Advancing Evidence-Based Care For Diabetes: Lessons From The Veterans Health Administration

A highly regarded EHR system is but one contributor to the quality transformation of the VHA since the mid-1990s.

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ABSTRACT: The Veterans Health Administration (VHA) is a unique laboratory for using the electronic health record (EHR) to transform health care and accelerate discovery. This is particularly evident in the care of veterans with diabetes, who constitute a quarter of those served by the VHA. Although EHRs have enabled rapid learning, additional factors were necessary, including the lead participation of clinician-investigators, accountability through performance measurement, a delivery system focused on population health, and favorable economic externalities. "Off-the-shelf" technology is unlikely to generate similar benefits if these attributes are not in place. [*Health Affairs* 26, no. 2 (2007): w156–w168 (published online 26 January 2007; 10.1377/hlthaff.26.2.w156)]

As the largest integrated delivery system (IDS) in the United States, the Veterans Health Administration (VHA) serves 5.3 million patients annually across nearly 1,400 sites of care. Although its patients are older, sicker, and poorer than the general U.S. population, the VHA's performance now surpasses that of other health systems on standardized quality measures.[1] These advances are related in part to the VHA's leadership in the development and use of electronic health records (EHRs). In this paper we describe the VHA's health information infrastructure and factors that made it possible, illustrating its impact on research in and care of diabetes, one of most prevalent conditions

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among veterans. We also describe how next-generation EHRs will facilitate veteran-centered care and continued improvement. We emphasize the human and system characteristics essential to the transformation of VHA care.

Historical Context Of Health Care For U.S. Veterans

Adding computers to a delivery system unprepared to leverage the advantages of health information can create inefficiency and other negative outcomes.[2] In contrast, during the period of time in which the VHA deployed its EHR system, the number of veterans seen increased from fewer than three million to nearly five million, while costs per patient and numbers of full-time employees per patient both decreased.[3] To understand how this could be possible, it is important to highlight historical and organizational factors that were important to the adoption of the VHA's EHR system.

Health care in the VHA is the product of decades of innovation. In 1930 Congress consolidated programs for U.S. veterans in the Veterans Health Administration under the Department of Veterans Affairs (VA, then known as the Veterans Administration). Facing more than one million returning troops following World War II, the VHA partnered with U.S. medical schools, gaining access to faculty and trainees and adding research and education to its statutory missions. That bold move created an environment uniquely suited to rapid learning. The VHA now has affiliations with 107 medical schools and trains almost 90,000 physicians and associated health professionals annually.

The VHA was originally based on inpatient care, and administrative and legal factors created inefficiency and inappropriate use. By the 1980s the VHA's public image was poor. In 1995, facing scrutiny from Congress, the VHA reorganized into twenty-two integrated care networks. Incentives were created for providing care in the most appropriate setting, and legislation established universal access to primary care. Those changes resulted in a reduction of 40,000 inpatient beds and an increase of 650 community-based care sites. Evidence-based practice guidelines and quality measures were adopted, and safeguards were put in place for vulnerable groups such as the mentally ill and those needing chronic care, while the VHA's performance management system held senior managers accountable for evidence-based quality measures. All of these changes created a strong case for robust information systems and spurred dramatic improvements in quality.[4]

VistA: The VHA's Electronic Health Record System

Because the VHA was both a payer and a provider of care, its information system was developed to support patient care and its quality with clinical information, rather than merely to capture charges and facilitate billing. In the early 1980s the VHA created the Decentralized Hospital Computer Program (DHCP), one of the first EHR systems to support multiple sites and health care settings. DHCP developers worked incrementally with a network of VHA academic clinicians

across the country, writing and testing code locally and transmitting successful products electronically to other sites, where they could be further refined. Over time, the group had created a hospital information system prototype employing common tools for key clinical activities. The system was launched nationally in 1982, and by 1985 the DHCP was operational throughout the VHA system.

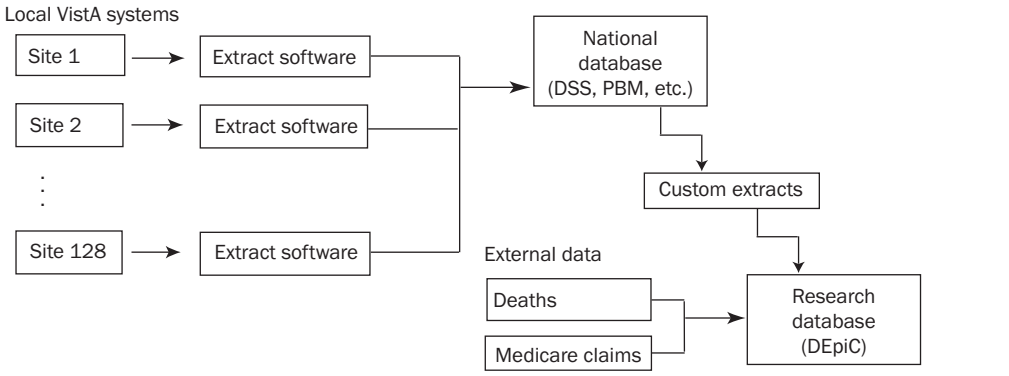
The DHCP evolved to become the system now known as the Veterans Health Information Systems and Technology Architecture (VistA), a suite of more than 100 applications supporting clinical, financial, and administrative functions. Access to VistA was made possible through a graphical user interface known as the Computerized Patient Record System (CPRS). With VistA/CPRS, providers can securely get access to patient information at the point of care and, through a single interface, update a patient's medical history, place orders, and review test results and drug prescriptions. Because VistA also stores medical images such as x-rays and photographs directly in the patient record, clinicians have access to all of the information needed for diagnosis and treatment. As of December 2005, VistA systems contained 779 million clinical documents, more than 1.5 billion orders, and 425 million images. More than 577,000 new clinical documents, 900,000 orders, and 600,000 images are added each workday—a wealth of information for the clinician, researcher, and health care administrator.

This brief description is not meant to minimize the inertia encountered with any major organizational change. Many clinicians (particularly those with poor keyboarding skills) initially resisted use of the EHR system. Convincing them otherwise took several approaches. Most important was involving clinicians at the onset. This meant working incrementally to ensure usability and integration of the EHR system with clinical processes. Both local and national supports were created: For example, local "super-users" were designated to champion the project; and a national "Veterans Electronic Health University" facilitated collaboration among local, regional, and national sponsors of EHR rollout. National performance measures, as well as the gradual withdrawal of paper records, made EHR use an inescapable reality. Finally, because economic costs to clinicians were blunted by a salaried environment, other beneficial effects (such as reductions in time wasted searching for missing paper records) emerged. Over time, staff came to view VistA/CPRS as indispensable for good clinical care.[5]

Leveraging The EHR: Diabetes Care In The VHA

■ **From individual records to population insights.** VistA/CPRS allows clinicians to access and generate clinical information about their individual patients, but additional steps are needed to yield insights into population health. Structured clinical data in the EHR can be aggregated within specialized databases, providing a rich source of data for VHA administrators and health services researchers (Exhibit 1). Additionally, unstructured text data, such as clinicians' notes, can be reviewed and abstracted electronically from a central location. This is of particular benefit to

EXHIBIT 1
Current Data Flow And Aggregation In The Veterans Health Information Systems And Technology Architecture (VistA), Simplified



SOURCE: Veterans Affairs (VA) Information Resource Center.
NOTES: This exhibit shows the resources and flow of the data most often used by Veterans Health Administration (VHA) researchers for national studies. Most data originate from the VistA system. To build a national database of health care information, each application must extract data from each of 128 separate local VistA sites. At the host site, specialized software cleans, translates, and loads the extract data into the national database. Researchers use custom extract software routines to access national databases and may combine VHA data with data from external sources such as Medicare claims data and the National Death Index. DSS is decision-support system (VHA clinical utilization data). PBM is pharmacy benefit manager. DEpiC is Diabetes Epidemiological Cohort.

researchers: VHA multisite clinical trials and observational studies are facilitated by immediate 100 percent chart availability. Furthermore, the VHA has invested in an External Peer Review Program (EPRP), in which an independent external contractor audits the electronic text records to assess clinical performance using evidence-based performance criteria. Finally, data derived from the EHR can be supplemented by information from other sources, such as Medicare utilization data or data from surveys of veterans.

Diabetes care in the VHA illustrates the advantages of a national EHR system supported by an intramural research program. Much of the work that follows has been supported by the VA Office of Research and Development through its Health Services Research and Development and Quality Enhancement Research Initiative (QUERI) programs.[6]

■ **Understanding disease burden: the VHA diabetes registry.** The VHA was an early leader in using EHRs for a national diabetes registry containing clinical elements as well as administrative data. While the VHA's EHR system made a diabetes registry possible, operationalizing data transfer and transforming those data into useful information did not come automatically or easily. In the early 1990s the VHA began extracting clinical data from each local VHA database into a central data repository. By 2000 the VHA diabetes registry contained data on nearly 600,000 patients receiving care in the VHA system, including drugs, test results, blood pressures, and vaccinations. This information has subsequently been merged with Medicare claims data to create the VHA's Diabetes Epidemiology Cohort (DEpiC).[7]

Seventy-three percent of diabetic veterans are eligible for Medicare, and 59 percent of dual eligibles (Medicare and Medicaid) use both systems. Adding Medicare administrative data results in less than 1 percent loss to follow-up; although those data are not as rich as the clinical information in the VHA's EHR system, their addition fills gaps in follow-up, complication rates, and resource use.[8] Combined VHA and Medicare data also reveal a prevalence of diabetes among veterans exceeding 25 percent. The impact of the diabetic population on health spending is considerable, including total inpatient spending (VHA plus Medicare) of $3.05 billion ($5,400 per capita) in fiscal year 1999.[9]

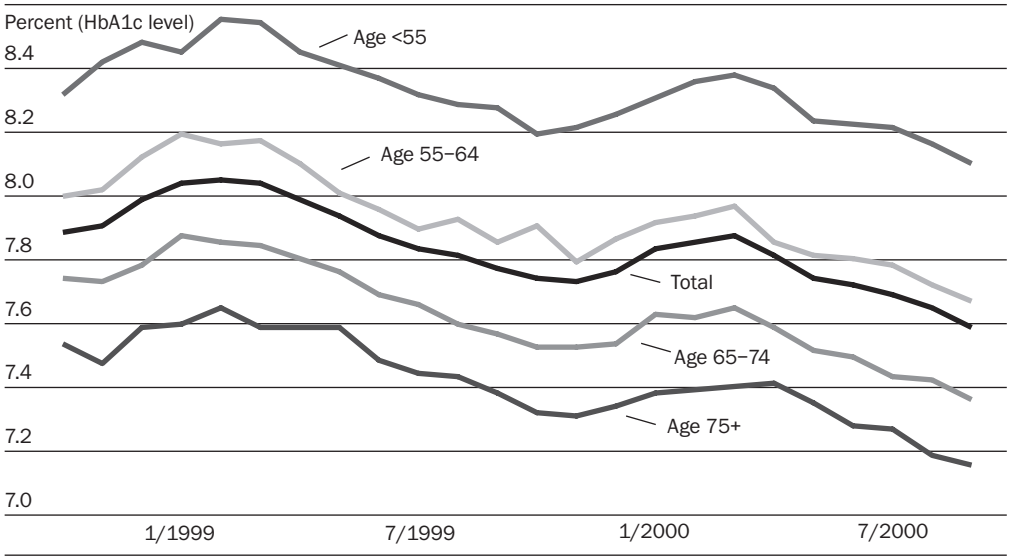
The rich clinical information made possible through the EHR system yields other insights. For instance, the VHA has identified a high rate of comorbid mental illness (24.5 percent) among patients with diabetes and is using that information to understand the extent to which newer psychotropic drugs, which promote weight gain, as well as mental illness itself contribute to poor outcomes.[10] The influence of sex and race/ethnicity can also be more fully explored using EHR data.[11]

Delineating and tracking diabetic complications are also facilitated by the EHR system. For example, using EHR clinical data allows identification of early chronic kidney disease in one-third of veterans with diabetes, fewer than half of whom have renal impairment indicated in the record.[12] The VHA is able to use the EHR system to identify patients at high risk for amputation and is distributing that information to clinicians to better coordinate their care.[13]

■ **EHR-enabled approaches to monitoring quality and outcomes.** Traditional quality report cards may provide incentives to health providers to disenroll the sickest patients.[14] The VHA's EHR system provides a unique opportunity to construct less "gameable" quality measures that assess how well care is managed for the same person over time for diseases such as diabetes, for which metrics of process quality, intermediate outcomes, and complications (vision loss, amputation, renal disease) are well defined. Using the VHA diabetes registry, longitudinal changes within individual patients can be tracked. In Exhibit 2, case-mix-adjusted glycosylated hemoglobin (HbA1c) values among veterans with diabetes decreased by −0.314 percent (range −1.90 to 1.03, $p < 0.0001$) over two years, indicating improved glycemic control over time, rather than simply the enrollment of healthier veterans.[15] These findings provide a convincing demonstration of effective diabetes care.

Longitudinal data have other important uses. For instance, knowledge of prior diagnoses and procedures can distinguish new complications from preexisting conditions. This was shown to be the case for estimates of amputation rates among veterans with diabetes, which were 27 percent lower once prior diagnoses and procedures were considered. Thus, longitudinal data better reflect the effectiveness of the management of care and can help health systems avoid being unfairly penalized for adverse selection.[16] Longitudinal EHR data are also important for evaluating the safety and effectiveness of treatments, which are critical insights for national formulary decisions.

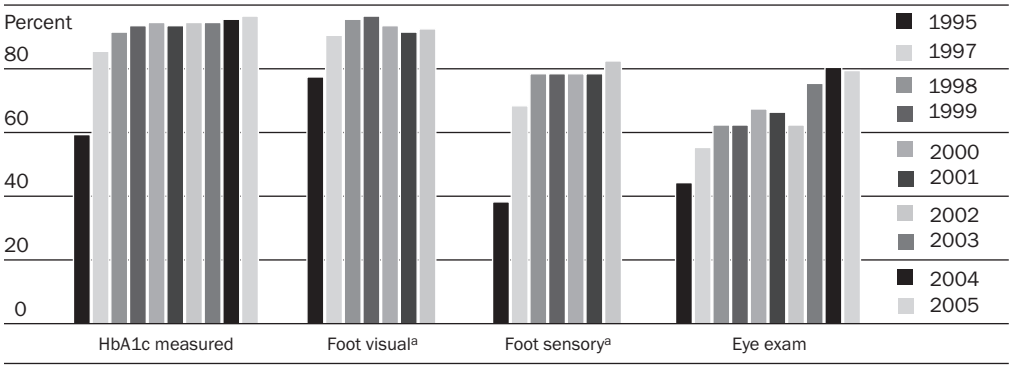
EXHIBIT 2
Trends In Mean Glycosylated Hemoglobin (HbA1c) Levels Among Veterans Health Administration (VHA) Clinic Users, By Age Category, October 1998–September 2000



SOURCE: Diabetes Quality Enhancement Research Initiative (QUERI).
NOTE: Additionally, a regression model that adjusts for clustering (patient and facility) and seasonal effects was used to confirm the downward linear trend in monthly HbA1c levels overall (–0.013, p </= 0.0001) and minimal differences in this trend by each age category (p = 0.492)

■ **Advancing evidence-based care.** Exhibit 3 shows the trends in the VHA's national performance scorecard for diabetes care based on EHR data. In addition to internal benchmarking, this approach has compared VHA performance with that of commercial managed care.[17] These performance data are obtained by abstracting the electronic chart; the completion of a national Health Data Repository with aggre-

EXHIBIT 3
Diabetes Process Quality In The Veterans Health Administration (VHA), Selected Years 1995–2005



SOURCE: Based on results from the VHA External Peer Review Program.
NOTE: Results are for VHA primary care outpatients with diabetes mellitus.
[a] Data for 2004 and 2005 are not provided.

gated relational data will eventually support automatic queries about quality and outcomes ranging from the individual patient to the entire VHA population.

The richness of EHR data allows the VHA to refine its performance measures. VHA investigators were able to demonstrate that annual retinal screening was inefficient for low-risk patients and inadequate for those with established retinopathy.[18] The VHA therefore modified its performance metrics and is developing an approach to risk-stratified screening that will be implemented nationally.

The greatest advantage of EHRs in the VHA system is their ability to improve performance by influencing the behavior of patients, clinicians, and the system itself. For instance, the VHA's diabetes registry has been used to construct performance profiles for administrators, clinical managers, and clinicians. These profiles included comparisons of facilities and identified the proportion of veterans with substantial elevations of HbA1c, cholesterol, and blood pressure. Patient lists also facilitated follow-up with high-risk patients. The EHR system also allows consideration of clinicians' actions to intensify therapy in response to that risk level (such as having a cholesterol medication started or increased when low-density lipid, or LDL, cholesterol is elevated). This approach credits clinicians with providing optimal treatment and informs them about what might be required to improve care.[19]

Data from the EHR system and diabetes registry also demonstrate the critical importance of defining the level of accountability in reporting the quality of diabetes care. EHR data show that for most measures in the VHA system, only a small fraction (2 percent or less) of the variance is attributable to individual primary care providers (PCPs) and that PCP profiling will be inaccurate unless panel sizes are very large (200 diabetics or more). In contrast, much more variation (12–18 percent) is attributable to overall performance at the site of care, a factor of relevance for the design of approaches to rewarding quality. Use of EHR data also highlights the important influence of organizational and system factors on providers' adherence to guidelines.[20]

The EHR system can identify high-risk populations and can facilitate targeted interventions. For instance, poor blood pressure control contributes greatly to cardiovascular complications, the most common cause of death in diabetics. In the VHA, investigators are working with pharmacy leaders to identify gaps in medication refills or lack of medication titration and thereby identify patients with inadequate blood pressure control because of poor medication adherence or inadequate medication intensification. Once identified, those patients can be assigned proactive management by clinical pharmacists integrated into primary care teams and trained in behavioral counseling.[21] Other approaches being tested and evaluated using EHR data are group visits, peer counseling, and patient-directed electronic reminders.

VistA/CPRS provides additional tools to improve care at the point of service. For example, PCPs get reminders about essential services (such as eye exams or

influenza vaccinations) at the time they see the patient, and CPRS functions allow providers and patients to view trends in laboratory values and blood pressure control. Perhaps most importantly, the VHA's EHR system allows for effective care coordination across providers, to communicate patients' needs, goals, and clinical status as well as to avoid duplication of services.

■ **Care coordination and telehealth for diabetes.** In-home monitoring devices can collect vital data for high-risk patients from the home and transmit those data to a care coordinator who can make early interventions that might prevent the need for institutional intervention.[22] Such an approach is possible only with an EHR. Based on promising pilot data as well as needs projections, the VHA has implemented a national program, Care Coordination through Home Telehealth (CCHT).[23]

Information technology (IT) also supports cost-effective access to specialized services. The VHA recently piloted the use of digital retinal imaging to screen for diabetic retinopathy and demonstrated that it could be a cost-effective alternative to ophthalmoscopy for detecting proliferative retinopathy.[24] Diabetic retinopathy is not only a preventable complication but also a biomarker for other end-organ damage (for example, kidney damage). In October 2005 the VHA began implementing a national program of teleretinal imaging, to be available on VistA/CPRS and for use by clinicians and researchers. In the future, computerized pictorial analysis and new tools for mining text data across millions of patient records have the potential to transform the clinical and research enterprise by identifying biomarkers of chronic illness progression.

Limits Of The EHR System In The VHA

Although the VHA has one of the most sophisticated EHR systems in use today, VistA is not a single system, but rather a set of 128 interlinked systems, each with its own database—that is, a decentralized system with central control. This limits its ability to make queries against all of a patient's known data. In addition, lack of standardization for laboratory values such as glycosylated hemoglobin and other data elements creates challenges for aggregating available data for administrative and research needs. The VHA diabetes registry, although a product of the EHR system, took years of effort to ensure data integrity.

A national data standardization project is under way to ensure that data elements are compliant with emerging health data standards and data management practices. Extracting data from free-text data fields—a challenge for all electronic records—will be addressed by defining moderately structured data elements for public health surveillance, population health, clinical guidelines compliance, and performance monitoring. Mapping of legitimate local variations to standard representations will allow easier creation of longitudinal registries for a variety of conditions.

Studies with the VHA's EHR system as well as others' systems have shown that electronic reminders, although effective at changing providers' behavior, have limited benefit, in part as a result of "signal overload" and other human-factor con-

"Through the MHV Web portal, veterans can securely view and manage their personal health records online."

straints.[25] The VA Office of Research and Development is funding work testing advanced decision-support systems that rely on artificial intelligence–based systems working in the background that integrate a broader range of patient clinical information with up-to-date care guidelines to provide tailored recommendations (for example, optimal choice of diabetes therapy). The hope, as yet unproven, is that such systems, by reducing provider burden, can improve process quality and patient outcomes.

The care of diabetes is complex and demanding, and delivering all indicated services might require more time than is typically available in a follow-up visit.[26] Studies of the impact of the EHR system on workflow and efficiency in the VHA and other settings have shown conflicting results.[27] Although it is unlikely that having EHRs saves time during the office encounter, downstream benefits such as better care coordination, reduction of duplicative and administrative tasks, and new models of care (such as group visits) translate into a "business case" when the reimbursement structure favors population management.

Creating Patient-Centered, Community-Based Care: My HealthEVet

The VHA's quality transformation since 1996 involved shifting from inpatient to integrated care. The next phase will involve empowering patients to be more actively engaged and moving care from the clinic to the community and home. Again, health IT has been designed to support the new delivery system.

My HealthEVet (MHV) is a nationwide initiative intended to improve the overall health of veterans and support greater communication between VHA patients and their providers. Through the MHV Web portal, veterans can securely view and manage their personal health records online and can get access to health information and electronic services. Veterans can request copies of key portions of their VHA health records and store them in a personal "eVAult," along with self-entered health information and assessments, and can share this information with their health care providers and others inside and outside the VHA. The full functionality of MHV, available online at http://www.myhealth.va.gov, will help patients plan and coordinate their own care through online access to care plans, appointments, laboratory values, and reminders for preventive care. Research itself can be facilitated by MHV: Patients will be able to identify ongoing clinical studies for which they are eligible to enroll, communicate with investigators via encrypted e-mail, have their outcomes tracked through computer-administered "smart surveys," and even provide suggestions for future studies. In addition, the effectiveness of patient-centered care can be evaluated.

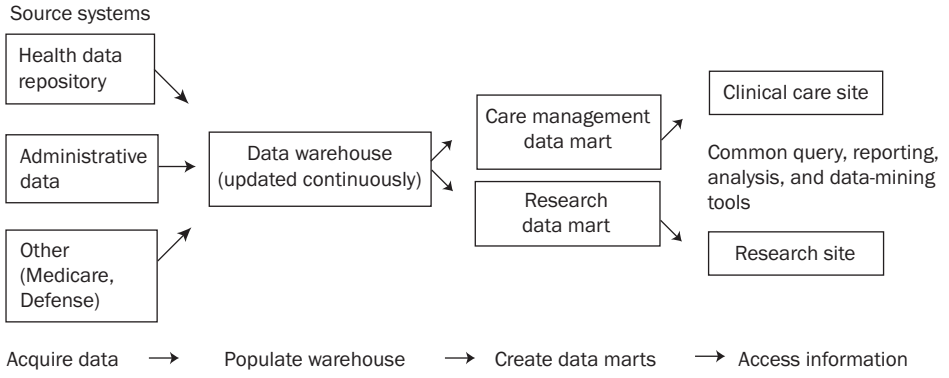
The Twenty-First-Century EHR

The next phase of VistA/CPRS will feature open-source applications and relational database structures. One benefit of the conversion will be easier access to national stores of clinical data through a unified Health Data Repository (HDR) that will replace the current 128 separately located VistA systems. The HDR is under construction; it now contains records from nearly sixteen million patients, with more than 900 million vital-sign recordings and 461 million prescriptions.

Additionally, a clinical observations database linked to Systematized Nomenclature of Medicine (SNOMED) terms and semantic relationships will greatly expand the scope of data available for research data-mining activities. Improved decision-support capabilities will help clinicians provide care according to guidelines and understand situations where it is appropriate to deviate from guidelines. The reengineered EHR will also link orders and interventions to problems, greatly increasing the VHA's clinical data-mining capabilities.

To support the delivery of consistent information to all business units, the VHA is developing a Corporate Data Warehouse (CDW, Exhibit 4), which will include the HDR as the primary source of clinical data but also encompass other administrative and financial data sets (including Medicare data) to create a unified view of veterans' care. Among other things, the CDW will supplement the capabilities of VistA by providing an integrated analytical system to monitor, analyze, and disseminate performance measures. This will assist population-based health services research by offering standardized data across all of the subjects it contains, tools for rapidly performing hypothesis testing, and ease of data acquisition. Unlike the VHA's current diabetes registry, which has been labor-intensive to create and maintain, future registries based on the CDW will be easier to construct and up-

EXHIBIT 4
Veterans Health Administration (VHA) Corporate Data Warehouse (CDW) Architecture



SOURCE: VHA Office of Information.
NOTES: The VHA's future Corporate Data Warehouse will combine health data, administrative data, and externally derived data for all patients seen in the VHA. This structure will facilitate the creation of automated data marts to facilitate care management (using patient identifiers) as well as research with appropriately deidentified data.

date. The CDW will eventually facilitate personalized medicine by allowing the linkage of genomic information collected from veterans to information on longitudinal outcomes. These changes will introduce more central control than was present during the early days of the VHA's EHR system, but clinicians and researchers will continue their involvement in developing innovations.

Conclusions And Policy Implications

The VHA has been an EHR innovator, developing a clinically rich system from the ground up that has become so integrated into the delivery of care and the conduct of research that one cannot imagine a veterans' health system without it. However, many factors in addition to the EHR system contributed to the VHA's quality transformation, including a culture of academician-clinicians that valued quality; scientific evidence and accountability (for which the EHR became an organizer and facilitator); the presence of embedded researchers who were active clinicians, managers, policymakers, and developers of VistA/CPRS; and a research infrastructure that could be applied to this topic.[28] Although the data structures are complex and sometimes flawed, they are, because of their user origins, effectively linked to the needs of clinicians and researchers, who in turn incorporate their input into the further evolution of the VHA's EHR system.

The design of the VHA system also ensures that overall incentives are aligned to realize EHRs' beneficial externalities. The VHA benefits, for instance, by being able to eliminate duplicative test ordering when veterans seek care at different facilities.[29] The cost of maintaining the EHR system amounts to approximately $80 per patient per year—roughly the amount saved by eliminating one redundant lab test per patient per year.[30] The VHA also benefits greatly by being an interactive, permeable entity in a free-market system: The VHA is an enrollment system, not an entitlement program or a safety-net provider, and thus has incentives for maintaining high satisfaction and perceived value among those it serves.

For patient care management, the VHA's EHR system has developed an infrastructure for collecting and organizing information from which a diabetes database (DEpiC) evolved to provide valuable information related to disease prevalence, comorbidities, and costs that is necessary for quality improvement, systemwide planning, and research. Longitudinal within-cohort assessment, made possible by EHRs, is a major advance in attaining precise measures of quality that mitigate the effects of adverse patient selection.

Home telehealth linked to EHRs has made possible novel patient-provider interactions of which the care coordination and teleretinal imaging initiatives are among the earliest prototypes. This approach has the capacity to expand care delivery to many others, and the benefits are not limited to the homebound: A new generation of Internet-savvy veterans will appreciate round-the-clock access to health care the same way they do for instant messaging and shopping. MHV, which is in its launch phase, is part of the future plan to give veterans control over

their health and includes many possibilities for research.

One more important EHR-enabled initiative has the capacity to greatly change the practice of medicine: adding genomics information to the medical record. With its EHR database, the VHA has an opportunity to identify the genetic correlates of disease and drug response, which may transform medical practice from a process of statistical hunches to one of targeted, personalized care.

Because of the vastly larger scale of the health care enterprise and the changing needs of veterans, the VHA's focus now has models in place to shift to issues involving clinical decision support, content standardization, and improved interaction among patients, VHA providers, and other systems. These capabilities are made possible by the VHA's EHR system. The VHA experience could provide a model for how federal health policies can help the United States bridge its "quality chasm." As we have described, this transformation involves far more than simply installing VistA/CPRS (or any other EHR system). The primary lesson the VHA can offer other health systems is to emphasize the necessary clinical and organizational factors needed for successful EHR implementation and to link those factors to a research and quality infrastructure capable of using electronic health information for discovery and improvement.

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