We have witnessed a major paradigm shift in healthcare information management over the past decade, instigated by the birth of electronic medical records and medical informatics. This new world of electronically entered, stored, and exchanged medical information has addressed many of the shortfalls of the world of folders and paper medical records.

This shift in information management is ongoing, accompanying the new focus on accountable, affordable, high quality and patient-centric healthcare. Caradigm’s population health management solutions and intelligence platform are focused on helping healthcare organizations embark upon this new era of medical services by leveraging analytics and big data.

Healthcare Analytics

According to PricewaterhouseCoopers, there are four stages of maturity in analytics; namely, getting access to data, gaining insights, making informed decisions and finally acting on those decisions. The latter three become increasingly important as healthcare organizations are subject to the clinical and financial risk within populations for which they are accountable, thus requiring special focus on making analytics actionable within workflows.

Healthcare Analytics Scenario

Before diving into the technical details, let’s consider an example of how healthcare analytics enables insights from data and then translates those insights to decisions and actions at the point of care. City Center Health System (CCHS) is a fictitious 5-hospital health system in the Seattle area. With the changes in healthcare reimbursement models, there is a set of key performance metrics that must be monitored and acted upon to ensure that CCHS’s set of hospitals are in compliance.

CCHS’s Healthcare Administrator Team monitors key performance metrics to gain insight and make decisions that initiate care quality improvement actions. The three metrics of interest are the 30-day readmissions rate, the number of hospital acquired conditions (HAC) per 1,000 patient discharges, and average length of stay (LOS) in the hospital. CCHS uses the Caradigm Intelligence Platform to aggregate and visualize data across all of its hospitals. The team notices that readmissions and HAC rates have gone from green to yellow to red, and LOS, a leading indicator, has gone from green to red.
Using interactive drill down (or “slice and dice”), the team can pin-point specific hospitals and medical conditions that are the leading cause and thus require intervention to improve the hospitals’ scores.

The frontline clinician, nurse or a clinical analyst is notified about the status of hospital acquired conditions. This individual turns to the HAC configurations available with Caradigm intelligence platform, e.g. CAUTI (catheter urinary tract infection) or SEPSIS, and Cohort Management Designer to easily identify these patients and further drill down and execute the enrollment action into care management programs to mitigate the identified high-risk issues.

As all of these events are taking place, on the back-end, clinical notes from CCHS hospitals are uploaded to a cloud-hosted data cluster. These notes are searched for mention of catheter insertion. Patients with catheters are flagged as being at risk of CAUTI. The big data integration and analytics, including readmission score computation leveraging predictive analytics, are all invisible to the user. Caradigm’s seamless integration of technologies, population health management, and analytics enable clinicians to gain insight from data and affect their actions through decision support.

### Technology Trends

Now that we have painted the picture of what is possible, let’s look at the current technology trends related to analytics and big data that are paving the way for accountable healthcare and services.

Gartner describes healthcare analytics as a rapidly emerging phenomenon with huge future potential. Healthcare is starting to catch up with other industries in its demand for more performance analytics and advanced data mining techniques. Analytics is all about gaining insights from data to make informed decisions. Organizations across the globe are now using data-driven insights for clinical, financial and operational excellence. Analytics is now front and center for HIMSS (Healthcare Information and Management Systems Society), which describes healthcare analytics as the “systematic use of data and related clinical and business insights developed through applied analytical disciplines such as statistical, contextual, quantitative, predictive, and cognitive spectrums to drive fact-based decision making for planning, management, measurement and learning.”

In addition to analytics, adoption of big data continues to grow steadily in healthcare, fueled by the digital explosion of structured and non-structured data. We are reaching a tipping point where hype is now being replaced by successful adoption stories. We’re also seeing the emergence of an ecosystem that extends the capabilities of the core big data systems focused on Hadoop, a framework that supports the processing of large data sets in a distributed computing environment. SQL-like capabilities with real-time processing are now available on top of Hadoop. Coupled with natural language processing (NLP), this enables finding the “needle in the haystack” in unstructured data.

How is Caradigm leveraging these two technology trends? To answer this question we must take a closer look at what Caradigm offers in terms of platform services and healthcare analytics.

### Caradigm Intelligence Platform

Unlike many other healthcare solution providers, Caradigm offers a suite of solutions for population health management and healthcare analytics that are powered by a data intelligence platform. This suite of solutions enables transformation of data into insights that drive actions through decision support.

Some of the key building blocks of the Caradigm Intelligence Platform (CIP) are:

- **Data** – Ingesting healthcare related data from a variety of federated data sources,
- **Insight** – Defining a semantic entity model over data that leverages clinical terminology,
- **Decisions** – Facilitating decision support based on rules as well as healthcare analytics, and
- **Actions** – Aligning clinical workflows, decisions, and financial incentives.

### Turning Data into Insight

Healthcare data come in various formats and from disparate source systems. There exists a need for disparate data to be aggregated and abstracted in order for applications to glean the desired insight. CIP can take data from electronic medical records (EMRs), health information exchanges (HIEs), lab systems, claim systems as well as other systems and store the data in one central location.

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An enterprise data warehouse (EDW) is a structured data store typically used for retrospective reporting. CIP can ingest data from an EDW as well as export data to it. While traditional EDW systems typically update weekly or monthly, CIP will ingest, tune, aggregate and make data available in near real-time.

Hadoop is an open source system that supports data-intensive distributed applications. It is often used to query large unstructured data sets. Hadoop lacks an entity modeling layer and is not a realtime system. Queries to Hadoop-based databases such as Hive or Casandra are translated into MapReduce jobs and then executed to crunch through massive amount of data. CIP can upload data to Hadoop as well as extract and ingest results from Hadoop queries.

CIP transforms data into insight through:

- **Near Real-time Aggregation** – CIP aggregates and transforms disparate healthcare data from a multitude of sources including EMRs, HIEs, EDWs and Hadoop with NLP over unstructured and semi-structured big data.
- **Semantic Tagging** – CIP uses terminology to add meaning to data.
- **Semantic Modeling** – CIP applies semantic modeling to create intuitive and meaningful healthcare concepts (aka healthcare entities).

This set of common healthcare concepts is a unique differentiator for Caradigm solutions and a significant breakthrough in analytics applications. It abstracts solutions from the complexity and fluidity of data. Entities enable applications to be portable across different healthcare organizations, hence decoupling these solutions from the actual data source and its schema. Additionally, unlike traditional EDWs or most analytics apps, CIP allows you to read and write actions, making it a powerful tool for deriving actionable analytics.

**Leveraging Insights for Decisions**

Healthcare data analytics facilitates decision making based on insight gleaned from data. Healthcare analytics falls under four main categories:

- **Retrospective Analytics** provide historical insight into what happened in the form of reports, dashboards and key indicators;
- **Diagnostic Analytics** provide insight into why an event happened through ad hoc queries, outlier detection, segmentation, relationship traversal, and association;
- **Predictive Analytics** provide foresight into what will or could happen through risk modeling and assessment on potential factors with hypothesis testing; and
- **Prescriptive Analytics** provide decision support, process optimization, and eventually automation.

To illustrate how analytics is applied to healthcare, consider these two common examples. The score depicting the likelihood of readmission of a discharged patient in 30 days is computed using predictive analytics. The average length of stay, however, is computed using retrospective analytics.
CIP’s Cohort Management Designer (CMD) enables visualization of computed data as well as ingested and aggregated data. One of the key features of CMD is enabling clinicians to define a patient list based on one or more potentially complex criteria across multiple entities spanning clinical, financial, utilization, assets, location, and care management data. In essence, CMD is a diagnostic analytical tool specifically designed for clinicians, requiring little or no understanding of relational models or language syntax. CMD leverages both retrospective and predictive analytics.

In addition, CMD boasts built-in support for analytic visualization using graphs, charts, and reporting controls as part of its multipatient and single patient views. Cohorts defined using CMD can be accessed by advanced data trend and key performance indicator (KPI) visualization tools such as power view, power pivot, SSRS, Excel, and several other charting and business intelligence (BI) tools.

**Decision Support Driving Actions**

Decision support in CIP is enabled using prescriptive analytics such as clinical rules, events, and data visualization. Reports and dashboards enable users to view and act on multiple KPIs. In addition, predictive analytics enable users to forecast future events using various models and what-if analyses, and help clinicians make decisions about enrolling patients in care management programs. Proactive and reactive mitigation actions in CIP make use of decision support for plan of care processes and procedures. Actions and workflows can be custom-tailored to the specific needs of the individual patient or financial conditions.
In addition to CIP and CMD, Caradigm offers analytics applications and solutions that span reporting, surveillance, disease management, and population health management.

**Reporting Applications**
Caradigm’s planned reporting applications will track and report regulatory quality measures and KPIs that would help transform care quality and service line performance. These applications will include:

- Population Analytics to aggregate and correlate clinical, financial, claims, and satisfaction data.
- Patient Flow Management to explore operational efficiency against benchmarks by unit, service line, or staffing.
- Quality Improvement to calculate and report measures for VBP, ACO, HEDIS, and STAR.

**Surveillance Applications**
Caradigm’s planned surveillance applications will identify patients at risk for hospital acquired conditions (HACs) and other adverse events, and readmissions. These applications will facilitate timely interventions by clinicians to help improve quality of care and patient satisfaction while minimizing associated costs.

These applications will include:

- Care Transitions Management to identify patients at risk of readmission in near-real time using a predictive algorithm, optimize discharge planning, and manage/explore readmission rates.
- Hospital Acquired Conditions Management to help institutions manage existing HAC (including HAIs) rates and financial implications relative to national benchmarks and targets, facilitate root cause analysis, and submit regulatory reports.

**Disease Management Applications**
Caradigm’s planned disease management applications will be used by clinicians to identify and manage patients with chronic diseases and conditions across the continuum of care. Some of these diseases include Congestive Heart Failure, Coronary Heart Disease, COPD/Asthma, Diabetes, Osteoarthritis, and Cancer.

**Population Health Solutions**
Caradigm’s existing and planned population health solutions help organizations understand clinical and financial risk within patient populations for which they are accountable. This insight helps them to manage that risk across the continuum of care to achieve targeted patient outcomes and financial results. These applications include Risk Management and Care Management, as well as plans for Utilization Cost Management, and Wellness Management.

Caradigm Care Management leverages aggregated information to help organizations identify candidates for program enrollment and enables care managers to assess individual patient conditions, personalize a plan of care and manage that plan across the community.

**Caradigm Analytics Vision**
Current technology trends encompassing big data, analytics, and cloud computing are paving the way for another paradigm shift in healthcare to enable accountable quality healthcare and services.

Caradigm’s analytics vision is focused on enabling clinical analysts to derive insight from data and drive actions through decision support. The Caradigm Intelligence Platform and Cohort Management Designer are tools designed to enable the clinical analyst to realize this vision; however, tools alone are not sufficient.

Caradigm’s growing portfolio of population health management solutions builds upon the raw power of CIP and CMD, allowing healthcare organizations to transform data into insights, and insights into decisions and actions, reaping the benefits of this vision.

By leveraging analytics and big data technologies, Caradigm’s combination of population health management solutions and intelligence platform will enable healthcare providers to embark upon the new era of accountable quality healthcare and services.
About The Author

Prior to joining Caradigm as Vice President of Engineering, Hamid held various technical leadership positions at Microsoft and IBM focusing on analytics, big data, distributed large-scale system monitoring and management, and relational database engines. Hamid has published more than 38 articles and submitted 17 patent applications. Hamid’s technical contributions have earned him 22 special recognitions awards including the prestigious IBM CTRE award for outstanding technical achievement and Microsoft’s SQL Server special innovation award.

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