high heart failure readmission is associated. Since heart failure and pneumonia are part of the cardiopulmonary system, when a hospital poorly manages the care of pneumonia cases, it is possible that it associates with poorly managed HF cases as well.

Discussion

A major strength of this solution is that the association rules data-mining technique has not been applied to the readmission dataset and the HCAHPS dataset in previous literature. Other attempts at using association rules were applied to different datasets, but not the two used in this study.

Association rules can provide insight to the probability of a HCAHPS domain associating with a high readmission for heart failure, but the study also found that there were association rules between the high readmission types being monitored by CMS. It was identified that cleanliness, high readmission for pneumonia, and communication about medications reveal an association to high heart failure readmissions.

A limitation of the proposed solution is the varying response rates from the HCAHPS data. Since the dataset comes from patient responses, it may be difficult to get a response from every patient that comes in. A second limitation is the age range of the individuals captured from the surveys. As Medicare beneficiaries are typically aged 65 or older, there is not a full representation of the entire healthcare population. This means that results from these association rules may only apply to a certain age demographic covered by Medicare and Medicaid programs.

Conclusion

In this study, the data-mining technique of association rules was implemented to explore any patterns between HCAHPS domains and readmission types. Since the diagnosis of heart failure is a major condition that affects millions of Americans each year, and frequently brings patients to the hospitals, the readmission rates for this specific condition were the focus. The Excess Readmission Ratio and the HCAHPS Domain Star Rating were used to find any association with a high readmission of heart failure.

The analysis produced three significant rules from the combined datasets. High heart failure readmission was the determining right-hand rule for the association rules that remained after pruning. In the left-hand rules, we identified high pneumonia readmission, a low cleanliness star rating, and low star rating for medication communication. The results from this analysis would indicate that if a healthcare provider has a high readmission rate (i.e., greater than the national average) for heart failure, they might also have high readmission rates for pneumonia cases. Furthermore, it was identified that low star ratings in the HCAHPS domains of the hospital's cleanliness and communication about medications were strongly associated with high heart failure readmissions. If a healthcare provider wants to improve their high heart failure readmissions, these two areas may be considered to focus improvement efforts.

In future work, this analysis could be expanded to focus on finding other patterns among the other excess readmission types monitored by CMS. Other data-mining techniques could also identify relationships among the domain star ratings themselves or find connections to other areas like hip replacements or acute myocardial infarctions, which are other conditions that frequently bring patients to seek care.

Author Biography

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Notes

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