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Why Healthcare Requires an EDW, Analytics Applications, and Visualization Tools for Quality Improvement Initiatives

by Chris Rains and Michael McCuistion

THE GROWTH OF BUSINESS INTELLIGENCE ACROSS ALL INDUSTRIES

Industries across the world have become very good at accumulating data. But until recently, they didn't have the means to make use of the data. It just sat there without providing any strategic value. Advances in technology, however, have led to the rise of a discipline that helps organizations gain deeper insight to their vast stores of data. This discipline is called business intelligence (BI).

THE RISE OF HEALTHCARE BI

The healthcare industry is interested in BI technology as a result of federal mandates to reduce costs, improve care, and report on improvement metrics. To comply with these mandates, health systems need tools that enable users to access valuable knowledge contained within volumes of stored patient data. Once users unlock these insights, they gain the ability to identify cost and opportunities that lead to quality improvement in healthcare.

Because of healthcare's increased demand for BI, a healthcare-specific BI market is rapidly growing and is expected to increase in the coming years. In fact, the global market research company MarketsandMarkets published the following in their May 2014 report: "The global healthcare BI market was

valued at an estimated $2,376.6 million and is expected to grow at a compound annual growth rate of 14.8 percent in the next five years." With this emerging specialty market offering such lucrative profits, it is not surprising that many technology suppliers are touting their ability to deliver BI solutions.

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The high demand for BI has led to the overuse of the term "business intelligence" in the market. Vendors have adopted the term to describe a wide collection of technologies and tools with varying degrees of actual BI capabilities. For example, some tools inform long-term decision-making while others show a "snapshot" of former or present conditions. These types of tools can be quite useful to a healthcare organization. However, problems set in when health systems believe they are purchasing a robust tool, but it lacks the processing power and framework necessary for a comprehensive.

THREE CRITICAL COMPONENTS NEEDED FOR A ROBUST BI SOLUTION

For a BI solution to provide the powerful performance health systems need for cost and quality improvement initiatives, three components are necessary: an enterprise data warehouse (EDW), analytics applications, and BI visualization tools. The EDW has the processing power and architecture to aggregate and standardize data across the organization; analytics applications allow users to interpret the data and translate it into meaningful information; BI visualization tools present the data to users in easy-to-understand charts, tables and graphs. Adopting the three solutions together ensures that health systems have the robust functionality needed for reducing costs and improving quality.

The Healthcare Enterprise Data Warehouse Component

A healthcare EDW is a database that extracts data from transactional application databases (source systems). The EDW pulls data from the source systems into one central repository, or single source of truth. The repository is optimized for and dedicated to analytics. Because the EDW's architecture is constructed to efficiently read and retrieve large data sets and aggregate data, users can create and manage data sets across a wide range of source systems (e.g., clinical, research, human resources, and billing). This eliminates the performance burden that an analytics application places on a source system.

EDWs also provide users with the flexibility to determine which data to report depending on their needs. For example, an analytics application for quality improvement might contain data from several source systems, such

as clinical, patient satisfaction, and costing. An application for operational purposes, however, might contain staffing levels and clinical data.

The EDW's capabilities are particularly critical when discussing complex healthcare data, with many data elements being highly variable (e.g., calculating length of stay (LOS) or defining patient admission, discharge, or transfer rules). In addition, each patient's visit with a provider has many conditional data points associated with it. For example, a physician typically sees patients who have had multiple encounters with multiple caregivers, multiple diagnoses, multiple procedures, and multiple results. For one visit alone, a blood pressure reading requires documentation of several data elements, such as:

- Systolic numbers
- Diastolic numbers
- Date of visit
- Time of visit
- Type of blood pressure device
- Whether the patient was standing, sitting, or lying down

Despite an EDW's tremendous computing power to manage large, complicated data models, however, without analytics applications or a BI visualization tool, analysts must rely on software solutions such as Access or Excel, which only largely produce numerical, data-heavy reports. While these types of software provide limited functionality for healthcare's massive data stores, there are significant downsides to using such non-centralized solutions. For example, analysts spend most of their time tracking down data from various source systems rather than analyzing it. This creates delays in the reporting of timely information, increases expenses, and limits analysts' ability to provide accurate, real-time data analysis. In addition, these tools lack the ability to convert rows upon rows and columns upon columns of patient data into meaningful visual representations that are easy for the human brain to comprehend. Such limitations can be overcome, however, by running appropriate analytics applications with a BI visualization tool on top of the healthcare EDW.

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The Analytics Application Component

Analytics have to do with how data is made accessible for use, how data is used, how work is measured, how improvement opportunities are prioritized and how improvement efforts are monitored over time. Organizations need to effectively unlock their data, broadly distribute it to individuals across the organization and teach them how to access and use it. Improvement teams need to discover patterns in data so they can target areas for improvement. This is made possible through the use of analytics applications supporting—and supported by—an EDW.

Advanced applications can be used to manage population health and ACOs, prevent patient injuries, improve operational efficiency, monitor performance, and analyze finances. They support active measurement of the effectiveness and outcome of goal- and aim-based care improvement interventions. Appropriate applications can even support the needs of academic research and provide the tools needed to translate that research into actual clinical practice.

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The Visualization Tool Component

Visualization tools enable users to turn rows of numerical data into graphs, charts, tables or other visual representations. This makes the information easier to understand. Some of the more sophisticated BI visualization tools allow users to drilldown into different levels of the data (e.g., hospital cost summary information or costs by department or room). Additionally, because many BI vendors offer a cloud-based option, users can access the visualizations securely, whenever they want to, without knowing querying languages, such as SQL.

One of the greatest advantages visualizations offer is their ability to engage frontline staff because of their ease of use. Specifically, nurses, doctors, and program heads benefit by running visualizations and applying the knowledge to make informed, strategic decisions.

What visualizations are unable to provide organizations, however, are the technical tools needed for adequate processing, storage, and governance of data. Such limitations can be overcome, however, by running the visualization tool on top of a healthcare EDW.

TOP 5 ADVANTAGES OF INTEGRATING ANALYTICS APPLICATIONS AND BI VISUALIZATION TOOLS WITH AN EDW

Because EDWs, analytics applications, and BI visualization tools do not offer comprehensive solutions when used independently, it is advantageous for workers to use them simultaneously. The top five advantages of adopting all solutions together include:

Advantage 1: Users gain the ability to visualize queries in near real-time despite working with massive amounts of data.

Processing power in the form of CPU usage and disk bandwidth is required for working with the large volumes of data produced in the healthcare industry. Take, for example, the data created after a single patient encounter. One emergency department visit can generate hundreds or even thousands of rows of data in a hospital database. Multiply those rows of data by thousands of patient visits, and the result is millions and possibly billions of rows of data.

While BI visualization tools lack the architecture to handle large analytical queries across entire populations of patients or events from the many source systems, EDWs have this functionality. This eliminates the performance strain an analytics application would place on a BI visualization tool. Once users model the data in the EDW and process it through an analytics application, the output can then be consumed and displayed by the visualization tool.

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Advantage 2: Users gain the ability to work with complex data at varying levels of granularity.

In data warehousing, granularity refers to the level at which data is stored or displayed. It also refers to how data elements relate to one another. For example, one database list might store patient names while another list might store each individual patient encounter. The lists have a one-to-many relationship (since one patient can have many encounters). When discussing granularity, the patient encounter list has a finer level of detail, or granularity.

With a BI visualization tool, a common way to display data granularity might be a report header showing a patient's summary, with multiple encounters showing in a detailed list. Handling the data's one-to-many and many-to-many relationships requires a sophisticated system, especially when millions of rows of data are involved. How well the data warehouse handles granularity is critical for analysis and system performance.

Many BI visualization tools have difficulties processing and displaying different grains in a way that is intuitive and easy to use, although some tools do a better job than others. EDWs, however, are designed to manage data with many different levels of granularity, down to very fine levels. Users can then access the various levels of granularity with a BI visualization tool to gain actionable insights into the data.

Advantage 3: Changes to data models can be centrally stored with appropriate version control.

The design of the EDW enables it to store a centralized record of the most recent changes made to the data models in the data warehouse. A centralized version of all of the data and logic guarantees the health system's ability to maintain common definitions and common logic across the entire organization. This also eliminates a frequent challenge analysts face: reaching disparate assumptions because they are developing different BI visualizations based on the lack of system wide business rules and logic.

For example, if two analysts develop their own reports with separate analytics applications and BI visualization tools, and conduct their own logic without a centralized EDW, they may build in filters or definitions of metrics (e.g., LOS) using assumptions they believe apply across the entire organization. However, departments that consume those reports may use different business rules and definitions for the same terms (again, an example could be LOS). This could result in analysts making assumptions with their visualizations. Consequently, departments may report on the same metric using different data sets and therefore show different results. This hurts credibility and doesn't provide leadership with accurate quality improvement data. Using an EDW, analytics applications, and a BI visualization tool together, however, provides users with the most current data and the most current business rules and definitions that apply across the entire organization.

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Advantage 4: Business users with various skillsets become enthusiastic about engaging with data to solve their problems.

Once the organization loads their data into the EDW, the next step is to make it available to business users in different functional roles who want answers to problems they are facing. Not all business users will have the same questions, though. A data architect, an executive, a nursing manager, a clinician, a lab administrator, and a person responsible for regulatory reporting will each be looking for different improvement insights from the same data. Applying all of the logic against the data to make it understandable at multiple

levels for different audiences is not necessarily what BI visualization tools are designed to do. But advanced analytics applications that target specific improvement areas are usually the perfect solution.

An EDW is designed to hold multiple subject-specific data marts. This design enables users to query data that applies specifically to their needs, yet through the analytics application and visualization tool of their choice (and to which they have access).

For example, lab administrators are primarily concerned about the efficiency of their labs. They want the process of returning results to the ordering physician to be as effective as possible.

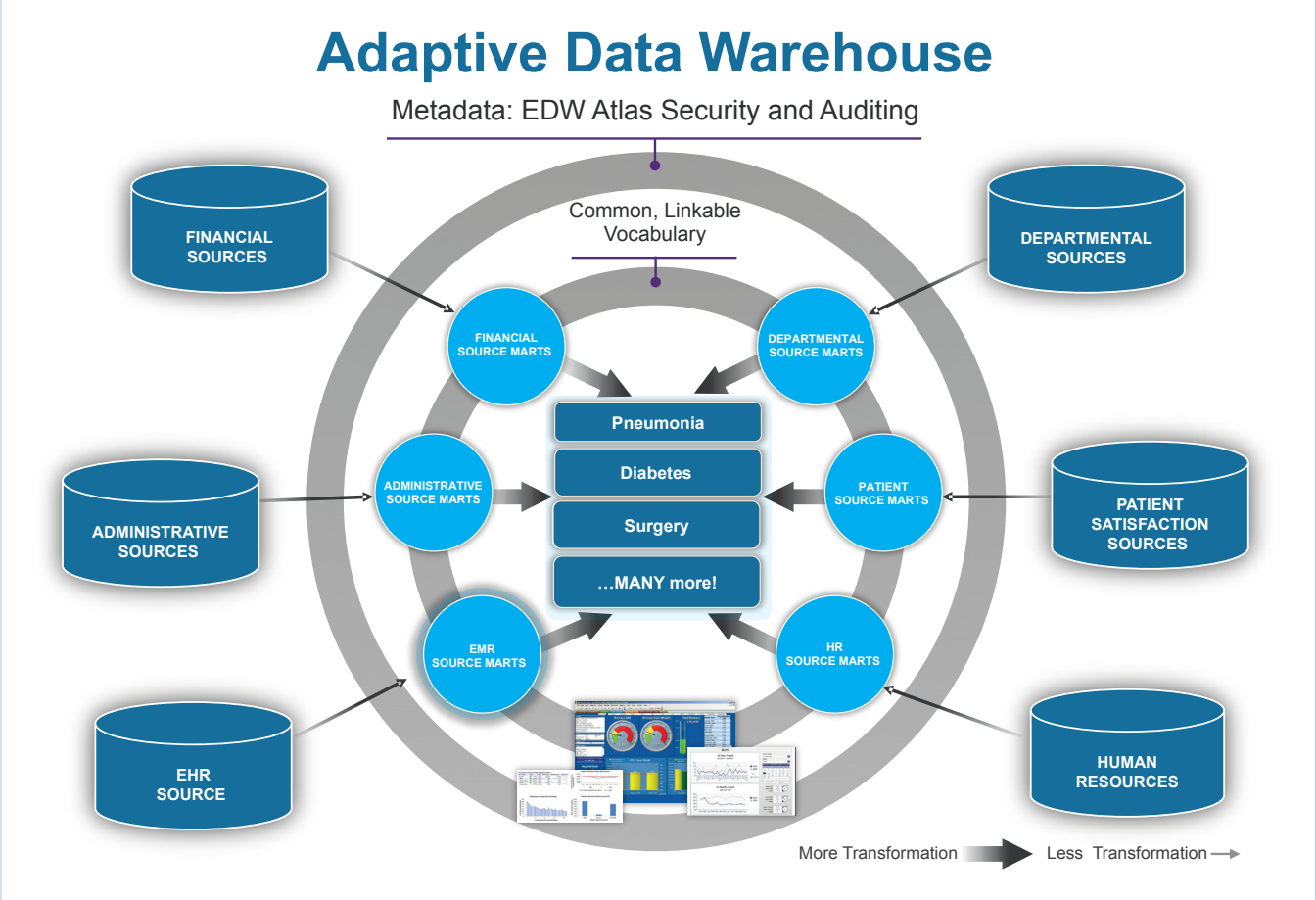

Figure 1: An adaptive EDW provides each hospital service with the ability to extract only the data that provides value for its specific improvement initiative.

Figure 1 shows an example of the data a lab administrator would be interested in analyzing. The laboratory information system ("Departmental Sources" blue cylinder) can accommodate as many queries as a lab administrator needs in order to determine the lab's operating efficiency. All data analysis remains within the EDW. They do not need to go outside of the EDW to perform any data analysis.

Adding an analytics application with a BI visualization tool on top of the EDW enables users like the lab administrator to drill down into complex data to discover much needed insights and patterns—all without the need to learn querying languages. When users are no longer restricted to long wait times for reports that are outdated by the time they arrive, and they can ask their own questions and get answers in near real-time, users want to engage with the data.

Consider this real-life example of using the power of data to engage users:

A hospital targeted LOS following appendectomy surgeries because reducing LOS offered significant opportunities to improve both quality and cost. The organization's frontline team looked at the data in the EDW. Their findings showed that clinicians were not consistent with the antibiotics they prescribed for appendectomy patients. Digging further, the team also looked at the outcomes data. Based on the outcomes data for each antibiotic, the team decided on a protocol for the entire facility. The protocol recommended a particular antibiotic be prescribed after all appendectomies. The antibiotic was expensive, though, and clinicians ordinarily might have preferred to prescribe a lower-cost, alternative medication. However, dashboards linking clinical and financial data from the EDW showed clinicians that while pharmacy costs rose, a parallel drop in LOS more than offset the costs of the more expensive antibiotic. When clinicians saw the encouraging data, they requested further refinements to the system. They began asking questions like, "Are we giving patients the antibiotic at the correct time after surgery?" The clinicians had engaged with the data because of the knowledge and value it provided. This resulted in clinicians asking more questions to find other improvement possibilities.

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Advantage 5: Access to data can be effectively governed.

When data is spread across many different source systems, it is extremely difficult for anyone to control and audit who is viewing the data and for what purpose. Such lack of governance can be detrimental to maintaining a secure organization. Even built-in safeguards within source systems have limitations and do not provide adequate governance. Take, for example, a user with good intentions who copies data from a source system to a shared drive or another unprotected database. The security of the data becomes compromised, exposing the hospital or health system to pointless risk.

With an EDW, the organization has a central, secure repository for all data within the organization. Individual departments can still maintain their own repositories, but data is now visible to all authorized users. In addition, alarms and alerts can be set for unauthorized access, giving the organization vital control over its data.

Then, by combining the EDW with analytic applications and a visualization tool, data managers and auditors tell who is using what data. They can also drill down into query metadata (data describing other data in the EDW) to determine if the data has been inappropriately accessed.

PUTTING THE EDW, ANALYTICS APPLICATIONS, AND BI VISUALIZATION TOOL INTO PRACTICE FOR IMPROVEMENT INITIATIVES

Organizations face a large challenge when selecting a BI solution because many tools require specific training. In fact, a 2012 *InformationWeek* survey discovered that nearly half (45 percent) of their 414 respondents cited "ease-of-use challenges with complex software/less technically savvy employees" as the second barrier to adopting BI or analytics products. Overcoming these barriers is possible, though, by implementing both an EDW and BI visualization tools.

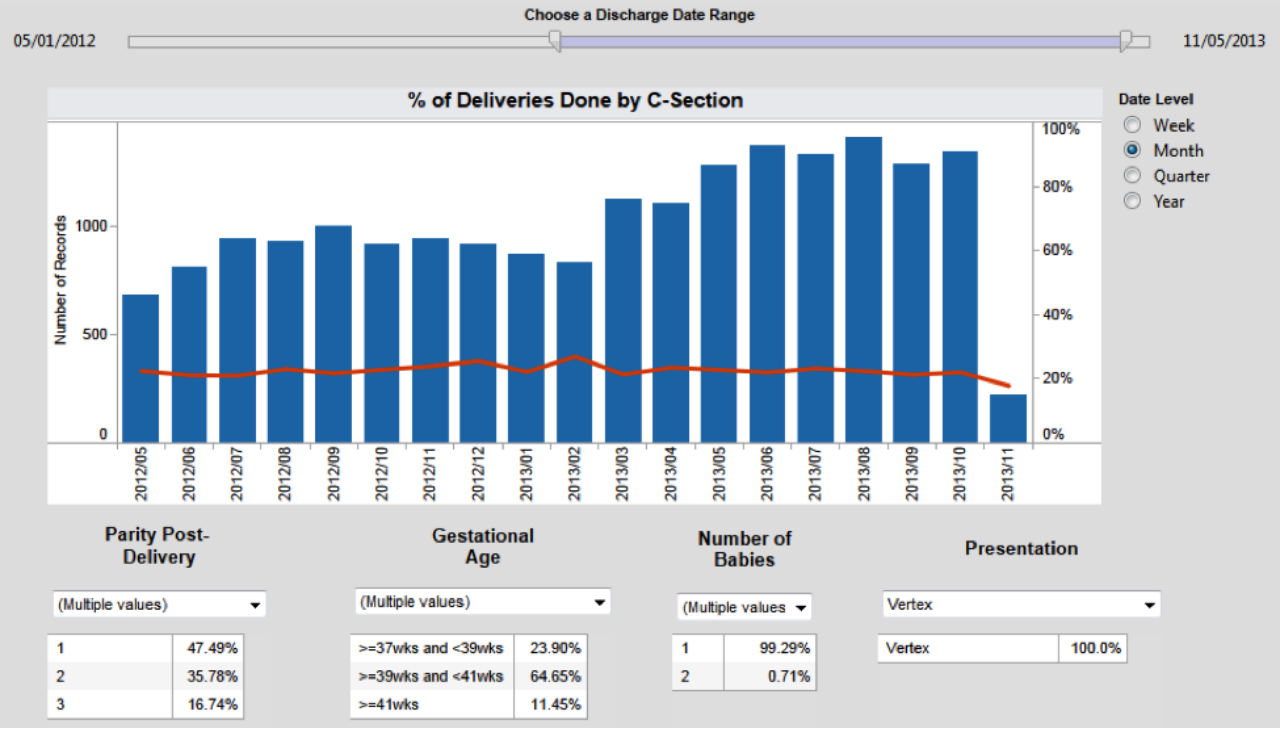

Figure 2: This scenario analysis visualization tool image shows a hypothetical example of how different values correlate to the C-section rate. It is an example of granular filtering.

One way to use BI visualization tools and analytics applications with EDW data is to create a scenario analysis. With a scenario analysis, users do not just see a metric. They also use a variety of filters to choose what variables or inputs should be included in the graphs and calculations. In addition, users can view the likely outcome. For example, a visualization might feature age filters that help determine how an intervention drives different outcomes for patients in different age groups.

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Figure 2 shows a straightforward scenario analysis visualization for a hypothetical hospital seeking to reduce the rate of unnecessary C-sections. In this simulation, the analysis shows the correlation between different values (e.g., gestational age) and C-section rates. The visualization tool provides filter options, so users can easily sort data based on gestational age values (from 23 weeks to 41 weeks in duration) to see how C-sections rates change for different duration values. The tool also allows users to filter data on additional criteria, such as parity (number of children post-delivery), twins, single births, and which way the newborn was facing at birth.

From a practical standpoint, the scenario analysis visualization tool can be used to analyze how often a baby's delivery occurs through a C-section procedure instead of natural labor. From that point, the user can delve into the data to answer the question, "If we did not allow the mother to progress to vaginal birth, why not?" A visualization such as this, along with the analytics application, can be used to help reduce the number of medically unnecessary C-sections.

Reducing unnecessary C-sections is an important quality improvement initiative because of the significant impact C-sections can have on costs and outcomes. A 2009 study published by the American Journal of Obstetrics & Gynecology demonstrates that elective deliveries before 39 weeks increase the risk of newborn respiratory problems and length of hospital stay for mothers and babies. Moreover, a 2007 report issued by the Institute of Medicine found the annual societal economic costs—medical, educational, and lost productivity—associated with preterm birth were at least $26.2 billion. By using BI visualizations, decision-makers will be able to identify whether an issue exists, and if so, where it exists. Then they can take steps to improve the problem.

EDWS, ANALYTICS APPLICATIONS, AND BI VISUALIZATION TOOLS ON THE FRONT LINES: TWO SUCCESS STORIES

Visualization Tool Drives Quality Improvement

The following example shows how a large health system successfully made a visualization tool available to frontline staff to help drive quality

improvement efforts. The health system wanted to reduce its 30-day and 90-day readmission rates for heart failure patients. One of the interventions the organization put in place was to schedule follow-up appointments for each patient within 48 to 72 hours of being discharged from the hospital.

First, the hospital obtained a baseline of how often individual staff members scheduled these appointments. Most staff members scheduled follow-up appointments below the 50 percent range, and some were lower than 20 percent. Digging deeper into the data, those studying the problem discovered that some of the low numbers resulted from staff documenting the appointment data in free-form text fields. Scheduling systems have a difficult time consuming this type of data.

First, the hospital obtained a baseline of how often individual staff members scheduled these appointments. Most staff members scheduled follow-up appointments below the 50 percent range, and some were lower than 20 percent.

To help drive improvement, the hospital next set up a simple incentive program: the staff members with the best statistics for setting up follow-up appointments would receive a small prize at the end of the competition period. For the appointment to count, the data had to be entered properly in discrete form fields in the system. Leaders then made the improvement data available to participants through a dashboard developed by the workgroup. Participants reviewed the dashboard at a weekly meeting, so everyone could track their own statistics.

Over the course of the intervention, the hospital saw significant improvement from everyone involved. Participants whose scores had started at 20 to 30 percent rose all the way up the 70 to 80 percent range. A bit of healthy competition, driven by the ability to visualize their progress, helped change staff members behavior—not just for that particular intervention but also for other improvements that continue to this day.

This example shows that changes do not have to be sweeping or system wide to be effective. Access to quality data at the frontline level, and the ability to visualize the data effectively, can help drive improvements (e.g., cost, quality, process, patient satisfaction) that support the organization's goals from the ground up.

Advanced Analytics Application

A large children's hospital had established a solid foundation for capturing and sharing patient satisfaction information, but they needed to overcome significant obstacles in order to use this data to drive enterprise-wide improvement. One of the biggest challenges they faced was making patient satisfaction data actionable for the executive team, clinicians and operational leaders.

Although these internal audiences had access to high-level information, they did not have an easy way to gain access to granular data that would enable them to analyze their performance. They did not have convenient access to trended key performance indicators across the system or by service units. Nor could they easily drill down and analyze their patient satisfaction data at the individual question level. This situation made it cumbersome and confusing for key personnel to understand question-level or unit-level performance. What they needed was a solution that allowed system-wide access to data in a format that was easy to consume and analyze.

The hospital had previously deployed an enterprise data warehouse (EDW) platform and analytics applications to drive operational efficiencies and clinical improvement in many areas. Leaders determined to use this same platform to measure and improve patient satisfaction. The hospital integrated patient satisfaction data into the existing EDW platform by simply creating a patient satisfaction data mart. Then, the team deployed an advanced patient satisfaction explorer application to run on top of the platform.

SAMPLE PATIENT SATISFACTION VISUALIZATION, LOCATION VIEW

1. Ability to filter by service type (outpatient, ED, inpatient, etc.) and campus
2. Ability to select different survey units (Women and Newborns) and locations (Womens Tower)
3. Detailed experience rating (number, mean, goal) for each survey unit—with displayed goals
4. Trended overall patient satisfaction ratings versus goal
5. Detailed trended rating by survey question
6. Easy identification of Magnet and priority questions

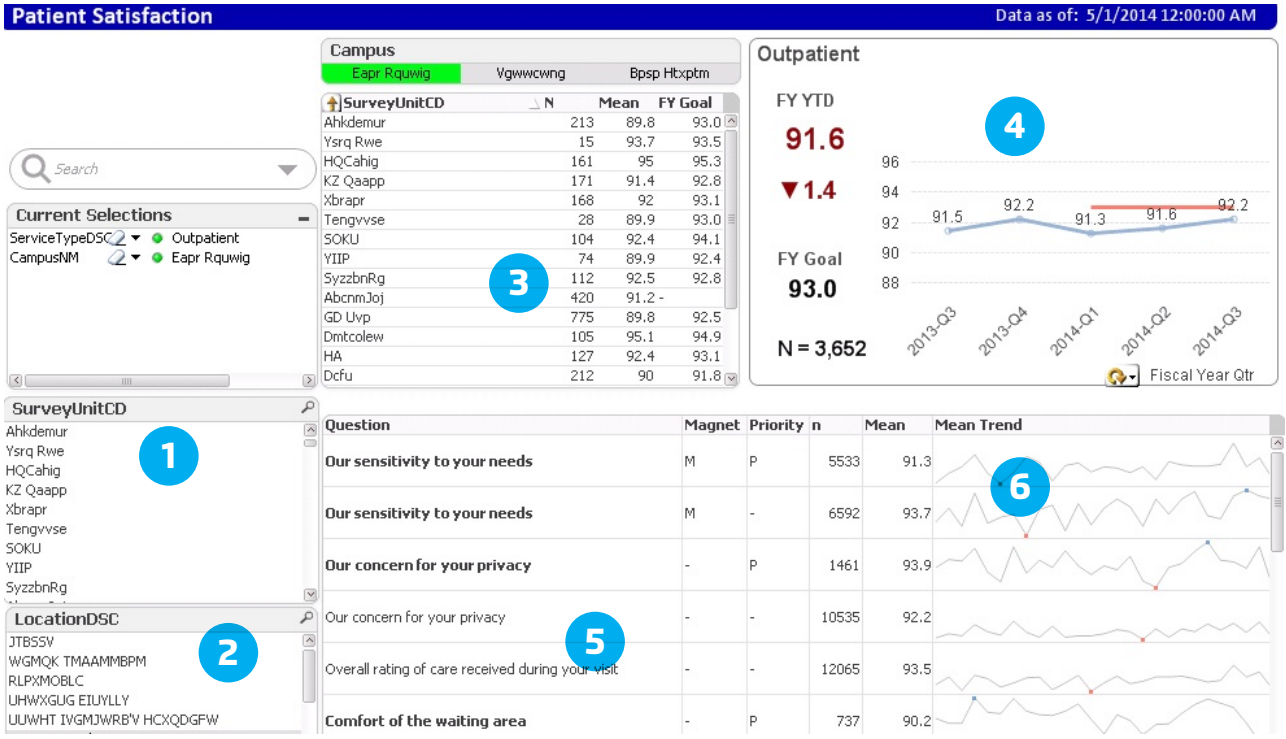

Figure 3: Using an analytics application, the current score for each unit, along with the unit-specific goal, and trend lines over time, can be displayed.

The application enabled users to view up-to-date patient satisfaction information at any time and, most importantly, to understand the drivers behind patient satisfaction trends. It delivered a dashboard that displayed patient satisfaction scores for each of the five areas targeted by the hospital: ambulatory surgery, medical practice, outpatient, pediatric inpatient and emergency center. At one glance, users could see these scores in comparison to organizational goals. The current score for each unit, along with the unit-specific goal, and trend lines over time, could be displayed.

Additionally, the analytics application was able to meet the needs of different user types and different hospital departments. Users could customize the application and filter the data by area, by initiative or by section (e.g., nursing, provider). They could also track, trend, and drill down to look at specific question performance and comments related to their particular area.

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CONCLUSION

The IT industry broadly uses the term "business intelligence" to describe an assortment of solutions and approaches designed to provide leaders with insights into their organization's operations. The intent is to help leaders at all levels make better business decisions. While BI visualization tools are an important component of this process, when used alone, their functionality is limited. In reality, their design prevents them from delivering the breadth and depth of information required for the complex, dynamic world of healthcare.

Ensuring the right data is available in the right quantity with the right quality and at the right time requires the type of processing power only an EDW can provide. Without an EDW as a foundation and supporting analytics applications, the best BI visualization tools in the world are incapable of providing effective data governance, data preparation, data visualizations, and user engagement. Together, however, EDWs, analytics applications, and BI visualization tools create actionable insights that speed up the implementation of process, cost, and quality improvement initiatives. The insights these solutions provide will enable healthcare organizations to drive critical initiatives to significantly improve outcomes and reduce costs for the patients they serve.

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ABOUT HEALTH CATALYST

Health Catalyst is a mission-driven data warehousing, analytics, and outcomes improvement company that helps healthcare organizations of all sizes perform the clinical, financial, and operational reporting and analysis needed for population health and accountable care. Our proven enterprise data warehouse (EDW) and analytics platform helps improve quality, add efficiency and lower costs in support of more than 50 million patients for organizations ranging from the largest US health system to forward-thinking physician practices.

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