OUTCOMES & INSIGHTS
Vol. 3; Issue 1 January 2012
In Health Management

Predictive Modeling: The Application of a Customer-Specific Avoidable Cost Model in a Commercial Population

Adam Hobgood, MS, Karen Hamlet, MA, Chastity Bradley, PhD, Elizabeth Y. Rula, PhD, Carter Coberley, PhD, James E. Pope, MD

ABSTRACT

Although the rate of increase in health care expenditures continues to be a major challenge for the United States, a significant portion of this burden could be avoided or at least limited with timely interventions. In an effort to improve quality of life and limit unnecessary medical expenses, a total population health (TPH) approach is becoming increasingly popular among health care service providers. Unlike traditional, disease-specific approaches, TPH is a holistic approach that monitors the entire population (both diseased and non-diseased members) to deliver impactful, personalized interventions to members in greatest need. To better identify members with emerging health risks, Healthways Center for Health Research developed an avoidable cost predictive model that specifically identifies the high-risk segment of the population likely to have near-term, costly yet avoidable inpatient events. This allows prioritization of these patients for personalized programs aimed at mitigating or managing their risk.

The custom-built model was constructed using neural networks based on historical member claims data from a specific customer. A comparative analysis was conducted to assess model performance within the realm of total avoidable inpatient costs. In the comparative assessment, a superior capture rate of avoidable inpatient costs was observed with the avoidable cost model compared with other models. Compared with a model developed to predict high-cost members in a diseased population, the avoidable cost model captured an additional $15 million dollars in total avoidable inpatient costs. Optimal model performance was attributed both to customization of the model specific to the study population of interest and to the target variable of avoidable inpatient costs. Overall, these results demonstrate the success of the newly-developed avoidable cost model in identifying members for cost-effective interventions aimed at identifying and mitigating the factors likely to lead to a hospital admission.

BACKGROUND

Health care spending in the United States is projected to grow at an annual average rate of 5.8% from 2010 through 2020, at a rate that is 1.1% faster than the expected growth in gross domestic product.[1] By 2020, health care spending is estimated to reach $4.64 trillion dollars.[1] New, creative approaches are needed to identify and impact a larger population and effectively mitigate rising health care costs.

Given these national trends, only a small proportion of the total population accounts for the majority of health care costs.[2] A recent Healthways analysis further substantiated this claim by demonstrating the dynamic nature of a continuously enrolled health care population over a 3-year time period (Figure 1). In this analysis, members (n=146,210) were categorized as high- (≥$3,335 PMPY costs), medium- ($667–$3,335 PMPY), or low-cost ($0–$667 PMPY). Transitions of members into higher- or lower-cost groups in each year were captured. For example, in Year 1 approximately 20% of the total population was classified as high-cost. At the end of Year 3, an estimated 11% of the initial high-cost population remained high-cost while the remaining 9% of members transitioned into a lower-cost category. A similar fluctuation in members within the medium- and low-cost groups was also shown, with a percentage of those members shifting into the high-cost category in Years 2 and 3. These cost transitions indicate that the total health care cost in a given year is not a sufficient predictor of cost in subsequent years.

The rate of health care spending, in combination with the evidence that shows many high-cost individuals often do not remain high cost over time, demonstrates an opportunity for claims-based predictive models (PM) to identify individuals

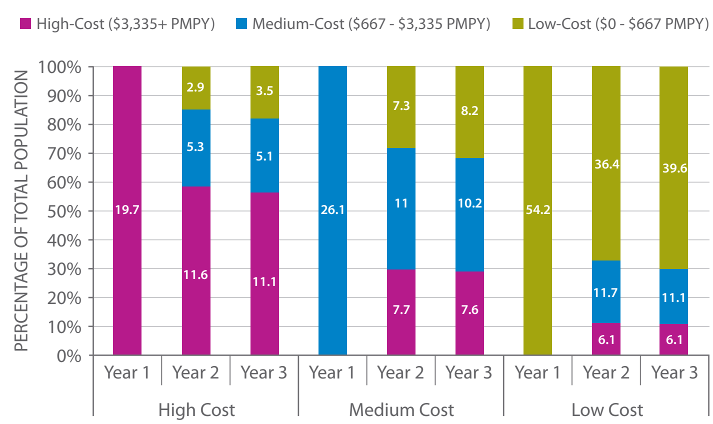

Figure 1. Dynamics of health care population over a 3-year period. The analysis is based on a total population comprised of continuously enrolled members (N=146,210) over 3 years. In-bar percentages of the total population represent the percentage of low-, medium-, or high-cost individuals in Year 1. Years 2 and 3 in-bar percentages represent the percentage of Year 1 population that is either low-, medium-, or high-cost. Total health care costs in Year 1=$446 million, Year 2=$634.9 million, and Year 3=$663.5 million.

Direct correspondence to: Center For Health Research
Healthways, Inc.
701 Cool Springs Blvd.
Franklin, TN 37067 USA
research@healthways.com

who will remain in the same cost category or transition between cost categories. While this objective is still a work in progress in the field, it is clear that the distinction of these members is likely to increase optimization of resource allocation and care management such that members can be prioritized for appropriate personalized health and lifestyle interventions with the expectation of achieving better outcomes and reducing medical costs.

The purpose of the current research is to provide an overview of Healthways' approach to predictive modeling and its applications in delivering impactful and cost-effective interventions to the segment of the population at highest risk for an inpatient event that may be avoidable. The newly-developed avoidable cost model will be introduced and model performance results, in comparison with a traditional high-cost model, will be reported. The traditional high-cost model was designed as a tool to predict chronically-diseased members who may incur high-cost events; all costs were targeted, with no differentiation between avoidable and unavoidable costs. Additionally, a significant limitation of this approach is that it is applied only to patients with a qualifying diagnosis identified in claims data, as is typically the case with traditional disease management. In contrast, the avoidable cost model is applied to an entire population with the aim of identifying the segment of the population with avoidable high-cost future events for the appropriate customized program aimed to prevent those events. Therefore, the avoidable cost model offers a broader range of opportunity to identify all members (diseased and non-diseased) with potentially avoidable events who otherwise may not have been identified with standard disease management (DM) approaches.

PREDICTIVE MODELING: PAST TO PRESENT

Traditional PM approaches have focused on identifying and understanding the correlates of poor health and risk of hospital admissions in diseased study populations in order to develop large-scale models that help guide efficient allocation of health care resources. A number of historical models (e.g. risk assessment, age/sex demographic, pharmacy-based) have been designed and used in DM to identify members in greatest need of these programs. However, most of these models are limited by algorithms that trigger members for interventions based the number and type of disease-specific claims within any given time period.[3] In addition, these models often rely on cost triggers to identify individuals who exceed certain cost thresholds.[2,4] Although disease-specific algorithms and cost triggers can be informative, they do not offer a holistic, comprehensive approach to predict future risk of an individual. Furthermore, disease alone is not a reliable indicator of current or future health care costs as the level of risk and self-management is highly variable across most diseases.[5] For example, a member categorized as low cost is not necessarily low risk for a disease/condition, but may be a "ticking time bomb" as a result of not maintaining their health.[2]

Today, the application of PM has broadened beyond DM towards a proactive care management or total population approach that can accurately predict future health risks among all members. This is particularly important since predictive modeling restricted to specific disease conditions could lead to missed opportunities within a large segment of the population resulting in the suboptimal allocation of intervention resources, further limiting the opportunity to achieve optimal cost savings. On the other hand, a total population approach that includes all individuals, even those who have not been diagnosed or have not triggered for a disease program, further optimizes the opportunity to influence overall health care savings.[6]

AVOIDABLE COST MODEL

Why develop avoidable cost models? The goal of avoidable cost models is to identify individual members predicted to have high-cost, inpatient events that are avoidable or likely to be impacted by personalized program interventions. These events are not limited to individuals with chronic conditions.

To illustrate an avoidable inpatient event, consider an actual high-risk member's profile as described below. For the purposes of this paper, we will refer to this high-risk member as Kathy. In Year 1, Kathy's medical and pharmacy claims indicated that she had hypertension, high cholesterol, osteoarthrosis, and atrial fibrillation. Although her claims offered insight to her current health issues, according to algorithms that identify members for the core DM programs she did not qualify for one of these specific disease programs (diabetes, coronary artery disease, coronary heart failure, chronic obstructive pulmonary disease, asthma) and, therefore, received no interventions. During Year 2, Kathy continued to experience atrial fibrillation and eventually had an inpatient stay related to atrial flutter resulting in approximately $12,000 of inpatient costs. Based on Kathy's medical and pharmacy claims information from Year 1, the avoidable cost model leveraged in total population health (TPH) is likely to have identified Kathy as a high-risk, non-diseased member with avoidable inpatient events that could be impacted by personalized interventions.

Early identification of Kathy using this new modeling approach may have helped avoid the medical costs incurred from hospitalization in Year 2 further demonstrating the ability of this model to assist in driving savings previously unattainable in traditional DM.

AVOIDABLE COST MODEL TESTING AND VALIDATION

The process of testing, validating, and evaluating PM has been extensively discussed in earlier publications.[5, 7, 8] A number of methodology tools, such as neural networks, logistic regression models, and decision trees are often used in combination to develop a new PM. Briefly, the steps in the process used herein include:

- Extract approximately 180 total population factors broadly classified into demographic, pharmaceutical, utilization, diagnosis, medical procedure, and financial categories (e.g. total costs, physician costs, inpatient admits, counts of various procedures or diagnoses, pharmaceutical usage, intra-year changes in cost/utilization metrics) from Year 1 and outcomes from Year 2.
- Identify target variable of interest, e.g. the model's target in this paper is avoidable inpatient costs.
- Divide the study population, comprised of continuously enrolled members with at least 2 years of claims data, into training and validation groups.
- Determine the factors that are most consistently predictive of the target of interest via multiple samples of data and multiple statistical techniques.

- Train and develop several neural network models that predict Year 2 outcomes based on Year 1 total population factors.
- Determine the champion model by evaluating the newly developed neural net models with respect to accuracy in predicting Year 2 outcomes from Year 1 data using the validation data set to ensure that the model optimally fits the data.

AVOIDABLE COST MODEL PERFORMANCE RESULTS

The total population, avoidable cost model was developed and evaluated using the process outlined above. Results from performance analyses assessing its accuracy in identifying members with avoidable inpatient costs are shown in Figure 2. Each series, or color-coded curve, on the graph represents the percentage of avoidable inpatient costs captured by different PMs run using data from the same commercial population (N=312,183 members) as well as by random selection of the same proportion of the population.

The model developed here, a custom avoidable cost model, was compared with a high-cost model that did not discriminate between avoidable and unavoidable costs, along with two avoidable cost models (Plan A and Plan B) previously built for different populations to illustrate the difference between custom-built and non-specific (i.e. different customer population) models. As shown in the figure, model performance varies among the different models. Using a cut-point of individuals with the top 3% PM scores, the high-cost model (green curve) captured only 20% of all avoidable inpatient costs compared with a 38% cost capture rate with the customized, avoidable cost model (blue curve). Non-specific avoidable cost models (orange and red curves) also demonstrated inferior performance in relation to the customized, avoidable cost model. The model performance of Plan A and Plan B avoidable cost models were shown to confirm that optimal inpatient cost capture can often only be achieved when the model is customized to a customer's unique member population, not by applying a model built for a different population. This feature of model customization is particularly important to reflect variations in demographics, practice patterns, and coding practices often observed within different regions. Overall, higher cost capture rates of avoidable inpatient costs observed with the customized, avoidable cost model can be attributed to two key features of the model: customization of the model specific to both this study population and the target variable of total population health (avoidable inpatient costs).

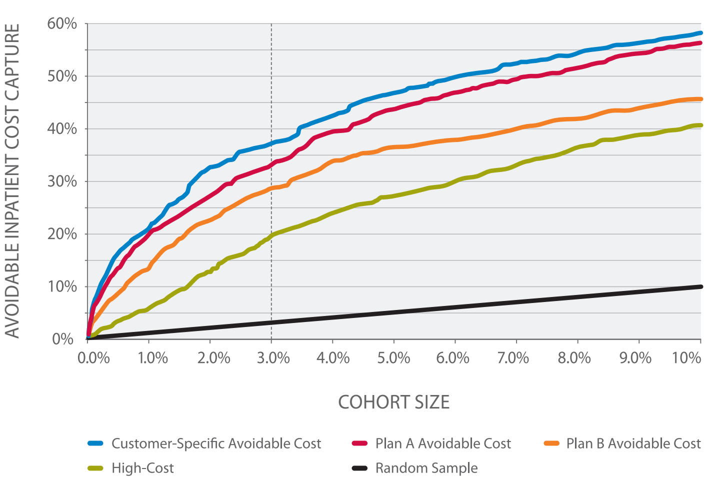

Figure 2. Performance of customized, avoidable cost predictive model (N=312,183 commercial population). Four models (customer-specific avoidable cost, high-cost, Plan A avoidable cost, Plan B avoidable cost) are assessed for model performance in terms of the percentage of avoidable inpatient cost capture. The percentage of avoidable inpatient cost captured by chance is also shown in the random sample curve.

Superior model performance of the avoidable cost model correlated with an improved opportunity to capture higher inpatient costs (Figure 3). Compared with the high-cost model, nearly double the total avoidable inpatient costs, or an additional $15 million dollars, are captured using the avoidable cost model. Together, these data offer supportive evidence of the model performance as well as the associated inpatient costs that may be avoided using the avoidable cost model, suggesting an improved cost savings opportunity.

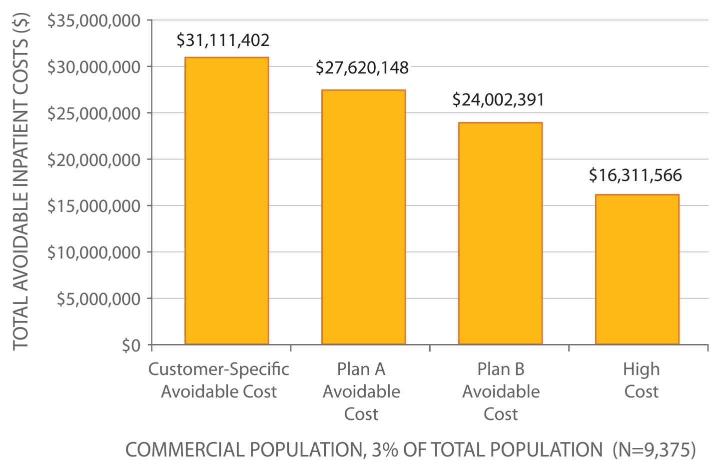

Figure 3. Total avoidable inpatient costs capture. The total avoidable inpatient costs ($) are shown for four models (customer-specific avoidable cost, high-cost, Plan A avoidable cost, Plan B avoidable cost) assuming a 3% screening threshold.

DISCUSSION

Timely identification of members who are predicted to have avoidable high-cost inpatient events offers a valuable opportunity to deliver more intensive support to members with whom there is the greatest opportunity to have an impact, with different levels/types of support for the remainder of the population, allowing for cost-effective total population interventions. The evidence reported here demonstrates the effectiveness of avoidable cost models in capturing avoidable inpatient costs from a total population and offers insight on the new direction of PM applications as a means to mitigate increasing health care costs.

Predictive modeling is considered one of the most effective ways to accurately identify people with whom to intervene;[4, 9-11] however, the approach can vary widely. The unique approach of Healthways avoidable cost models is different than the standard, disease-specific models that are frequently used to predict future health risks. In terms of avoidable cost model development, Healthways ensures accuracy of its custom-built PM by accessing historical member data specific to that customer to ensure that the final model represents that population. The advantage of a custom-built model is that it enhances the development process by optimizing the model for a specific customer's unique population.

Predictive Modeling: The Application of a Customer-Specific Avoidable Cost Model in a Commercial Population

In this report, the significance of model customization was demonstrated by the suboptimal performance of non-specific avoidable cost models Plan A and Plan B.

The disease-independent feature of avoidable cost models is another important feature as it allows for a more comprehensive prediction of total population members, accounting for all previous high-cost claims in diseased and non-diseased members to predict the occurrence of future avoidable events. Early intervention with these members improves prioritization of care and helps guide individualized intervention plans. Healthways is committed to delivering impactful, total population interventions, rather than targeting specific diseased populations; therefore, PM tools that adequately support this new, solutions-driven approach are required. As a result, the avoidable cost model was developed to bridge the gap between the conception of the TPH approach and reality.

Evaluation of the newly-developed, customized avoidable cost model performance in relation to the other models demonstrated superior performance with respect to opportunity capture. Although the variable of interest (avoidable inpatient costs) is a small target relative to the entire high-cost population, especially within a total versus diseased population, the opportunity to impact more individuals in greatest need, validates it as a credible target, and results indicate that accuracy can be achieved despite the greater challenge imposed by these goals.

As in any PM case scenario, the larger the percentage of the population targeted, the greater the likelihood of nonspecific identification (i.e. false positives) of the target variable (i.e. avoidable inpatient costs) ultimately resulting in suboptimal rates of avoidable costs captured. Likewise, a screening threshold that is too low will decrease model sensitivity and marginalize the potential impact of the intervention. Therefore, the screening threshold should ultimately be based on the customer's opportunity analysis and business considerations to generate an accurate prediction of future avoidable inpatient costs. In our example, a 3% screening threshold was used in the analysis; however, this can vary depending on the customer's unique population, resources, goals, etc. Lower screening thresholds may be sufficient when screening a typical population; however, higher thresholds may be necessary to screen a population with higher morbidity as demonstrated in a recent study where 5.36–11.01 was reported for optimal cut points when high-costs were being predicted in a diseased population.[12]

While we are confident that avoidable cost models are capable of identifying members who otherwise may not have been targeted for disease-specific interventions, the success of accurate avoidable cost model predictions is limited by the availability of multiple data sources. In the current study, medical and pharmacy claims were the primary source of data to predict future avoidable inpatient events. Members without any previous high-cost claims, but who are at-risk for future avoidable events based on current unhealthy habits, may not be identified using this avoidable cost model. Currently, a model is under development that uses well-being factors from Well-Being Assessment (WBA) data to predict inpatient costs. Utilization of both member claims and WBA data will offer a more comprehensive approach, based on medical history, behavioral risk, and physical, emotional, and social well-being, to enhance the member program selection process.

In conclusion, customized avoidable cost models allow for the optimized delivery of cost-effective interventions to members with the highest likelihood of avoidable inpatient costs across the total population, not just among diseased members. This unique approach is likely to increase the efficacy of program interventions and further enhance overall return-on-investment.

REFERENCES

1. Fleming C. U.S. Health Spending Projected To Grow 5.8 Percent Annually. Available at: http://healthaffairs.org/blog/2011/07/28/u-s-health-spending-projected-to-grow-5-8-percent-annually/. Accessed August 8, 2011.
2. Masud M, Guszcza J. Bridging the Data Gap: Leveraging Electronic Medical Record and Consumer Business Data to Improve Predictive Segmentation in Healthcare; 2006.
3. Hollenbeak CS, Chirumbole M, Novinger B, Sidorov J, Din FM. Predictive Models for Diabetes Patients in Medicaid. Popul Health Manag. Apr 19 2011.
4. Cousins M, Shickle L, Bander J. An introduction to predictive modeling for disease management stratification. Dis Manag. 2002;5:157-167.
5. Rula E, Hobgood A, Hamlet K, Zeng H, Montijo M. Maximizing care management savings through advanced total population targeting. Outcomes & Insights in Health Management. 2009;1(2):1-5.
6. Rust G, Strothers H, Miller WJ, McLaren S, Moore B, Sambamoorthi U. Economic Impact of a Medicaid Population Health Management Program. Popul Health Manag. Apr 20 2011.
7. Kudyba S, Hamar G, Gandy W. Enhancing efficiency in the health care industry. Communications of the ACM. 2005;48:107-110.
8. Kudyba S, Hamar G, Gandy W. Utilising neural network applications to enhance efficiency in the healthcare industry: predicting populations of future chronic illness. INt J Business Intelligence and Data Mining. 2006;1:371-383.
9. Baan CA, Ruige JB, Stolk RP, et al. Performance of a predictive model to identify undiagnosed diabetes in a health care setting. Diabetes Care. Feb 1999;22(2):213-219.
10. Sylvia ML, Shadmi E, Hsiao CJ, Boyd CM, Schuster AB, Boult C. Clinical features of high-risk older persons identified by predictive modeling. Dis Manag. Feb 2006;9(1):56-62.
11. Weir S, Aweh G, Clark RE. Case selection for a Medicaid chronic care management program. Health Care Financ Rev. Fall 2008;30(1):61-74.
12. Murphy SM, Castro HK, Sylvia M. Predictive modeling in practice: improving the participant identification process for care management programs using condition-specific cut points. Popul Health Manag. Aug 2011;14(4):205-210.