The Integration of Clinical and Business Intelligence into Clinical Workflows

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Introduction

This paper is the first in a series that will explore the topic of integrating Clinical and Business Intelligence (C&BI) with operational workflows in the clinical environment. We begin this series with the challenges faced by healthcare organizations, both in business and technical terms. In subsequent white papers we will present various solutions for successful integration, resulting in improved financial performance and health outcomes.

Lessons from Other Industries

Before exploring this topic within the domain of the healthcare industry, it is valuable to consider first the relevance of data analytics within the day-to-day activities of industries outside of healthcare. The challenges we propose to address are not unique to our industry, and contemplation of the ‘bigger picture’ can help us better understand the challenges and opportunities, as well as illuminate the path for solutions. Solutions can be in the form of human capital, workflow processes, and enabling technology. Our focus in this series will be on software-enabled C&BI systems that are designed, developed, and deployed to inform clinical decision making. Essentially any healthcare software system that is considered “smart” is incorporating some sort of C&BI into the workflow.

One example of combining C&BI with workflow in the non-healthcare sector is the scenario of a police officer who pulls over a driver in a vehicle. In the pre-computer world, the officer would pull over the driver with little to no information. However, in today’s world, it is routine for the officer to perform a ‘license check.’ Think of the ‘license check’ as a form of C&BI. In a law enforcement database, data has been aggregated and the criminal history of the driver(s) of this vehicle are identified. If one of those drivers happens to be known to law enforcement, the police officer’s next steps will be materially changed.
Other examples include online market sites, such as Amazon, that utilize tools called “recommender systems” to assist users in selecting other products based on what products the user has reviewed or purchased in the past.

We highlight these examples to make the case that healthcare industry, while it is enormously complex, shares many of the same basic needs for analysis to provide insights for the improvement performance and outcomes as in other industries.

**The Business and Clinical Perspective**

**Stakeholders**

In healthcare, the stakeholders are varied and widespread throughout the organization and are completely dependent upon the organization’s workflow, as well as their own. For example, a hospital based workflow involving medication administration would potentially involve physicians, nurses, and pharmacy roles. Whereas a physician may round on patients as dictated by the hospital, but have his/her staff care manage the attributed patients in the ambulatory settings in accordance with his/her own workflow and resource constraints. In the end, it is imperative that the process of integrating C&BI into workflows include a thorough stakeholder analysis and an understanding of the interdependencies specific to the targeted outcomes. Additionally, participation from the IT department is critical if needs are to be identified and met in an effective and timely fashion.

**Desired Outcomes**

The integration of C&BI into workflows will improve data collection, share information, which in turn, will improve decision making, creating efficiencies in care delivery processes, and potentially improving patient outcomes.

**Different Types of Workflows**

While we can differentiate workflows by roles as described above, workflows also differ by whether they are episodic or systemic in nature.

An *episodic workflow* might be triggered by events or information. An example would be clinical decision-making resources that are based upon evidence-based guidelines. Episodic workflow tools might be: configuring onscreen alerts for the care teams to address gaps in care; clinically based decision-making resources for physicians when diagnosing patients based on the presenting symptoms; and/or workforce management software that assists in coordinating and scheduling staffing appropriate to fluctuating patient volumes. The nature of an episodic workflow is that it is adaptive based upon a number of conditions, which vary from facility to facility, department to
department, and even by providers and caregivers. All which reinforce the need to identify efficient workflows and configure them appropriately to address episodic scenarios.

An example of a **systemic workflow** is a clinical pathway for a disease/condition. This systemic workflow might include the critical actions required to optimize clinical and financial outcomes consistently and efficiently. Although there is no “cookie cutter” approach to diseases and conditions in healthcare, there are consistent preventive and chronic care management activities that benefit all patients, regardless of health status. These activities should be part of the plan of care and therefore included in the workflow of the providers.

As the healthcare industry has moved to electronic health records (EHRs) and other administrative, clinical, financial, and operational technology solutions, there has been an explosion of data made available for healthcare professionals across the continuum of care. The key is transforming this voluminous data into meaningful information and insights that support the healthcare professionals so they can focus on the Triple Aim of healthcare, rather than the standard entry and consumption of data.

**Obstacles to Workflow Focused Business Intelligence**
The following paragraphs identify a number of obstacles for integrating CB&I into the workflow of healthcare professionals.

- **Relevant Business Intelligence versus Data.** It seems our systems these days are rich in data (raw or processed), but often poor in relevant C&BI. An example of relevant C&BI versus data would be a patient’s use of diabetic medications like Glucophage®. The patient’s medication data is often available in the patient’s medical record. Intravascular administration of iodinated contrast media during a CT scan to patients who are receiving Glucophage®, can result in renal impairment and in some cases lactic acidosis that results in renal failure and death. If the patient were to have a CT scan with a contrast study ordered, it would be critical to have a C&BI alert to the ordering physician and radiology staff that the patient is taking Glucophage®. Relevant C&BI, such as this real-time alert, would help the provider consider whether contrast is required or if the study could be delayed to allow the patient to be temporarily removed from the Glucophage medication for the recommended period to have the CT scan performed without risk of a contrast reaction. The *lesson* from this example is that the data in the EMR must be mined for insights that can help healthcare professionals avoid mishaps and optimize outcomes. The *challenge* is surfacing the data within the workflow that is highly relevant based on the (situational and temporal) context.

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- **Alert fatigue.** Even when relevant C&BI is identified, the frequency and volume can desensitize the healthcare professionals. This desensitization is often referred to as “alarm fatigue”. It has been well documented that alarm fatigue has resulted in healthcare professionals miss the signs and symptoms related to the deterioration of a patient’s condition.

- **Scanned Documents.** Although scanning documents are prevalent in most healthcare organizations, access and review of the scanned documents by providers is limited. The ability to glean the discrete clinical and financial data from scanned documents is still developmental in nature and therefore is a limiting factor for BI solutions.

- **Multiple Cohorts.** The healthcare industry is faced with patients that are insured by various providers; managed by disparate care teams and/or individual practitioners; with a wide spectrum of care givers; and who have very complex clinical, financial, and social profiles. The ability of a BI system to manage the patients in various types of cohorts that may have different clinical and social needs; financial and insurance constraints; disparate clinical metrics and reporting requirements is essential to an effective workflow focused BI solution.

- **Standardization and Interoperability.** EMRs and other clinical systems are transactional in nature. Although the systems may offer C&BI solutions integrated within their clinical systems, too often the design is proprietary in nature and restricts interoperability with other clinical systems and does not have the ability to view the longitudinal patient record incorporating claims; healthcare analytics, such as risk scores; and other EHR/HIE data. Additionally, the lack of standardization in data formats, file layouts, and use of Enterprise Master Patient and Physician Index systems has resulted in data that is not normalized and standardized for use in C&BI systems. In some cases the data is duplicated, not aligned, or even nulled out in the data set. Many health information exchanges (HIEs) have struggled with this issue. In their effort to connect to all of the providers across a geographic region or health system, they have accepted any and all data and file layouts resulting in a “garbage in and garbage out” situation where their data requires auditing, normalization, and semantic mapping by the end users to perform any meaningful analytics.

- **Weighting and Prioritization by Data Source.** Not all data are equal in their importance and confidence of accuracy. As an example, some C&BI systems weight pharmacy and lab diagnostic data more heavily than admission data. In another example, most insurance companies receive up to five diagnoses on a medical claim. The diagnoses are related to the procedures and care provided, weighted by the expense incurred, and therefore may not identify the primary or a contributing comorbidity. For example, a diabetic inpatient may
have claims listing sepsis and other diabetic related complications without listing the patient’s primary diagnosis of diabetes based on the episodic nature of the inpatient admission. Unless a full understanding of the patient’s condition is incorporated into the C&BI system, the diabetic patient might be mislabeled a sepsis patient without accounting for the primary diagnosis when assessing the claim for approval for payment and/or when forecasting the patient’s long-term health risk.

- **Multidisciplinary Team.** In healthcare, patients will see multiple providers who may or may not be working together or have access to the patient’s longitudinal patient record. Even when the providers are connected via the EMR, they practice according to their credentials and focus on the aspect of care related to their specialty. Often in the community hospital setting, physicians act as individual entrepreneurs managing their patients with ad hoc clinical “teams” that are temporary and are extremely interdependent when managing the patient’s care. Furthermore, many times the patient’s primary care physician relinquishes his coordinating role to hospitalists when the patient is admitted to a hospital or to the medical director of hospice, the skilled nursing facility, or home health agency when those services are deployed. Consequently, the accountability for the patient is episodic in nature and somewhat fragmented. As with the financial and mass market domains, an effective BI system must account for a universally unique identifier, or perhaps a set of linked values that generate a unique, but complete, longitudinal record for each patient.

- **Who’s in Charge?** It is difficult or nearly impossible for a C&BI solution to be able to determine who is in charge of the patient’s care and who has accepted accountability for a particular condition, system, or type of care. Furthermore, the attribution models used for assigning patients to accountable care organizations and “at risk” arrangements have been problematic. Not only is the attribution data delayed, due to claims lag and lack of system interoperability, but the nature of healthcare may require a patient to seek care at multiple hospitals and with multiple providers/specialists to receive the care they need. Determining who is ultimately responsible for and intervening to coordinate the care for optimizing the clinical and financial outcomes is difficult.

- **Collaboration and Feedback Timeliness.** Healthcare is a waiting game. Unless emergent care is required, the patient generally waits a few days or weeks to see the healthcare providers for diagnosing their symptoms. The healthcare providers order diagnostic tests and procedures which can then add to the delay in diagnosis. Once diagnosed, the scheduling of the procedures and treatment adds another delay, which then is followed by the delays in ease stage of the follow-up care. Managing the data from the diagnostic tests and procedures, treatments, and follow-ups is difficult for an individual provider or healthcare professional to
perform; much less coordinate with multiple care team members and stakeholders. C&BI solutions need to address the ever changing nature of the data received and inform the stakeholders and multidisciplinary team members so they can collaborate with the other team members, accept responsibility for an aspect of the patient’s care, and be alerted to any change in the patient’s status.

Overcoming these obstacles is critical to any workflow focused C&BI solution.

**The Technical Perspective**
At each point of a user interaction with the C&BI solution, the user interface should expose (situationally and temporally) relevant information to the user-decision maker so that optimal business and clinical decisions can be rendered. The current technical challenge faced by the health care industry is that this integration of aggregate information does not generally exist across the disparate systems and platforms; and as a result users are frequently making decisions based on incomplete information.

**Evolution of Business Intelligence**
To understand how we have arrived at a state where our information systems are not adequately surfacing relevant business/clinical information, it is useful to consider the evolution of computing systems. Roughly stated and as a gross generalization, we could consider the evolution of computing systems as follows in Table 1:

**Table 1. The Evolution of Computing.**

<table>
<thead>
<tr>
<th>Computing Era</th>
<th>Characteristics</th>
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</thead>
<tbody>
<tr>
<td>Mainframe</td>
<td>Punch cards - batch processing, Online Transaction Processing (OLTP)</td>
</tr>
<tr>
<td>Client server</td>
<td>Online Analytical Processing (OLAP) &amp; Data Warehouses, Relational Databases, Personal Computers</td>
</tr>
<tr>
<td>Network</td>
<td>World Wide Web, Cloud, wireless networks, pervasive devices, big data</td>
</tr>
</tbody>
</table>

**Mainframe Era** – In the first era of computing, mainframe systems dominated the landscape. These systems first started with “batch” processing and then began to evolve towards “Online Transaction Processing” (OLTP). Both of these computing techniques are designed to allow businesses to model and automate business state changes through the computing platform. The important point here is
that business workflow gets automated and enshrined in computer code through these systems. Modern day EMR systems, for example, which capture much of the workflow of clinical workers, are OLTP systems.

**Client Server Era** – In the next era of computing, with the advent of hardware alternatives to mainframe systems, new computing styles became possible. In this era, sometimes called the client server era, relational databases became a dominant model for computing and lead to the rise of “Online Analytical Processing (OLAP)” and the “Data Warehouse.” With OLAP, businesses exploited the relational data model to build out BI capabilities that leveraged all of the data from the OLTP systems. A key development for our challenge above is that the OLAP systems generally were built out as completely separate systems from the OLTP systems. The division of business intelligence from workflow was an accepted and in fact preferred computing paradigm during this era. However, the delegation of healthcare analytics to analysts who were physically separated from the clinician’s workflow resulted in lags in clinical and financial interventions.

**Network Era** – Following the client-server era, more computing capabilities have become available and in many instances has the division of C&BI from business workflow. In this network-centric era, we have become accustomed to and expect real time data to be available for a multitude of purposes in multiple systems across the continuum of care. Whether through social media or from pervasive devices with network connectivity, users have become conditioned to a constant stream of information. Big data has made us realize that completely new insights are possible and we want to leverage those insights in real time. Unfortunately, the historical and continued division of OLTP from OLAP has simply not positioned us for nimble delivery of information to decision makers at the point of their interaction with clinical systems. This schism has not gone unrecognized and presents opportunities for evolution of our technical capabilities.¹

**The Technical Challenge**
Solving the challenge of providing relevant C&BI findings and access to the relevant underlying data requires that systems are designed to integrate the awareness from C&BI systems with the business transactions that automate clinical workflows. As detailed above, there are many obstacles to integrating C&BI with workflows. Each one of the obstacles represents an opportunity for creative approaches to systems integrations.

¹ See [http://www.sigmod09.org/images/sigmod1ktp-plattner.pdf](http://www.sigmod09.org/images/sigmod1ktp-plattner.pdf)
Conclusion
We have defined in this white paper what we believe to be the challenges and opportunities for the integration of C&BI into healthcare workflows. Subsequent papers will further explore potential solutions for the challenges identified herein and then propose practical applications of C&BI integrated into healthcare workflows.

Task Force Contributors
This paper is a product of the HIMSS Clinical & Business Intelligence Data and Analytics Task Force, and the HIMSS C&BI Population-Health and Accountable Care Task Force. Its contributors include:

Authors and Contributors
Brian Gaffney, MS
Solution Architect
Caradigm

Michelle Vislosky, MBA, FACHE
Zone Sales Executive
Caradigm

Tamara J. Winden, MBA, FHIMSS
Manager, Clinical Research Informatics and Analytics
Allina Health

Contributing Editors
Kala Guidry
Program Manager, Clinical and Financial Reporting
CHRISTUS Health Performance Effectiveness

Kevin Gormley, Ph.D.
Lead Healthcare Analyst
The MITRE Corporation

Julie Rosen
Chief Scientist, Health Solutions Group
Leidos Inc.
**Data-Analytics Task Force Co-Chairs**

Carol Muirhead, MBA
Clinical Analytics Consultant
SpectraMedix

Raj Lakhanpal, MD, FRCS, FACEP
CEO

**Population Health-Accountable Care Task Force Co-Chairs**

William Beach, PhD
Regional Dir, Accreditation, Northern CA
St. Joseph Health System

Jennifer Jackson
Senior Dir, IT Population Health Data Solutions
Banner Health System

**HIMSS Staff**

Shelley Price, MS, FHIMSS
Director, Payer & Life Sciences
HIMSS

Nancy Devlin
Senior Associate, Payer & Life Sciences
HIMSS

For more information about this or other HIMSS Clinical & Business Intelligence resources or activities, please contact Shelley Price, Director, Payer and Life Sciences, HIMSS at sprice@himss.org.