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Business Intelligence, Data Mining, and Future Trends

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This series has endeavored to direct the thinking and mind-set of radiologists to embrace the ACR's Imaging 3.0™ strategic initiative through the concept of the imaging value chain. This vision was in response to the complex and uncertain changes afoot in health care policy, delivery, and reimbursement. A fundamental tenet of health care reform is the move from a transactional fee-for-service model to one that is value driven and focused on patient outcomes—the "volume-to-value" paradigm. In response, the health care profession has yet to fully understand, grasp, and reengineer its workflow, but Imaging 3.0 serves as a roadmap for radiologists to gear their businesses toward delivering better value.

Addressing each link of the value chain, this series has offered radiologists practical ideas and solutions to reengineer their workflow toward the emerging value-based delivery systems. In this final article, we discuss metrics and data necessary to monitor performance in the new outcome- and value-driven domain and outline how such business intelligence can inform strategy, design, and implementation of Imaging 3.0. IT is fundamental to driving this agenda, and the advent of big data and future trends are explored.

In the current fee-for-service environment, performance metrics focus mainly on processes and inputs, which are financial (eg, revenue, expenses, days in accounts receivable), productivity-based (eg, examination volume), or access metrics (eg, turnaround times, backlog). These and other metrics are readily available and should be evaluated frequently, if not daily, and have been discussed in prior articles in this series and by others [1]. Few of these metrics, however, measure what is important from the patient's perspective: value and outcomes. Although these process metrics will remain important indicators of performance, they rarely substitute for measuring outcomes [2]. As health care evolves into a value-driven framework, outcome- and quality-based indicators will become increasingly important, even essential.

Most organizations are struggling to reorganize their operations and measure them in way that reflects value to patients, rather than themselves. It has been proposed that efforts to deliver more effective care will necessitate a deep and fundamental restructuring of the way care is currently organized and processed, moving away relatively "siloed" delivery environments to those that are disease based, ideally through integrated practice units (IPUs) [2]. These units would be composed of multiple different specialty providers, nurses, social workers, and others, each with their own mandates, governance structures, and shared accountability. Because success will be determined primarily by patients, IPUs will need to organize their activities on the basis of patient conditions and needs, with all services and activities then being measured according to those criteria [2]. For radiologists, this will mean defining a set of value metrics and dashboards, which when aggregated will demonstrate imaging's contribution to the overall value unit provided during a patient's episode of care.

Many organizations have already reorganized some of their care delivery into center-based models (eg, cancer centers), but it will be some time before IPUs can be practically embedded across most organizations. Some radiologists may thus argue that it is too premature to reorganize activities into a value-driven paradigm, but this will likely prove shortsighted. The call of Imaging 3.0 is for radiologists to take a leadership role in shaping America's health care system so that the profession can remain relevant and robust. Using the concepts discussed in this series and the Imaging 3.0 imperatives, radiologists can begin to imagine more relevant metrics that will demonstrate how radiologists are indispensable to the care redesign process and central to the delivery of value-focused care.

There is currently active debate within the radiology community as to what value metrics should be measured, with some worthy early contributions [3]. It may also be helpful for readers to refer back to the framework discussed in this series. A closer look at each link in the value chain will help identify many value activities that can be readily measured and benchmarked, which reflect radiology's contribution to patient outcomes. A comprehensive list is outside the scope of this article, but some

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Table 1. Imaging value chain metrics

Value Activity	Possible Value Metrics
Imaging appropriateness	▪ Compliance with ACR guidelines and ACR Appropriateness Criteria by specialty and physician
	▪ Adherence to order entry decision support tools
	▪ Identification of duplicate examinations
	▪ Part of integrated care pathway
Patient scheduling	▪ Scheduler response time
	▪ Scheduler customer service feedback
	▪ Time from examination request to appointment
	▪ Scheduled at convenient time and location to patient
	▪ Time to schedule and perform same day add-ons
Patient preparation	▪ Ease of access to scanning facility
	▪ Time from arrival at suite to scanning
	▪ Staff customer service feedback
Protocol	▪ Compliance with departmental standard protocol
	▪ Radiation dose measurement and benchmarking
	▪ Protocol length
Modality operations	▪ On time scanning
	▪ Time performing scan (room time)
	▪ Overall time from arrival to discharge
	▪ Contrast reactions and extravasation
	▪ Staff customer feedback
Reporting	▪ Adequate history
	▪ Access to relevant collateral data in the EMR
	▪ Adherence to ACR incidental finding criteria
	▪ Frequency of recommendations
	▪ Structured reporting
	▪ Standard lexicon and language
	▪ Report grammatical or voice recognition error
	▪ Time from examination completion to finalized report
	▪ Is the report actionable?
	▪ Accuracy of report to final diagnosis
Report communication	▪ Time for report availability to patient
	▪ Time for closed-loop critical results reporting
	▪ Ease of report access by patient
	▪ Report understood by patient
	▪ Report consultation to patient
Examination outcome	▪ Did the referring physicians find the information useful (as per NOPR methodology)?
	▪ Did results of imaging change diagnosis or therapy?
	▪ Did the use of imaging eliminate need for more invasive/expensive procedures?
	▪ Did use of imaging reduce length of stay?
	▪ Complications
	▪ Patient satisfaction
	▪ Referring physician satisfaction

Note: EMR = electronic medical record; NOPR = National Oncology PET Registry.

suggestions following the sequential activities in the imaging value chain are highlighted in Table 1.

Measurement and display of such value activities will require an enabling IT platform requiring 6 elements [4]. First, it must be centered on patients through their full cycle of care. Second, it must use common data definitions, with all caregivers using a standard lexicon. Third, it must encompass all types of patient data. Fourth, data must be accessible to all parties involved in care, including patients. Fifth, it must include templates and expert systems for each medical condition so that teams can enter and find data, execute procedures, and identify best practice actions. And last, its system architecture must make it easy to extract information.

That final element will become increasingly critical to future care delivery.

Currently, most information systems harbor "dumb" data, which are difficult or impossible to mine. As big data algorithms are realized, "dumb" data from multiple repositories in the diaspora will be mobilized, both in advance and at the point of care, to release new knowledge that can inform clinical practice [5]. Big data will also facilitate systems biology integration with electronic medical record data and facilitate patient interaction, both key goals of personalized medicine [6]. For radiologists, there will be a host of customized, premined collateral clinical and biomarker information helping inform their clinical decisions during image interpretation.

We hope this series has challenged radiologists to think of themselves as fiduciary owners of the entirety of the imaging value chain, not just image interpreters. By engaging with key stakeholders, radiologists have the opportunity to reengineer current operations into a value-driven workflow, with the ultimate goal of influencing patient outcomes through actionable reporting. New information systems using big data tools will create new knowledge to inform clinical practice in a perpetual cycle of innovation, and to remain maximally relevant, radiology must be integral to such initiatives.

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