EVERSANA®

EVERSANA's Predictive Analytics:

A Capabilities Compendium

Harnessing the Transformative Power of Machine Learning in Healthcare

In the fast-changing world of healthcare, machine learning (ML) and real-world evidence (RWE) bring us closer to the goal of precision medicine: delivering the right treatment to the right patient by the right physicians at the right time.

EVERSANA is proud to introduce this collection of case studies that demonstrate the transformative power of ML in healthcare.

- Our work in RWE illustrates how ML predictive analytics contribute to significant advancements in precision medicine and precision targeting, ultimately enhancing patient care and driving healthcare innovation.
- This collection of work also showcases how ML-driven predictive models are making significant strides in precision medicine by precisely targeting both physicians and patients who will benefit most from specific interventions, thereby improving patient engagement and making care delivery more efficient.

This compendium of work emphasizes the role of ML in identifying sentinel events before the correct diagnosis, targeting the right patients and the right physicians. By analyzing physician practice profiles for key attributes such as target patient volumes and clearly defined patient personas, ML models can pinpoint the healthcare providers most likely to adopt new therapies and the patients most suitable for those therapies, thereby optimizing healthcare delivery and resource allocation.

As we continue to harness the power of advanced analytics, EVERSANA is poised to improve patient care, optimize resource allocation and drive innovation in healthcare.

Pierantonio Russo

Pierantonio Russo, MD, FCPP, FAAP, member STS
Corporate Chief Medical Officer

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CASE STUDY:

Predictive Modeling for Treatment Switching in Paroxysmal Nocturnal Hemoglobinuria (PNH) Patients

Designing Machine Learning Models From Both Patient and Physician Perspectives

BACKGROUND

Paroxysmal nocturnal hemoglobinuria (PNH) is a rare and life-threatening condition that poses significant management challenges to the medical community. Traditionally, SOLIRIS® (eculizumab) has been the primary treatment. However, with the advent of ULTOMIRIS® (ravulizumab), which offers similar therapeutic benefits but with less frequent infusions, understanding the dynamics influencing treatment switching has become crucial. This knowledge can lead to improved patient outcomes and more refined treatment strategies.

OBJECTIVE

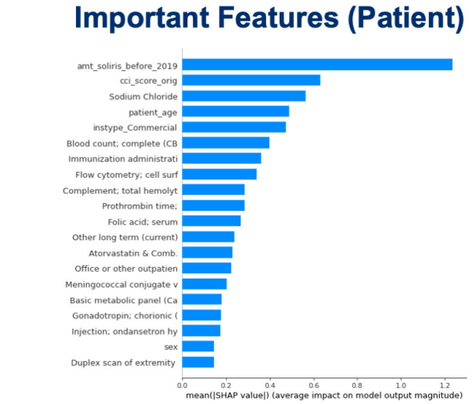
The client's goal was to identify the factors influencing the switch from Soliris to Ultomiris from both the patient and physician perspectives. EVERSANA was contracted to develop predictive models that analyzed extensive demographic, clinical and therapeutic data to construct robust frameworks that would anticipate trends and optimize treatment strategies for managing PNH.

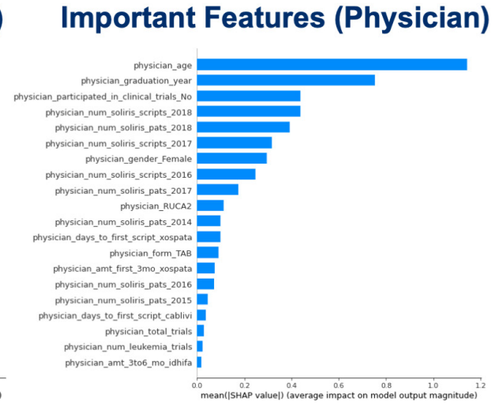
CHALLENGES

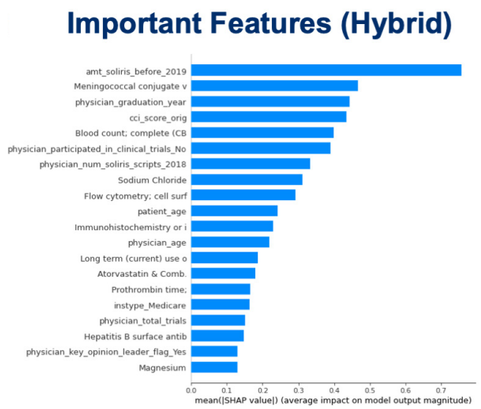
One of the main challenges was managing the high-dimensional healthcare data, which includes diverse patient profiles, treatment patterns and outcomes. Integrating vast datasets to identify significant predictors required advanced analytical techniques and meticulous modeling. Additionally, overcoming biases inherent in retrospective healthcare claims data and ensuring model applicability across different patient demographics posed significant hurdles.

STRATEGY

EVERSANA's approach involved developing three predictive models: a physician-focused model, a patient-focused model and a hybrid model incorporating both sets of features. These models analyzed data extracted from healthcare claims, including treatment histories, healthcare provider characteristics, patient demographics and clinical outcomes. We employed advanced machine learning algorithms and statistical techniques, such as gradient boosting and mutual information analysis, to enhance prediction accuracy regarding treatment-switching behavior.







Plots comparing feature importance between the patient-based model, the physician-based model and the hybrid patient-physician-based model.

RESULTS

The findings of this study underscore the significant roles both patient characteristics and physician practice behaviors play in PNH management decisions.

Key insights revealed:

- Younger patients with frequent hospitalizations and those treated by experienced hematologists are more likely to switch treatments.
- Older, sicker patients; those with less response in their Soliris treatment; and those treated by more experienced physicians are more likely to switch treatments.

These models enhance the client's ability to forecast treatment transitions, offering valuable insights that could lead to more personalized patient care and better overall treatment outcomes.

The predictive models designed during this project not only demonstrate EVERSANA's capability in handling complex datasets, but also validate our methodological approaches in deriving actionable insights from healthcare data. Our deep dive into PNH treatment dynamics provides a clear example of how predictive analytics can significantly enhance therapeutic decision-making, thus offering substantial value to healthcare providers, payers and patients alike.

CASE STUDY:
Use of Machine Learning to Identify Gastroparesis Patients Suitable for Nasal Spray Metoclopramide

Utilizing Supervised and Unsupervised Learning, With Hierarchical Patient Embeddings to Build Predictive Models

BACKGROUND

Oral metoclopramide (OMCP) is the first-line treatment for gastroparesis (GP), but nausea and vomiting may reduce OMCP tolerability, and diabetes may delay oral absorption. In 2020, the FDA approved a nasal spray formulation of metoclopramide (NMCP). However, the clinical profile of patients who could benefit from NMCP in clinical practice is not well established, in part because there is increasing evidence that GP and functional dyspepsia (FD) may be on a spectrum of gastric dysfunction and because patients with clinical phenotypes meeting the criteria for the Gastroparesis Cardinal Symptom Index (GCSI) are not always identified with the clinical or administrative diagnosis of GP in electronic health records and claims databases, respectively.

OBJECTIVE

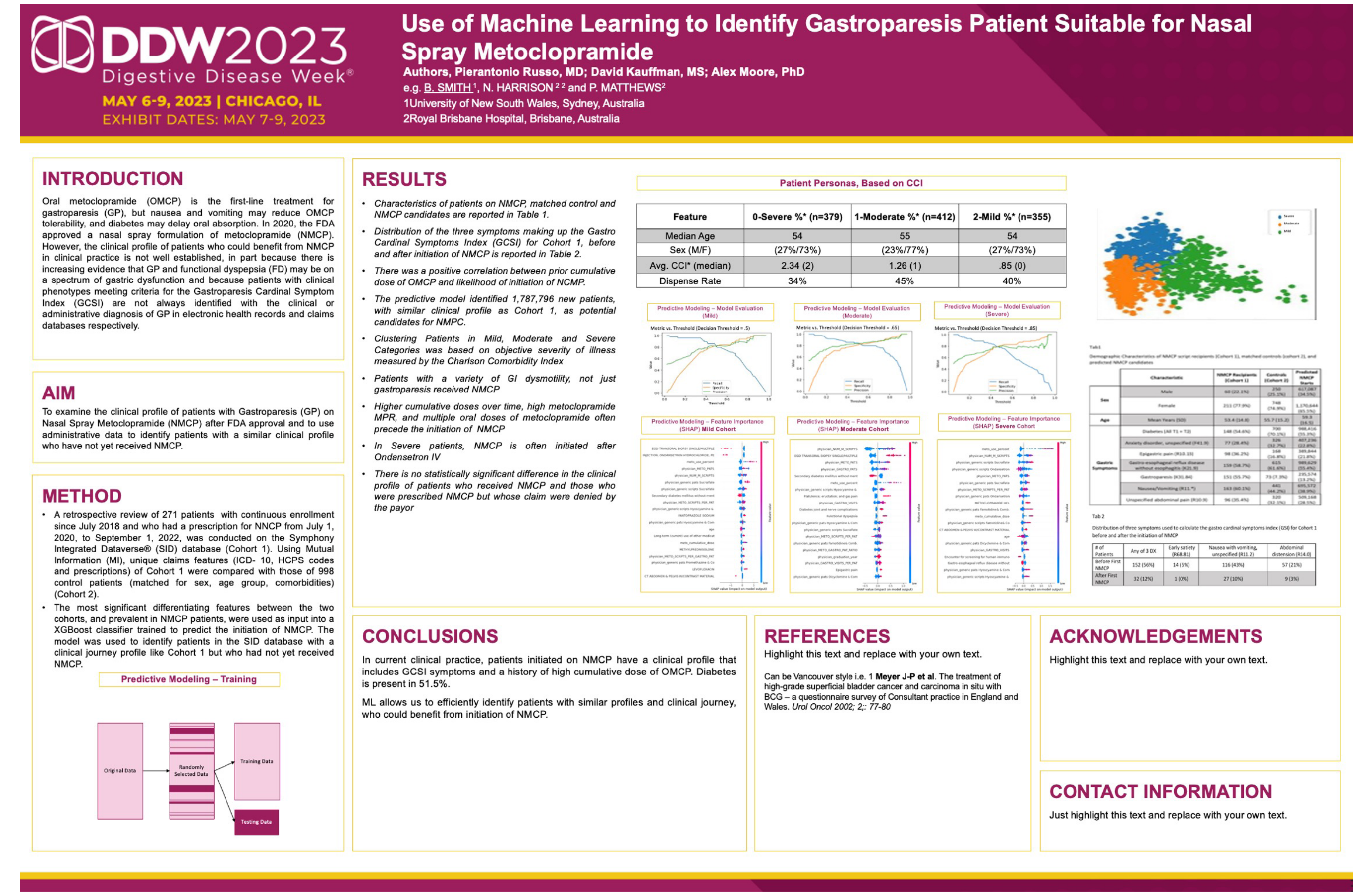
A midsize pharmaceutical company needed to identify patients with a similar clinical profile who might benefit from NMCP. EVERSANA was contracted to examine the clinical profiles of current patients with GP on NMCP using administrative claims data, then develop a predictive model to identify these patients.

CHALLENGES

The project faced several challenges, including the complexity of GP and its lack of consistent identification in administrative claims. Additionally, compiling comprehensive and accurate patient data posed significant hurdles, requiring meticulous validation and integration of information from various sources. The wide variety of potential factors that can influence a patient's treatment type requires intensive feature engineering and statistical techniques.

STRATEGY

A retrospective review of 271 patients who had a prescription for NMCP was conducted on EVERSANA's open claims database (Cohort 1). Using mutual information (MI), unique claims features of Cohort 1 (ICD-10, HCPCS codes and prescriptions) were compared with those of 998 control patients (Cohort 2). The most significant differentiating features between the two cohorts, and prevalent in NMCP patients, were used as input into a gradient-boosting classifier trained to predict the initiation of NMCP. The model was used to identify patients in the database with a clinical journey profile similar to Cohort 1, but who had not yet received NMCP. Then, unsupervised learning was used to cluster hierarchical embeddings of the patient journeys, which identified Mild, Moderate and Severe segments of patients. Additional predictive models were designed to sort potential patients into these categories.



Poster presented at Digestive Disease Week 2023 outlining model performance, feature importance and patient clustering in gastroparesis patients suitable for nasal spray metoclopramide.

RESULTS

The designed predictive models identified nearly 1.8 million additional patients with similar clinical profiles as the NMCP patients, utilizing clinical features such as GI dysmotility diagnoses and cumulative metoclopramide doses over time. The patient personas, identified via unsupervised learning algorithms, align well with the clinical measures of mild, moderate and severe comorbidities.

CASE STUDY:

Improving an AATD Predictive Model Using EMR Data

Strengthen the Robustness of a Machine Learning Model by Incorporating EMR Data

BACKGROUND

Alpha-1 antitrypsin deficiency (AATD) is a genetic condition with significant variability in clinical presentation and outcomes, making accurate diagnosis challenging yet crucial. EVERSANA was initially approached by a midsize pharmaceutical company to perform advanced predictive modeling to improve the identification of AATD among patients using electronic medical records (EMRs) and open claims. The original model, validated using initial EMR datasets, was designed to optimize the prediction and management of AATD by incorporating comprehensive diagnostic, medication and laboratory features.

OBJECTIVE

The project aimed to enhance the diagnostic precision and reliability of the predictive model for AATD by validating and retraining it with a newly integrated EMR dataset. Key objectives included increasing predictive accuracy metrics, refining the patient definition to ensure a more precise diagnosis and extending the model's applicability across different EMR systems without compromising performance.

CHALLENGES

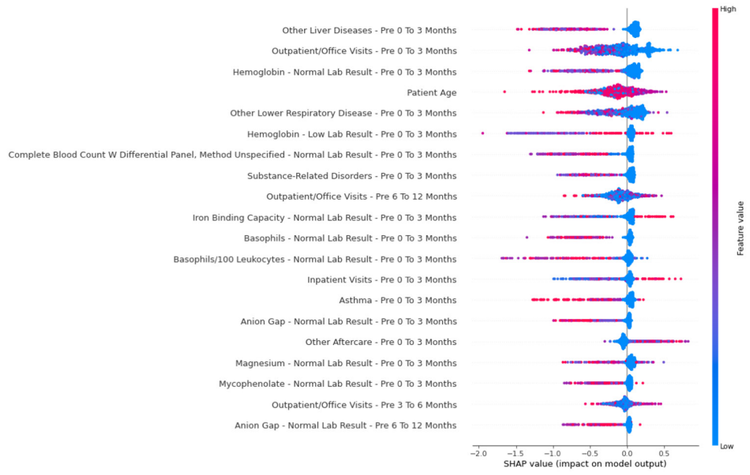
Initial analysis revealed a decrease in model performance when applied to a new EMR dataset, with predictive accuracy dropping notably. This was attributed to variations in the availability and distribution of clinical data across EMRs. Additionally, the complexities of integrating and normalizing data from various sources posed significant hurdles in maintaining consistency in model training and validation processes.

STRATEGY

To address these challenges, the team implemented a comprehensive retraining of the analytic model. This involved revising the patient cohort definitions based on updated clinical data and diagnostics, employing advanced feature selection techniques such as mutual information to refine the predictive variables, and retraining the model with new data subsets to test and enhance its performance under varied clinical scenarios. Ongoing collaboration between the clinical and technical teams to get feedback and address the integration of data and model adjustments was essential to achieving the desired outcome.

Model Results – Important Features

A combination of diagnoses, lab results, and location of service features drive the performance of the model. Most of the top 20 features are features that are 0 to 3 months prior to index.



SHAP values of top features from the highest-performing predictive model, including diagnoses, lab results and location of service factors.

Other liver diseases, Outpatient and Office visits, and Hemoglobin with a normal lab result within 0 to 3 months prior to index date were the top predictive features of the model.

Other significant contributors to the model include patient age, other lower respiratory disease, hospitalization, asthma, etc.

RESULTS

The retrained model demonstrated a significant improvement, increasing the predictive accuracy from 78% to 85%. The enhanced model now effectively incorporates a wider range of clinical features, making it more representative and inclusive of diverse patient populations. Sensitivity and specificity analyses indicated high efficacy in diagnosing true positive and negative cases, thus validating the model's utility in a clinical setting.

This predictive modeling capability not only promises to improve diagnostic accuracy for AATD, but also serves as a scalable blueprint for other genetic and chronic conditions. For potential clients, adopting this model can translate to better patient outcomes, optimized treatment pathways and, ultimately, a higher standard of personalized care.

This comprehensive project summary encapsulates EVERSANA's capabilities in harnessing predictive modeling for enhancing disease diagnosis and management, showcasing a profound impact on healthcare delivery through innovation and technology integration.

CASE STUDY:

Scoring and Segmenting Key Opinion Leader Physicians With Innovative and Customizable Machine Learning Techniques

Influence Mapping for Healthcare Providers in Oncology

BACKGROUND

A pharmaceutical company with an existing cancer therapy recently received approval to label its treatment for first-line use. With the potential to reach a new market, the client aimed to identify priority healthcare providers (HCPs) likely to adopt its therapy as a first-line treatment.

OBJECTIVE

An EVERSANA client sought to determine the most influential key opinion leaders based on factors such as patient and prescription volume, early adoption of comparable products and influence metrics related to scholarly activities (e.g., involvement in clinical trials, publications and participation in scientific meetings).

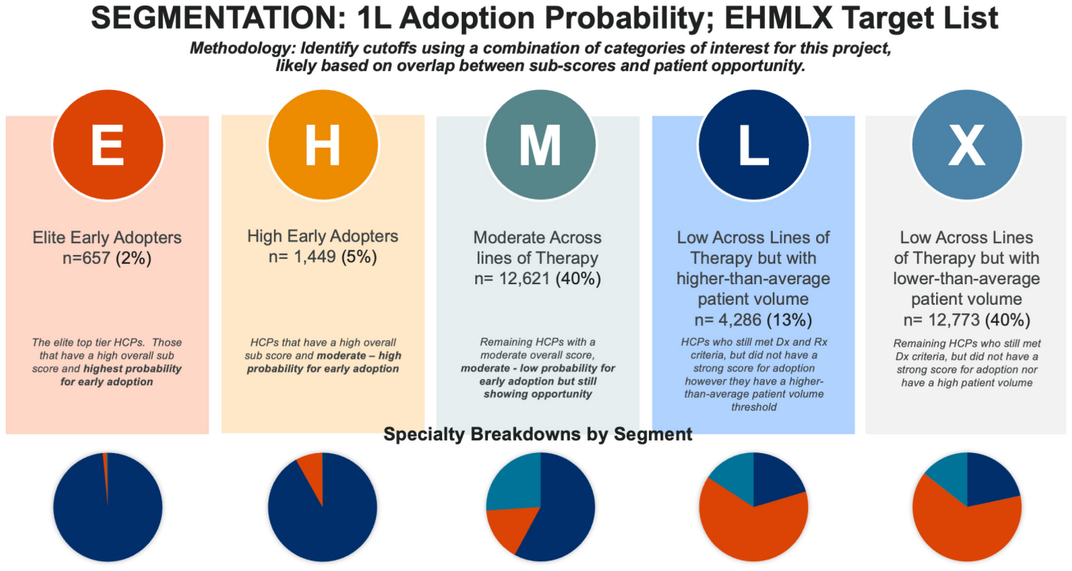
CHALLENGES

The key challenges included identifying precise metrics to pinpoint key opinion leaders in this specific therapy area, consolidating information from various sources and using this data to generate meaningful, targeted segments of healthcare providers.

This process required extensive data integration, technical and clinical expertise, and the use of customizable machine learning (ML) techniques. Customizable ML refers to the development and application of ML models that can be tailored to meet the specific requirements and preferences of a particular use case or user, allowing them to influence model behavior based on their unique requirements or domain knowledge.

STRATEGY

EVERSANA collaborated with the client to generate the patient cohort and understand their treatment journeys to identify relevant HCPs. Data on HCPs was gathered from diverse sources, including claims, clinical trials, open payments and publications. Scores were calculated for each HCP based on these data points. Finally, EVERSANA employed ML-based clustering to create segments of HCPs with varying priorities for targeted marketing.



Five segments of healthcare providers based specifically on the likelihood of adopting the oncology product for first line use.

RESULTS

EVERSANA generated personalized influence scores for over 30,000 HCPs in the target therapy domain using a wide variety of data. We employed unsupervised learning techniques to generate five HCP segments, with additional priority placed on those HCPs most likely to adopt the product for first-line treatment, including Elite (top 2%) and High (top 7%) priority HCP targets that maximized value for the client.

CASE STUDY:

Identifying Potential High-Risk Factor Arrhythmia Patients Using Predictive Modeling

A Robust Approach Combining Clinical, Demographic and Social Determinants of Health Data

BACKGROUND

For its flagship product, the Zio monitor, iRhythm was interested in knowing the populations that would best benefit from early monitoring of arrythmia to build a value story for payers. EVERSANA collaborated with iRhythm to harness real-world data (RWD) and predictive modeling techniques for enhancing arrhythmia patient management. This project sought to leverage EVERSANA's robust data infrastructure and predictive capabilities to address critical healthcare questions, such as "What are the key risk factors for arrhythmia?" and "Who are the most suitable patients for monitoring?"

OBJECTIVE

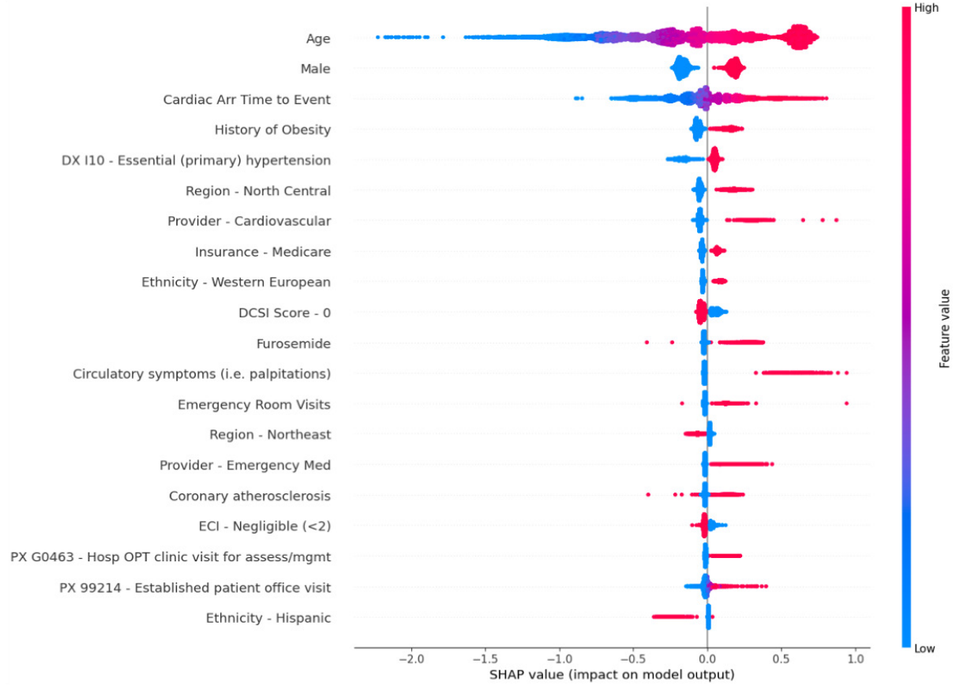
The primary objective of this project was to develop a predictive model to accurately identify patients at risk of arrhythmias and to tailor treatment strategies effectively. By utilizing extensive patient data, including clinical, demographic and social determinants of health (SDOH), the model aimed to provide actionable insights into patient care and improve the efficiency of healthcare providers (HCPs) in managing high-risk patients. The ultimate goal was to enhance the quality of life for patients while ensuring cost-effective healthcare delivery.

CHALLENGES

The project faced several challenges, including integrating and normalizing vast amounts of diverse healthcare data, ensuring patient data privacy and compliance with healthcare regulations, and dealing with the complexity of developing a robust predictive model capable of accommodating the multifaceted nature of arrhythmias. Additionally, the need to tailor and segment patient treatment required sophisticated clustering algorithms and advanced analytics to accurately predict arrhythmia risks.

STRATEGY

To address these challenges, EVERSANA employed a multipronged strategy.
A comprehensive data aggregation platform was set up, integrating various sources of healthcare data and allowing models to analyze features extracted from healthcare claims data, such as treatment histories, healthcare provider characteristics, patient demographics and social determinants of health. Then, advanced machine learning techniques, including SHAP analysis and clustering algorithms, were utilized to dissect and predict risk factors associated with arrhythmias, as well as understand different patient phenotypes.



Top predictive features of arrhythmias from the diabetes patient model (left). Plots demonstrate the positive correlation between age and predictive importance (top right) and between months from initial diabetes diagnosis and predictive importance (bottom right).

RESULTS

The project successfully demonstrated the capacity of predictive modeling to revolutionize arrhythmia patient care. Key findings revealed significant risk factors that can aid in crafting targeted, personalized treatment plans. These results could lead to not only improved patient outcomes, but also optimized resource allocation, proving the immense value of predictive modeling in healthcare. For potential clients, these insights and capabilities highlight EVERSANA's commitment to advancing healthcare analytics and its continued impact on global health systems.

CASE STUDY:

Assessing the Telehealth Treatment Landscape and Building Predictive Models (AI/ML) to Identify Patients/Providers Most Likely to Use Telehealth

Strengthen the Robustness of a Machine Learning Model by Incorporating EMR Data

BACKGROUND

A top 10 pharmaceutical company wanted to launch a direct-to-consumer (DTC) campaign to promote its drugs directly to patients in three therapy areas (obesity, diabetes and migraine). The client realized that telehealth is an important and emerging channel for health services delivery to patients in the post-COVID era.

OBJECTIVE

The client's primary objective was to assess how telehealth is being used by patients and healthcare providers (HCPs), assess the drivers of and barriers to telehealth and identify telehealth user segments (patients and HCPs) within each of the three therapy areas of interest.

CHALLENGES

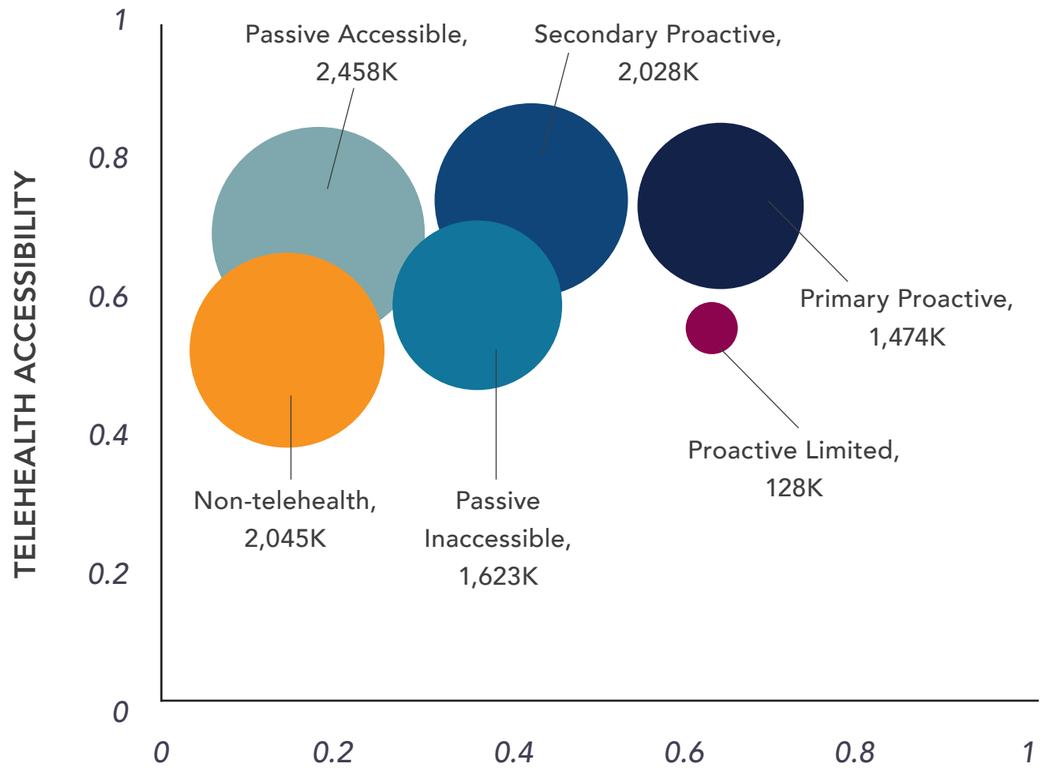
Factors influencing a patient's use of telehealth can be difficult to assess. There are personal factors (preferences, inability to travel) and external, systemic factors. Additionally, the drivers of and barriers to telehealth use in patients are unlikely to be identified from administrative claims data alone and require an in-depth understanding and consolidation of social determinants of health. Each of these factors may also differ between various therapy areas.

STRATEGY

EVERSANA collaborated with the client to develop a detailed understanding of the telehealth landscape and key factors that predict telehealth use. EVERSANA assessed historical telehealth use (from open claims data) and built predictive models, utilizing claims data as well as social determinants of health, to identify key factors driving telehealth use. We also leveraged our proprietary machine learning (ML) models to score and cluster patients, deriving personas based on two distinct models: one designed to identify the likelihood that a patient will choose telehealth services and one designed to measure a patient's access to telehealth services.

Finally, HCPs were identified based on their propensity to use telehealth and their predicted volume of telehealth patients.

SEGMENTATION DISTRIBUTIONS



Patient segments were identified using telehealth proactivity and telehealth accessibility as the two major axes.

RESULTS

EVERSANA identified five distinct consumer segments per therapy area based on two key dimensions: propensity to use telehealth and access to telehealth. We also identified 2,000 high-value HCPs responsible for treating 40% of high-value patients, as well as the health systems more likely to drive telehealth use among patients.

CASE STUDY:

Predictive Modeling for Treatment of Relapsing-Remitting Multiple Sclerosis (RRMS)

Understanding First-Line Treatment and Factors Leading to Treatment Switching via Machine Learning

BACKGROUND

Early recognition of the progression from relapsing-remitting multiple sclerosis (RRMS) to secondary progressive MS (SPMS) remains challenging. EVERSANA has conducted a study utilizing data from administrative claims to employ predictive models that determine disease progression and appropriate disease-modifying therapies (DMTs) for patients based on a multitude of factors, including demographics, disease characteristics and clinical patterns.

CHALLENGES

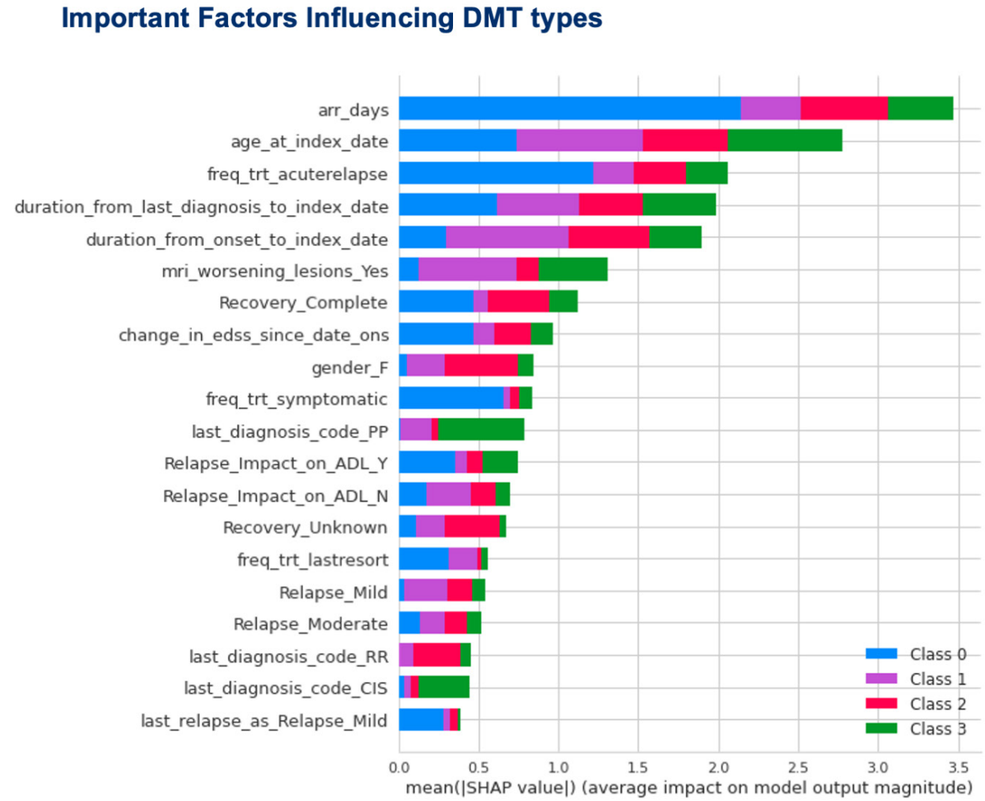
The project faced several challenges, including the complexity of MS as a disease with diverse manifestations and progression rates among patients. Additionally, compiling comprehensive and accurate patient data posed significant hurdles, requiring the validation and integration of information from various sources. The variability in treatment response factors also added layers of complexity to model development and required sophisticated analytical techniques.

OBJECTIVE

A midsize pharmaceutical company needed to recognize the disease progression of RRMS and identify therapeutic interventions to slow its progression. EVERSANA partnered with this client and used machine learning (ML) to build predictive models using an observational study leveraging a Kuwaiti MS clinical registry (N=2,265 patients). These ML-driven predictive models needed to identify risk factors associated with progression from RRMS to SPMS, as well as the role of specific DMTs in delaying the progression.

STRATEGY

EVERSANA's approach involved a multi-phase strategy starting with the collection and integration of detailed patient data from Kuwait's national MS registry. Following data integration, predictive models were developed using advanced ML techniques, including gradient boosting and SHAP values, to determine the impact of different variables on treatment efficacy and understand the rationale for a patient progressing to a second-line treatment. The models were then rigorously tested and validated to ensure their reliability in clinical decision-making processes.



SHAP values of factors influencing the first-line class of DMTs of treated patients.

RESULTS

Based on the output of these models, key predictors of progression were identified. These included the duration of symptoms, age, a high frequency of an expanded disability status scale (EDSS) score greater than 3 and more than three lesions on a recent MRI.

A high-efficacy DMT used as first-line therapy played a key role in delaying progression. Additionally, patients older than 30 were helped the most by switching to a highly effective DMT as a second-line therapy.

The client was able to utilize these predictive models developed by EVERSANA to recognize MS patients who were potentially transitioning from RRMS to SPMS and inform treatment modifications to mitigate disease progression. These models can predict treatment needs with high accuracy, thus ensuring patients receive the best therapy sooner. Our findings provided the client with a robust foundation for the future of personalized medicine in managing patients with MS, potentially affecting clinical practice.

CASE STUDY:

Machine Learning Model Using Insurance Claims Data to Help Predict ALS Diagnosis

Reducing the Time to Diagnosis of ALS

BACKGROUND

Amyotrophic lateral sclerosis (ALS) often faces significant diagnostic delays. Utilizing machine learning methods on large healthcare databases has the potential to create models that can expedite ALS diagnosis, leading to improved quality of life and potentially an improved survival rate for ALS patients.

OBJECTIVE

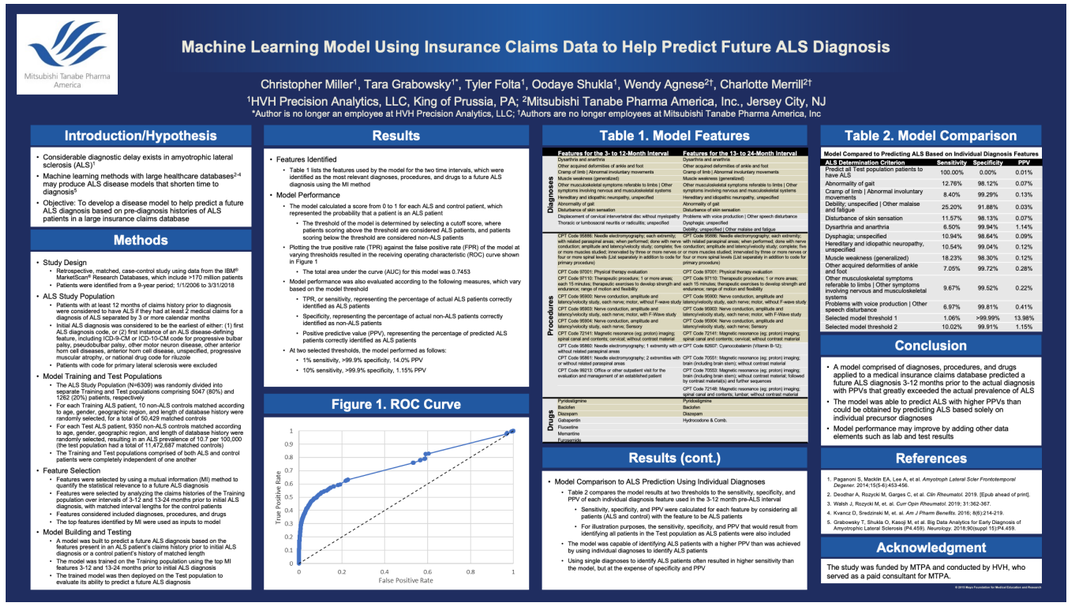
A small pharmaceutical company wanted to find a way to shorten the time to diagnosis to get treatment to patients faster. It approached EVERSANA to develop a predictive disease model that could identify future ALS diagnoses by analyzing the pre-diagnosis medical histories of ALS patients within a large insurance claims database.

CHALLENGES

Diagnosing ALS is inherently complex and may be inconsistently documented in medical claims data. Designing a high-quality predictive model for ALS requires a blend of clinical and technical expertise to handle data processing and feature engineering effectively.

STRATEGY

A retrospective analysis was performed on EVERSANA's claims database for patients diagnosed with ALS. Using mutual information (MI), the study compared unique clinical features of the ALS cohort with those of demographically matched control patients. The top differentiating features were then used to train a classifier to predict ALS diagnoses. This model was subsequently applied to identify patients in the database who had clinical profiles similar to those in the ALS cohort but had not yet been diagnosed.



Poster presented at Mayo Clinic Annual Conference 2019 outlining model performance and feature importance in the prediction of future ALS diagnosis.

RESULTS

A model comprised of diagnoses, procedures and drugs applied to a medical administrative claims database predicted ALS diagnosis three to 12 months prior to actual diagnosis with positive predictive values (PPVs) that exceed the actual prevalence of ALS. The model was able to provide the client with the tools to predict ALS with higher PPVs than could be obtained by predicting ALS based solely on any individual precursor diagnoses.

CASE STUDY:
Finding APDS Patients Using Predictive Models

Utilizing Machine Learning to Predict Patients Without a Specific ICD Code

BACKGROUND

Activated PI3K delta syndrome (APDS) is a rare immunodeficiency disorder caused by mutations in the PIK3CD or PIK3R1 gene that affect critical immune system functions. Patients with APDS suffer from severe recurrent infections, predominantly affecting the lungs, sinuses and ears, alongside symptoms such as lymphoproliferation and autoimmunity.

OBJECTIVE

A midsize pharmaceutical company's main objective was to enhance the early identification of patients with APDS using predictive machine learning (ML) modeling techniques applied to administrative claims databases. EVERSANA utilized an extensive medical claims dataset, targeting a deeper understanding and earlier diagnosis through predictive modeling, addressing a significant unmet need in APDS patient care.

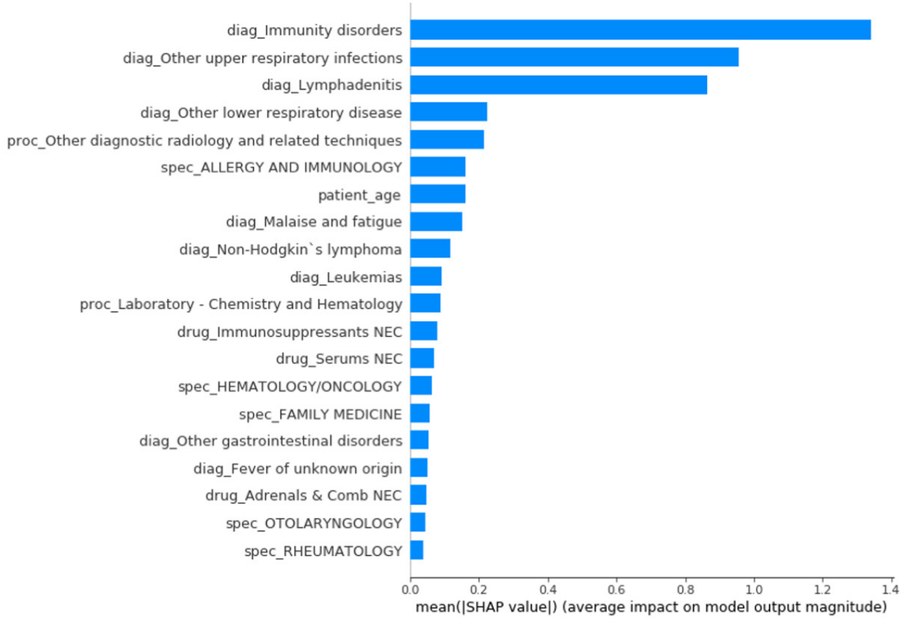
CHALLENGES

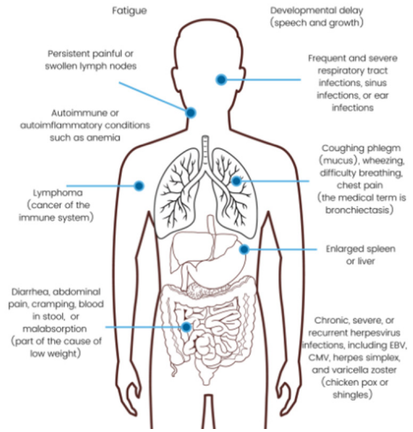
Finding APDS patients is complicated due to the absence of a specific ICD-10 code and the variability of symptoms among affected individuals, even though they share the same genetic mutation. The challenges extended to constructing a predictive model capable of accurately finding APDS phenotypes in administrative claims databases.

STRATEGY

EVERSANA segmented the data into two age-based cohorts to refine analysis and model accuracy. Predictive modeling used ML algorithms to analyze patterns within the claims data, focusing on key indicators such as immune disorders, lymphadenitis and respiratory infections.

The team also employed various data validation methods, such as comparing cohort data with the European Registry and patients with confirmed genetic testing results, ensuring robustness and accuracy. By integrating clinical and technical expertise, and comparisons with cohorts of patients with a diagnosis confirmed with genetic testing, the model could more effectively predict APDS phenotypes and potential treatment paths. These models were then applied to find in the database undiagnosed patients who are candidates for genetic testing to confirm the diagnosis.





Summary of typical APDS symptoms (left) and importance of features output by the predictive model for patients over the age of 12 (right).

RESULTS

The EVERSANA model achieved high precision and sensitivity, underscoring its effectiveness in finding potential APDS patients, who are otherwise invisible to the healthcare system. Ultimately, the project demonstrates the transformative potential of predictive analytics in healthcare, paving the way for broader applications in managing other complex diseases.

CASE STUDY:

Assess MPS II Diagnosis and Treatment Referral Pathways and Identify Potential Patients via Predictive Modeling

Machine Learning and Algorithmic Network Mapping in Rare Diseases

BACKGROUND

Mucopolysaccharidosis type II (MPS II), or Hunter syndrome, is a rare disease caused by a deficiency in the lysosomal enzyme iduronate-2-sulfatase (I2S). This enzyme is crucial for the degradation of glycosaminoglycans (GAGs). Early diagnosis and symptoms management are critical to prevent irreversible neurological and organ damage and improve patient outcomes.

OBJECTIVE

A pharmaceutical company developing a new therapy for MPS II sought to understand the journey of current patients to drive referrals to specific regional treatment centers where its therapy would be offered. The goal was to identify both the experts providing the initial diagnosis and/or treatment and the adept providers referring patients to these experts, facilitating the adoption of its therapy.

CHALLENGES

Identifying MPS II patients is challenging due to the inconsistent use of specific ICD-10 codes and the variability of symptoms among affected individuals. Accurately singling out potential MPS II patients using extensive medical claims data is also difficult. Additionally, mapping the pathways leading patients to the company's treatment centers is complex due to the often-incomplete information in claims data, requiring both technical and clinical expertise.

STRATEGY

EVERSANA first identified the correct patients' cohort treated with ELAPRASE® specifically indicated for MPS II and then found patients in the database who share the same features with the Elaprase-treated patients but had not received Elaprase.

In addition, the EVERSANA team identified the distinct phases of the patient's journey. Historical data from open claims was analyzed to map referrals to key events along the treatment pathway – from first clinical suspicion to initial diagnosis to the first treatment – to algorithmically identify the most influential providers. EVERSANA created a machine learning model to identify key predictors of this rare disease and deployed it across millions of patients in the claims database, identifying strong candidates for genetic screening.

Human Phenotype Ontology Frequent Associations

The following MPS II associations are listed as "very frequent" or "frequent" by Human Phenotype Ontology

Very frequent

Frequent

Phenotype	ICD Group Model Feature(s)
Short stature, growth delay	Lack of expected normal physiological development in childhood
Macrocephaly, coarse facial features	Congenital malformations of skull and face bones
Frequent ear infections	Otitis media, Disorders of Eustachian tube
Conductive and sensorineural hearing impairment	Unspecified hearing loss, Conductive and sensorineural hearing loss
Sleep apnea	Sleep apnea
Abnormal heart / heart valve morphology	Nonrheumatic mitral valve disorders, Cardiac murmurs and other cardiac sounds
Umbilical hernia	Umbilical hernia
Hepatomegaly and splenomegaly	Hepatomegaly and splenomegaly

Very important feature

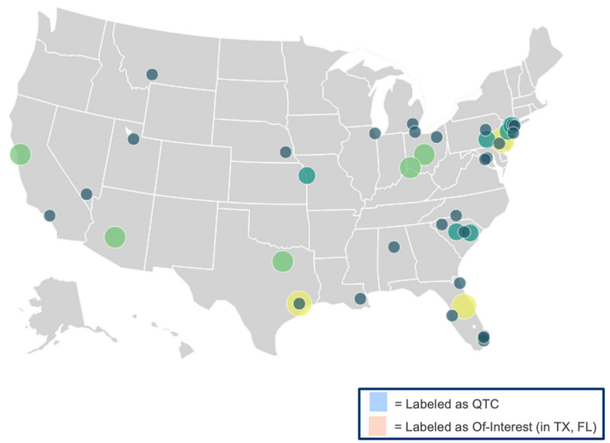
Important feature

Source: Human Phenotype Ontology

Top features from the designed predictive model align well with the human phenotype ontology associations for MPS II.

Top Overall Treating Hospitals

Hospitals are ranked by number of patients who were provided ERT or HSCT treatment for MPS II; Many treatment centers are located in the Northeast, South, and Southeast



Hospital	# of Patients	# of HCPs
Childrens Hospital of Philadelphia (AKA CHOP) (Philadelphia, PA)	4	4
Texas Childrens Hospital (Houston, TX)	4	3
Orlando Health Orlando Regional Medical Center (Orlando, FL)	4	1
Childrens Medical Center Dallas (Dallas, TX)	3	1
Phoenix Childrens Hospital (Phoenix, AZ)	3	3
Nationwide Childrens Hospital (Columbus, OH)	3	3
Cincinnati Childrens Burnet Campus (Cincinnati, OH)	3	3
UCSF Benioff Childrens Hospital Oakland (FKA Childrens Hospital & Research Center Oakland) (Oakland, CA)	3	1
Penn State Health Milton S Hershey Medical Center (Hershey, PA)	2	1
Hackensack University Medical Center (Hackensack, NJ)	2	1

Data Source: EVERSANA Open Claims (Jul 2018 - May 2023)

The top treatment centers across the country for MPS II patients based on patient volume and mapped referrals.

RESULTS

The results of this analysis revealed that median time to treatment for patients retained by the same provider from first diagnosis to first treatment was three months faster than those referred out. EVERSANA identified top providers and high-value treatment centers for retaining patients for diagnosis and treatment across six distinct regions, providing the client with top targets for its novel therapy.

The top features predicted by the model aligned with those reported in Human Phenotype Ontology, with metabolic disease literature and with results expected by expert clinicians. The model found an additional 11,000 patients who were recommended for confirmatory diagnosis with genetic testing and had not previously been diagnosed or treated with Elaprase.

EVERSANA is the leading provider of global commercialization services to the life sciences industry. The company's integrated solutions are rooted in the patient experience and span all stages of the product life cycle to deliver long-term, sustainable value for patients, providers, channel partners and payers. The company serves more than 650 organizations, including innovative start-ups and established pharmaceutical companies, to advance life sciences services for a healthier world. To learn more about EVERSANA, visit EVERSANA.COM or connect through LinkedIn and X.