FORUM

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Commentary

Getting the Most Out of an EHR System Requires Research and Development

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Since the electronic health record (EHR) has become such a powerful element in the process of healthcare delivery, many health services researchers have undertaken projects directly examining its roles, effects, and potential to improve care—"the HSR of EHR." Beyond VistA and the Computerized Patient Record System, VA has seen decades of companion projects, additional developments, and iterations of the EHR system itself: VistA Evolution, VistA Web, the Enterprise Health Management Platform, the Joint Legacy Viewer, and others. Typically, skilled VA-employed developers have undertaken these projects in-house, at times working with selected contractors. As VA "begins" a transition to a commercial EHR system through its contract with Cerner Corporation—slated to cost at least $10 billion over the next ten years—questions arise about VA's research and development in informatics: why, what, how, where, and when? This article provides suggestions for some of the answers to these questions.

Why

A fundamental question is why we should study the EHR system, whichever one it is. Won't everything change next year (month, week), rendering today's studies unhelpful? Everything will change next year, because that is the natural course of technology and always has been, inside and outside VA. Therefore, we keep moving: study what we have and where we think the technology is headed next. As with other aspects of healthcare, which also change every year, we make our best educated guesses, learn from the practices, processes, and policies in effect, and design and test innovations that hold promise for improvement. Veterans and VA professionals need improved EHR structures, processes, and outcomes *today*, and we can help with that.

Won't our studies rooted in a (*select*: commercial, public, old, new, special, large) EHR system fail to be generalizable to other sites and systems? *Not necessarily.* The question of generalizability comes up in almost all of the grant proposals I have seen that include an aspect of the EHR. The naïve critic offers the comment, "they are studying just one system, so it's not generalizable." Although the scientists might study one system or more than one, a basic concept still holds: *all systems are unique*. Even with a single commercial EHR product, every site has a unique instance and implementation of that product. This results in unique templates (even at the user level), features, and functions. Should we then throw up our hands in defeat? Not in the least. Our goal is to study the common ground or even the special and potentially beneficial features, identifying which approaches work, why they work, and how to change current practices to improve outcomes. You can perhaps see the parallels between a unique EHR environment and a unique healthcare environment: a unique Veteran seeking care in a unique medical center, with unique healthcare professionals. Such systems—human, clinical, organizational, and technical—can, should, and must be studied.

Key Points

- Lessons from today's EHR system can inform uses of tomorrow's.

- Some lessons from local EHR implementations are also relevant to distant ones.

- Decision-making, usability, interoperability, surveillance, risk prediction, population management, telehealth, patient-generated data, and support of patients' preferences are a few key areas of needed research and development.

- The Cerner EHR system contains research-oriented tools, such as alerts about research participants and their visits.

- Many study designs targeting EHR systems will benefit from thoughtful selection of comparison groups.

- The process of technical development should not slow the planning of EHR research.

- The Office of EHR Modernization may facilitate study of the EHR.

What

The topic of what to study is too large to capture in this brief article and will be covered elsewhere. Many of the essential elements of biomedical informatics—both clinical and more basic aspects—need study in

DIRECTOR'S LETTER

In the November 12 edition of *The New Yorker*, Atul Gawande writes insightfully about the conflicting effects of the electronic health record (EHR) on doctors and medical care. Clinicians are increasingly frustrated with their electronic records, which have inundated them with reminders, lab alerts, notes from colleagues, and queries from patients, to the point that they are taking hours of computer work home with them each night. An increasing share of each office visit is spent typing into the computer rather than building real relationships with their patients. Not coincidentally, burnout rates among physicians are at worrisome levels. Yet at the same time, it is only through the EHR's ability to capture standardized data that health systems have been able to track performance across all their clinicians and patients, and drive out unnecessary variation. Gawande quotes Gregg Meyer, CMO of Partners Health System in Boston, who observes that EHRs are for patients not clinicians. Patients are the beneficiaries of this improved quality, and they are now the most numerous among users of EHRs, whether to ask questions of their healthcare team, renew medications, or check test results. Even as everyone complains about the current state of EHRs, no one actually envisions going back to paper records.

Gawande cites experts who have documented the inevitable progression of computer systems: they often begin as small, homegrown tools built to solve very specific tasks efficiently, but as they succeed they grow to serve larger audiences with more diverse needs. This growth brings with it a need to control the level of variation across the system, bringing bureaucratic change control processes that squelch the innovation and customization that made the original tools so useful. This was the exact conflict that played out in the evolution of VA's Computerized Patient Record System (CPRS). It began as a locally grown program designed by computer-savvy clinicians to make their job easier, but it gradually grew into a national medical record system responsible for coordinating a much larger set of tasks across multiple different data systems. As CPRS spread to over 160 medical centers, it developed many local variations and customizations which made it impossible for VA to easily deploy useful new tools and advances across a national system. This failure to modernize, as much as the need to share records with DoD, made moving the VA to a new EHR system necessary.

Gawande poses two possible paths forward, one bleak and the other hopeful. In one, the record continues to evolve to make care safer and more efficient, while making the daily lives of clinicians and staff more depersonalized and miserable. The more hopeful vision is one enabled by open application programming interfaces (APIs) that retains a consistent, standardized core of the EHR but allows for innovators to create (and clinicians to choose) customized apps that present data in a way that better suits specific clinical needs. Initially resisted by large vendors as a threat to their revenue, open API is slowly being adopted. One could dream of a future where Cerner and VA cooperate to allow bright VA clinicians to innovate on the Cerner core, producing advances that make clinicians' lives better while building value for the Cerner platform.

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Gawande A. "The Upgrade: Why Doctors Hate their Computers," *The New Yorker*, November 12, 2018, p. 62-73.

the VA environment. These include how the EHR can most effectively facilitate clinical management, shared decision making, efficiency, and safety through improved usability, interoperability to facilitate cross-institutional and community-based care, automation of surveillance and risk prediction, population management, telehealth, capture of patient-generated data, and the support of Veterans' preferences for care. There are many more topics! No one reading this article could run out of important ideas to pursue in an entire career.

How

Implementation of EHR innovations has always required numerous steps in VA and elsewhere. We need approvals—sometimes local, regional, and national—and people who can do the work, not to mention training, monitoring, safety assessments, etc. We will still need those basic elements in a Cerner or other commercial EHR environment. Cerner's presence in VA might make aspects of technical development more challenging, since VA can't get "inside the box" easily or quickly (but were we doing that anyway?). Our hope is that VA will help the HSR&D community work with Cerner to extract data for detailed retrospective studies and to design, implement, and test aspects of the EHR system prospectively. Fortunately, Cerner's system actually contains certain tools to facilitate research. In addition, modular and interoperable applications, such as through technologies like Fast Healthcare Interoperability Resources, hold promise for development and study in conjunction with modern EHR systems.

Where

Where are the best places to study the EHR? Everywhere. We need studies of current technologies as well as planned or imagined ones. We need studies in small and large systems, urban and rural ones, north and south ones, more and less electronic ones. For obvious reasons relating to our confidence in causality and the design of improvements, having *comparison groups* will be a key element of many of the best studies.

When

You know, they are just about to start something new at your facility, right? Should you wait for Cerner or (xyz) before getting started? Um, of course not—do not wait—unless you are planning for a very active retirement. The Cerner implementation process is unfolding in stages, starting now, and extending for approximately one decade. My basic approach to engaging in technology is *do not wait for technology*, because it changes constantly. Get started now, learn what we can learn, and do what we can do. "Won't the politics of the Cerner implementation kind of get in my way?" If you receive a paycheck from any organization, then you are involved in a political

Response to Commentary
Advancing EHR Implementation Science and Research at VA

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The Veterans Health Administration (VHA) is approaching a health information technology (HIT) crossroads as the organization looks to transition beyond the familiar, reliable, but ultimately limited combination of the Veterans Health Information Systems and Technology Architecture (VistA) and the Computerized Patient Record System (CPRS) to a new, commercial electronic health record (EHR) system developed by an external organization, Cerner Corporation. After years of iterative planning, projects, and initiatives, the nation's largest integrated health care system now faces the daunting task of implementing a new EHR, one that will undeniably be very different than the one its practitioners, researchers, and HIT specialists have adapted and grown accustomed to over many years.

There is no standard blueprint for implementing an EHR system in one hospital, much less a nationwide network of interconnected medical centers and outpatient facilities. The implementation of EHR systems is a complex matter involving a wide range of factors, including organizational structure and culture, technical infrastructure, financial resources, and coordination. Installation of EHR systems in hospital settings has produced a growing body of literature on the science of EHR implementation, and researchers in different settings—including but by no means limited to VHA—have applied quantitative and qualitative research methods to better understand aspects of EHR implementation that increase the likelihood of success. What have we learned from this research?

A thorough systematic review, published in 2014,[1] revealed that the existing literature is diffuse, and with few exceptions published articles generally failed to build on earlier studies to increase the theoretical knowledge on EHR implementation. Nevertheless, the review offers an initial framework of interventions that can help address typical implementation challenges. These interventions, several of which were developed and/or studied within VHA, could be used as a guide for organizations to increase the likelihood of successful EHR implementation. An effort such as the one about to be undertaken at VHA also represents an opportunity to substantially build on the existing knowledge base.

Primarily through its embedded intramural research programs in HSR&D and QUERI, VHA has been able to cultivate an impressive ensemble of informatics health services researchers and implementation scientists across the country with the experience and expertise to support this enormous HIT implementation challenge. VHA can and should utilize this opportunity to connect these research groups with relevant operational partners to design implementation strategies and to create a pipeline of new evidence to support future EHR implementations.

Two key strengths have contributed to the success of the informatics health services and implementation science research programs supported through HSR&D and QUERI, both of which can serve this broad new implementation effort well. The first is the historically strong grounding of VHA research in theoretical frameworks—the principles, constructs, and concepts of a theory that form the foundation upon which research is constructed and established as credible and generalizable.[2] A significant portion of EHR implementation research has not used a particular theoretical approach to identify and categorize its findings.[1] By partnering with HSR&D and QUERI investigators well-versed in theoretical constructs and frameworks, VHA's upcoming EHR implementation efforts can be designed to be more productive, lead to more useful, actionable, and generalizable knowledge, and further establish VHA investigators as clear leaders in this emerging field.

The second strength is the growing emphasis and necessity within VHA on partnerships between researchers and operational groups. Through these partnerships, researchers are better able to connect with front-line providers, identify the most pressing areas of need for investigation or intervention, and generate findings that have a greater potential for rapid impact. At the same time, by working together these groups have a better opportunity to set national priorities and establish initiatives.

Key Points
- Although the new system promises to modernize the delivery of health care to our nation's Veterans and to bring better integration of Veteran health information across a broader range of systems and agencies, the road from here to there will be long, complex, and challenging.

- As VHA prepares to embark on this challenging, decade-long journey, HSR&D, QUERI, and our corps of informatics and implementation science research experts will provide the leadership, strategy, and guidance needed to ensure a successful transition.

With regard to the transition away from VistA and CPRS, groups within VHA such as the Office of EHR Modernization (OEHRM), working with the Department of Defense and Cerner Corporation, offer opportunities for researchers to collaborate with key groups to help establish implementation goals and priorities. Working together, they can contribute to new solutions and services and ensure that the new EHR implementation not only continues to support research needs, but also supports investigations that can take advantage of the more sophisticated computing environment.

Through the application of rigorous quantitative and qualitative methodologies, grounded in strong theoretical frameworks of informatics and implementation science, a research-operations collaboration can drive the EHR transition in ways that generate a profusion of new knowledge, advance the science, and guide ensuing installations. Further, this collaboration has the potential to affirm VHA as the leader in the science and practice of EHR implementation.

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Using Electronic Health Records to Improve Diagnoses

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The National Academy of Medicine highlights the harmful effects of diagnostic errors in their report, *Improving Diagnosis in Health Care*. The report defines diagnostic error as "the failure to a) establish an accurate and timely explanation of the patient's health problem(s), or b) communicate that explanation to the patient." Without timely and accurate explanations of their health problems, patients will not receive the treatment they need when they need it.

We previously estimated that diagnostic errors affect 12 million U.S. adults per year (or approximately 1 in 20 adults) in outpatient settings alone.[1] This extrapolates to an estimate that at least 1 million Veterans could experience diagnostic errors every year. This figure is likely an underestimate because Veterans may be disproportionately affected by diagnostic errors due to the presence of more medical conditions.

Both cognitive processes related to diagnostic decision making and systems issues are targets for improvement, but the interplay between physician cognition and technology (as depicted in Figure 1) is particularly challenging and poorly understood. This interplay is the focus of this brief. Health information technology, especially electronic health records (EHRs), offers solutions for improving diagnosis by helping to overcome or minimize human limitations. For example, EHRs can give quicker access to both patient data and reference information; facilitate documentation through the use of templates; ensure coordination, continuity of care, and reliable follow-up; and provide decision support.[2,3]

However, EHRs have also fundamentally transformed the way physicians do their work. Evidence from physician interviews suggests that EHR use might worsen cognitive performance, for example, by diverting attention away from the primary task of diagnosis, making information access burdensome, reducing attention to detail, worsening situation awareness, degrading communication, and requiring the input of overly comprehensive and fragmented pieces of information instead of richly organized narratives made of noteworthy information.

The reality is that most EHRs were developed as billing agents and physician attention is often diverted away from making diagnoses as physicians spend substantial time documenting for reimbursement purposes. Documentation requirements lead to copying and pasting, and the ease by which information can be easily entered and transferred in the EHR could lead to superfluous information. Clinicians experience consequences of information overload, sometimes leading them to miss abnormal test results or critical clinical findings in the EHR. Additionally, the way information is displayed across EHRs is not standardized, and some EHRs make tracking of information over time difficult. Overall, there is less time spent with patients at the bedside, which has also possibly led to the decay of bedside diagnostic skills.

Making accurate diagnoses in the EHR environment might also depend on *how* clinicians use the EHR for diagnosis. Variation in EHR use patterns may occur from physician to physician and by clinical experience. For example, we might expect to see variation in the breadth or depth of search for diagnostic data such as historical lab values, in the use of templates and copy or paste functions, or in the creation of tabular versus graphical displays to assess trends in lab results. We thus hypothesize that *how* physicians use the EHR is also a key factor in understanding and reducing diagnostic error. Identifying patterns of EHR use that facilitate accurate diagnosis may enable us to develop future interventions to improve diagnostic decision making using the EHR.

Key Points

- Health information technology, especially EHRs, has the potential to improve diagnosis by offering quicker access to patient data and reference information.

- Much remains to be understood about how the work of physicians has been transformed by EHRs, and particularly the impact of EHRs on diagnostic processes.

- VA's upcoming EHR transition will further affect diagnostic processes.

Much remains to be understood about how physicians' work has been transformed by EHRs and the ramifications of that transformation on diagnosis. VA's upcoming EHR transition will further impact the diagnostic process, necessitating a rigorous examination of this area. A better exploration of these issues can guide implementation of effective interventions in health services delivery, ultimately improving diagnosis in the EHR environment.

In a newly funded HSR&D career development award, we will embark on a multi-year research project to understand how physicians use the EHR to diagnose patients and how we can improve EHR use to improve diagnosis for Veterans. Themes included will be EHR documentation, information overload, information seeking, metacognition (thinking about one's thinking), situation awareness, and other factors that might play key roles in diagnostic error. We will use Naturalistic Decision Making (NDM) methods and simulation to examine how physicians use the EHR as they diagnose standardized patients. NDM involves the study of cognition in natural settings,

especially cognition performed in dynamic conditions with time pressure, uncertainty, organizational constraints, and high stakes (in contrast to tightly controlled, experimental studies performed in a laboratory).

Our research will examine diagnostic decision making in a more naturalistic environment, taking into consideration both contextual and patient-related issues using NDM methods, while also allowing us to examine cognition during diagnostic decision making in a relatively controlled setting. We will then observe physician behaviors inside and outside of the EHR (for example, actions taken navigating the EHR, but also actions taken outside of the EHR, such as talking to patients). During this time, we will collect time and motion data, from which we can identify patterns of EHR use related to diagnostic accuracy. This information could be used to generate new knowledge on how to provide feedback to physicians about ways to better incorporate the EHR into their diagnostic decision making in order to improve diagnostic accuracy for the Veterans they treat.

While EHRs promise quicker access to information, along with improved coordination and continuity of care, understanding their potential pitfalls and how we can overcome them is necessary to improve diagnosis. We consider this one of the most timely and exciting opportunities for health services researchers.

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Figure 1. The Interplay between Physician Cognition and EHRs
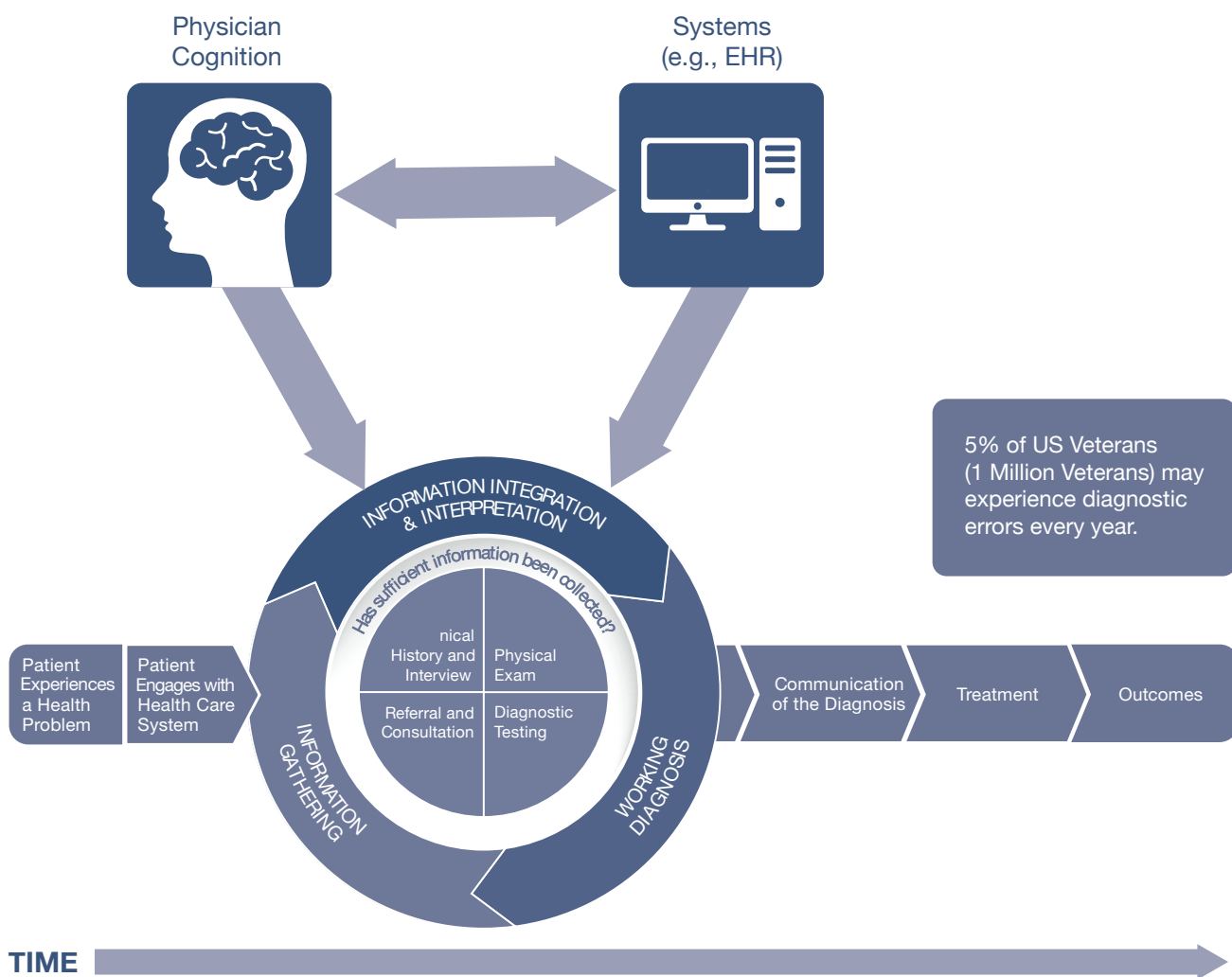
Adapted from National Academy of Medicine Report, Improving Diagnosis in Health Care, 2015.

Electronic Health Record Modernization Comes to VA Research

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In June 2018, VA announced a contract with Cerner Corporation to bring the Cerner electronic health record system onboard as the replacement for CPRS/VISTA (the legacy VA electronic health record system—CPRS stands for Computerized Patient Record System and VISTA stands for Veterans Integrated System Technology Architecture). This effort will involve a large scale cultural transformation as well as business process transformation for one of the largest healthcare systems in the United States. This transformation will assist VA in its dual goals of interoperability with the Department of Defense (DoD) and with many private sector healthcare systems (since Cerner complies with modern data exchange standards as well as hosts the CommonWell Health Alliance - Health Information Exchange network).

For VA research, the Electronic Health Record Modernization (EHRM) effort offers several opportunities. First, Cerner hosts a robust data warehouse platform (HealtheIntent) that represents a significant technology upgrade from existing Corporate Data Warehouse (CDW) hardware platforms. Unlike the CDW, the HealtheIntent platform can host data from outside sources, from patient generated data (patient portal), payers, outside pharmacies, and wearable devices (Figure 1).

Additionally, the Cerner contract provides VA research with PowerTrials as part of Cerner Millennium (the main EHR replacement for CPRS/VISTA). PowerTrials provides a cohort qualification tool based on the characteristics of potential study patients and allows a clinical trial team to 'qualify' potential subjects for recruitment and enrollment.

The governance of this massive project is being handled at the Secretary-VA level. The EHRM program office reports to the Secretary through the Deputy Secretary. EHRM has organized the principal VA Central Office program offices into working groups and involves informatics

teams at the national, regional (VISN -Veterans Integrated Service Network), and VA Medical Center level (Figure 2).
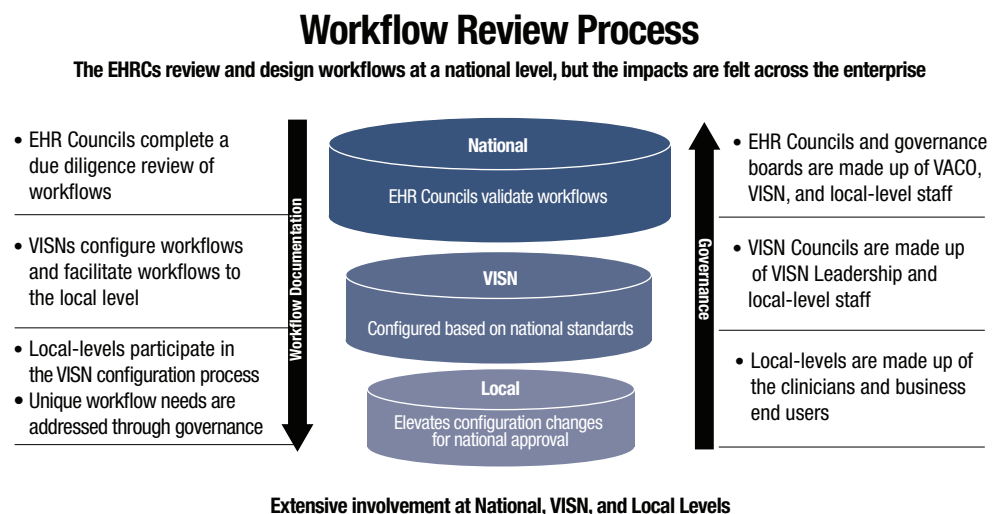
The initial phase of the program (Phase 1) involves EHRM implementation at VAMCs in the Pacific Northwest and will follow DoD implementations down the coast and then across the country. It is expected to take 8 to 10 years to complete the national implementation at all VAMCs.

Figure 1. Cerner Integrates data from many more sources than legacy CPRS/VISTA
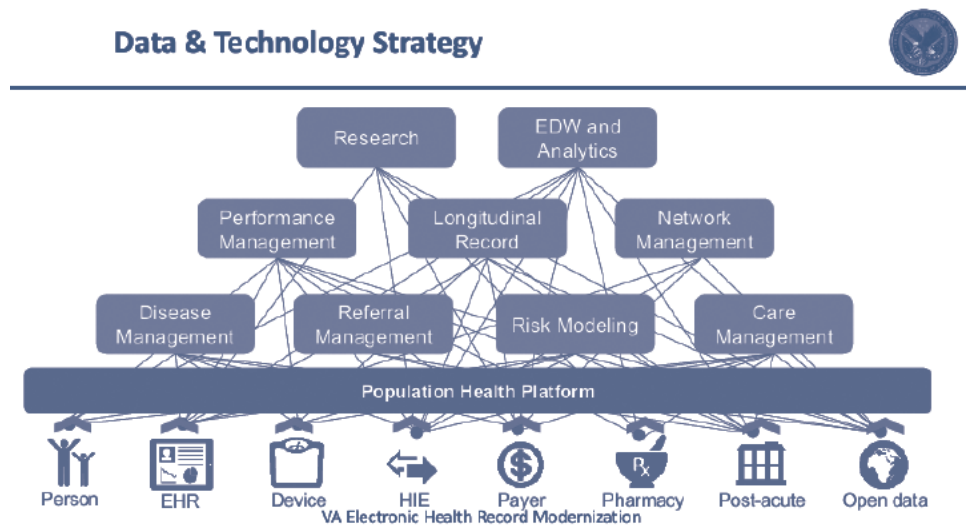
Figure 2. The EHRM Process involves VA users at the local, VISN, and National level in an extensive change process

Workflow Review Process

The EHRCs review and design workflows at a national level, but the impacts are felt across the enterprise

Extensive involvement at National, VISN, and Local Levels

Health Information Exchange Holds Potential to Benefit Veterans

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A large proportion of Veterans utilize both VA and non-VA providers to address their care needs. Non-VA care is common when Veterans have other insurance and when non-VA care is paid for by VA (i.e., "fee basis"). Non-VA care has expanded because of VA Choice, a program designed to increase access for Veterans who have distance and scheduling barriers. Aside from elective use, Veterans in emergency situations may receive non-VA services for problems that require immediate care at the nearest health facility.

Because of the division between systems and the increasing complexity of healthcare, accurate and timely communication between healthcare personnel is increasingly important for appropriate decision-making, and it is a key research area for informatics. Electronic health information exchange (HIE) has the potential to benefit Veterans by giving providers the information they need in real time to make appropriate decisions, regardless of whether the providers are VA or non-VA and regardless of where the information originates. Access to accurate cross-system information is especially important for providers taking care of high risk patients (e.g., older Veterans or those with advanced or complex conditions).

There are several HIE tools available for VA providers. First, VA's enterprise-wide HIE tool (formerly Vista Web, now Joint Legacy Viewer) contains encounter information from every VA location and the Department of Defense. Second, VA providers nationwide can communicate with each other through the electronic health record, internal secure email, as well as instant messaging tools. These functions, when considered together as a suite of tools, provide a service well beyond the capability of most private sector organizations.

Furthermore, since 2010, VA has partnered with non-VA organizations to provide parallel HIE capabilities that connect VA with non-VA health systems. The Veterans HIE Program (https://www.va.gov/VLER/index.asp), formerly known as the Virtual Lifetime Electronic Record (VLER) Health Program, provides internal and external access to care summaries with information from both VA and non-VA providers. This program includes VA Direct, which enables VA and non-VA organizations to exchange secure messages containing protected health information.

A recent systematic review of high quality research studies demonstrated benefits from HIE such as fewer duplicated procedures and imaging, lower costs, and improved patient safety.[1] However, knowledge gaps exist regarding situations in which HIE is most effective (including the best information delivery and response methods), which outcomes of HIE are most important to Veterans, and how best to overcome barriers to uptake and implementation.

We have conducted VA HSR&D-supported research to help close these knowledge gaps. In a randomized controlled trial at the Bronx VA (IIR 10-146, PI Boockvar), patients admitted to the VA hospital received structured medication reconciliation by a pharmacist with (intervention) or without (control) access to a regional HIE. Patients who received medication reconciliation with non-VA pharmacy insurance data available had more medication discrepancies identified than those who received usual care (8.0 v. 5.9). In addition, among intervention patients, there were 10 medication discrepancies in 51 patients that would otherwise not have been recognized when pharmacy insurance data were available, and 2 discrepancies in 131 patients when pharmacy insurance data were not available. Our conclusion was that HIE may improve outcomes of VA medication reconciliation but that blocked access to non-VA pharmacy benefit medication information (because of financial charges) halts this effect.[2]
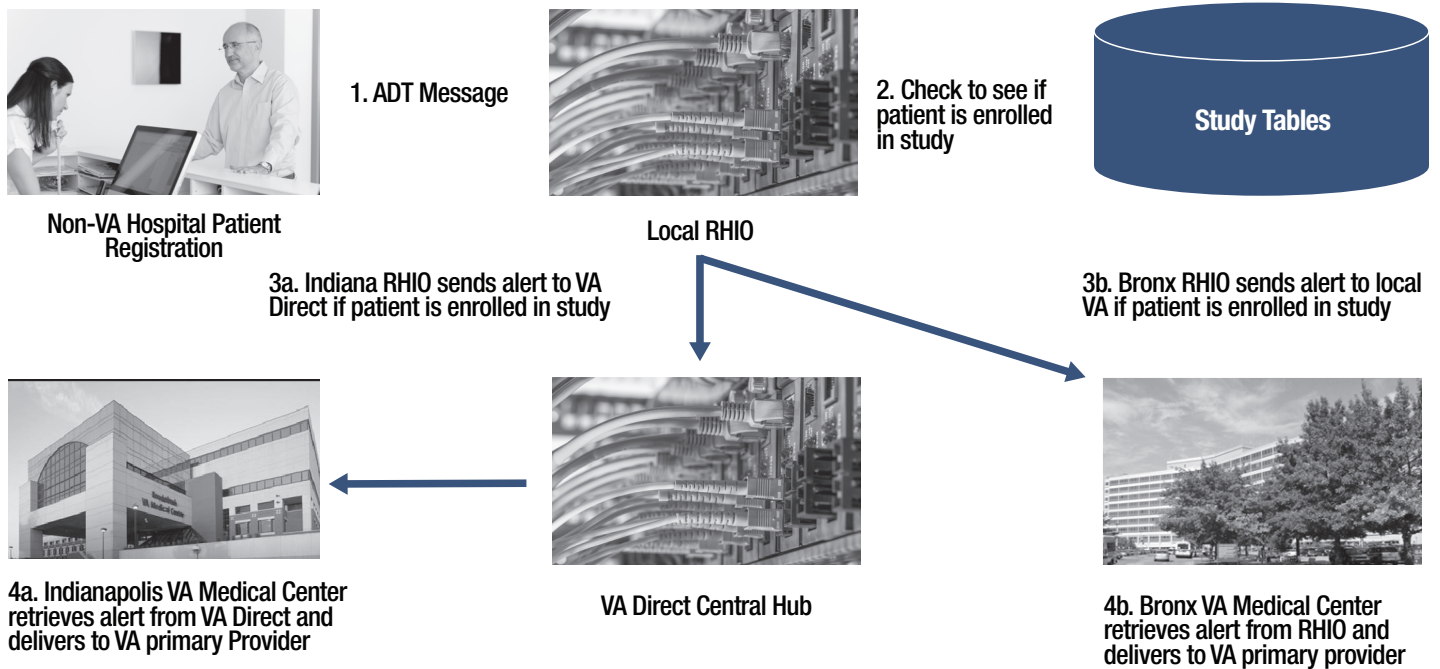
Key Points

Recent and ongoing VA HSR&D-supported research sheds light on situations in which HIE is most effective, and how to overcome barriers to HIE implementation.

- HIE may improve outcomes of VA medication reconciliation, but blocked access to non-VA pharmacy benefit medication information halts this effect.

- Real-time provider notification of non-VA hospital admission or ED visit, when combined with structured geriatric care coordination, may result in reduced hospital utilization and better quality of care.

As a component of research on HIE implementation (IIR 11-058, PI Haggstrom), researchers at the Indianapolis VA examined the characteristics of Veterans who enrolled in the VLER Health program. During its first year, 12 percent of Veterans who visited the Indianapolis VA enrolled. Medical complexity (e.g., Charlson co-morbidity score $\geq$ 1), greater utilization (e.g., >1 primary care visit), female gender, urban residence, being less than 65 years old, and having co-insurance (e.g., Medicaid, military) were characteristics associated with a greater likelihood of enrollment. Identifying predictors of enrollment could drive efforts within VA to target Veterans who may benefit from greater access to non-VA providers, including female Veterans, older Veterans, and rural Veterans, and guide testing of HIE's benefits.[3]

Because of the high frequency of non-VA inpatient use and the risk of adverse events among older Veterans, improving non-VA to VA hospital transitions among older Veterans is important to achieving improved care across sites. In a new study (IIR 14-049, PI

Figure 1. Technical Infrastructure to Support VA Provider Notification of Non-VA Admissions and ED Visits

1. ADT Message

Non-VA Hospital Patient Registration

2. Check to see if patient is enrolled in study

Local RHIO

Study Tables

3a. Indiana RHIO sends alert to VA Direct if patient is enrolled in study

3b. Bronx RHIO sends alert to local VA if patient is enrolled in study

4a. Indianapolis VA Medical Center retrieves alert from VA Direct and delivers to VA primary Provider

VA Direct Central Hub

4b. Bronx VA Medical Center retrieves alert from RHIO and delivers to VA primary provider

ADT = Admission/Discharge/Transfer
RHIO = Regional health information organization

Boockvar, Co-I Dixon), Bronx and Indianapolis researchers are examining the impact of VA provider HIE notification when older Veterans utilize non-VA inpatient or emergency department (ED) services, and comparing approaches to responding to this notification. Each VA study site has a relationship with a well-functioning regional HIE network that can provide real-time notification of non-VA encounters. The study will provide real-time VA provider notification of non-VA hospital admission or ED visit (Figure 1) followed by post-hospital geriatrics care coordination for older Veterans, as compared to groups receiving usual care and notification alone (without geriatrics care coordination). As of August 2018, we have enrolled 551 patients who have experienced 167 eligible non-VA encounters. We hypothesize that notification and structured geriatric care coordination will result in reduced hospital utilization (primary outcome) and better quality of care compared to notification alone. We are also conducting semi-structured interviews with Veterans, VA providers, and non-VA providers. Findings will identify opportunities for improvement and inform future implementation.

In summary, dual system care exposes Veterans to the risk of adverse events due to the lack of communication between providers, and inpatient-to-outpatient transitions are particularly risky for older Veterans. If HIE notification followed by a structured geriatric care coordination intervention is shown to be effective, it could be integrated into services provided by PACT teams, Home Based Primary Care (HBPC), and/or telehealth and care coordination programs. HIE between VA and non-VA healthcare providers has gained salience as a result of the Veterans Choice Act of 2014 and MISSION Act of 2018, which have expanded Veterans' access to non-VA care. VA providers, including primary care providers, specialists, hospitalists, care coordinators, and nurses will see the direct relevance of this research to their practice. Providers and health systems outside of VA may apply our research findings to development and refinement of their care delivery models.

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Harnessing the VHA EHR to Improve Prevention and Identification of Pressure Ulcers

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The VHA Spinal Cord Injury/Disorders (SCI/D) system of care consists of an integrated network of care providers based on the longstanding hub and spoke model, with the SCI/D Centers serving as the hub. Locally accessible SCI/D primary care is provided at select VHA facilities within specified catchment areas, which then serve as the 'spokes' supporting the SCI/D system of care. Quality assurance studies have found that there are relatively few hospital-acquired pressure ulcers among Veterans in the VHA SCI/D system of care, yet pressure ulcers are still among the most significant complications suffered by Veterans with spinal cord injuries, resulting in lower quality of life and increased cost of care.

Across VHA, clinicians employ the Braden Scale to measure risk and make decisions about pressure ulcer prevention efforts in both the inpatient and outpatient setting. While the Braden Scale is the most widely used pressure ulcer risk assessment tool in the United States, researchers originally devised the scale for nursing home populations, so it may not adequately measure risk in Veterans with SCI/D, particularly those living in the community. Information stored in the VHA electronic health record (EHR) offers an important opportunity to target prevention strategies and improve outcomes for these high-risk Veterans by developing improved risk models that combine longitudinal data from multiple facilities.

A recent study undertaken by researchers at the James A. Haley Veterans Hospital in Tampa sought to capture this opportunity by using information from the VHA EHR to develop improved risk models and assessment tools for pressure ulcers in Veterans with SCI/D. In consultation with an expert panel and VHA SCI/D leadership, Tampa investigators are targeting these new models to serve community dwelling Veterans. The study identified potential risk factors through a literature review that was supplemented with expert panel discussion

and review. The study examined nearly 100 potential risk factors, including patient demographics, co-morbidities, severity of injury, living situation, and travel distance to an SCI Center. We employed both traditional methods based on structured data (ICD-9-CM, etc.), combined with text extraction and classification techniques. The study findings serve as an example of how combining text with structured data can improve identification of pressure ulcers.

Employing a five-year (FY 2009-2013) longitudinal retrospective cohort design, we obtained data from the VHA national EHR including both structured (i.e., coded in database or table) and narrative (i.e., text in clinical notes) data. In our analysis of structured data, we examined over one million records of inpatient and outpatient care in the VHA, care paid for in the community by VA, medication and laboratory data, and information about equipment provided by VA. We analyzed all inpatient and outpatient clinical text (over nine million records), employing two distinct text-based techniques to identify pressure ulcers. We used both top down, rule-based, natural language processing (NLP), and bottom up, machine learning, statistical text mining (STM).

We emphasized specificity in our interpretation of text results. For NLP, we required both evidence of a term describing a pressure ulcer (pressure ulcer, pressure sore, etc.) and a description of the ulcer stage to be considered a case. For STM, we required two documents with probabilities of 0.75 or higher of correctly identifying a pressure ulcer found within one month to classify a case as positive. We defined inclusion criteria as follows:

- Veterans with SCI (excludes MS and ALS), seen at an SCI/D Center (hubs) during FY 2009;

- Veterans with no evidence of a pressure ulcer in the prior 12 months; and

- Veterans who had at least one Comprehensive Preventive Health Evaluation in the study period.

Key Points

- The VHA EHR offers an important opportunity to improve outcomes for Veterans with SCI/D by improving identification of pressure ulcers and targeting prevention strategies.

- A recent study used information from the VHA EHR to develop risk models for identifying pressure ulcers among Veterans with SCI/D.

- This study found that by combining structured data with text-based data, researchers could improve pressure ulcer case identification in the research cohort.

The SCI/D Centers are required to offer the preventive health exam annually. While Veterans may or may not take advantage of the service, when they do, it represents an opportunity for clinicians to identify risk early. The first annual exam completed by our cohort Veterans during the study period became a reference point for the analysis, with risk factors identified in the year before the exam, and the first recorded pressure ulcer within one year after the exam treated as an incident case.

Findings from our research illustrate how combining structured data and text-based data can improve pressure ulcer case identification, a crucial component of the study.

A total of 15,819 Veterans were seen at the VHA SCI/D System of Care in FY 2009. Of these, we excluded Veterans if they had MS/ALS (n = 2,114), a pressure ulcer in 2008 or before their first preventive exam (n = 4,715), or if they did not have an annual exam in the five-year study period (n = 3,740). The remaining study cohort (n = 5,250) participants were predominantly male (97 percent), white (70 percent), with a mean age of 57. Most Veterans (70 percent) lived with nuclear or extended family, a caregiver

Figure 1. Number of New Pressure Ulcer Cases Identified within One Year, by Method

ICD9

NLP

79   96   361

265

12   118

20

STM
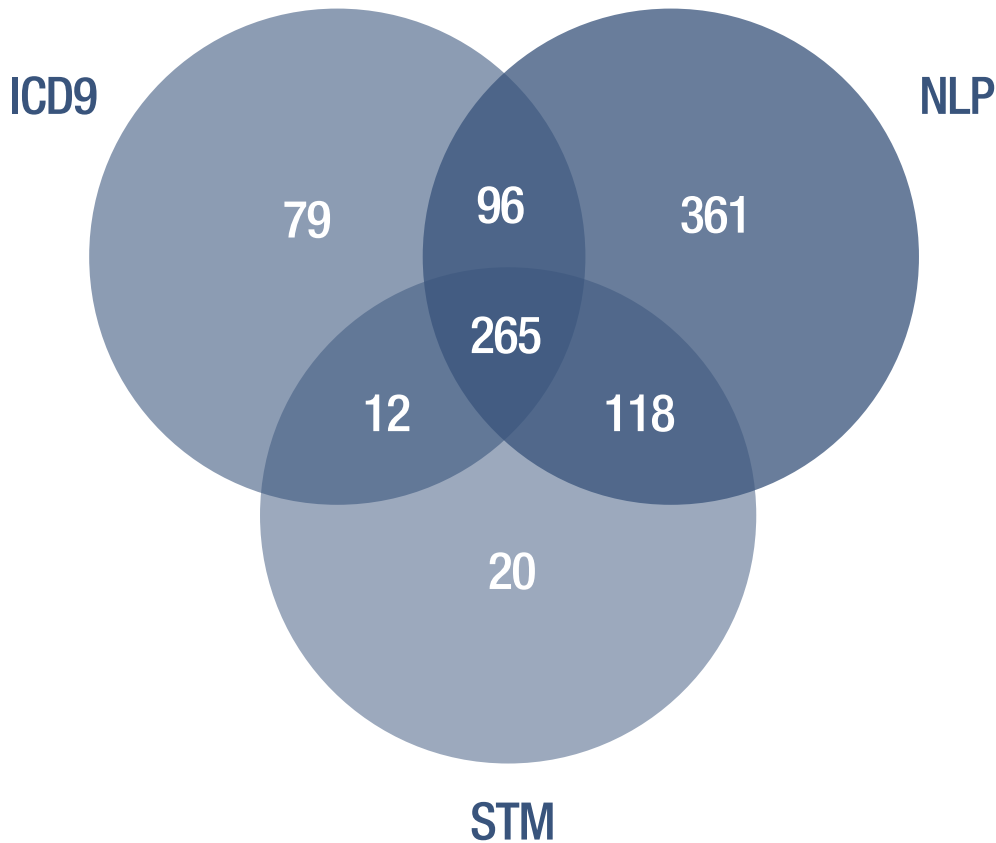
or roommate (70 percent), while 26 percent lived alone. We selected a stratified sample of 1,233 text documents from across study facilities. Clinical annotators then reviewed the text documents, and a clinical expert adjudicated them in order to create a reference standard for NLP/STM analysis. Using structured (inpatient and outpatient ICD-9-CM codes) data alone, we found the incidence of pressure ulcers at three, six, and twelve months to be 4.3 percent, 6.3 percent, and 8.6 percent. When we combined structured and text data, we found the incidence more than doubled to 9.9 percent, 12.8 percent, and 18.1 percent at three, six, and twelve months, respectively.

These results suggest that ICD-9-CM data alone underestimate the incidence of pressure ulcers. Our finding supports the concerns

expressed during the expert panel discussions. We improved the identification of incident pressure ulcers by combining traditional ICD-9-CM with two text analysis techniques.

Figure 1 presents a Venn diagram of results for each method at one year. While we found significant overlap, each method identified unique cases. NLP contributed the greatest number of unique cases (n = 361) followed by ICD-9-CM (79) and STM (n = 20). NLP requires much more effort to complete chart review and in the programming of rules but provides more specific information for subsequent analysis. STM requires simple labeling of documents as case/not case and can be very effective depending on the task. Combining the techniques can maximize results when studying complex clinical problems in big data.

HSR&D has made significant investment in infrastructure to enable researchers to access text-based data to supplement traditional secondary data resources. Leveraging the resource of text-based data and analytic environment allowed us to better describe the incidence of pressure ulcers among Veterans with SCI/D.

References

1. Wilchesky M, Lungu O. "Predictive and Concurrent Validity of the Braden Scale in Long-term Care: A Meta-analysis," *Wound Repair and Regeneration* 2015; 23(1):44-56.

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My HealtheVet Supports Veterans' Management of Diabetes

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The My HealtheVet (MHV) patient portal and personal health record allows patients convenient access to a subset of information contained in their electronic health records, including laboratory, pathology, and radiology results, clinical progress notes, wellness reminders, immunization records, and medication history. The MHV portal also contains beneficial features such as secure messaging, online refills, trusted health information resources, and the ability to self-enter and track health information. While the upcoming electronic health record migration to Cerner may impact the content and appearance of My HealtheVet, the future version of the portal will no doubt continue to provide VA patients with access to these valuable features.

Nearly 25 percent of Veterans receiving care from VA have diabetes.[1] Current work at the Bedford VA examines how Veterans use MHV for their diabetes management. As part of this research, 40 Veterans participated in interviews in which they described their overall management of diabetes and how MHV and other technologies support their diabetes management.

Secure Messaging

Secure messaging (SM) emerged from our data as an important and widely used feature of MHV. First introduced in 2008, SM is a secure email message exchange that enables asynchronous patient-provider communication outside of the traditional face-to-face clinical visit. Nearly 2 million Veterans have opted in to use SM; research has found that SM is helpful to Veterans for requesting medication renewals and refills, scheduling appointments or tests, and reporting or asking about medication or other health issues.[2]

For rural Veterans, SM enables increased access to healthcare teams. In our interviews, one Veteran described living far away from the nearest hospital or clinic in an area with unreliable cellular phone service. SM became a platform to enable the patient to maintain reliable and clear communication with their healthcare team despite these obstacles. For other Veterans, SM enabled them to ask questions or express concerns as they came up, whether on the weekend or in the evenings.

Blue Button

The Blue Button enables Veterans to view, download, and print or share important health information extracted from their electronic health record. A number of those we interviewed reported that, following a visit, they will look at their notes to remember important information, confirm changes to their care plan, or contact their provider and correct any information that they believe was entered incorrectly. Veterans mentioned notes as being especially helpful at the time of a health crisis, such as a new cancer diagnosis, making it easier to share accurate health information with family members.

Veterans most frequently cited their ability to view lab and test results as a beneficial feature of the Blue Button, helping them to prepare questions for upcoming face-to-face visits with care providers. Others stated that they download and print their results so that they have a paper copy to take with them to visits with any non-VA care providers.

Medication Refills

In our study, Veterans reported that the most helpful aspect of MHV was their ability to refill prescriptions. One Veteran commented that they combine this feature with other medication management strategies so they know when they are running low and can plan ahead to order refills. For those who live far from a hospital or pharmacy, the medication refill feature means that they can stay current with their medications without needing to travel.

Not every MHV feature is perceived as helpful, however. While measuring and tracking one's blood glucose is important for diabetes management, patients preferred to do so outside of MHV. The design of the portal is such that patients must log in and click through multiple screens in order to enter and track their readings. Many patients track their readings manually, or via phone apps, instead of using MHV. However, patients report that, if developed, they would choose an MHV app over their existing options. Veterans' experiences can inform wish lists for future improvements to MHV.

MHV features such as medication refills and SM enable Veterans to accomplish important self-management tasks from home in a timely manner. The introduction of electronic communication features and the Blue Button empower patients to engage and participate in their own care. Overall, Veterans were enthusiastic about their experience with MHV. The team is currently working with three Veteran co-Investigators who are helping us incorporate these lessons learned into an MHV training for Veterans with diabetes.

Key Points

- Managing physical activity, diet, medications, and tracking blood glucose levels are critical tasks for diabetes self-management.

- Preliminary analysis of interviews with Veterans at the Bedford VA reveal a number of MHV features that are important for diabetes management.

- Secure messaging, Blue Button, and medication refills are just a few of the MHV features that help Veterans stay informed and engaged in their diabetes care.

References

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2. Shimada SL, Petrakis BA, Rothendler JA, et al. "An Analysis of Patient-provider Secure Messaging at Two Veterans Health Administration Medical Centers: Message Content and Resolution through Secure Messaging," *Journal of American Medical Informatics Association* 2017; 24(5):942-9.

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system, so get over it and keep moving. I'm not saying that we won't face roadblocks, but we will not overcome any of them without trying. As always, we will uphold our values in improving care for Veterans.

VA now has an Office of EHR Modernization (OEHRM). It is working with the Department of Defense and includes a Governance Integration Board, EHR Councils, and a Legacy EHR Modernization "Pivot Working Group." OEHRM's principles include standardizing clinical and business processes across VA, designing a Veteran-centric system focusing on quality and safety, pursuing a flexible and open solution, accommodating scalability, and reengineering clinical business processes. The roadmap for platforms, solutions, and services includes research tools such as Cerner's Health Facts and PowerTrials (thanks, Jim Breeling, for many of these details). Health Facts is a HIPAA-compliant electronic database with

rich clinical EHR data available in de-identified form, representing the care of nearly 50 million patients in at least 90 health systems that contribute to the database. PowerTrials provides EHR indicator flags of patients' participation in clinical research, shows protocol and study contact information, and notifies the study's contact when a research subject is scheduled for a clinical visit. It will also ultimately have features designed to enhance recruitment using screening tools based on a study's inclusion and exclusion criteria. VA's governance group will facilitate VA scientists' understanding of EHR capabilities, and engagement in research about VA's EHR system.

So remember, when it comes to the HSR of EHR, the time is now, and the person is you. A tip for grant writers: many reviewers will not read this article, so help them when needed, through reminders about any of the key points.