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ARTICLE

The Agenda for the Next Generation of Health Care Information Technology

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As the diffusion of value-based health care efforts accelerates globally, the need for interoperable information technology systems that support value-based care is essential. Such systems are needed to facilitate dramatic improvements in patient outcomes and efficiency and, importantly, to end an era in which health IT has entrenched the status quo, perpetuated silos, and blocked reimbursement reform. A value-enabling IT platform must organize data around conditions and must enable integrated practice units to integrate care both within and across health systems. In addition, the electronic health record should be the sole source of costing information so that accurate costs for every encounter can be tracked, aggregated, shared, and used for improvement. This is the next generation of health care IT.

Value-based health care is spreading rapidly; it is being adopted and refined by numerous providers and payers globally. However, current information technology (IT) systems are a major barrier to achieving value in health care. To enable the transformation to value, a new generation of IT is needed. Although there have been major efforts to accelerate the adoption of IT in health care over the last several decades, the capabilities of today's IT infrastructure fall well short of what is needed to truly support value-based care.

There is general agreement that the U.S. health care delivery system is in need of major transformation, as are the health systems in numerous other countries. Multiple attempts have been made to reform health care, but these efforts have failed to control costs or address the major quality variations that persist. A new approach that focuses on value for patients was introduced by Michael Porter and Elizabeth Teisberg in 2006, and a substantial body of literature on value-based health care has followed.[1]

Value is defined as the health outcomes achieved per dollar spent to achieve them.[2] The core features of value-based health care delivery include:

- The formation of multidisciplinary teams of clinicians and support staff that are organized around care for medical conditions or patient segments over the full care cycle
- The measurement of a set of outcomes that matter to patients for each condition and the use of new accounting methods to understand the full cost of delivering their care
- The use of reimbursement models that directly reward good outcomes as well as efficiency in delivering them
- The integration of care for conditions in health systems and the delivery of care in the right locations across the care cycle

Our purposes here are (1) to discuss the evolution of health IT over recent decades, (2) to assess its progress in delivering the capabilities required to support value, (3) to offer a strategy for developing and implementing the IT platforms necessary to enable value-based health care, and (4) to propose how all sectors of the health care industry can best support and accelerate the value agenda through IT.

Value-Based Health Care Delivery and the Role of IT

For more than a decade, Michael Porter's team at Harvard Business School has been building out the framework and methods for value-based health care delivery. The value-based approach involves greater implementation challenges than those faced during many previous reform efforts. The implementation of value-based care has yielded major improvements in care delivery in leading systems such as Cleveland Clinic, Mayo Clinic, Texas Children's Hospital, Children's Hospital of Philadelphia, the University of Utah, Vanderbilt University Medical Center, and many others, including community providers in the United States.[3-7] Many other countries, such as the Netherlands, Singapore, Sweden, England, and Wales, are also implementing value-based health care agendas.[8,9] While some nations, payers, and delivery systems have made important efforts to implement value-based health care, the transition has been difficult as most delivery systems are firmly tied to their current reimbursement systems. In the United States, where fee-for-service (FFS) payment has been in place for many years, the transition to value-based reimbursement has been slow. For that reason, IT systems must support fee-for-service as well as value based-health care; the ideal health IT platform could do both.

The Value Agenda

The strategic agenda for moving to value-based delivery consists of several mutually reinforcing elements, as described below with particular attention to IT.[10]

Organizing Care around Medical Conditions

Delivering value in health care begins with organizing care delivery centers that are focused around well-defined acute or chronic medical conditions or groups of closely related conditions requiring similar provider skills and facilities. These condition-focused centers, known as *integrated practice units,* represent a multidisciplinary team-based approach that extends throughout the full care

cycle. In primary care, this same basic structure applies when managing segments of patients who have similar primary and preventive needs.[11] The IT that is needed to support integrated practice units must provide a platform that (1) brings together all of the relevant data needed to care for a condition, (2) provides a structured presentation of information that facilitates team care, (3) facilitates access for both referring physicians and patients, and (4) enables the integration of patient information and care data across the full care cycle and across sites, even if multiple provider organizations are involved.

Measuring Outcomes and Costs for Every Patient

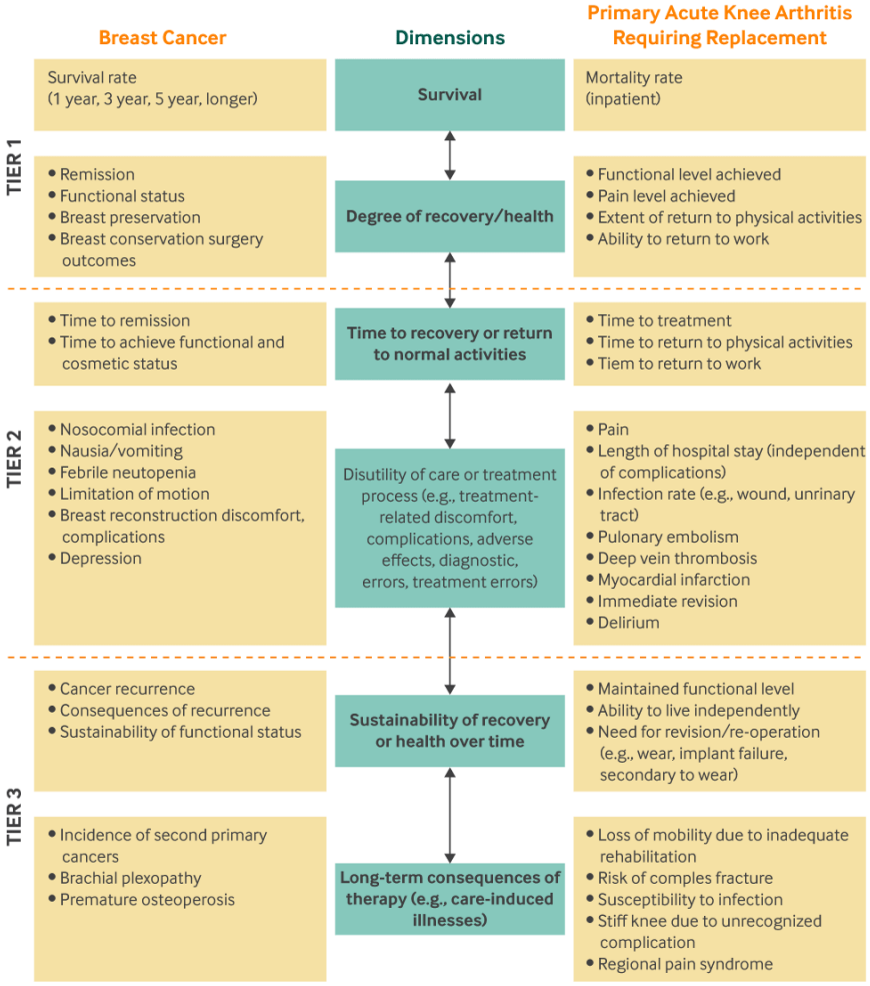
The most powerful driver of improvement in any industry or activity is the ongoing measurement of value and comparison of results. This process requires universal measurement of the outcomes that matter for patients (by either condition or patient segment) and the cost to deliver them. IT needs to be configured to support efficient, structured outcome measurements as well as the integration of data collection into standard workflows. IT also must allow patient tracking across the care cycle, in both time and resource use for every step in the process, in order to support accurate costing.

Outcome measurement: For each condition, there is a three-tiered hierarchy of outcomes that matter to patients and providers (Figure 1).[2,12] Tier 1 relates to the patient health status achieved, including survival, clinical outcome, and functional outcome (e.g., mobility, return to work). Tier 2 encompasses the patient's experience during the care cycle, including time to diagnosis, time to treatment, time to recovery, and care-related pain, discomfort, errors, and complications. Tier 3 pertains to the sustainability of health as reflected in the prevalence of and time before recurrences or complications due to the therapy itself.

FIGURE 1

Example of the Outcome Hierarchy for Breast Cancer and Knee Osteoarthritis

There are three tiers for health outcomes. Tier 1 involves survival and immediate recovery. Tier 2 relates to the time to recovery and complications of treatment. Tier 3 relates to the sustainability of health. Using breast cancer and knee osteoarthritis as examples, one can see that there are condition-specific measures for each tier. IT needs to support the routine and efficient collection of these outcomes (clinical and patient-reported) in the patient care workflow and enable the routine aggregation of outcomes for the purposes of clinical management, performance improvement, and public reporting.



Source: Adapted from Porter ME. What is value in health care? N Engl J Med. 2010; 363(26):2477-81.
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> *"To enable the transformation to value, a new generation of IT is needed."*

IT needs to support the routine and efficient collection of these outcomes in the patient care workflow and enable the routine aggregation of outcomes for the purposes of clinical management,

performance improvement, and public reporting. Patient-reported outcome measures (PROMs) require capture in different ways than clinical outcomes. Specifically, clinical outcomes are collected in the electronic health record (EHR), whereas PROMs must be captured with use of a variety of methods, depending on patient and provider organization preference (e.g., e-mailed surveys, use of tablets in the waiting room, manual entry by clinic staff in the examination room, etc.) and then must be entered into the EHR for integration with the clinical outcomes. The IT systems of the future will enable routine and efficient collection and aggregation of meaningful outcomes throughout the cycle of care in order to support and improve clinical care. Other clinical information, such as risk factors and genomic data, will be combined with outcomes to allow advanced analytics and decision support. During clinical encounters, structured elements or templates will be used to allow outcome collection while minimizing the administrative burden to clinicians.

Cost measurement: The cost of care needs to be measured according to patient and condition and not according to departments or support functions. The cost of care includes all of the personnel, resources, supplies, and supporting services that are involved across the full cycle of a patient's care for a condition. Costing systems start with the documentation of actual care processes, the time spent by personnel and equipment, and other resources used. Time-driven activity-based costing (TDABC) is becoming the new gold standard for accurate health care costing, but in the absence of IT solutions it remains a time-consuming manual process.[13] IT can facilitate TDABC in all health care settings by automatically capturing the time and the resources actually utilized in each clinical process, and enterprise resource planning systems can be used to link this information with data on staff salaries, supply costs, facility costs, and so on. This capability allows continuous, real-time cost measurement for each patient. Most current costing systems do not identify which provider is providing each service, the time taken to perform the service, and other key inputs involved in patient care. Emerging technology will allow routine and efficient collection of such data and will make TDABC a routine element of value-based measurement.

Moving to Bundled Payments for Care Cycles

The fee-for-service reimbursement model rewards the volume of services instead of value and has been a major contributor to the relentless rise of health care costs. We believe that bundled payments (i.e., risk-adjusted single payments that cover the full cycle of care for a condition, from diagnosis through rehabilitation) are directly aligned with value and are the best way to pay for care. In this model, payment is contingent on the achievement of good outcomes, thereby allowing providers to directly benefit by improving efficiency. IT systems that capture both costs and outcomes over the care cycle are essential for modeling bundled payments and estimating costs for the purpose of price-setting. IT solutions also are needed to manage the billing and claims-management cycles involved in bundled payments for both providers and payers. Current claims-based fee-for-service reimbursement involves very high administrative costs in comparison with bundled-payment processing. In addition, current billing systems require bundled payments claims to be manually separated from fee-for-service claims and to be submitted in a separate process, leading to inefficiency and lengthier times to payment.

> *"The systems that persist in health care today are essentially revenue cycle tools that are designed to maximize charge capture and billing but often fail to support other core functions such as clinical data integration, measurement, reporting, decision support, and advanced analytics."*

Billing systems of the future will identify patients who are covered by bundled-payment claims versus fee-for-service claims or capitation. Bundled-payment claims, involving a single price and a small number of contingencies, will be submitted separately by the provider to the payer along with accompanying information as specified in the contract. For payers, IT solutions for bundled-payment claims processing will result in far lower administrative costs and will ensure transparency and immediate payment once care is completed. Providers also will be positively impacted as the documentation and administrative requirements for bundled payments will be diminished dramatically in comparison with those for fee-for-service payments.

Integrating Care-Delivery Systems and Geographically Expanding Centers of Excellence

Much care in the United States and around the world is provided by regionally focused single-provider units or multisite delivery systems. Historically, providers duplicate many services across locations, leading to fragmentation of patient volume and duplication of services and facilities for a given condition. Care that takes place in multiple locations is often poorly coordinated.

Conversely, in value-based care delivery, sites of care and services are integrated into true delivery systems. Patients with a given condition are concentrated in one or two sites, with complex services being concentrated in high-resource locations and lower-complexity services being shifted to lower-cost facilities that are often more convenient for patients. IT is used to support integrated multisite care delivery and coordination across geography, with clinical and other data being collected and shared via a common platform. Multiple sites of care are examined with respect to outcomes and costs measured across the care cycle, and data are easily compared across sites to determine the optimal location of different clinical services.

The Evolution of Health IT

Today's IT systems reflect the fragmented legacy structure of care delivery as well the limits of IT capabilities. We must understand the nature of legacy IT systems and their technological foundations in order to understand clinicians' frustration with current EHRs and the limitations of these systems for value-based care.

The heart of a health IT system is the patient's medical record. Medical records initially were paper-based. This approach persisted with very few changes through most of the 20th century. The early use of computers in health care involved punched-card systems that initially were adopted to support epidemiological public health surveys in the 1920s and 1930s. By the 1950s, much faster mainframe computers began to be widely adopted in the United States. The earliest hospital systems using the new technology emerged in the 1960s and were pioneered by G. Octo

Barnett, MD, the founder of the Laboratory of Computer Science at the Massachusetts General Hospital. Barnett was one of the first to develop an electronic hospital-based health record using an early programming language know as MUMPS (Massachusetts General Hospital Utility Multi-Programming System), which is still in use today in many commercial EHR systems. Lower-cost minicomputers emerged in the 1970s and ran software that focused on specific departments, such as laboratory medicine and pathology. While this development moved the technology into the hands of individual clinicians and administrators, it reinforced clinical department silos and the separate worlds of hospital medicine and ambulatory medicine. IT applications designed around those silos and sites of care were independent and were not integrated in meaningful ways.[14]

It was not until the early 1990s that the use of departmentally based IT became widespread in the United States. Increasing numbers of hospital departments (e.g., anesthesiology, critical care, and radiology) had separate, often stand-alone IT solutions for care documentation. These systems excelled in their ability to automate the processes used by particular specialists or to support single department operations (e.g., the clinical laboratory) or single functions (e.g., operating room scheduling). These standalone departmental systems, which came to be known as *best-of-breed* systems, failed to integrate with each other. Thus, there was no way to capture data and care across all of the units in the hospital and outpatient environments.

Many major health care institutions — notably Vanderbilt University Medical Center, Duke University Health System, Partners HealthCare, and The University of Texas MD Anderson Cancer Center — embarked on the development of their own *home-grown* EHR systems. These institutionally developed systems allowed clinicians to view information coming from several siloed sources but had many limitations (e.g., lack of interoperability, lack of data analytics, etc.). While some organizations, such as Vanderbilt and Partners, successfully developed computerized physician order entry and became leaders in the field, others did not.[15] Computerized order entry was a particular problem for organizations focusing on the treatment of cancer (e.g., MD Anderson) because the complexity of the conditions made order creation difficult. Leading home-grown systems also were slow to progress because organizations were focused on clinical care, research, and education, and not on software development. These factors created an opportunity for commercial EHR providers to develop alternative systems that addressed the deficiencies of home-grown systems.

> *"Rather than making clinical care simpler and more efficient, electronic entry made some routine tasks more difficult and time-consuming."*

In the 1980s and 1990s, a number of commercial software vendors, such as Epic and Cerner, set out to create all-inclusive EHR systems. However, those systems had their origins in billing solutions that processed fee-for-service payments. As such, those systems matched the claims being sent to payers with the complex documentation requirements for evaluation and management services that providers must perform to maximize their revenue. The systems that persist in health care today are essentially revenue cycle tools that are designed to maximize charge

capture and billing but often fail to support other core functions such as clinical data integration, measurement, reporting, decision support, and advanced analytics. While there have been some successes in areas such as clinical decision support,[16] data integration, and reporting, health IT has not been as successful in terms of measuring and analyzing outcomes and cost for all patients in all systems.

By the turn of the 21st century, truly integrated EHR systems remained rare or nonexistent in hospitals and physician practices in the United States and elsewhere. In his 2004 State of the Union Address, President George W. Bush spoke of the need for computerizing health records to avoid mistakes, reduce costs, and improve care. . In April 2004, Bush issued an Executive Order to create the position of National Health Information Technology Coordinator. At the time, researchers at the RAND Corporation projected that health IT, if widely adopted, would save more than $81 billion annually (2.5% of total health care spending), reduce adverse events, and improve the quality of care.[17] Later, in 2009, Congress passed, and President Barack Obama signed, the American Recovery and Reinvestment Act (ARRA), which established the Office of the National Coordinator for Health Information Technology (ONC) to accelerate the improvement, interoperability, and implementation of EHR systems across the United States.

Despite the bold goals, the adoption of electronic records by physicians and hospitals remained slow because of both cost and provider resistance. Physicians, in particular, who had learned how to document with use of paper charting, did not find existing EHR systems very user-friendly. Interfaces were not well designed and did not make the process of documentation simple. Physicians using EHR systems often had difficulty locating information that had previously been simply laid out and easy to find in paper charts. Many physicians resisted administrators' efforts to implement EHR systems. By 2007, only 4% of physicians reported using a fully functional electronic record in their offices.[18] In 2008, a survey of all U.S. acute-care hospitals revealed that only 1.5% had a comprehensive electronic record system and that those that did were primarily teaching hospitals in urban settings.[19]

As part of the 2009 ARRA, hospitals and health care organizations were given major monetary incentives to shift from paper to EHRs. A subset of ARRA, known as the Health Information Technology for Economic and Clinical Health (HITECH) Act, earmarked $2 billion to help health care providers implement health IT into their practices and to provide training. Through the Centers for Medicare & Medicaid Services (CMS), the federal government funded more than $38 billion in incentives to providers between 2011 and 2018 with its Promoting Interoperability (PI) Program.

> *"Ironically, the meaningful use criteria approach, by biasing IT development toward capabilities that were not directly connected to improving value for patients, created substantial barriers to innovation in health IT."*

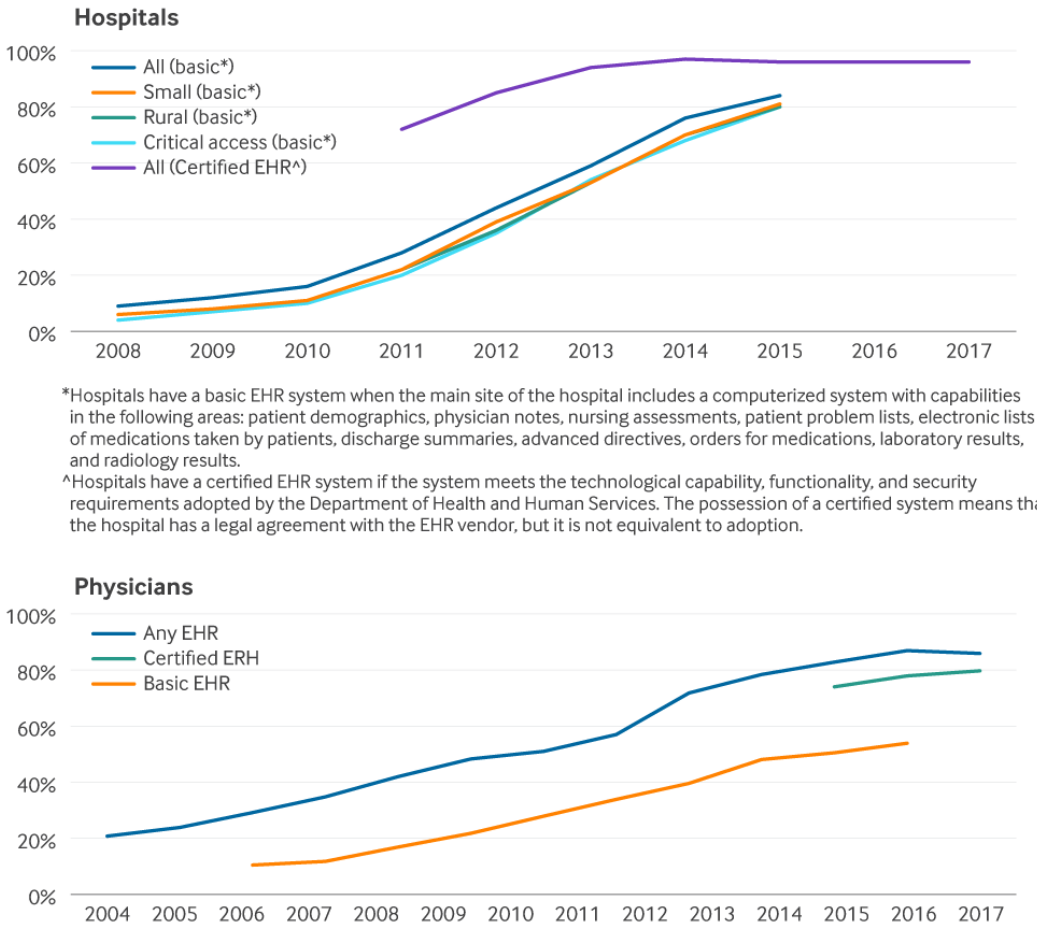
HITECH Act bonuses rewarded providers who performed certain designated clinical functions electronically. These functions, called *meaningful use functions*, included computerized order entry, electronic prescribing, and electronic messaging with patients. Yet rather than making clinical care simpler and more efficient, electronic entry made some routine tasks more difficult and time-consuming. In a study conducted at four sites using the two major EHR vendors, Epic and Cerner, investigators found tremendous variability in terms of the time and the number of keystrokes that physicians needed to accomplish simple tasks. For example, at one center, a previously simple order for oral Tylenol took an average of 62 clicks to complete.[20]

Despite clinician objections to the meaningful use program, the available financial incentives triggered a wave of health IT investment in systems certified for meaningful use in the first year of the program. Meaningful use incentives, coupled with prospective financial penalties of up to 4% of Medicare payments for the failure to demonstrate meaningful use of EHRs, stimulated many health care organizations to purchase and quickly implement new EHR systems. Organizations with uncertified EHR systems were driven to replace them with more modern technology. By 2015, more than 95% of hospitals and more than 75% of physicians reported using EHR systems that were approved for meaningful use (Figure 2).[21-23] Meaningful use requirements catapulted a number of health IT vendors into leading positions in the EHR market, while others without the necessary enabling technology faded.

FIGURE 2

Adoption of Electronic Health Records by Hospitals and Physicians.

Both hospitals and physicians have rapidly introduced electronic records in the first portion of the 21st century.



*Hospitals have a basic EHR system when the main site of the hospital includes a computerized system with capabilities in the following areas: patient demographics, physician notes, nursing assessments, patient problem lists, electronic lists of medications taken by patients, discharge summaries, advanced directives, orders for medications, laboratory results, and radiology results.

^Hospitals have a certified EHR system if the system meets the technological capability, functionality, and security requirements adopted by the Department of Health and Human Services. The possession of a certified system means that the hospital has a legal agreement with the EHR vendor, but it is not equivalent to adoption.

Source for hospital data: Office of the National Coordinator for Health Information Technology. 'Non-federal Acute Care Hospital Electronic Health Record Adoption,' Health IT Quick-Stat #47. dashboard.healthit.gov/quickstats/pages/FIG-Hospital-EHR-Adoption.php. September 2017. https://dashboard.healthit.gov/quickstats/pages/FIG-Hospital-EHR-Adoption.php

Source for physician data: Office of the National Coordinator for Health Information Technology. 'Office-based Physician Electronic Health Record Adoption,' Health IT Quick-Stat #50. dashboard.healthit.gov/quickstats/pages/physician-ehr-adoption-trends.php. January 2019. https://dashboard.healthit.gov/quickstats/pages/physician-ehr-adoption-trends.php

Despite IT advances in most areas of health care, technological progress in the area of mental health care lagged behind. Only 15% of psychiatric hospitals had adopted EHR systems by the time that more than 75% of other hospitals had done so. Psychiatric hospitals were not included in the meaningful use program, and most psychiatrists worked in small or solo practices in which EHR systems were frequently not affordable. Other providers, such as psychologists and social workers who were involved in mental health care, were not eligible for the incentive program.[24]

The Current State of Health IT

Despite the widespread implementation of EHR systems, their impact on reducing the cost and improving the quality and integration of health care has been limited. Most systems were focused on fulfilling discrete meaningful use criteria and on improving billing speed and accuracy. These systems managed documentation for fee-for-service billing but provided limited capability for coordinating, measuring, and improving clinical care. One of the areas in which EHR systems have had their greatest impact is in fee-for-service billing and revenue capture.

Ironically, the meaningful use criteria approach, by biasing IT development toward capabilities that were not directly connected to improving value for patients, created substantial barriers to innovation in health IT. Meaningful use also triggered consolidation and rising prices in the EHR market. In 2016, the American Medical Association and 40 other medical organizations called for the suspension of the meaningful use program, noting that it was unduly cumbersome and constituted a potential risk to patients.[25] Criticisms led large vendors to begin building decision-support capabilities and reporting capabilities into their systems, but there was little progress in facilitating the essential aspects of care integration, outcomes measurement, and accurate costing.

Today's commercial EHR systems consist of modules for specific care areas (e.g., ambulatory care units, operating rooms, inpatient wards, or intensive care units) rather than around integrated care for specific patient conditions. This architecture, however, has made it difficult for multidisciplinary teams that are focused on conditions to coordinate and to work together efficiently and effectively across the care cycle.

Another weakness of today's systems is in recording, aggregating, and reporting the outcomes of care. The clinical workflow is disrupted by the additional steps required for data collection and recording. Extracting outcome data from EHR systems is difficult unless an EHR element is designed to be extracted when the system is built. If it is not, rewriting code to allow for data extraction and transfer to a reporting system is difficult, time-consuming, and expensive.

Current cost-measurement systems have remained standalone systems — not integrated with the EHR system — that use charges to estimate cost rather than measuring true costs. Current costing systems lack the capability to track actual resource use (such as the processes, personnel time, and facilities used in care), rendering them inaccurate and making it difficult to identify cost savings resulting from specific performance improvements. The lack of costing integration with EHR systems and enterprise resource planning systems also makes accurate cost measurement time-consuming and manual.

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The field of IT has put forward concepts such as big data, advanced analytics, and learning systems that are frequently mentioned as "solutions" that will transform health care. However, such concepts are far ahead of today's EHR capabilities and current care-organizational models. While EHR systems, in theory, have the ability to dynamically collect, store, analyze, and transmit seemingly unending amounts of information, current systems are not structured to adequately accomplish these functions, much less capture care processes, outcomes, or true costs by condition. Health care systems currently lack sufficient standardization of care processes and terminology to be able to make an immediate change to value-enabling IT. Over time, the variability of care processes within delivery organizations will need to be minimized, and standardized outcome measures, cost measures, and data definitions will need to be adopted and broadly applied before meaningful benchmarking and improvement can occur.

To leverage big data concepts, IT systems will need to (1) focus more on clinical conditions, (2) make data elements easily extractable for storage in a searchable data warehouse, and (3) facilitate data integration between EHR systems and other systems (e.g., institutional, state, and federal databases). Advanced analytics and precision medicine are hampered by the current IT architecture, which is focused on specialties and service areas rather than on integrated care models, rendering the promise of artificial intelligence in health care a goal and not a reality.

The Imperative of Interoperability

Interoperability — the ability of systems and devices to exchange and interpret data — is a major prerequisite of IT that enables value-based health care. One of the most serious defects in current health IT is the frequent inability to share data among providers and provider organizations. While there has been significant progress in this area over the past 5 years, more progress is needed to accelerate the implementation of value-based health care. Measurement and data standards need to be agreed upon before data are shared; otherwise, the interoperability of EHR information will only be useful for the care of individual patients but not for broader issues that can be assessed with aggregated data. The lack of interoperability between vendors has made information-sharing difficult as patients move from clinician to clinician and across care locations. The result is major redundancy in terms of both data gathering and clinical testing. By standing in the way of data aggregation, the current architecture and the lack of interoperability make the concepts of learning systems and using big data difficult to achieve in practice.

The Limits of Health Information Exchanges

Health information exchanges were introduced as a short-term fix to the interoperability problem by facilitating the exchange of information between providers lacking interoperable EHR systems. These exchanges are organizations that facilitate complete sharing of all or parts of the medical record or that provide the records to patients who then transmit them directly to other providers. In effect, health information exchanges serve as the electronic "middleman" to address the lack of interoperability of EHR systems, but they are not a long-term solution. Evidence of their efficacy is limited; however, a recent analysis of hospitals in Florida suggested that participation in a health information exchange lowered hospital readmission rates for patients with acute myocardial infarction.[26]

Information Blocking

Another important problem restricting data extraction from EHRs is the concept of *information blocking*, which is a practice used predominately by EHR vendors to limit the ability of anyone but the vendor to easily extract data from the EHR. This practice makes each commercial EHR unique, blocks data exchange between systems from different vendors, and makes data extraction by third-party vendors difficult. Information blocking is also practiced by provider organizations that do not want to share their health information data with other provider organizations.[27] Information blocking has made outcome and cost measurement difficult and, until recently, has made true interoperability possible only for systems using a single EHR vendor.

Application program interfaces (APIs) are designed to enable data extraction for multiple purposes (e.g., schedule openings or important test results) and control how one application can "talk" with another. Although APIs can facilitate interoperability, information blocking has meant that APIs cannot easily extract data from EHR systems. As a result, many API developers have been forced to turn to workarounds, such as creating PDFs of EHR files and extracting data from them. Such workarounds have limitations, mainly related to the depth of data analytics possible.

Incomplete Data Standards

The Fast Healthcare Interoperability Resources (FHIR, pronounced the same as *fire*), a draft standard designed to improve the ability to exchange EHR data between different systems, was introduced by Health Level Seven International (HL7) in 2014. HL7 is a not-for-profit, American National Standards Institute (ANSI)–accredited standards-developing organization that is dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information to support clinical practice. These standards have enabled easier information exchange between EHR systems.

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The HL7 FHIR Standard, released in three successive versions between 2014 and 2017, allows for discrete data to be extracted from EHR systems despite differences in data models. This standard is now being supported by large vendors such as Cerner and Epic.[28] However, it should be noted that the complexity of health care data sometimes makes it difficult to match up data elements across the data management models used by different EHR systems because of how the data are formatted.

Cost and Priorities

A final challenge to interoperability is its current cost. Modifications to existing systems are costly and add to annual IT budgets. IT departments are also being asked to address other post-EHR

implementation modifications coming from a variety of stakeholders, including clinicians and administrators. Achieving interoperability is not always at the top of the list when compared with the need to make a new EHR installation functional and safe when going live. Once an EHR system is installed and an organization has gone live with its use in patient care, provider organizations are often left with many issues that need to be addressed, such as regaining productivity, further staff training, patient education, optimization of information presentation, and implementation of additional features such as new templates and order sets. All of these tasks are now left to a much smaller EHR team. The post-go-live period often requires as much time and effort as the pre-go-live period, leaving interoperability far down on the list of priorities.

From Electronic Health Records to Value-Enabling IT Systems

In the move toward value-based care, the path forward is clear. IT systems must have the capability to enable each aspect of the value agenda while providing ubiquitous and seamless information-sharing with patients and across providers, payers, and vendors. Key tools for doing so will include condition-based templates for coordinating care and clinician-oriented tools enabling outcome measurement, cost measurement, and bundled reimbursement. The implementation of such templates and tools will require the time of dedicated support teams to modify existing EHR systems, but the cost savings associated with the move to a value-based system should outweigh the implementation costs over the long term.

Condition-Based Templates and Platforms

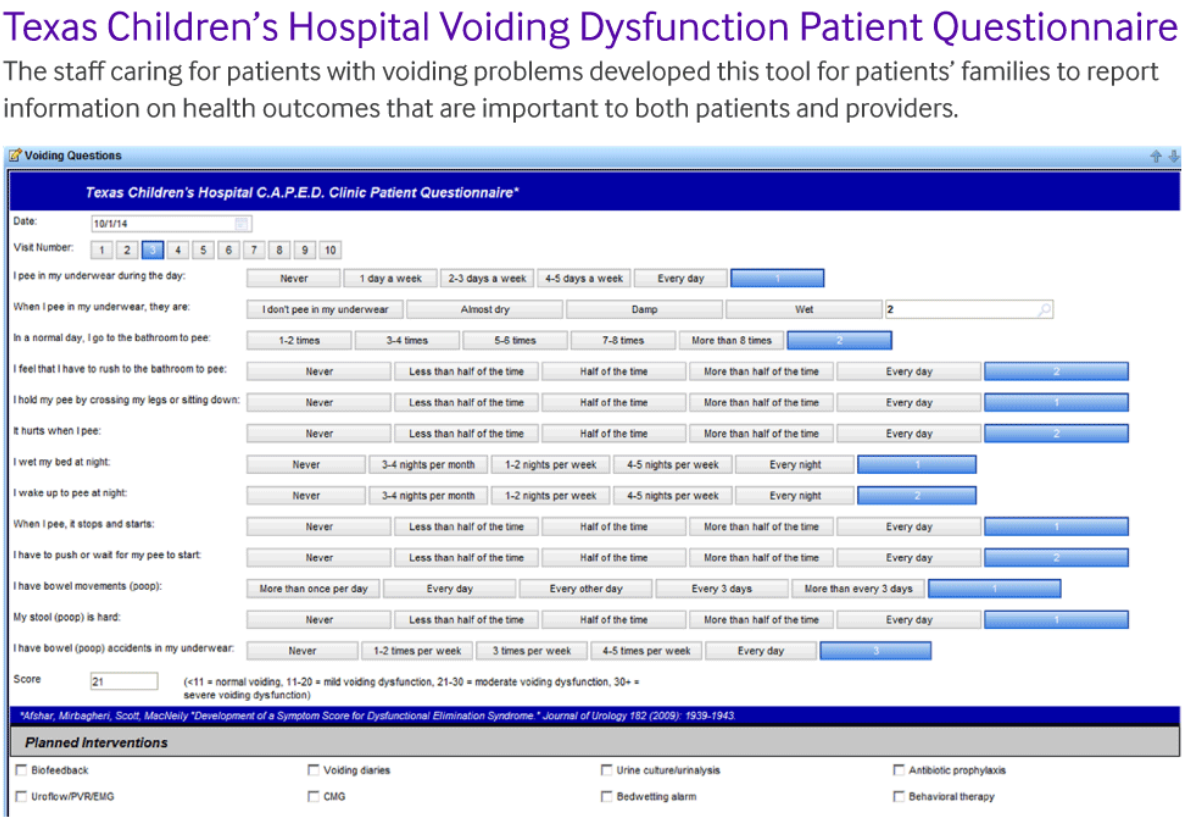
A value-enabling IT platform must organize data around conditions and must enable integrated practice units to integrate care both within and across health systems. Multidisciplinary teams must be able to jointly view data, collaborate, communicate, discuss care choices, and measure outcomes as well as other relevant patient data across the care cycle. Condition-based care requires interfaces that are centered on care for the condition rather than on individual specialties, services, or care locations. A value-enabling IT platform would be organized around the condition or conditions using a problem-list format. Problem lists, a form of template for medical conditions, were introduced in health care in 1968 by Lawrence Weed.[29] A problem-oriented record consists of a list of all of the conditions affecting a patient and how each condition is being managed. For example, a confused elderly patient who is admitted to the hospital from the emergency department with diabetes, foot ulcers, and poor nutrition would have the following problem list in her EHR that could be used to support her inpatient care:

1. Diabetes mellitus type II
2. Diabetic ulcers x 3
3. Malnutrition
4. Anemia
5. Confusion (rule out early-onset dementia)

On the basis of such a list, plans for managing each problem can be developed and integrated. Problem lists highlight the most important problems and deemphasize inactive problems. Most vendors have the capability to organize data around problems. However, problem lists have not been used uniformly by clinicians. The use of problem lists and other templates for capturing and reporting data by condition are critical to care delivery, reporting, and data transfer. Broader use of problem lists in EHR systems can simplify the data-extraction process. Most EHRs provide good support for problem lists, including the ability to import them into patient notes.

In health care organizations with the resources and commitment to substantially customize commercial EHR systems, condition or problem-based templates are already starting to appear. Texas Children's Hospital, for instance, has designed dozens of customized forms within its commercial EHR system that are centered on conditions such as supracondylar fractures, congenital heart disease, and even bed-wetting. Clinical teams use these condition-based templates to track and coordinate a patient's care across time, collect functional and patient-reported outcomes, display meaningful outcomes to clinicians and patients, and embed access to evidence-based decision support for use in real-time care (Figure 3).[30]

FIGURE 3



Source: Carberry K, Landman Z, Xie M, Feeley TW, Henderson J, Fraser C. Incorporating longitudinal pediatric patient-centered outcome measurement into the clinical workflow using a commercial electronic health record: a step toward increasing value for the patient. J Amer Med Inform Assoc. 2016;23:88-93.

Commercial EHR systems have added the capability to customize views, but customization is difficult, is usually expensive, and typically is left to the provider. In the ideal state, the EHR vendor would present the clinician (and the patient) with an off-the-shelf condition-specific platform (such as for stroke or knee arthritis care) that supports the functions of all members of the team as well as the patient (via the patient portal or mobile app). As the patient moves through the care cycle from prevention through recovery, key data elements such as process maps, process status (such as physical therapy progress), outcomes, and cost status would be easily accessible by the team.

Evidence-based treatment alerts should be integrated into the EHR when available. Children's Hospital of Philadelphia, for example, has integrated information across the care pathways and condition-based evidence into its Epic EHR system. The clinical pathway program at that institution advises all clinicians about optimal care for a condition, keeps clinicians up to date with new treatment advances, and monitors the performance of clinicians relative to adherence to evidence-based care pathways.[4]

Enabling Outcome Measurement

IT must integrate outcome measurement into condition workflows. Outcome measurement is essential in order for organizations to gather comparative data about the results of care that are important to patients as well as to clinicians focused on improving care. Outcome measures also are important for public reporting and ultimately for use in new reimbursement methods that reward providers who achieve good outcomes while penalizing those who do not. Current obstacles to outcome measurement and reporting could be dramatically reduced by advances in health IT.

> *"A value-enabling IT platform must organize data around conditions and must enable integrated practice units to integrate care both within and across health systems."*

Implementing outcome measurement in today's EHRs is difficult because of the absence of standardized vocabularies — that is, using the same terms to describe clinical conditions. This may sound simple, but many EHR systems allow clinicians to use free text to identify the clinical condition being treated. For example, a patient with early-stage breast cancer could have the condition listed as *breast cancer stage 0, carcinoma of the breast stage 0, ductal carcinoma in situ, DCIS,*etc. In the absence of a standardized vocabulary, searching for all patients with early-stage breast cancer is challenging. The conversion to ICD 10(International Classification of Diseases, Tenth Revision), in conjunction with the wide adoption of SNOMED-CT (**S**ystematized**No**menclature of**Med**icine-**C**linical**T**erms) terminology in most EHR systems, has helped to move toward standardized vocabularies.

Once vocabularies are standardized, they must be used consistently. The simplest way to address this problem is through the use of structured documentation in the EHR. Structured documentation requires clinicians to click through lists of clinical conditions to find the most appropriate description of the patient's problem and then add any specific modifiers to the

description in order to be as accurate as possible. Structured elements using standard terminology are essential for defining the condition but also for identifying the outcomes of care such as disease remission and complications. The person entering the data needs to be precise about selecting the condition and identifying the relevant sequelae of the condition in order to enable searching and data analysis.

Unfortunately, structured clinical documentation is not consistently utilized in clinical processes. Many clinicians dislike structured documentation because of the sometimes-large number of structured fields; they prefer free-text entries, feeling that a narrative can capture a clinical situation more precisely than structured text. Even when structured text is used, it is often not stored in a manner that can later be aggregated and analyzed. Many clinicians also still rely on dictation. While dictation can be incorporated into a reporting environment with use of techniques such as natural language processing (NLP), the use of NLP is challenging and has not been broadly implemented. Using structured text and other approaches to outcome measurement creates the need for more data input, increasing frontline burnout. Many clinicians feel that the extensive use of dropdown lists requires more time and effort for already-busy clinicians. The complexity of many conditions requires many dropdown lists for accurate characterization. Younger clinicians express fewer concerns with the use of structured documentation given their more extensive experience in the use of digital technology in comparison with older clinicians. Appropriate use of value-based strategies, such as use of lower-cost scribes to assist clinicians, can help to address this problem.

Outcome measurement is one of the keys to value-based health care. As such, routine collection of outcomes data must be facilitated through the mandated use of structured documentation without burdening the clinician with additional tasks. Outcome measurement tools such as the creation of fields that populate both the chart and a database or other location (e.g., *SmartLinks* in Epic) are needed when an EHR is implemented, ideally early in the build stage. The incorporation of such data links enables key data to flow directly from the EHR into data repositories for subsequent analysis and reporting.

Patient-reported outcomes present additional challenges. These measures of functional status remain rare in clinical care. Many clinicians still view these measures as being useful research tools for drug trials but do not believe that they are needed for clinical care, despite the fact that they reflect outcomes that are of great importance to patients. The measurement of patient-reported outcomes requires standardized, validated, condition-specific survey tools that are administered systematically on an ongoing basis, with the data being integrated into the EHR system. These validated tools can be administered through a variety of platforms, including mobile technology, patient portals, mailed surveys, and personal communication, ensuring that information is captured from all patients on a timely basis. The IT system must then aggregate the results and apply appropriate risk adjustment to produce reports that are easily read and meaningful to clinicians, administrators, payers, and patients.

Standardized condition-specific outcome measures have been created by the International Consortium for Health Outcomes Measurement (ICHOM) and are being tested and validated for use in health care improvement through benchmarking and public reporting.[12] They are also being

embedded in value-based payment strategies. Without the IT tools outlined above, however, such initiatives will remain in the pilot phase and will not be generally applied in health care.

Enabling Cost Measurement

Costing systems must allow real-time tracking of costs by patient and condition over the full cycle of care in order allow for reporting to clinicians, regular analysis, and tracking of variability. Measuring costs based on resource consumption requires that IT platforms track processes of care in real time. Over time, this tracking will be automated and linked to enterprise resource planning systems to provide access to data on the costs of supplies, people, and assets.

> *"Outcome measurement is one of the keys to value-based health care. As such, routine collection of outcomes data must be facilitated through the mandated use of structured documentation without burdening the clinician with additional tasks."*

Of all the elements needed for time-driven activity-based costing, the most difficult to achieve is the automation of the processes of care experienced by patients, including the time spent in care activities by identified clinical care providers. IT can facilitate TDABC through advances in EHR systems for detecting clinical activity and time or through the use of personnel and patient tracking systems that assess time and location. For example, real-time tracking systems, the equivalent of GPS for indoor activities, have the potential to track individual provider times for use in costing. Newer emerging tracking technologies under development also can be employed to follow patients through the care cycle and to collect the information needed for TDABC software solutions. To date, no unifying software for health care costing has been developed and implemented, which represents an important need and vendor opportunity.

Ideally, the EHR should be the sole source of costing information (including the personnel interacting with a patient, the time spent, and the resources consumed) so that accurate costs for every encounter can be tracked, aggregated, shared, and used for improvement. Costing needs to be combined with outcome measurement to ensure that process changes that reduce costs do not adversely impact outcomes. Once developed, robust costing tools can be utilized to facilitate the implementation of alternative payment methodologies such as bundled payments.

Enabling Bundled Payments

In order to facilitate value-based reimbursement for clinical conditions, IT systems must track processes and facilitate outcome and cost measurements as outlined above. Additionally, IT systems must support the analysis of patient groups with given conditions to build pricing models for new reimbursement methods. The IT system of the future, then, must incorporate claims management for value-based payment systems, not just fee-for-service systems. Patients who are eligible for bundles must be identified electronically, their care tracked, and their claims sent

electronically to payers along with agreed-upon outcome information. Similarly, payers need automated processes to calculate bundled reimbursement amounts adjusted for outcomes.

Integrating Delivery Systems

IT systems need to support seamless exchange of data within organizations, across sites of care, and, ideally, across entire health systems as well as with independent service providers. Patient and condition-related data, including outcomes and costs by process step, should be compared across delivery sites to guide site-of-care selection and to ensure that the highest-value care is being delivered.

Limits on the interoperability of EHRs remain a major impediment to integrating care within networks and in referring care across providers. Integrated practice units also must be able to seamlessly share information with primary care providers in order to achieve a true value-based delivery system. Commercial solutions, such as Allscripts' db Motion, have been developed to enable interoperability across proprietary systems. However, adoption remains limited because of the complications outlined above in the section on interoperability. Coordination among vendors, driven by newer HL7 FHIR interoperability standards, is improving the situation. Outcome and cost data must be able to be shared and compared across care delivery sites in order to determine the best location of care for a given condition or procedure.

Integrated networks are increasingly using telemedicine in parts of the care cycle. The use of telemedicine is particularly important in networks that span large geographic areas. Outcomes are improved when patients can get immediate answers to clinical concerns, eliminating long waits for in-person visits. Costs are reduced when patients do not have to travel long distances for visits that can be accomplished electronically. Telemedicine and mobile technology can facilitate the delivery of the right care at the right location, including when that location is the patient's own home. Current barriers are primarily due not to technology, but to restrictions in the use of telemedicine by physicians and nurses as a result of prohibitive state licensing laws.

What Vendors Need to Do

Major EHR vendors are failing to support the value agenda and continue to protect proprietary legacy architecture that inhibits rather than supports health care innovation. New regulations are needed to halt information blocking, to open platforms to APIs, and to facilitate interoperability among vendors. While HL7 FHIR interoperability standards have improved the situation, the problem is still far from being solved.

> *"In short, vendors should be leaders in supporting value-based care, rather than anchors dragging their feet until forced to act by providers and government."*

EHR vendors need to be proactive in incorporating the ability to measure established outcome measures into their systems. Respected condition-based standards such as those created by ICHOM should be built into off-the-shelf products. Vendors also need to enhance their data-capture and reporting systems to facilitate outcome measurement while also incorporating methods for collecting real-time cost information. Finally, vendors should extend their revenue cycle tools beyond fee-for-service reimbursement and create capabilities for value-based reimbursement models such as bundles and capitation. In short, vendors should be leaders in supporting value-based care, rather than anchors dragging their feet until forced to act by providers and government. However, all of the blame should not rest with the vendors, who have an obligation to respond to consumer demands; in this case, the consumer (i.e., the health care community) demanded solutions to meaningful use and not value-enabling IT.

While new and disruptive IT platforms could possibly supplant existing inadequate systems, the huge investments already made by the health care industry in the current generation of EHR systems is a barrier to innovation. Public policy needs to require existing vendors to improve. If this improvement does not occur, there needs to be support for developing disruptive IT platforms. The rapid changes in data technology make a new disruptive technology a real possibility, and current vendors need to adapt to support a value-based delivery system or be prepared to see the entrance of less-expensive, more user-friendly systems that support value in the near future.

What Physicians and Provider Organizations Should Do

Providers and provider organizations need to take a more active role in demanding change in the current EHR systems. The poor design of these systems has created more rather than less work for frontline clinicians and has been implicated in the increasing burnout of physicians and other providers.[31] Time-consuming documentation on nights and weekends by health care providers detracts from the mission of helping patients. Physicians and provider organizations should insist on interoperability among all systems to facilitate the creation of value-oriented networks. They also should demand that vendors provide systems to collect and report the essential measurement elements of value: that is, transparent outcomes and costs of care. Providers also should demand that computer interfaces become more user-friendly, and physicians should work with developers to decrease keystroke activity. They also should advocate for the ability to incorporate more patient-entered information into the record.

The Patient's Role

While rating services are commonly used for everything from retail products to transportation, dining, and accommodations industries, patients have failed to demand ratings of providers based on outcomes and cost. Patients need to feel that it is their right to know the anticipated outcomes of a treatment and not merely the potential complications of a treatment. Patients are the consumers of health care, yet they fail to demand from their clinicians what they would demand from any other service provider. Patients should insist on having full electronic access to their records, a full disclosure of a clinician's record of the outcomes of care for a condition, and a transparent estimate of out-of-pocket costs. Patients also should be strong proponents of unified electronic billing in the

form of bundled payments in order to put an end to the confusion of receiving multiple printouts of bills from providers and explanations of benefits from payers that rarely match each other.

Payers Can and Should Enable Value in Health Care

The least-active proponents of value-based care in the United States seem to be the private payers, who seem to be content with the status quo and do not seem to be encouraging the implementation of value-enabling IT. Payers could have a profound effect if they were to insist on only paying for good outcomes, as that stipulation would require the collection of standardized outcome measures with use of a value-oriented IT system. Payers also could insist on knowing the costs of care delivery before reimbursing a fee from a charge master that bears no relationship to the true cost of the service being paid for. Payers could transform health care if they were to insist that they need outcome and true cost information before paying for a service. Doing so on a large scale would mean that both outcome measurement and cost measurement would have to be enabled by IT. Payers also could insist that IT systems be able to identify high-cost and lower-cost locations for the same service and not pay for services in high-cost setting when a lower-cost setting can produce similar outcomes.

How Public Policy Can Help

Public policy can accelerate the shift to value-based IT systems through regulations mandating value-enabling capabilities. Health IT policy needs to focus on three major areas: (1) seamless data extraction and interoperability, (2) standardized outcomes measurement, and (3) improved IT penetration in the area of mental health.

Accelerating Seamless Data Extraction and Interoperability

The problems of data extraction can be resolved if the provisions of the 21st Century Cures Act are enforced.[32] This law sets standards for EHR interoperability, prohibits information blocking by vendors, and includes steps to improve clinical workflows (e.g., allowing nonphysician scribes to document patient encounters as long as the notes are approved and signed by a clinician). The Office of the National Coordinator for Health Information Technology (ONC) recently published the Cures Act Final Rule spelling out how the new law will be enforced. The new rule on interoperability eliminates the practice of "information blocking" by now requiring developers of certified health information technology to provide APIs that will enable patients and other appropriate uses to have full access to view and exchange health information collected in electronic health records. This is a major priority for the ONC with the potential to transform health information technology by turning back the control of the information in medical records to patients. The U.S. Department of Health and Human Services Office of Inspector General (OIG) is charged with enforcement of the new rule to be phased in over 2 years.[33,34]

> *"In the move toward value-based care, the path forward is clear. IT systems must have the capability to enable each aspect of the value agenda while providing ubiquitous and seamless information-sharing with patients and across providers, payers, and vendors."*

There is also a need to further simplify the rules for health information exchanges (HIEs) and clarify ambiguities in the statutes governing HIEs needed to encourage and streamline the process of forming Clinically Integrated Networks. These networks allow financially independent physicians and physician organizations to exchange information, improve performance, and share technology without financial penalties or legal hurdles. Even when existing IT systems have allowed electronic health information to be shared across organizations and geography, concerns about conflicts with existing federal and state laws and regulations have complicated the spread of the exchanges. While many of the legal barriers have been eliminated, there remains an issue with patient-consent requirements, which vary from state to state.[35]

Standardizing and Accelerating Outcomes Measurement in Reporting and Reimbursement

The process of developing, testing, and implementing outcome measures that matter to both patients and clinicians must be accelerated. We need reputable standard measures that are developed by leading clinicians and are regularly reviewed and updated on the basis of research. The use of trusted, nongovernmental organizations to develop and vet condition-based measures is critical to accelerate progress. ICHOM (mentioned above) is a nonprofit organization that has developed and published a growing number of global consensus-based standard measure sets for different conditions along with detailed measurement parameters and risk factors.[12] The value-based payment reform focused on outcomes that began in 2015 needs to continue.[36] The MACRA legislation that went into effect in spring 2019 creates a pressing need for accelerated paths to the development of outcome standards. MACRA offers two new methods for physician reimbursement based on value. The Merit-Based Incentive Payment System (MIPS) rewards or penalizes providers on the basis of performance measures, including outcomes.[37] Physicians also can be paid with use of alternative payment models that include bundled payments that are contingent on outcomes. CMS and other payers will need faster pathways to endorse condition-based outcome measures to implement these reimbursement reforms.

Improving IT Penetration in Mental Health

The diffusion of EHR systems in the area of mental health has lagged well beyond that in health care as a whole, primarily because of the absence of meaningful use incentives, but also because of more restricted data-sharing requirements for psychiatric patients. While the Health Insurance Portability and Accountability Act of 1996 (HIPAA) does not require patient permission for treatment-related data-sharing for conditions not related to mental health, psychiatric patients have to grant permission to share data even for treatment purposes, as this information can be both sensitive and subjective. These rules need to be modified. The Department of Health and Human

Services needs to take the lead in simplifying data-sharing and permissions for mental health treatment purposes. At the same time, incentives for EHR adoption by mental health providers will help to speed the process. Vendors also need to design EHR modules to meet the clinical and privacy needs of mental health patients and providers.[24]

The Future for Value-Enabling Health IT

The diffusion of value-based approaches to health care is accelerating globally. The development of interoperable IT systems that support value-based care will facilitate dramatic improvements in patient outcomes and efficiency and will end an era in which health IT has entrenched the status quo, perpetuated silos, and blocked reimbursement reform.

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