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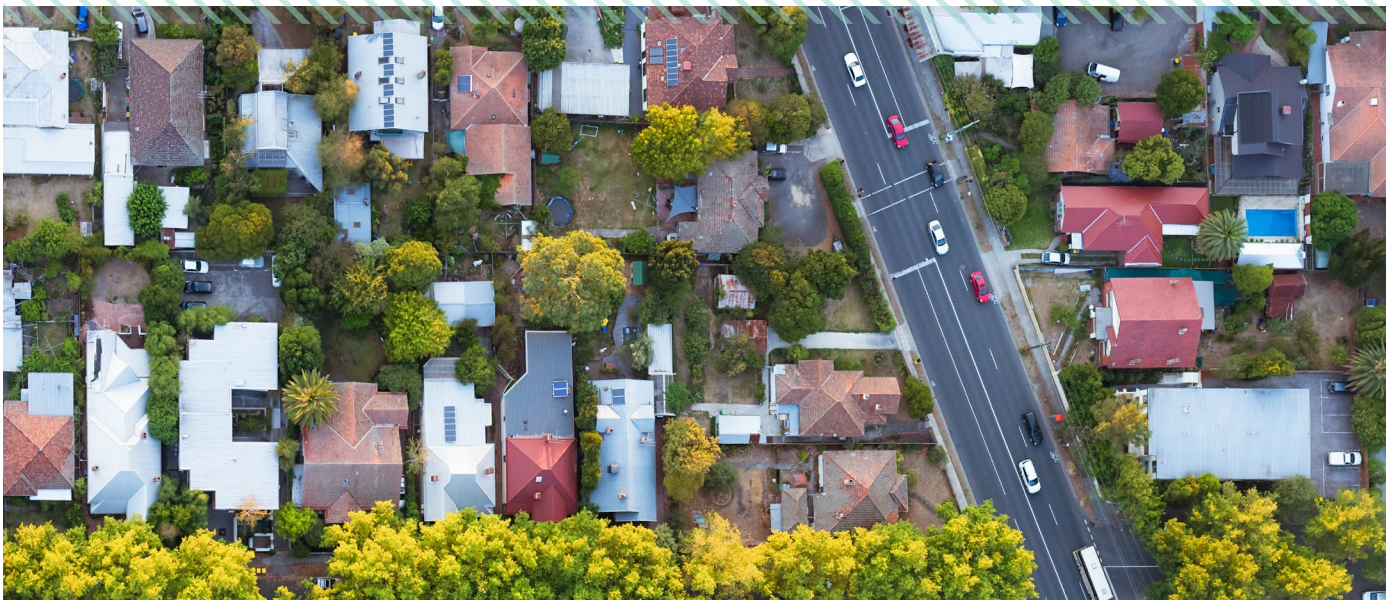

Predictive Models for Hospitals

Promoting and encouraging strategies for prevention and quality, safety, and care coordination

As the healthcare landscape continues to change, hospitals can harness consumer data and modern analytics to develop sound strategies. Use predictive models to maximize your market share, manage costs, strengthen physician relationships, and improve patient care.

Predictive Models for Hospitals

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Healthcare has undergone a radical transformation. Reimbursements continue to shift from volume to value. Increasingly, single hospitals have been absorbed into larger systems. Physicians now opt for employment over private practice. And consumers, who had few healthcare choices in the past, are making informed decisions and driving their own care.

How can hospitals benefit from these fundamental changes? Healthcare predictive models are one solution. When designed and implemented using best practices, these models can empower hospitals to intelligently acquire new patients, manage populations by providing the right care at the right time, and increase alignment and loyalty from affiliated physicians.

Predictive models allow hospitals to plan for the future to maximize market share, improve patient care, and manage costs.

01

Understanding predictive models

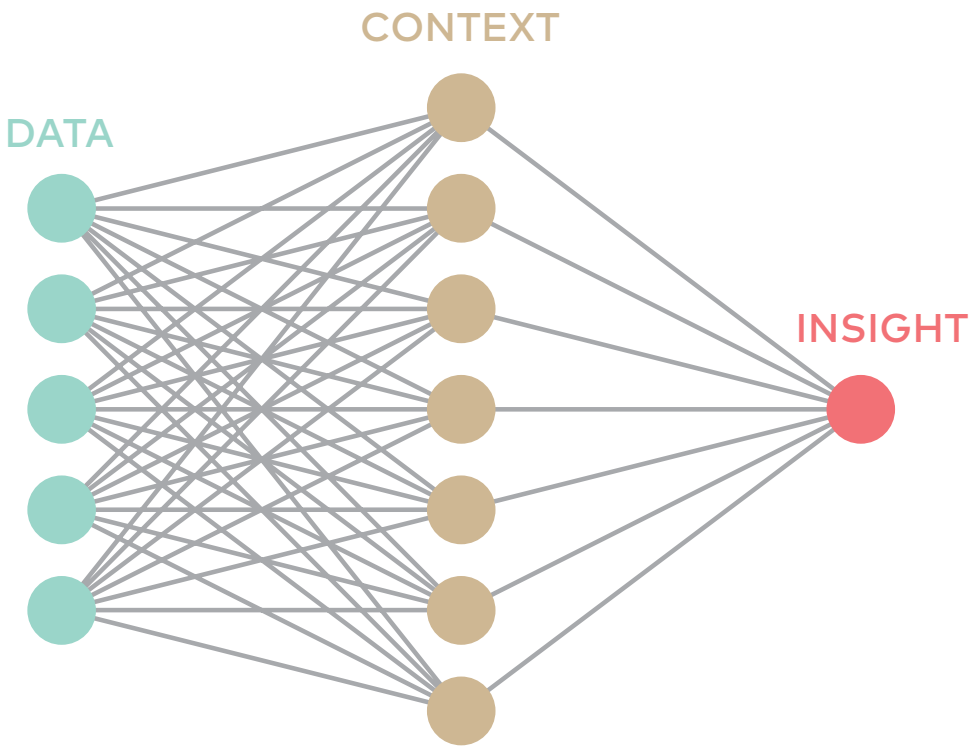
What value do healthcare-specific predictive analytical models provide? They tell hospitals exactly who their patients are and who may need their services soon. Standard analytics can tell hospitals what happened in the past. Monitoring can tell them what is happening now. But predictive analytics can provide a glimpse into what may happen in the future — so hospitals can plan for it.

PREDICTIVE MODELS ARE:

- Statistical formulas designed to capture trends and relationships between variables. Predictive models are based on detailed, collected data. They are validated and revised as additional data becomes available.
- Mathematical methods to best analyze a particular problem. Sophisticated development methods produce a simple outcome that is easy to understand.
- Tools used to predict future behavior. In healthcare, predictive models forecast the likelihood of a future health event for individuals. Hospitals can then project future population health needs for strategic planning and communication.

EXAMPLES OF PREDICTIVE MODEL APPLICATIONS:

Predictive models solve problems in a wide variety of contexts. Credit card companies can flag suspicious buying behavior to detect fraud. Consumer websites like Netflix and Amazon can make highly relevant, personalized recommendations. Predictive models revolutionized direct marketing by allowing managers to focus on the individuals most likely to make a purchase.



PREDICTIVE MODELS SOLVE PROBLEMS IN A VARIETY OF CONTEXTS

In healthcare, predictive modeling adds value by identifying individuals most likely to have medical needs. Neural networks are the most useful predictive modeling method for healthcare. Neural networks identify risk by capturing the uniquely complex interaction between healthcare utilization, demographics, medical codes, and visit history.

HOW DO NEURAL NETWORKS WORK?

A neural network is a mathematical model that converts input values to an output score through a process called artificial learning. Four key attributes make neural networks effective at understanding health utilization:

1. Scalability: Neural networks quickly score large data sets, allowing a score refresh with each database update.
2. Focus: Neural networks automatically identify important variables and ignore noise. For example, if RV ownership does not impact diabetes risk, the neural network ignores an "RV owner" input variable to avoid over-fitting.
3. Identification of nonlinearities: Many healthcare relationships are complex. For example, aging from 20 to 30 years old has only a small impact on the risk of heart disease relative to aging from 70 to 80 years old.
4. Recognition of interactions: The effect of some variables can be enhanced or mitigated by other variables. For example, heart disease risk increases with age more quickly for men than for women.

02

Building a smart model

All patients are unique, and smart predictive models can help identify specific health risks and needs. A hospital database might contain a patient — we'll call him John Smith — who is a sedentary, 55-year-old man. John might be considered a typical cardiac patient, given his age and aversion to exercise. His younger wife, Susan (also in the database), is 40 and an avid runner. She doesn't appear to be an obvious candidate for cardiology services.

Surprisingly, Susan is more likely to need cardiology services than her husband. This insight is possible because her predicted risk scores for heart-related diseases are much higher than John's. The data reveal that Susan has a family history of heart disease and was recently diagnosed with hypertension.

Patients are not typical and do not always fit a stereotype or persona. Smart predictive modeling enables hospitals to find individuals who need health services. It finds at-risk audiences, so physicians can provide appropriate patient diagnosis and care.

LEGACY MODEL: CLUSTER CODES

In the past, predictive modeling in healthcare was difficult due to a lack of comprehensive and historical patient data. Prior to using predictive models, marketers, statisticians, and clinicians used cluster codes to find prospects.

Cluster codes place households into cohorts sharing a set of socioeconomic characteristics. A cluster will typically span a range of ages and incomes, and possibly ethnicity, urbanization, and patterns of consumption. Cluster assignment is based on geo-coded address, with this organizing principle: Someone who lives in the same neighborhood as households with known characteristics probably shares those characteristics. Cluster codes use very small geographic divisions such as census blocks and six-digit postal code extensions. Clusters are given creative names such as "Milk and Cookies" or "Shotguns and Pickups" to evoke images of their lifestyles and associated economic behaviors.

Cluster codes perform well for general, nonmedical household data based on zip codes, buying patterns, and generic information. But they don't enable hospitals to understand a population's health situation or identify individuals who may soon need certain services.

CONSUMER MODEL

A consumer model is designed to run in an environment in which access to health records is not available. It uses market demographics to predict future health needs for both patients and non-patients.

Every patient in a hospital database should receive a set of scores from multiple (100 or more) patient models. In addition, patients and prospective patients should also receive a set of scores from multiple consumer models, which can be recalculated monthly for each individual. Including a geo-coded component provides U.S. Census information about the neighborhood where the individual lives.

Hospitals can create consumer and patient models for nearly all service lines and some sub-service line specialties. Some models can also target utilization by encounter type: inpatient, outpatient, or emergency services.

Consumer models are trained using only the demographic data for patients who have used medical services for the procedures or diagnoses targeted by the model. When a consumer model assigns a risk score to individuals, it is based on how closely their demographics resemble the patient the model was trained to recognize.

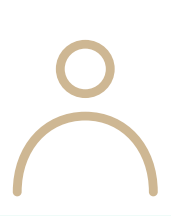
The solution for each of these individuals is more targeted and economical than cluster coding or random selection. Consumer models serve as predictors for the kinds and quantities of disorders and diseases in a market, helping hospitals to optimize strategic plans by identifying who needs what health service.

Healthcare Predictive Models	Cluster Codes
Based on healthcare variables and predictive algorithm	Based on non-healthcare variables and clustering algorithm
Segment market based on differences	Segment market based on similarities
Predict individual service use	Predict group/family behavior
Can be based on millions of encounters	Based on 10 variables
Scores based on ICD-9, MS-DRG, CPT categories	Scores based on single market model
Provide multiple individual scores when consumers and patient models are combined	One score per family
Dynamic, updated, and integrated with EHR data	Static, stale data that is not integrated with EHR data

In the examples below, hospitals learn about the demographics and likey health risks in a specific geographic area.

The scores are based on output of what the models identify about each person in the database.

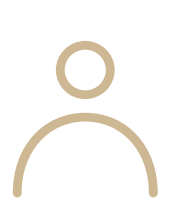
EXAMPLE 1



DEMOGRAPHICS
- Male
- Age 45
- Married
- Children present
- Median household income
- Zip code

CONSUMER SCORES
- Medical cardiology inpatient score: 731
- Diabetes outpatient score: 773
- Knee replacement: 568

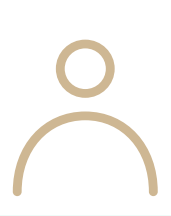
EXAMPLE 2



DEMOGRAPHICS
- Female
- Age 60
- Divorced
- No children present
- High household income
- Zip code

CONSUMER SCORES
- Medical cardiology inpatient score: 537
- Diabetes outpatient score: 443
- Knee replacement: 555

EXAMPLE 3



DEMOGRAPHICS
- Female
- Age 30
- Single
- Children present
- Low household income
- Zip code

CONSUMER SCORES
- Medical cardiology inpatient score: 324
- Diabetes outpatient score: 394
- Knee replacement: 179

PATIENT MODEL

With the widespread adoption of electronic health records (EHRs), hospitals can now obtain an accurate picture of their patient population and make decisions based on real data, not assumptions. A patient model assigns medical utilization risk, taking into account an individual's medical history. It examines recency, frequency, type, and service line of a patient's medical visits.

Ideally, the model should use hundreds of demographic data points and all available medical records to predict patients' future health needs. It should consider the same demographic variables used in the consumer model, as well as codes for chronic conditions, personal and family history, evaluation and management, and medical imaging.

The patient model should be trained using the coded medical histories of patients who have used medical services for targeted procedures or diagnoses. It can then assign risk scores to ensuing patients based on how closely their medical history resembles the patients it has been trained to recognize.

In the examples on the following page, hospitals can predict what health condition(s) a current or past patient has, and assign them a risk score to provide a sense of urgency. The scores are based on the output of what the models identify about each person in the database.

A patient model scores patients higher or lower depending on events in their medical history. Medical codes that appear more frequently prior to the target utilization raise the score, while medical codes appearing less frequently lower the score. The model should also be sensitive to code combinations seen more frequently prior to a visit.

In the examples below, hospitals can predict what health condition(s) a current or past patient has, and assign that patient a risk score to provide a sense of urgency.

EXAMPLE 1

Patient has normal cholesterol, diagnosed with patellofemoral pain syndrome (runner's knee)

DEMOGRAPHICS

- Male
- Age 45
- Married
- Children present
- Median household income
- Zip code

PATIENT SCORES

- Medical cardiology inpatient score: **628**
- Diabetes outpatient score: **674**
- Knee replacement: **832**

EXAMPLE 2

Patient has personal history of tobacco use, diagnosed with benign essential hypertension (elevated blood pressure)

DEMOGRAPHICS

- Female
- Age 60
- Divorced
- No children present
- High household income
- Zip code

PATIENT SCORES

- Medical cardiology inpatient score: **813**
- Diabetes outpatient score: **782**
- Knee replacement: **686**

EXAMPLE 3

Patient has family history of heart disease, diagnosed with impaired fasting glycemia (prediabetes)

DEMOGRAPHICS

- Female
- Age 30
- Single
- Children present
- Low household income
- Zip code

PATIENT SCORES

- Medical cardiology inpatient score: **660**
- Diabetes outpatient score: **627**
- Knee replacement: **327**

INTERPRETING CONSUMER AND PATIENT MODEL SCORES

Consumer models and patient models should be created using several years of pooled de-identified data, preferably from multiple healthcare organizations that present a cross-section of the national population.

An individual's medical history then allows consumer and patient model scores to be generated at a specified point in time. Hospitals can measure model performance by examining the individual's medical history following the score.

SCORE

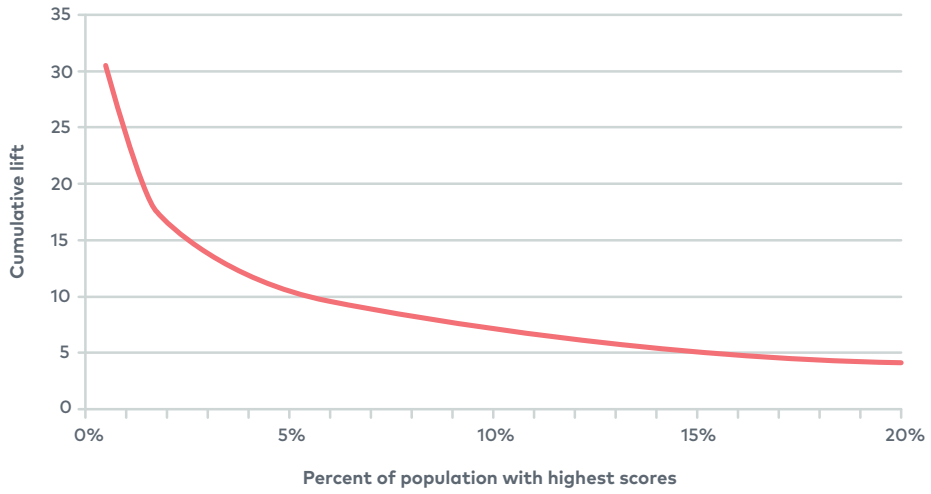
Each individual should receive a score of 0 to 999 for each consumer model and patient model. These scores represent risk in an actuarial sense, meaning a relative abstract likelihood of the targeted event occurring within the next 12 months. A score of 800 indicates greater risk than 400, but not necessarily twice the risk; it simply serves as a metric that sorts individuals according to risk.

It is important to note that relative risk is not the same thing as probability. Actual probability of the event occurring for a particular score depends on the utilization rate at which the event occurs in the population, and on the predictive power of the model. The term "risk" can also apply to positive events (for example, obstetrics patients and foundation donors).

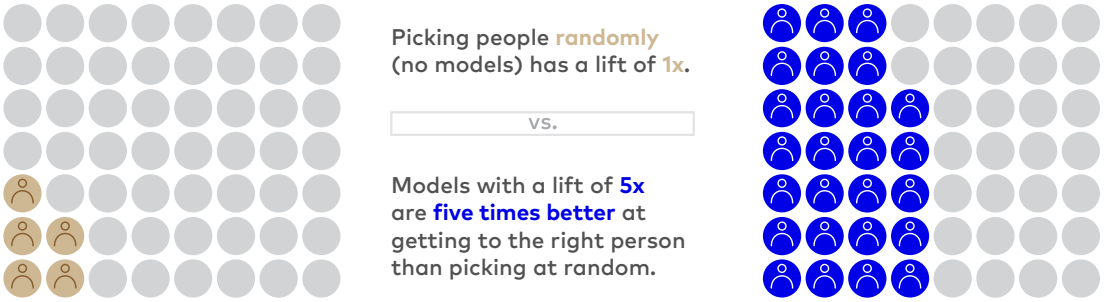
LIFT

Lift (and cumulative lift) is a useful metric to convey the predictive power of a model [Figure 1]. It is the factor multiplied by the population utilization rate to produce the rate of utilization for a given score.

FIGURE 1: CUMULATIVE LIFT MEDICAL CARDIOLOGY



Cumulative lift is assessed over a sorted or classified interval of population. A model with a cumulative lift of 5 at 900 means that individuals with a score of 900 or higher have the targeted medical event five times as often as the general population. Describing predictive power in terms of lift as a multiplying factor removes variation in population utilization rate for differing medical events.

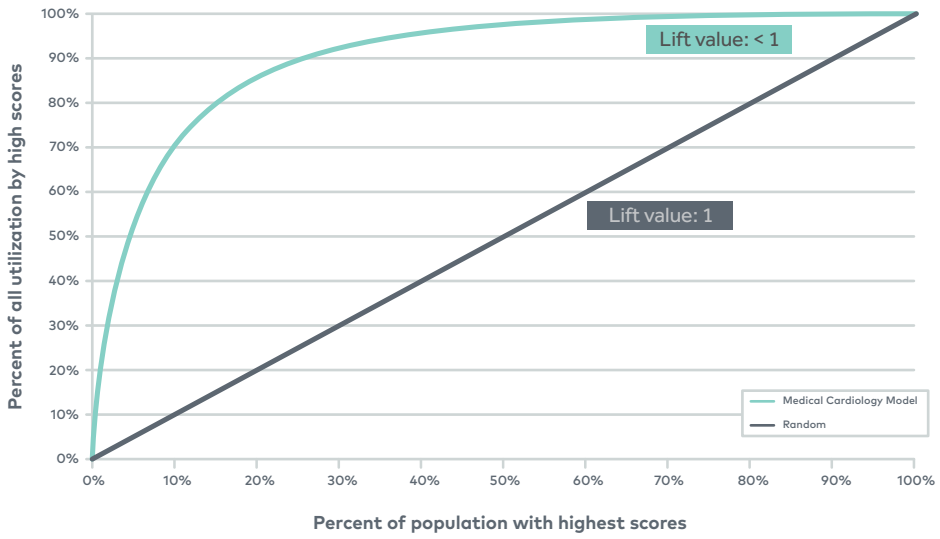


Lift extends directly to campaign planning. If 10 percent of the population falls in the 900+ score range, then for the cost of messaging 10 percent of the population, a campaign will reach 5 x 10 percent = 50 percent of the individuals who may have the targeted medical event in the next year. This estimate is possible without knowing the exact service utilization rate. A known utilization rate permits estimates of specific numbers of individuals and medical encounters.

UTILIZATION CURVE

A utilization curve (also known as a cumulative response curve) extends the concept of lift. It shows the cumulative percent of the total population using services for the targeted medical event (vertical) for the cumulative percent of population as ranked by score (horizontal). Lift is the slope of the curve on the graph in Figure 2. A diagonal line has a lift of 1, and is equivalent to using no model, or to randomly selecting individuals using no criteria. On the left there is high lift, where the curve rises sharply. Where the curve rounds out, there is low lift. Where the curve is flat near the top of the chart, there is a lift value lower than 1. Messaging individuals in the flat range of the utilization curve is counterproductive because utilization is concentrated in the high-scoring population. Reading a utilization curve gives a quick sense of the ROI that a model provides.

FIGURE 2: PATIENT UTILIZATION MEDICAL CARDIOLOGY



03

Using predictive models strategically

The future of healthcare is hardly certain. CMS programs for value-based purchasing and meaningful use of information technology, combined with other Affordable Care Act provisions and a shifting quality focus, make for a confusing path forward.

Predictive models can help hospitals set and meet goals in the face of uncertainty. They indicate

priorities in consumer, patient, and physician engagement to increase satisfaction and improve health outcomes. Knowing individual medical risks empowers economical, data-driven strategies to address them through preventive care and timely interventions.

Benefit the community: Proactively manage population health and optimize health outcomes.

Predictive models identify and stratify individuals within populations, enabling actions that can save lives. Whether someone is at high risk or is already diagnosed with one or more diseases, hospitals can target an intervention and guide that person to the most suitable physician. They can also plan for utilization and staffing in risk areas by identifying physicians for increased alignment or loyalty. By focusing on those who need it most, hospitals can deliver higher-quality care and ultimately improve outcomes.

Innovative hospitals engage at-risk patients while reducing costs.

While hospitals can easily identify high-risk patients from their medical records, predictive models empower them to find moderate-risk individuals — both patients and prospects — before they become high-risk. These people benefit most from proactive communications that provide education and encourage a doctor's visit. Strategic use of consumer and patient models for this purpose combines the predictive model with filter criteria to select patients and prospects with high scores who have not already had a major procedure or diagnosis. When hospitals identify and engage these individuals, they lower their direct costs of care by preventing major medical events.

Growing market share still matters.

Growing market share is important to the financial health of many hospitals. Consumer models can map utilization versus risk throughout a service area. Hospitals can then message prospects in areas where consumer model scores indicate higher potential demand for healthcare services. Used strategically, predictive models can help hospitals offer preventive care, proactively engage patients, and take positive steps toward population health, increased care quality, and proven ROI.

04

Conclusion

Armed with powerful consumer and patient data models, hospitals can reach the right audience with the right message via the right channel at the right time.

Predictive models are advanced mathematical techniques that can be used to more accurately identify individuals in the marketplace based on their health status. They are superior to cluster codes in selecting appropriate patients and consumers for education, disease management, and intervention programs. Predictive modeling is more efficient in reaching the right individuals with the right message, so hospitals can ensure they deliver the right care.

Using predictive-model best practices improves targeted population health by helping consumers and patients make healthier choices.

About Healthgrades

We're not simply experts in patient and physician engagement. We actually invented health relationship management nearly 25 years ago. Let us show you engagement solutions that combine evidence-based, multichannel communications with a business intelligence platform to build relationships, influence behaviors, and improve healthcare utilization — all with a measurable contribution margin for your hospital.

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