Clinical & Business Intelligence: An Analytics Executive Review
Industry Capabilities – Available Tools, How & Where Applied
February 2013

Introduction

Healthcare analytics is the systematic use of data and related clinical and business (C&B) 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. It involves application of statistical tools and techniques to understand historical patterns within previously collected data (structured and unstructured), with the goal of improving operational performance.   Analytics may be descriptive, retrospective, predictive or prescriptive.

Healthcare analytics are used for business decision making, as well as medical practice decision making. For example, healthcare organizations may use data analytics to evaluate alternative treatments. The outcomes of such analysis may reveal which treatment works best, disease patterns, patients at high risk, or evaluate the performance of individual physicians. Analytics capabilities include real time methods that support rapid turn-around decision making; for instance, clinical decision support software with active knowledge systems use two or more characteristics found within patient data to generate case-specific advice. On the other hand, batch analytics explore a large set of previously collected data such as patient records and claims data from an insured population to help in predictive modeling and cost control measures.

Rapidly expanding, the healthcare analytics market has an estimated growth rate for 2012 to 2017 of 23.7%.[1] Healthcare analytics, including traditional business intelligence (BI) methods and emerging capabilities for clinical intelligence (CI), are used for a range of functions from suggesting the most accurate diagnoses, cost reduction, fraud prevention, revenue generation, and service improvement to real-time view of the business. Healthcare analytic markets by applications embrace clinical, financial, predictive modeling, operational and administrative, and research niches. While there are

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[1] Healthcare Analytics/Medical Analytics Market – Trends & Global Forecasts to 2017. *Research and Markets*. December 2012. http://www.researchandmarkets.com/reports/2328868/healthcare_analyticsmedical_analytics_market#description

many solutions for employee health, hospital and health systems, medical devices, physician practices, extended care, individuals and families, pharmacies and research, only 33% of healthcare organizations are using BI.[2] Still, the following areas are receiving high awareness because of the American Recovery and Reinvestment Act of 2009 (ARRA), which offers incentives for hospitals and physicians who adopt technology and document related to patient safety, coordination, and quality of care:[3]

- Enterprise analytics
- Predictive analytics
- Accountable care organization analytics
- Healthcare integration/data warehousing
- Population health

Reference Model

The information technology (IT) industry has many vendors who provide tools and solutions for healthcare analytics. One useful way of understanding the various ways vendors can contribute to healthcare analytics is to consider a reference model of the capabilities typically needed. Consider the following reference model as an example of the various components of a healthcare analytics solution:

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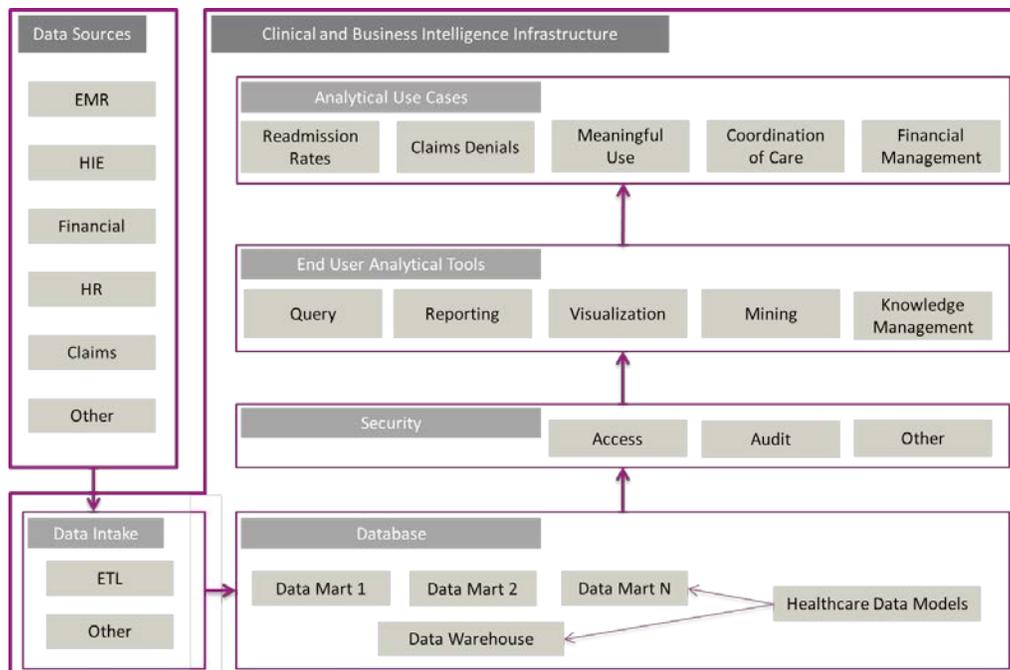
[2] Roney K. 33% of Healthcare Organizations Don't Use Business Intelligence Tools. *Becker's Hospital Review*. October 31, 2012. http://www.beckershospitalreview.com/news-analysis/33-of-healthcare-organizations-dont-use-business-intelligence-tools.html
[3] *Ibid.*

Any healthcare organization considering building out healthcare analytics solution will need to consider all of these components and more depending on the specific use case. Healthcare IT industry vendors will be able to contribute in various ways and the healthcare organization can either rely on those vendors or build their own internal capabilities to complete a solution. As a reference model there may be other domains to consider not pictured above, such as normalization of codes during data ingestion or integration with an internal Enterprise Master Patient Index (EMPI) source. Regardless, this high level view can still be a useful starting roadmap for organizations considering their journey into healthcare analytics.

An organization may implement part or whole of this model depending on the approach. For example, in a completely outsourced model, the organization might provide data to an external analytics vendor and receive reports in return. For that organization, the only relevant part of the reference model would be the various data sources provided to the vendor for integration with the overall architecture. Other organizations wanting to develop their own use cases internally might build out all of this infrastructure (and more).

The reference model consists of the following components:

- **Data Sources**
  - There is an abundance of data available in the organization which usually resides in a number of 'transactional' systems. Transactional systems are designed for the various aspects of running day to day operations. These systems are the originators of data for analytics and while it is possible to run reports right out of the transactional systems, most organizations will eventually move to some sort of data warehouse structure as depicted above.
- **Data Intake**
  - In order to analyze the data from the transactional systems, the data must be ingested into the warehouse. This capability is typically referred to as 'Extract – Transform – Load' or 'ETL' and is the process of taking selected transactional data (both structured and unstructured) into the warehouse into an organized form.
- **Database**
  - As the data are ingested, they are stored into a database of some type. Traditionally, this storage is typically some sort of relational database (RDBMS), but as data volume and ingestion speeds increase, non-relational data repositories are being deployed.
  - The databases that store the data often are referred to by different labels for their usages ranging from data warehouses, to data marts, to operational data stores. In this paper, 'repository' refers generically to these different usages.
  - Finally, the configuration of the data in the databases follows some sort of 'data model' that governs how the data are organized internally. Typically data models are

specific to the industry and problem area being studied, thus the need for 'healthcare data models.'

- **Security**
  - o The healthcare industry has very formal definitions around the security and privacy of data. Any healthcare analytics solution needs to provide the security layer in order to protect the data in the warehouse. Some of the security capabilities could include the following:
    - ▪ 'Access' is defined to be the capabilities surrounding the login authority to gain access to the data. Audit includes services that track who has accessed what data. Finally, 'Other' services may include facilities such as encryption and/or de-identification of data.
- **End User Analytical Tools**
  - o Users will have various tools to work with data residing in the warehouse. Sophisticated users will have access to tools such as data mining, while less sophisticated users might see the data through portals using pre-defined dashboards. These tools can be used by the organization to supplement the vendor-supplied solutions, or for the organization to develop its own solutions.
- **Analytical Use Cases**
  - o Most importantly are the real-world analytical use cases, from which the organization derives (clinical and business) value and return on investment (ROI). Some of that value might be determined from simple direct exploration of the data. Typically analyses congregate around various business/clinical problem areas, and analytical solutions are purpose built for these areas.

In the sections that follow, this reference model outline is further described in detail. Given the value to an organization accrues from the use cases, this area is the first to be discussed. The remaining components of the reference model, which are intended to support the use cases, are described in 'Technical Infrastructure' section.

Use Cases: User Communities and Analytics Capabilities[4]

In healthcare integration, a clinical and business intelligence (C&BI) product can leverage insights enabled by the clinical detail in electronic health records (EHRs) – combined with financial and operational data – to allow the provider to manage risk, reduce cost, and ensure best practices and measure outcomes. Analytic systems also may have access to healthcare data models, such as the

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[4] These strategic decisions, which cut across the entire enterprise, fall under one category of user critical needs to address with business and clinical analytics capabilities. For other examples of use needs, see the *Needs Assessment* and *Building a Business Case* modules at www.himss.org/ClinBusIntel.

Patient-Centered Medical Home (PCMH) or the Accountable Care Organization (ACO). Moreover, these systems include healthcare dashboards and metrics that present and evaluate the effectiveness of data warehouse programs.

Enterprise Systems

Enterprise C&BI products provide a platform for delivering clinical, financial, and operational information across departments, service lines, episodes, and patients to improve patient care and operational efficiency.

C&BI capabilities and related applications/tools may offer solutions to help healthcare providers achieve Meaningful Use, and transform into ACOs by turning financial, clinical, and administrative data into information that clinicians, staff, and administrators need for evidence-based decision-making. Solutions may include clinical and quality outcomes, claims and payment integrity, care coordination and enhancement.

For hospital systems, C&BI products can be used in self-serve ad hoc queries and enterprise-wide modeling and analysis projects, such as:

- Reducing venous thromboembolic events
- Reducing congestive heart failure readmissions
- Hospital readmission monitoring
- Disease coordination views
- Length of stay monitoring
- Pharmacy IV to PO
- Nursing documentation dashboard

For instance, a clinical intelligence product can enable the user to look at data in real-time to reduce venous thromboembolic events. Moreover, such analytic features support the identification and suggestion of appropriate patient therapy to avoid adverse outcomes, such as:

(1) taking the first step to identify the patients at risk for DVT,
(2) presenting the data in timely views that allow staff to see which patients are high risk or low risk, and finally
(3) determining whether the appropriate level of prophylaxis has been provided. Resulting impact from using such analytic findings has shown to decrease VTE incidences and increase DVTY prophylaxis.

Another example involves analytics that support a reduction in congestive heart failure (CHF) readmissions. Clinical users would benefit from the use of effective C&BI products that can:

(1) assess the number of patients with CHF readmitted to the hospital,
(2) identify patients on multiple medications,
(3) present the data in timely views that allow discharge nurse to view the list of current CHF patients, and finally
(4) allow the discharge nurse to provide targeted patient education and follow-up care.

The impact of such C&BI products has shown an increase in the ability to identify at-risk patients, a decrease in CHF readmissions and gained patient satisfaction.

Some further examples of hospital functions requiring analytics would be:

- Revenue Cycle
- Clinical Quality and Outcomes
- Patient/Customer Satisfaction
- Chronic Care/Disease Registry/Population Management
- Marketing (to assess campaign ROI)
- Labor Management

Hospitals

Hospitals may use a clinical intelligence product to improve the value and effectiveness of their physician networks through data-driven engagement. They may gain from solutions to improve regulatory compliance, enhance physician network development, and enforce network referral management and physician network processes and protocols.

Some specific capabilities they may realize are the ability to do the following:

- Track hospital readmission rates to avoid or reduce CMS penalties
- Track Medicaid and insurance claim denials trends
- Track Meaningful Use metrics
- Improve workflow and coordination of care across service lines and departments
- Improve financial management and reporting, revenue cycle, budgeting, and planning
- See key performance indicators across service lines and departments

Providers

For individual healthcare providers, analytics may assist them in taking steps to adopt an ACO model or satisfy Centers for Medicare and Medicaid Services (CMS) requirements to avoid reimbursement penalties, and/or solutions to identify and reduce the occurrences of Potentially Preventable Events (PPEs), such as offering tools focused on the following:[5]

- Readmissions Management
- Chronic Disease Detection
- Inpatient Length of Stay Management
- At Risk Population Detection,
- Hospital Acquired Condition Prevention
- Healthcare Plans

Other analytic solutions may offer tools to identify patient populations, manage costs and promote wellness. Example tools include:[6]

- Chronic Care Management
- Tailored Benefit Design
- Wellness Program Management
- Disease Detection & Early Intervention

The pressure for efficiency and quality patient care is increasing; making fast, dynamic reporting and analysis a competitive edge that may make or break an organization.   Silo reporting systems represent barriers to current healthcare management demands. For an example, if a provider is involved in an ACO, he/she needs pertinent information regarding the following questions:

- Which patients are at risk of readmitting within 30 days of discharge?
- What is each patient's expected length of stay?

Life Sciences

Life science companies may use a clinical intelligence product to improve the value and effectiveness of their physician networks through data-driven engagement. In the pharmaceutical area, to build a significant market share in an expanding and competitive drug market, pharmaceutical companies

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[5] Predixion Software. Predixion on Healthcare. Accessed February 19, 2013.
http://www.predixionsoftware.com/predixion/Solutions/Healthcare.aspx
[6] *Ibid.*

need information management solutions that allow them to make better business decisions, thereby, achieving revenue growth.

In an increasingly competitive market, pharmaceutical companies can use BI to grow by:

- Improving product development
- Enhancing go-to-market strategies
- Increase operational performance
- Optimizing their supply chains
- Regulatory compliance
- Drive revenue and market share

Technical Infrastructure[7]

The landscape

The current competitive landscape for BI vendors in the healthcare industry is diverse, consisting of players with varying technology portfolios and market approaches. Some vendors provide organizations with horizontal BI tools to integrate, analyze, report and measure performance data, while other vendors offer development environments (platforms). Furthermore, some vendors supply a full suite of C&BI tools while others specialize in one or two technology areas, such as reporting or predictive analytics. Therefore, organizations can build healthcare analytics capacity suited to their unique needs, whether custom-built or commodity solutions.

Reference model considerations

As described above, there are several different domains that will need to be investigated in order for an organization to build out healthcare analytics. Expanding on the components of the reference model discussed above, the following thoughts are offered when an organization is considering building the infrastructure:

- **Data Ingestion**
  - Typically provided by the vendor of the database itself. Data ingestion tools (ETL) will 'scrub' the data being ingested into the data warehouse database.

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[7] For further information about data infrastructure, see *End-to-End Data Management Process*, HIMSS February 2013 at www.himss.org/ClinBusIntel.

- Data can come from a variety of sources. Warehouses in the healthcare industry might ingest data from an EMR transactional system, from perhaps a Health Information Exchange (HIE), or even a stand-alone spreadsheet file. A priori identification of the required data sources will help determine what sort of data ingestion tooling is required.

- **Database**
  - Theoretically, the database for a data warehouse could be any type of database but today most organizations settle on using a relational database management system (RDBMS). There are many choices for RDBMS systems and there are a few very large vendors of RDBMS systems. As data volumes and ingestion rates increase, non-relational data management tools, used today in transactional finance and national security intelligence applications, are emerging as healthcare implementations.
  - Data models are needed to know how to organize the data in the database. The use cases for analytics and the user's needs drive data organization decisions. Data models can be purchased from vendors or can also be developed in house by organizations.
  - Using the underlying database technology, organizations will build out the various repositories that are used for healthcare analytics. Some of the more popular terms for the repository types include:
    - **Data Warehouse**
      - The 'data warehouse' is typically where an organization will store all of their aggregated healthcare analytic data. In a smaller organization this may be the only analytic database while in larger organization this might be one of several.
    - **Data Mart**
      - Large organizations may also set up 'Data Marts.' Data Marts are usually used to serve the purpose of one particular subject area because various technical issues (data model, usage scenarios) help justify having another repository. By doing so, Data Marts generally speed up end user reporting as the data in the Data Mart has already been organized for a subject area.
    - **Operational Data Store**
      - Large organizations might opt to have an Operational Data Store (ODS). An ODS usually serves the purpose of a central collection point of all incoming transactional data before being aggregated in the data warehouse.

- **Security**
    - Organizations which host their own infrastructure in the healthcare industry likely will already have security tools for other IT systems. The analytics solution ideally will integrate with some of that existing infrastructure so that a complete duplicate security infrastructure does not need to be built.
    - In the case where the analytics solution is hosted by an external vendor, security will likely be handled by the vendor, after the users identify which data are to be accessed and for what purposes.

- **Analytical Tools**
    - There are many types of analytical tools available to organizations building out analytical solutions. Some of these include:
        - **Query**
            - Query tools allow end users to explore the data warehouse without having to know deep technical details such as Structured Query Language (SQL).
        - **Reporting**
            - Reporting is like query except it generally refers to the ability to pull out structured reports on an automated basis. Those reports can be shared with users in a variety of ways such as through 'web portals.'
        - **Visualization**
            - Visualization allows users to see data in visual ways. In a healthcare context, for example, this could mean mapping out a disease outbreak on a geographical map so that hospital analysts can determine their potential exposure.
        - **Data Mining and Knowledge Discovery**
            - Mining includes a variety of methods to find deep relationships in the underlying data that would not be normally determined by casual user querying. Sophisticated querying, typically prescribed by automated methods, can return results across all available data fields, rather than the more constrained searches performed manually. Moreover, machine learning (ML) tools that are "trained" to work with structured (e.g., numeric, categorical) and unstructured (e.g., text, images) data can be used to discover patterns that likely would not have been considered (much less found) when performing a static query. Data can be fed into data mining / knowledge discovery tools for trends and predictions to be identified based on the data. As example, consider the detection of anomalous billing over time (e.g., fraud) and change in

treatment options executed across physician populations (improved quality of care).

- o Analytical tools can be purchased separately from the vendors of the databases or in the cases of very large analytics vendors, be purchased in conjunction with the database.

Organizations seeking to build out their healthcare analytical environments will need to solve the above infrastructure issues whether using internal or external capabilities. Combinations of these components can be selected both across vendors and within the organization to build out an analytical capability that matches the needs of the business. By doing so, the analytics can drive the value in the organization that will justify the expenditure.

Integrated Environments

With integrated environments supported by some vendors, repositories are extended to include patient portals, claims submission, Physician Quality Reporting System (PQRS) submission, Meaningful Use dashboards, care models, networking, preventative healthcare solutions, provider scoring, fraud detection cost containment and other use cases. When successful, such integration enables healthcare organizations to use analytics as a competitive edge or survival tool within the market. For example, hospitals may combine different products to get ultimate data aggregation, such as combining modular EHRs with a Clinical Repository to strategically transform care to:

- Aggregate data across a number of clinical systems,
- Leverage and integrate workflow process with dashboards and graphs
- See different views of single patient visit, group of test results, etc

Indeed, the scope of today's C&BI products, as well as the need for emerging and improving capabilities, is diverse in the healthcare industry. When utilized and developed to full capacity, effective analytics technology will be a driver in the Department of Health and Human Services Office of the National Coordinator's current objective, to improve healthcare outcomes while reducing costs.

Cloud vs. On Premises

The IT industry continues to move towards providing more and more applications through cloud based infrastructure. For organizations implementing healthcare analytics, there are solutions available that can either be secured through the cloud or on premises. The healthcare organization's analytical solutions can therefore be comprised of cloud services, on premises systems, or a combination of both.

The implication of this is that as the healthcare organization designs an analytics solution that meets the needs of their users, attention must be paid to the security capabilities of those solutions. Going back to the reference model, the solution design must be developed by working through the layers of the model to determine how the analytics solution(s) will be architected.

While there are many design considerations for architecting the analytical solutions, the key design consideration that always seems to surface is that of data consistency. This consideration revolves around how an organization will ensure that the various analytical queries/reports/results out of the various solutions will always yield the same results. Users will become quickly disenfranchised if the analytical solution allows for different answers to the same question. Resolving this issue requires that the organization think through how data will be stored, organized and retrieved in the various portions of the solution so that consistency is maintained.

Moving Forward

For larger healthcare organizations, the journey to healthcare analytics most likely has already begun and the information herein is a confirmation and reference to the work that is already underway.

For smaller organizations including practices and hospitals that have not begun their work efforts, the path may not be entirely clear, even given the roadmap above. A suggested strategy for moving forward can be derived from either a 'top down' or 'bottom up' approach.

In the top down approach, the organization can start with the informational needs derived from the questions that need to be answered. If the organization is seeking to answer questions around readmissions, for example, then the data that will be needed to answer these questions likely will revolve around that subject area. The organization then can determine where this information exists and start to map out strategies to answer questions around readmissions.

In the bottom up approach, the organization can map out current existing data sources and then devise a strategy to combine parts or all of that data into a data warehouse so that the organization now has that data in a format ready to interrogate.

In either case, the challenge for smaller organizations is to determine how they want to map out the various elements of the reference model cited above. Many smaller organizations rely on hosted services for their core systems and will therefore have to figure out how they will leverage those data for healthcare analytics. The smaller organization can determine whether they rely on the same vendor of the core systems, or additional other vendors to build out the layers of the infrastructure.

For More Information

Organizations beginning their work efforts in healthcare analytics are also advised to seek out other modules in the HIMSS C&BI Analytics and Information Delivery Task Force's *Clinical & Business Intelligence: An Analytics Executive Review*:
- Needs Assessment
- Building the Business Case

Task Force Contributors

This paper is a product of the HIMSS Clinical & Business Intelligence Analytics and Information Delivery Task Force. Its contributors include:

Task Force Chair
Carol Muirhead, MBA
PinnacleHealth

Task Force Contributors
Brian Gaffney, MS -- *team co-lead*
Caradigm

Beth Mary Hall, MS -- *team co-lead*
NJ-HITEC (New Jersey's Regional Extension Center)

Amit Mishra, MHA
HIMSS Asia Pacific India Chapter

Julie Rosen, Ph.D.
Science Applications International Corporation

HIMSS Staff
Shelley Price, MS, FHIMSS
HIMSS

Nancy Devlin
HIMSS