



BRINGING ARTIFICIAL INTELLIGENCE TO HEALTHCARE: ENHANCING RISK MODELS TO PREDICT THE FUTURE COST OF CARE

***A new way of thinking about “risk” with
actionable insights and intelligent workflows***

WITH COMMENTARIES FROM

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PHIL FASANO, MBA, BS
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COMMENTARIES

“People are not averages. Innovaccer’s data-driven approach supports unprecedented accuracy in predictions of cost and quality. Their Data Activation Platform is the most comprehensive integration solution out there. It creates a true 360-degree view of the patient and enables care teams to focus on what matters most. A dream for years, real-time, personalized healthcare, is finally within grasp. All the data, about all the patients, all the time--for each patient, one at a time. This is the technology that can take every healthcare system into the future. Innovaccer is the future of healthcare!”

Phil Fasano is a sought-after Fortune 100 C-Level strategist, with essential experience as former CIO at both Kaiser Permanente and AIG. During his 8 years at Kaiser, Fasano oversaw the funding and implementation of the nation’s most extensive connected care network. Kaiser received numerous quality and technology awards under Mr. Fasano’s leadership, including four consecutive years for “100 Best Places to Work in IT” from Computerworld, as well as the coveted HIMSS Davies Award. With his unique combination of knowledge and experience in the healthcare and financial sectors, Mr. Fasano will be instrumental in assisting Innovaccer in the drive for revolutionary changes within the healthcare industry.



GLENN STEELE JR., MD, PhD
Vice Chair, Health Transformation Alliance,
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COMMENTARIES

“The transformation from volume to value requires innovative strategies for assessing risk and predicting outcomes. This innovation must be based on a solid data foundation and it’s encouraging to see Innovaccer’s data-driven approach being applied to an AI-based risk scoring model - something that can address one of the most pressing needs in healthcare today.”

Dr. Steele is the Vice Chair of the Health Transformation Alliance and former President and CEO of Geisinger Health System. During his 14-year tenure, Geisinger became the exemplar for high quality and well-organized delivery of care with unique degrees of integration between hospital and physicians, use of advanced information technology, and a relentless focus on the improvement of care. Dr. Steele sits on the Board of Directors for WellCare Health Plans, Ingenious Med, PTC Therapeutics, among others. As a member of Innovaccer’s Strategic Advisory Council, Dr. Steele helps guide Innovaccer’s mission to drive efficiency and value in the U.S. healthcare system.

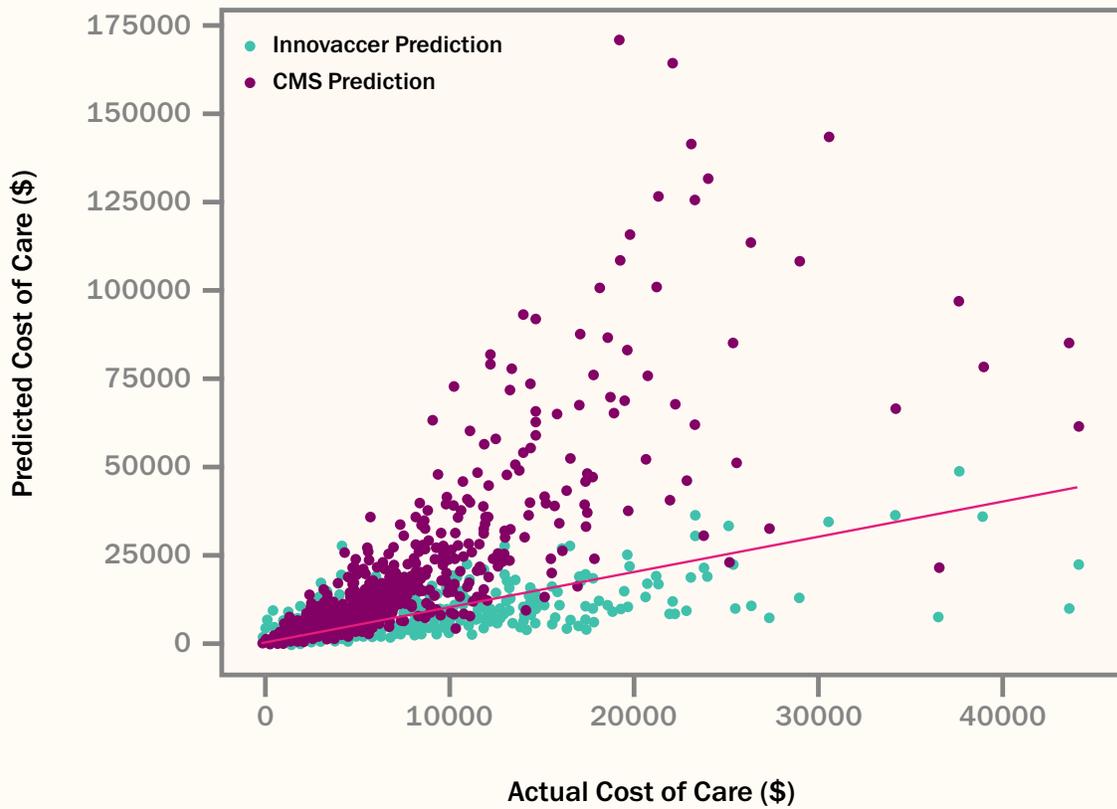
EXECUTIVE SUMMARY

The Centers for Medicare and Medicaid Services (CMS) is moving aggressively to shift healthcare payments from the traditional volume-based fee-for-service models towards value-based payment models. One of the goals of this ongoing transformation is to ensure continuous patient-centric care while taking in a long view of generalized patient trends and developing strategies to advance towards better health. Providers are required to provide the best quality of healthcare while ensuring they face a low risk.

Providers have been using the metric of risk scoring the population to estimate stratification of patients, health costs, number of ED visits, and many other outcomes to better manage the resources for enhanced outcomes in terms of quality of care. However, the organizations have struggled to predict the risk at an individual level, as the focus with the advent of value-based care requires better care at the patient level.

Traditionally, providers and health systems have relied on claims-based risk-models, such as the CMS-HCC, ACG, and DxCG, which were built to forecast the risk of populations but not for individual patients. These models give a fairly good estimation of the risk of the population, but exhibit poor estimation if used to predict the risk at an individual level.

Instead of relying solely on historical claims-based data for predicting the risk score of the patients, we can predict the future cost of care of a patient with much higher accuracy by integrating data from multiple sources such as EHRs, labs, pharmacy, and Social Determinants of Health by applying advanced machine learning techniques.



This research paper explores the basics of risk scoring and stratification, historical models of risk determination, and how cutting-edge ML techniques such as AI and advanced regression techniques are instrumental parts in the transformation to value-based care, from eliminating variations in care quality to ensure accurate reimbursements. Also, it highlights Innovaccer's approach in estimating the future cost of care based on past medical history, clinical and socio-economic data, and many other factors.

A DEFINING CHANGE IN PATIENT CARE

The shift from the fee-for-service paradigm to value-driven healthcare has been moving the traditional system of reimbursements and care provision, requiring providers to change the way they think about their patient population and how they leverage this information to make decisions. Instead of getting paid by the number of visits, tests, and procedures, providers are going to receive payment based on the value of care they deliver. This fundamental change in the structure of healthcare requires a more discrete approach to patient-centric care and leads the population towards health-first, preventive care.

A VALUE-DRIVEN PATIENT-CENTRIC CARE

With this value-based transition, many healthcare organizations are working on breaking down quality into different components and introducing initiatives aimed at enhancing the patient experience, improving population health, reducing the per capita cost of care, and ensuring the well-being of the care teams- widely known as the Quadruple Aim of Healthcare.



Quadruple Aim

In all essence, value-based care requires providers to improve the quality of care being provided to patients and improve the overall status of population health. While the two actions may require different sets of interventions and strategies, they both are the key representatives of the overall performance of the organization and its patients. Understanding and managing population health requires providers to identify, manage, and coordinate the care needs of their patients, and it begins with one patient at a time.

There could be as many strategies to manage population health as there are healthcare organizations, but there's no such thing as 'one size fits all.' Before providers deliver care, they need to have prior knowledge of who their patients are. Providing care in the value-based era requires providers to prioritize who needs the care first and how their problems can be addressed.

WHY IS RISK SCORING INSTRUMENTAL?

To put it simply, risk scoring is a standardized metric for the likelihood of a particular outcome that a patient can experience. Risk scores started in actuarial science, where they were widely used by healthcare insurance companies to anticipate the cost of covering their members. Estimating risk scores for non-actuarial purposes such as disease management or cost containment on the provider side of healthcare is fairly new- primarily shadowing care management. For actuarial purposes, payers are interested in moderating the risk of an entire population. On the other hand, for non-actuarial purposes, an accurate patient-specific risk is required.

With the estimation of future risk scores, healthcare providers can gauge the likelihood of outcomes such as the number of hospital admissions, emergency department visits, among others.

Healthcare organizations can greatly benefit by developing and assigning risk scores by examining large cohorts of patients with similar characteristics, observing key clinical and lifestyle metrics and using analytics to determine how these metrics impact the overall outcomes.

Often, 'risk scoring' and 'risk stratification' are two terms that are not well understood. Risk stratification is population-centric, dividing the population into cohorts based on individual risk, whereas risk scoring is a number attributed to the individual risk of the patient.

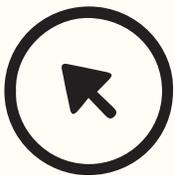
Risk scores, when attributed to the patient population, can be utilized for making contract decisions; whereas, when attributed to an individual patient, it can be used to predict the future liability at an individual scale. These risk scores can be utilized by the providers to estimate future liability in terms of cost, expenditure, and resource management.

Every year, nearly 18% of patients with rising risk jump into the high-risk category when not managed properly¹. This change in the risk score is due to the disparate trends in the health of the Medicare population. Identifying such patients whose risk is about to change becomes even more difficult if their symptoms are minimal and difficult to detect; Machine Learning can help detect such anomalies at a very minute scale due to the advantage of computer resilience to filter such rare events from the huge pool of training data.

CURRENT MODELS FOR CALCULATING THE RISK SCORE OF PATIENTS

Since the release of the Winkelman & Mehmud study in 2007², there have been considerable new entries into the risk scoring models segment. Several existing vendors have also increased the variety of models offered. One new development over the past decade has been the introduction of predictive models that aim to predict more than simple relative risk. For instance, some models now derive the probabilities of hospitalization and use them as an additional dependent variable for risk estimation.

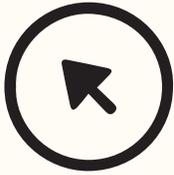
Some of the famous risk scoring models include²:



CMS-HCC (THE CENTERS OF MEDICARE AND MEDICAID SERVICES)

In order to calculate risks, The Centers for Medicare & Medicaid Services (CMS) uses a Hierarchical Condition Category (HCC) risk adjustment model. The Medicare CMS-HCC risk scoring model is specifically tailored for a Medicare population. The HCC model transforms diagnoses into categories to represent health conditions with similar problems pooled together. The categories are given a relative risk value based on how severe the health condition is, which is a proxy for health costs, as patients with higher risk scores cost more to Medicare.

The CMS-HCC risk adjustment model is retrospective. It uses “base-year” to predict the cost for the same year. Along with the diagnosis data, the factors considered include Medicaid eligibility status, gender, age, disability status, and whether the beneficiary lives in any community or institution or not.



ACG SYSTEM (JOHN HOPKINS UNIVERSITY)

The ACG System has concurrent and prospective models that predict the risk score of the patient based on the disease patterns derived from either the diagnostics, or the pharmaceutical codes, or sometimes both. This information is found in clinical and claims data.

The ACG model offers risk scoring and a range of clinical markers, such as markers for coordination of care or active treatment for specific disease categories, among many. This provides an additional context to the interpretation of risk scores.



CLINICAL RISK GROUPS (3M HEALTH INFORMATION SYSTEMS)

CRGs are a risk-classification system used for indicating the health status of individuals in an identified population. It relates the historical clinical and demographic characteristics of the patient, such as claims-based diagnosis, procedure, pharmaceutical, and functional health status, to the amount and type of healthcare resource that the patient will consume in the future. Additionally, CRGs can be linked to critical outcomes such as rates of potentially preventable readmissions and Emergency Department visits.



DxCG INTELLIGENCE (VERISK HEALTH)

Using predictive models, DxCG Intelligence turns healthcare data into risk scores for individual patients. Scores correlate with the cost of the underlying illness burden that individuals carry. Aggregating the scores of individuals with key attributes generates group-level predictive results that can be applied to answer questions fundamental to the ability to manage clinical and financial risks for an entire population or sub-population. Consisting of more than 100 models, DxCG Intelligence includes both concurrent and prospective variants. Models are grouped into three primary functional bundles— budgeting and underwriting, medical management, and performance assessment— which can be tailored for commercial, Medicare, and Medicaid populations.



HHS-HCC (THE CENTERS FOR MEDICARE AND MEDICAID SERVICES)

The HHS-HCC model was developed by CMS to normalize risk in the post-ACA commercial marketplace. The HHS-HCC model uses diagnoses and demographics to assign a risk score to each individual. There are separate models provided for infants, children, and adults, each of which reflects the specific contribution of particular conditions to risk for these groups. One unique aspect of the HHS-HCC model is that the model does not predict allowed costs, but rather predicts plan liability at each of the five ACA metal levels: platinum, gold, silver, bronze, and catastrophic. Because we measure accuracy in predicting total allowed costs in this study, we have used the HHS-HCC platinum model, as it represents the closest available proxy for allowed costs.

MACHINE LEARNING-DRIVEN APPROACH TO ADVANCE THE RISK SCORING METHODOLOGY

Traditionally, providers and health systems have relied on claims-based risk models, such as the CMS-HCC, ACG, and DxCG, which were built to forecast the risk of populations but not at an individual level. While these models give a fairly good estimation of the risk of the population, they exhibit unsatisfactory estimation if used to predict the risk at an individual level.

At Innovaccer, we have created a new risk scoring methodology which incorporates not only the historical claims data of the patients, but also the data from sources such as EHRs, labs, pharmacy, and Social Determinants of Health as its independent variables. This has brought many facets of the health picture of a patient to the model, starting at not only the prior medical conditions but also including the utilization behavior and the social lifestyle of the patients. By using advanced regression analysis, we have predicted the future cost of the patients with the coefficient of determination (R^2) varying between 0.5 to 0.65. The coefficient of determination is a measure of the closeness of the predicted values to the actual values. In other words, it depicts the accuracy of the risk scoring model. This future cost estimated by our model can be used as a proxy for gauging the risk at an individual level.

Innovaccer's model leverages advanced machine learning algorithms to adapt itself to the data and the goals of the user. The model analyzes data from multiple data sources including EHRs, social determinants of health, and claims data. The model performs a comprehensive analysis of social determinants of health and clinical history that are instrumental in identifying patients with high risk and predict their future cost of care.

A REVOLUTIONARY MODEL FOR PREDICTING THE FUTURE COST OF CARE

Innovaccer's proprietary technology for integrating healthcare data from different sources including EHR, claims, ADT, SDOH, pharmacy, lab, and many others allows us to use comprehensive and holistic patient data and patient-related data for our predictive models, thereby allowing us to predict the future health cost with greater accuracy that is unmatched in the industry.

After filtering, standardization, and normalization of data, we have used an ensemble of 6 different regression models including Lasso and Elastic regression models and 62 independent features to predict the future cost of a patient (dependent variable). Due to the use of varied regression models, our risk model is able to account for the outliers present in the data. We have also adjusted and made necessary transformations for non-linear distribution of variables such as resource utilization as well as the historical expenditures so that the regression ensemble can consume the data.

The data sets included in different risk scoring models are tabulated below*:

RISK SCORING METHODOLOGY	CONCURRENT MODEL	PROSPECTIVE MODEL
ACG System	Dx; Dx+Rx	Dx; Rx; Dx+Rx; Dx+Rx+\$
CRG (3M) System	Dx+Rx	Dx+Rx
DxCG System	Dx; Rx	Dx; Rx; Dx+Rx+\$
CMS-HCC and HHS-HCC	Dx	-
Innovaccer model	Dx+Rx+\$	Dx+Rx+\$

*Each figure has different value:

- Dx = Diagnosis data only
- Rx = Pharmacy data only
- Dx+Rx = Diagnoses and Pharmacy data
- Dx+Rx+\$ = Diagnoses and Pharmacy data along with prior cost

WEIGHTED REGRESSION TECHNIQUE TO ANALYZE THE DATA

Time plays a significant role in our analysis. In order to predict the right outcomes in the upcoming year, we need to have a clear view of what happened with the patient in the past. Innovaccer's model takes into account the past years' cost, utilization, and diagnosis data to help the model understand the patient's condition in depth.

As it is a well-known fact that health conditions adjacent to the targeted period have a higher correlation than the past, we have given weighted considerations to these values to supply this vital information into the model, elevating the predictive power of the methodology.

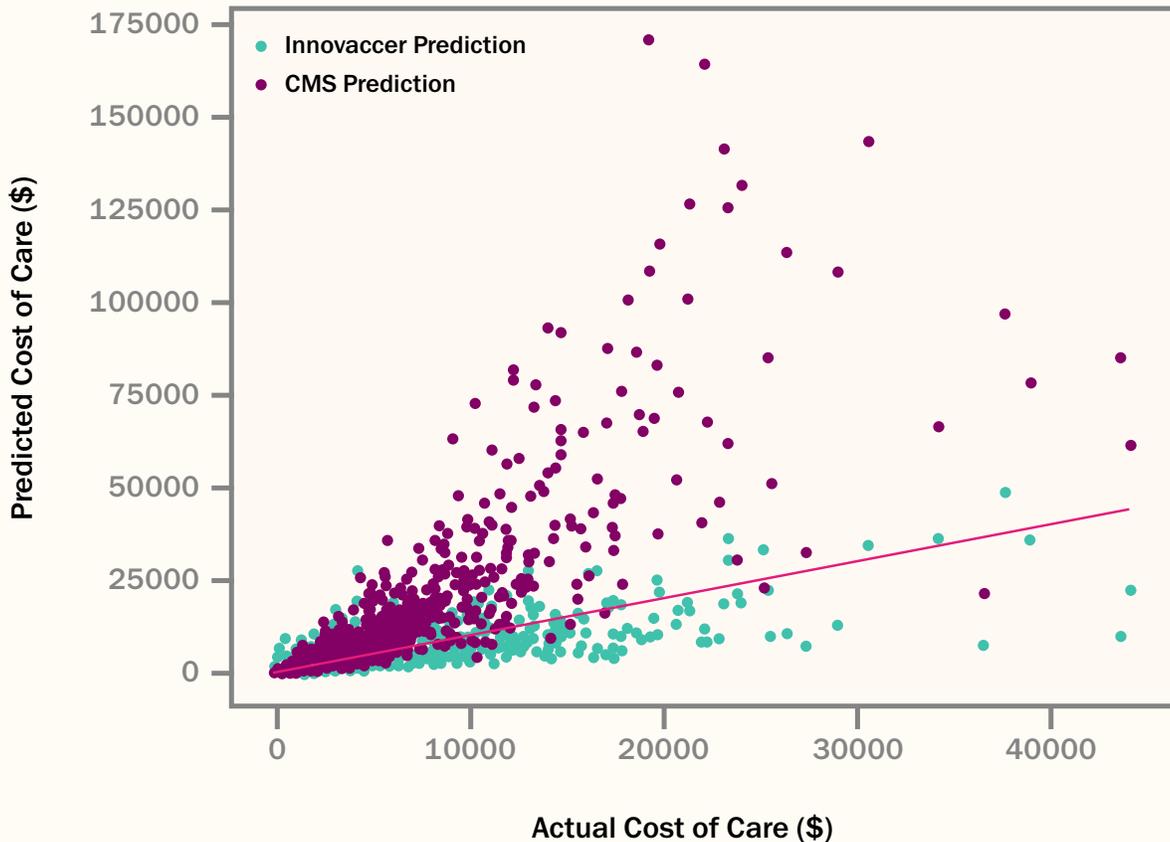
Another factor that we took into account was the inflation factor for the estimation, as past health costs cannot be directly correlated with the current cost as expenses vary across time. Since the model is generalized in nature and can be used to predict the cost of the patients across the US, we have also taken into account the demographic location of the patient and made necessary adjustments in the cost of the expenditure to reflect this vital piece of information to the model.

The 62 independent variables used in the model can be summarized into groups as shown below:

- Patient's medical condition and disease
- Past clinical performance for every month
- The frequency of lab tests and other diagnoses
- Inflation rate and the value of the dollar in a particular year
- Demographic adjustment of patients
- The socio-economic condition of the patient and his/her surroundings

THE VALUE THAT INNOVACCR'S MODEL BRINGS TO THE TABLE

Using high-quality data and advanced predictive models, we have been able to estimate the patient's cost-of-care for the upcoming year with much higher accuracy than the CMS model, which can be a substitute for risk scores.



The plot above shows the actual cost vs. the predicted cost for ~8000 patients calculated using the CMS-HCC models (in red) and Innovaccer's model (in blue). Here, cost refers to the overall expenditure incurred by an individual patient in a given financial year.

While both of the models perform equally well for patients with low cost, the CMS-HCC model exhibits low performance for patients with higher cost. On the contrary, the predicted cost by Innovaccer's proprietary model aligns well with the actual cost of care for these patients. Significantly, while the R^2 of the CMS-HCC model is 0.12, the model of Innovaccer is five times more accurate with an R^2 of 0.61 in the case of the prospective model.

In order to gain a clear understanding of Innovaccer's model accuracy and its comparative analysis against other existing models, we can compare them on the basis of the Coefficient of Determination (R^2). The higher the value of R^2 , the higher the accuracy will be for the model in predicting the future cost of care.

CONCURRENT MODELS (DX, RX, DX+RX)*

RISK SCORING METHODOLOGY	COEFFICIENT OF DETERMINATION (R ²)
ACG System	44%
CMS-HCC	12%
DxCG System	53.2%
HHS-HCC	42.2%
CRG	42.2%
Innovaccer model	52.0%

PROSPECTIVE MODELS (DX, RX, DX+RX, DX+RX+\$)*

RISK SCORING METHODOLOGY	COEFFICIENT OF DETERMINATION (R ²)
ACG System	17.8%
DxCG System	24.7%
CRG	16.8%
Innovaccer model	61.2%

*Each figure has different value:

- Dx= Diagnoses data only
- Rx= Pharmacy data only
- Dx+Rx= Diagnoses and Pharmacy data
- Dx+Rx+\$= Diagnoses and Pharmacy data along with prior cost

MOVING FORWARD WITH THE PREDICTION OF THE FUTURE COST OF CARE AND DELIVERING PATIENT-LEVEL INSIGHTS

With our unique ability to integrate clinical, claims, and other pertinent data from multiple sources across different EMR vendors and payers, we have built robust algorithms to accurately predict the future liability of a patient using a total of 62 cost and utilization features. By the generation of utilization and cost features from the past years' health data, our proprietary algorithm estimates the patient's cost-of-care for the upcoming year. The predictive model can thus help in stratifying patients for immediate care interventions and makes cost reduction easier and outcome-related, as the organization becomes aware of precisely what to improve on and how to improve it.

- **BETTER STRATIFICATION OF PATIENTS FOR CARE MANAGEMENT AND OUTREACH**

With better insight into the risk of individual patients and their future cost of care, we can segregate patients better based on their risk scores. With Innovaccer's model of predicting the future cost of care, providers can have a clear understanding of the clinical and non-clinical utilization of the patient, and can drive better interventions to scale up the care management processes.

- **BETTER IDENTIFICATION OF PATIENTS WITH FUTURE LIABILITIES**

Once we are able to identify the high-risk patients who will have a higher future cost of care, we can segregate them from the rest of the patient population. Care teams can then target this segment of patients in a more holistic manner and devise separate care plans for them.

Healthcare is exploring the use of new domains of data such as the social determinants of health as well as behavioral data from patients, which not only affect the patient's health, but can also turn out to be extremely useful in predicting the patient's vulnerability to non-clinical elements. With the rise of these datasets, we can enhance the predictability of the model to depict the future cost of care more clearly and accurately.

A DATA ACTIVATION PLATFORM TO POWER BETTER ANALYTICAL UNDERSTANDING IN THE NETWORK

Predicting the future cost of care requires an advanced analytics approach to population health management. In order to analyze the patient population, it is important that these analyses are powered by the right set of data. A data activation platform can incorporate multiple data sources to deliver clean, structured sets and can easily provide the diagnoses, pharmacy, and other data sets required to conduct predictive analytics. Different entities can use foundational analytics to better understand their networks, identify gaps in care, study the state of population health, and learn about the growth opportunities in their regions.

Innovaccer's Data Activation Platform has been purpose-built for righting the wrongs of healthcare technology by enabling a true connection across multiple data sets including the social determinant data, pharmacy data, claims data, and many more. With its 200+ automatic connectors, to its widely used healthcare data systems and applications, the platform enables rapid data ingestion and integration for a high-performance orchestration layer. The Data Activation Platform harmonizes disparate data sources into unique, longitudinal Patient-360 records which are exchanged via industry-governed standards. The platform ensures that providers don't make decisions based on an incomplete view of the patient, and reaches beyond the EHR and clinical data and provides healthcare providers with the right sets of data that can power smart clinical interventions, helping them to analyze the curve of patients' future cost of care.

The logo for Ingraph, featuring the word "ingraph" in a bold, lowercase sans-serif font. The "in" is in a light green color, and "graph" is in black.

Smart, AI-assisted
Care Management Solution

The logo for Innote, featuring the word "innote" in a bold, lowercase sans-serif font. The "in" is in a light green color, and "note" is in black.

Industry's Most Powerful Analytics Tool for
Population Health Management

The logo for Incare, featuring the word "incare" in a bold, lowercase sans-serif font. The "in" is in a light blue color, and "care" is in black.

Point-of-care Assistant for
Physician Engagement

The logo for Inconnect, featuring the word "inconnect" in a bold, lowercase sans-serif font. The "in" is in a light orange color, and "connect" is in black.

One-stop
Patient Engagement Solution

In order to provide a holistic and “intelligent” healthcare system, the following solutions are built on and available with Innovaccer’s Data Activation Platform:

- **INCARE:**

Smart, AI-assisted care management solution, with PCMH level care delivery, hardcoded into the workflow. InCare streamlines the care management process enabling care management systems, therefore, programs to scale at lower costs and with higher quality.

- **INGRAPH:**

InGraph is the most intuitive healthcare analytics offering for population management health strategies in the industry with over 800+ measures to track network performance and outcomes, customizable measures and dashboards accessible across the network, and automated reporting on quality measures.

- **INNOTE:**

A smart, lightweight physician’s digital assistant that surfaces critical system and population health insights derived from multiple data sources at the point of care. Using InNote, insights such as care gaps, dropped codes, process measures and referrals information can be shared with the clinician - without the provider having to leave the EHR experience.

- **INCONNECT:**

An automated analytics-driven patient engagement solution to scale patient outreach workflow and bring patients closer to the care team.

CONCLUSION

In an industry as vital as healthcare, the ability to predict potential future liabilities more accurately at an individual patient level is like gold - be it a reduction in disease outcomes, the cost of care, or even the ability to better leverage new technology trends that the future will bring us. Considering the present-day environment, the ability to predict the future costs of care, out of everything, could really change the way we approach healthcare in significant ways. As healthcare continues to put the quality of care at the forefront, predicting the cost of care for every single patient would be a huge advancement. The possibility of predicting the future has always intrigued us. What seemed like a dream some time ago has finally been made possible by combining data, technology and an evidence-based approach. From helping providers easily leverage data-driven insights to more specifically targeting patient-specific needs to projecting the cost of care, predictive analytics can significantly change the dynamics of healthcare. All that's needed is the training of data. We now have access to huge troves of data, we have the knowledge and potential, and most important of all, we have the technology and ability to scale. Done well, the result can be affordable, quality care finally realized.



ABOUT INNOVACER

Innovaccer Inc. is a leading healthcare data activation company making a powerful and enduring difference in the way care is delivered. Innovaccer's aim is to make full use of all the data our industry has worked so hard to collect by righting the wrongs, doing away with long-standing problems and replacing them with ideal solutions. The Gartner and KLAS-recognized products have been deployed all over the US across more than 500 locations, letting over 10,000 providers transform care delivery and work as one. The data activation platform has been delivering value to several institutions, governmental organizations, and several corporate enterprises such as Mercy ACO, StratiFi Health, UniNet Healthcare Network, Catalyst Health Network, Hartford Healthcare, and Osler Health Network. Innovaccer is based in San Francisco and has offices all over the United States and Asia.

For more updates, visit www.innovaccer.com.

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