Although it remains absent from most programs today, business intelligence (BI) has become an integral part of modern radiology practice management. BI facilitates the transition away from lack of understanding about a system and the data it produces toward incrementally more sophisticated comprehension of what has happened, could happen, and should happen. The individual components that make up BI are common across industries and include data extraction and transformation, process analysis and improvement, outcomes measures, performance assessment, graphical dashboarding, alerting, workflow analysis, and scenario modeling. As in other fields, these components can be directly applied in radiology to improve workflow, throughput, safety, efficacy, outcomes, and patient satisfaction. When approaching the subject of BI in radiology, it is important to know what data are available in your various electronic medical records, as well as where and how they are stored. In addition, it is critical to verify that the data actually represent what you think they do. Finally, it is critical for success to identify the features and limitations of the BI tools you choose to use and to plan your practice modifications on the basis of collected data. It is equally important to remember that BI plays a critical role in continuous process improvement; whichever BI tools you choose should be flexible to grow and evolve with your practice.

Key Words: Analytics, graphical dashboarding, business intelligence, business analytics, information visualization

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**OVERVIEW**

Business intelligence (BI), also known as business analytics, was likely not an elective during your radiology residency. Although it remains absent from most programs today, BI has become an integral part of modern radiology practice management. BI is the process of transforming raw, often unstructured data into meaningful and actionable information that can be used to influence practice decisions, identify new strategies, and assess efficiency and efficacy.

BI facilitates the transition away from “ignorance,” or lack of understanding about a system and the data it produces (Fig. 1). The analytics spectrum offers 3 levels of comprehension: descriptive, predictive, and prescriptive analytics [1]. These levels inform us what has happened, could happen, and should happen, respectively. Descriptive analytics typically encompass conventional reporting, whereas predictive analytics seek to use existing data to model and simulate the future. Prescriptive analytics use descriptive analytics to optimize for the best possible outcome given the original data and results of the models and simulations.

Consider the amount of data generated daily by your PACS and radiology information system (RIS) that could help you better understand your complex internal processes as well as referring physicians’ ordering patterns. BI tools have been used for nearly 2 decades in other fields but have only recently been implemented within medicine and particularly within radiology. Advanced reporting capabilities using BI tools are still not standard components of RIS but will be essential for radiologists to continuously innovate and improve efficiency [2].

The individual components that make up BI are common across industries and include data extraction and transformation, process analysis and improvement, outcomes measures, performance assessment, graphical dashboarding, alerting, workflow analysis, and scenario modeling. The latter encompasses both predictive and prescriptive analytics, whereas the other components are typically part of descriptive analytics. As in other fields, these components can be directly applied in radiology to improve workflow, throughput, safety, efficacy, outcomes, and patient satisfaction. In this...
article, we describe some applications of BI within and outside radiology and how your practice could benefit from the implementation of BI tools.

**BI IN OTHER INDUSTRIES**

Outside of medicine, BI has been used to transform entire industries [3,4]. Future sales forecasts and product successes are developed by analyzing past trends. BI tools are built to produce and examine multiple scenarios. Customer relationship data, decision support, geographic information, data mining, and visualization are all important components. For example, a retailer can evaluate product purchase patterns with BI resources to determine the best marketing strategies for certain products that are not typically related. Affinity marketing can be seen in the online shopping experience by looking at features such as “people who purchased this product also liked this one.” Meanwhile, customer satisfaction analysis, another BI activity, can provide valuable data regarding the impact of product updates.

**BI IN OTHER MEDICAL SPECIALTIES**

BI in medicine focuses on usability, workflow, and process improvement [5]. Dashboards can be used to synthesize information about patient demographics, clinical orders and results, patient safety, billing, and patient outcomes [6]. Data can be analyzed to reduce infection rates related to central lines and Foley catheters, reduce readmission potential, and even identify patients at risk for sepsis. Because of the large quantity of data collected, a number of BI efforts have focused on the intensive care setting [7]. For example, using analytics and decision support, the correlation between atrial fibrillation, hypokalemia, and absence of β-blockade can be determined. Throughout medicine, BI often relies on data collected in multiple electronic medical records (EMRs); it is rare that all clinical data resides in a single comprehensive system.

**BI BENEFITS FOR RADIOLOGY PRACTICES**

BI within radiology, as within other specialties in medicine, can be used to improve quality and safety, efficiency, service, cost-effectiveness, and patient outcomes [8]. As radiologists are increasingly asked to demonstrate their value, data that can be derived using BI tools are important in assessing each of these aspects of radiology practice.

**COMMON BI METRICS IN RADIOLOGY**

A number of BI metrics already exist in radiology [9]. These metrics provide valuable information about a radiology practice that can be used to improve cost-effectiveness, patient safety, and potential revenue. Many of these can be grouped under the umbrella of “efficiency,” such as turnaround time, scanner utilization, departmental patient throughput, and pre- and postprocedural wait times. Turnaround time is one of the most common and easily computed radiology metrics. However, it is only one component of workflow efficiency and is dependent on individual radiologists. Therefore, it is more difficult to systematically optimize.

Scanner utilization and patient throughput can also have a significant impact and have been associated with declining reimbursements secondary to recent increases in the Medicare equipment utilization rate. However, BI can be used to identify inefficiencies in the way patients flow through a radiology practice. For example, an analysis of the wait times for each stage of an outpatient radiology visit (eg, registration, changing, awaiting examination, undergoing examination) can reveal potential areas for improvement. Investigating the circumstances underlying “no-shows” (ie, patients who do not keep their outpatient appointments) can shed light on unrecognized problems that may have a significant impact on overall efficiency and throughput. More important, such analyses can help correctly identify areas for improvement and avoid the pitfall of creating scapegoats (eg, “the problem is always with X,” even though X may not, in fact, be the most inefficient part of the process). Some of these data can even be collected and tracked via participation in the General Radiology Improvement Database, part of the ACR’s National Radiology Data Registry [10].

Biopsy yield and interventional complication rates are also important to monitor but can be challenging to track; comprehensive data for an individual patient may be stored in disparate systems (eg, clinical notes in the outpatient EMR, radiology interpretation in the RIS, pathology results in the inpatient EMR). However, these types of data can be used to more effectively plan and manage interventional procedures.

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Fig 1. The business intelligence process.
BI tools can also be useful to look for mismatches between radiology coding and study reporting. Duszak et al. [11] illustrated this with ultrasound examinations: as many as 20% of abdominal ultrasound examinations are incorrectly documented, resulting in more than 5% revenue loss for a radiology practice.

In recent years, additional metrics have also been used in radiology practice: radiation dose monitoring and reduction, contrast extravasation event tracking and analysis, the Physician Quality Reporting System, and the more recent meaningful use compliance. Both radiation dose indices and contrast extravasation can be tracked through the ACR’s National Radiology Data Registry, specifically via the Dose Index Registry® and the IV Contrast Extravasation Registry [10].

A number of software applications for radiation dose monitoring now exist in both the commercial and open-source realms, and the Dose Index Registry will soon be expanded beyond CT to track radiographic dose indices. These tools can be used to collect dose parameter data and facilitate large-scale protocol review and modification without the need for unrealistic manual data entry.

Both the Physician Quality Reporting System and the meaningful use initiative will eventually require radiologists to transition from incentive- to penalty-based models and to track and report a variety of clinical and procedural metrics. BI can be used to mine these data not only for reporting purposes but also for eventual practice improvement.

BI TOOLS FOR RADIOLOGY

Both commercial and open-source BI tools are available in the marketplace. Commercial options are available as either stand-alone BI tools or integrated components of EMR software applications. Some are generic to medicine, whereas others are specific to radiology. In addition, Pentaho is an open-source BI application that can be used to perform a variety of radiology-specific analytics as well as tracking metrics previously described [12].

KEY LESSONS

When approaching the subject of BI in radiology, it is important to know what data are available in your various EMRs, as well as where and how they are stored. In addition, it is critical to verify that the data actually represent what you think they do. Finally, it is critical for success to identify the features and limitations of the BI tools you choose to use and to plan your practice modifications on the basis of collected data. It is equally important to remember that BI plays a critical role in continuous process improvement; whichever BI tools you choose should be flexible enough to grow and evolve with your practice.

FUTURE OF BI IN RADIOLOGY

As the use of BI in radiology becomes more widespread, additional analytics become more important. Medicine is increasingly moving toward outcomes-based practice, and radiology is no exception. More data will be needed to determine the effects of diagnostic imaging or therapeutic intervention on intermediate and final patient outcomes. With the impending transition from the current payer system to accountable care organizations, radiology may become a cost center rather than a revenue source. This will require radiology practices to be effective and efficient and prepared to operate without relying solely on referrals.

Many of the data with which to conduct these analyses are already available, but they may be stored in disparate systems that do not directly communicate with one another. Future analytics will be used to integrate these data and provide computerized decision support to referring physicians to ensure that patients receive appropriate imaging that improves outcomes.

TAKE-HOME POINTS

- BI has evolved and matured in other industries but is comparatively new in radiology.
- There are different levels of BI, which can be descriptive, analytic, and even predictive.
- It is important to know what data are available for analysis and how they are stored in the EMR.
- BI tools should be flexible enough to grow and evolve with your practice.

ADDITIONAL RESOURCES


REFERENCES