



■ AN ISSUE BRIEF ON HEALTH INFORMATION
■ TECHNOLOGY AND CARDIAC CARE



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About eHealth Initiative

The eHealth Initiative (eHI) is a non-profit, multi-stakeholder organization whose mission is to drive improvements in the quality, safety and efficiency of healthcare through information and technology. As the field of health information technology continues to evolve and transform the landscape of the greater healthcare system in the United States, eHI has engaged in research, education, and advocacy activities to not only inform its members but also develop consensus on important emerging issues, trends, and best practices. Over the course of 2012, eHI focused its efforts on innovative technologies that can impact the millions of patients and providers across the United States that are faced with the three most expensive, prevalent, and deadly chronic conditions: cancer, diabetes, and heart disease. To support this focus, eHI convened three national, multi-stakeholder councils to inform qualitative research and shape the development of this report.

National Council on Heart Disease Technology

The National Council on Heart Disease Technology is a multi-stakeholder group composed of eHI members that focuses on the intersection of heart disease, cardiovascular care, and health information technology. Under the leadership of co-chairs from the American College of Cardiology, American Heart Association, American Stroke Association, and NextGen, the Council has convened on a monthly basis to examine how health information technology can support the Triple Aim of cardiac care; highlight best practices in the field; and identify emerging opportunities and/or existing gaps of knowledge to be filled.

Purpose

This report aims to inform the field and create a roadmap towards achieving a robust, interoperable cardiac learning health system.

Formation of the Document

The Council met over the span of eight months to discuss a variety of relevant topics, interview leading organizations, and produce the following report through a multi-stakeholder, consensus-driven process.

Intended Audiences

This document is intended to inform a diverse group of stakeholders who are improving healthcare through the use of health information technology in the context of heart disease and the greater continuum of care. This includes, but is not limited to: cardiologists, clinicians, consumer and patient groups, employers and healthcare purchasers, health plans, health information technology suppliers, hospitals, laboratories, pharmaceutical and medical device manufacturers, pharmacies, public health agencies, quality improvement organizations, standards development organizations, and state, regional and community-based organizations.

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¹ The views expressed in this report do not necessarily reflect the policies of the organizations with which the individuals listed above are affiliated.

The National Council on Heart Disease and Technology

This report was developed by the National Council on Heart Disease and Technology, a multi-stakeholder workgroup led by representatives from eHealth Initiative, American College of Cardiology, NextGen, American Heart Association, and the American Stroke Association. Convening over the course of 2012, the Council explored a variety of topics to examine how patient- and provider-facing health IT can support the Triple Aim of cardiac care. By identifying best practices, emerging opportunities, and existing gaps in the field, the Council produced this report to provide a roadmap towards achieving a robust, interoperable learning health system for heart disease.

Introduction

Over the past several decades, an epidemiological transition in the United States has led to chronic diseases becoming the most expensive, prevalent, and often times preventable health conditions in the United States. Today, more than 133 million Americans live with at least one chronic condition, and this number is expected to rise to 157 million by 2020.¹ Currently, more than 25% of adults and 66% of Medicare beneficiaries are estimated to have multiple co-morbid chronic conditions, increasing their risk of health-related complications, hospitalization, readmission, and mortality.² These numbers are expected to rise unchecked in the face of aging population and convergence of the multifactorial causes and risk factors of chronic disease, such as obesity, sedentary behavior, environmental exposure, diet, and use of tobacco and alcohol.³

As chronic conditions such as heart disease have spread at an epidemic rate, the healthcare system has struggled to adapt and evolve to the changing landscape. The burden of chronic disease has shined a spotlight on a fragmented system that is defined by an inefficient, outdated reimbursement and delivery model that limits the quality and coordination of care. The nature and complexity of chronic diseases require not only an extensive continuum of care to prevent, treat, and manage disease over long periods of time, but also the active involvement, education, and engagement of patients, providers, and caregivers. Since the publication of the landmark report “Crossing the Quality Chasm” by the Institute of Medicine in 2001, a new era of healthcare reform at local, state, and national levels has emerged in which providers, hospitals, payers, and policymakers alike have strived to develop innovative strategies and approaches that will increase the coordination, quality, equity, safety, and efficiency of care.⁴ In the wake of the Patient Protection and Affordable Care Act (ACA) in 2010, new delivery models of care are emerging that fundamentally change the way in which patients and providers manage, treat, and prevent chronic disease with a more patient-centric, collaborative, and systems-based approach. However, the development and implementation of these models, such as patient-centered medical homes (PCMH) and accountable care organizations (ACOs), would not have occurred without the simultaneous advancements in health information technology.

Disruptive innovations in healthcare have been accelerated by the evolution of health information technology (health IT) to modernize the field of medicine. Today, health IT can harness robust, real-time data from clinical, claims-based, administrative, and patient-reported sources to provide actionable solutions and healthcare intelligence at the point of care and beyond. A surge in activity in health IT was largely spurred by the American

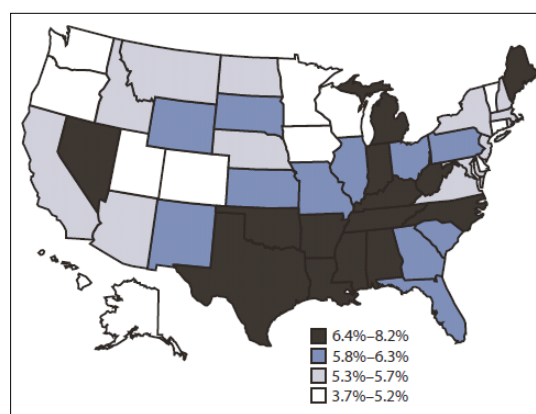
Reinvestment and Recovery Act (ARRA) in 2009, which included the Health Information Technology for Economic and Clinical Health (HITECH) provisions. By encouraging the adoption and use of electronic health records (EHRs) in health care practices and hospitals across the country through a series of policy levers, HITECH has catalyzed the implementation of a roadmap to improve health care outcomes at an individual and population level through the timely and secure electronic use, exchange, and reporting of health information. More importantly, it has provided the ways and means to achieve what providers have dreamed of for decades: the triple aim of improving healthcare at an individual level, reducing per-capita costs and improving overall population health. Developed by the Institute for Healthcare Improvement to optimize health system performance, the Triple Aim framework was a critical foundation to ACA reform which encourages health care organizations to bend the cost curve and redesign primary care to integrate prevention, wellness, and population health management. To meet the considerable challenge of providing value-driven, patient-centric, and quality care, the realization of healthcare reform provisions will depend upon the ability of health providers and patients to effectively integrate health IT and coordinate care across the continuum. As innovations in emerging areas such as personalized medicine, genomic, and data analytics further advance the field, patients and providers will have more resources, knowledge, and tools than ever before to reduce the burden of chronic diseases such as heart disease.

Overview of Heart Disease

Heart disease is the leading cause of death among men and women in the United States and is a major cause of disability. Approximately 595,000 people die of heart disease each year – or to put things in a different perspective, 1 in 4 deaths are caused by heart disease.⁵ Coronary heart disease (CHD) is the most common type of heart disease, and can refer to cardiovascular conditions that are generally caused by narrowed, blocked, or hardened coronary arteries restricting the supply of oxygen and blood to the heart. CHD also includes arrhythmia, congenital heart defects, cardiomyopathy, and heart infections, and can result in angina pectoris, stroke, heart failure, and myocardial infarction.⁶

Approximately 18.5 million Americans have CHD, with prevalence highest in the southeastern states of the U.S. as shown in Figure 1. Although the overall prevalence has decreased over time – most recently from 6.7% to 6.0% between 2006 and 2010 – significant disparities exist across age, gender, state of residence, and socioeconomic status. Prevalence of CHD is greatest among people above the age of 65 years (19.8%), followed by age groups 45-64 years (7.1%) and 18-44 years (1.2%), and remains significantly higher among men (7.8%) than pre-menopausal women (4.6%). Thanks in part to advancements in disease prevention, treatment, and management, the age-adjusted mortality rates for CHD have been steadily declining since the 1960s, and the double drop in both mortality and prevalence suggests

Figure 1: Age-adjusted CHD prevalence among adults (BRFSS 2010).



that the incidence of CHD is also moribund.⁷ However, the crude prevalence of CHD is estimated to sharply increase to 8.6% by 2020 and continue to rise unchecked in the face of an aging population, improved treatment protocols enabling patients with CHD to survive for longer periods of time, and growing prevalence of associated risk factors.

Disparities and Risk Factors of Heart Disease

Currently, more than 37% of the general population has multiple modifiable risk factors for heart disease, including sedentary behavior, obesity, high blood pressure and cholesterol, cigarette smoking, diabetes, diet, and stress.⁸ Among racial/ethnic populations, heart disease is most prevalent among American Indians/Alaska Natives (11.6%), followed by African Americans (6.5%) and Hispanics (6.1%), compared to Caucasians (5.8%). CHD is also twice as high among individuals with less than a high school diploma (9.2%) compared to those with a college degree (4.6%). These populations are at a higher risk of developing heart disease not only because of late diagnosis, inadequate control of risk factors and poor management of disease, but also interaction with determinants of health including insurance, education, employment, food deserts, and neighborhood environments that are not conducive to physical activity.⁹

The Burden of Heart Disease

Routinely one of the most expensive conditions to treat, direct coronary heart disease expenditures are estimated to cost the United States \$90.9 billion per year, and the American Heart Association expects that by 2030, total direct costs will reach \$218.7 billion.^{10,11} With more than 4 million people hospitalized due to heart disease each year and an average length of stay of 4.6 days, indirect costs currently account for an additional \$68.8 billion (\$58.6 billion for lost productivity from mortality and \$10.2 billion attributed to morbidity).^{12,13} Transitions of care remain a serious cause of concern and hospitalizations continue to constitute a majority of the annual costs associated with heart disease; more than 25% of hospitalized patients with heart failure and 33% of hospitalized patients with acute myocardial infarction are readmitted within 30 days of discharge.¹⁴

Once patients are discharged with a treatment plan, they fail to receive recommended care approximately 46% of the time and are subject to otherwise preventable complications and/or death. For example, an estimated 37,000 deaths could be prevented each year if heart attack patients received beta blockers or aspirin (currently, only 45% receive beta blockers and only 61% receive aspirin).¹⁵ However, even in the event that patients receive prescriptions, adherence remains a significant obstacle. A recent meta-analysis of more than 376,000 patients observed that only 57% of the individuals were adherent with prescriptions acquired post-discharge, with no significant differences among drug class or age of the patient.¹⁶ Many patients fail to adhere to a prescribed regimen for a variety of reasons, including cost, side effects, belief system, or the sheer challenge of managing the polypharmacy of a chronic disease. Poor adherence can lead to increased medical costs, hospitalizations, and adverse health outcomes that could otherwise have been prevented if patients had complied.

Managing Heart Disease

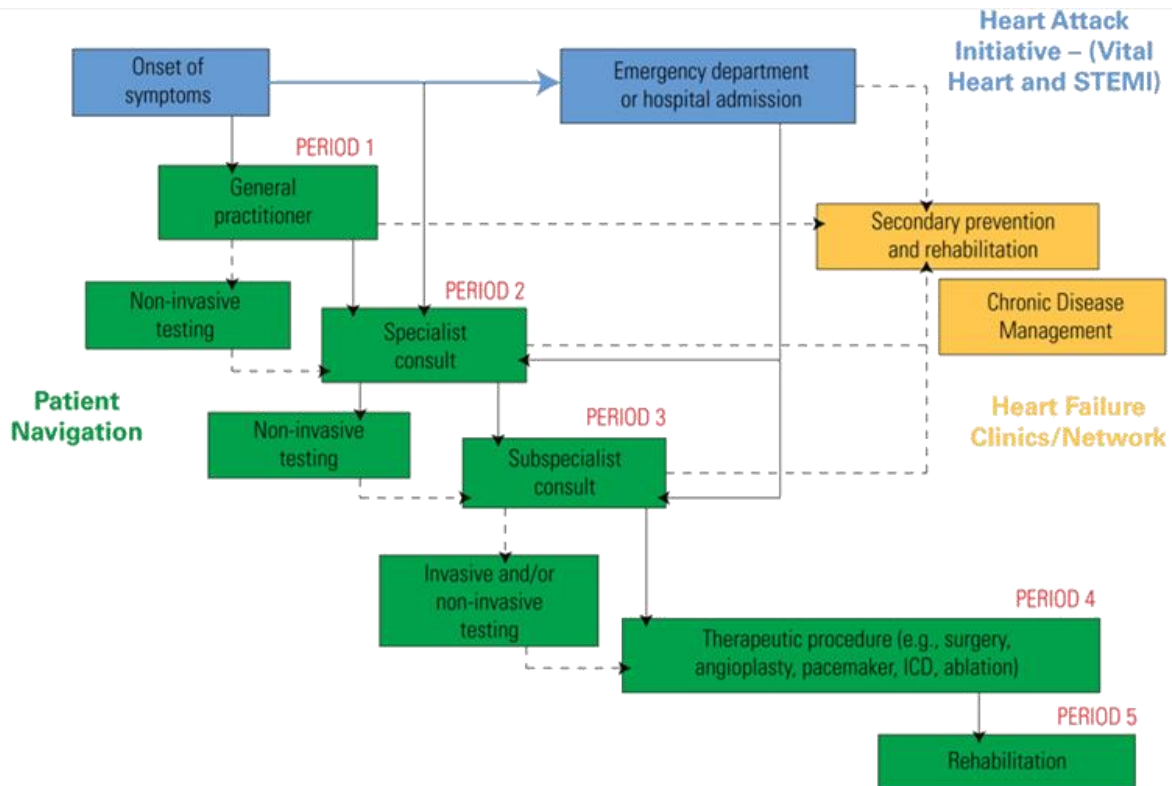
Although there are numerous ways to treat heart disease, including surgery, noninvasive procedures, and a variety of medications, lifestyle and behavior modification can effectively

prevent and/or treat forms of heart disease by focusing on weight management, physical activity, smoking cessation, and diet.¹⁷ Indeed, the adequate control of smoking, hypertension and cholesterol alone would reduce annual healthcare costs by as much as \$30 billion.¹⁸ By focusing on these problem areas, disease management can reduce hospital readmissions and cardiovascular-related complications, and lead to better health outcomes and overall quality of life.¹⁹ Like other non-communicable diseases that are best treated with the Chronic Care Model, effective cardiac care depends upon the participation and engagement of patients and providers in their respective shared responsibilities, many of which occur beyond the point of care. Successful management of heart disease requires key elements such as coordinated care, patient support and education for self-care, active communication between patients and providers, outcome measurement, and delivery system support.²⁰ Patients must measure and monitor indicators such as blood pressure and cholesterol levels at home, and undergo cardiac rehab and prevention regimens that include a combination of medication, diet, stress reduction, and physical activity. Cardiac rehab programs can improve a patient's quality of life and reduce the likelihood of another serious heart event.²¹ Because of the proclivity towards developing multiple diseases and complications that both cause and/or result from heart disease, patients must also be regularly screened for associated risk factors such as hypertension, diabetes, asthma, sleep apnea, and overweight.²²

Today, the traditional point of care is expanding and the frontlines of primary care are shifting from physicians to nurse practitioners and pharmacists. Notably, approximately 90% of Americans are estimated to live within 5 miles of a pharmacy, a ubiquitous facility which is more accessible and available to the general population than a hospital or clinic. And as the shortage of primary care physicians continues to grow over the next decade, nurse practitioners are stepping up in response to provide critical care for cardiac patients and assist with transitions across the continuum. New frontiers of care are not only breaking down barriers, but also increasing the role of health information technology and exchange in allowing patients to seamlessly move from one care provider to another. Emerging models of care such as accountable care organizations, which take on risk, must accordingly enable, manage, and control patient access to information. As heart disease is treated across the continuum of care from prevention to treatment to wellness, patients and providers need to communicate frequently about patient health status and care planning at all stages. By maintaining open communication, providers, caregivers, friends, and family members are better able to help individuals cope with their disease and surmount symptoms such as anxiety, depression, denial, and fear. Some patients may lack the health literacy or resources required to manage their condition due to barriers to access, services, insurance, and comprehensive coverage. Without continuity of care, these patients are less likely to understand their condition or address psychosocial issues with their provider, let alone be diagnosed and treated in a timely manner. As a result, it is vital that patients be educated about the prevention, treatment, management, and risks of heart disease in a culturally appropriate manner at critical "teachable moments" of care, such as pre-discharge.

The path from initial onset of heart disease symptoms to wellness can be long and arduous. Illustrated below is a sample figure that demonstrates the complex network of care that a cardiac patient might expect to undergo.

Figure 2: Example of Continuum of Cardiac Care²³



ICD = implantable cardioverter defibrillator; STEMI = ST segment elevated myocardial infarction.

As displayed above, a team of healthcare professionals is often involved in a cardiac patient’s care – including general practitioners, physician assistants, nurses, cardiologists, specialists, home health care clinicians and aides, pharmacists, case managers, social workers, mental health professionals, dieticians, and physical therapists – that can make continuity of care difficult. By definition, care coordination is a complex process that ensures that disparate healthcare services are appropriately delivered and that a patient’s needs and preferences are met across the continuum. Effective coordination relies upon access to and sharing of health data, organization of information and services, and co-development and implementation of care plans. As cardiac patients journey through the myriad of steps involved in prevention, screening, diagnosis, treatment, management, and wellness, health IT can enable a longitudinal view of care and facilitate bi-directional communication between patient and provider. The trail of data following a patient from provider to provider leaves behind a dense, interlocking web of health information that needs to be measured, monitored, analyzed, and exchanged across the cardiac continuum.

Health Information Technology and Heart Disease

Evidence-based interventions can reduce both the risk of and complications from heart disease through medication management, lifestyle coaching, reduction of obesogenic behavior, self-monitoring, and appropriate use of health services. Health IT can support these endeavors by surmounting common barriers to cardiac care; enhancing changes

within healthcare delivery; and enabling timely, secure access to real-time, actionable data for providers to manage patient health at an individual and population level. In the context of cardiac care, health IT offers numerous benefits and has been associated with improvements in the measurement and monitoring of heart disease, including risk factors such as blood pressure, arrhythmia, cholesterol, and weight, as well as the implementation of guideline-based decision support for providers. The use of health IT can also support interventions and programs focusing on disease management and wellness. Specifically, health IT has been used to help providers develop and share patient-specific care plans, enhance communication, strengthen the patient-provider relationship and provide access to evidence-based guidelines of care for clinical decision support. Patient-centric health IT can enable a partnership among practitioners, patients and their families to ensure that procedures and decisions respect patient needs and preferences.²⁴ Health IT can also provide clinicians with necessary information either remotely or directly to assist them in following evidence-based guidelines for care, and to exchange patient data with multiple providers via larger health information systems. Aiming to provide a more seamless transition between clinical and nonclinical settings of cardiac care, health IT tools can harness different communication channels to improve the prevention, screening, detection, diagnosis, treatment, monitoring, and management of heart disease. Given the nature of heart disease management, many patient-facing technologies today focus on supporting medication management to improve adherence; lifestyle modification to facilitate behavior change; and remote monitoring systems to track vital signs and provide adverse event alerts and notifications.²⁵

Framework for a Cardiac Information System

In order to support patient care and management of heart disease, a healthcare delivery system must implement a robust, interoperable cardiac information system (CIS). An effective and sustainable CIS features not only the individual technology components required by each stakeholder involved across the continuum, but also provides an interoperable infrastructure capable of collecting, storing, analyzing, and exchanging a vast array of clinical information. In many ways, however, the sum is more important than the parts; if value is to be derived from the health IT components described below, interoperability of devices and data is essential to unlock their potential. As the volume, liquidity, and complexity of big data continue to change the paradigm of healthcare intelligence with innovations in personalized medicine, the ability to harvest data efficiently will be all the more critical. CIS components must therefore also provide the flexibility to be customized according to the changing panorama of care, and the individual needs and priorities of stakeholders. Described below in greater detail are the CIS features highlighted by the Council as essential components to be developed and/or adopted by a forward-facing organization.

Data Collection and Care Coordination

At their core, **EHR systems** serve to collect, store, manage, and aggregate clinical, pharmacy, laboratory, radiology, and administrative data – however, their capabilities and functionalities are constantly expanding and evolving with the new iterations of technology. By increasing access to information, EHRs can support patient empowerment and decision support, increase communication and coordination between and among providers and

patients, and improve the quality of care delivered. Today, advanced EHRs feature many of the components mentioned below, while basic systems can be fortified by integrating siloed subsystems, applications, or layers of software. Patient data can be documented in an EHR to record important information such as demographics, reported symptoms, vital signs, medical history, medications, allergies, and physician notes. Once collected, data is stored in a **clinical data repository (CRD)**, such as a clinical data warehouse. **Clinical documentation systems** enhance the value of EHRs by processing discrete, structured data and **natural language processing** can unlock further meaning from unstructured data within sources such as clinical notes, summaries, and abstracts. Cardiac catheterization lab and ultrasound images are captured, stored, and transmitted with a **cardiology picture archive and communication system (CPACS)**. If follow-up is deemed necessary, diagnostic exams and services can be ordered through a **computerized physician order entry (CPOE)** application. Health IT offers immense promise to improve the quality of cardiac care simply by providing more accurate problem and medication lists to reduce the occurrence of medical errors and adverse events. EHRs can support medication safety and management with a number of features. Medication can be prescribed, transmitted and filled electronically (**e-prescribing**) through CPOEs to pharmacies and reduce the traditional risks associated with handwritten prescriptions. **Pharmacy clinical decision support** can dramatically improve medication reconciliation and identify potential drug interactions, and patient adherence can be facilitated with **electronic dispensers** to help encourage that the appropriate dosage and frequency to be observed. Administrative tasks such as **centralized scheduling and billing** can be automated via the EHR to improve workflow, operational efficiency, and case management. Similarly, patient outreach can be streamlined via automated telephone, text, and electronic messages to rapidly deliver reminders and notifications. In the context of heart disease, EHRs are critical to supporting transitions of care by allowing multiple providers to access, update, and complete information about disparate patient encounters and changing cardiac condition.

Population Health Management

EHRs have evolved beyond individual-level tools intended for patient-provider interactions to also support population-level surveillance and management. Today, many systems feature **dashboards** that display on-demand metrics and trends of a patient population that allow providers to quickly identify those at risk or in greater need of care. As dashboard applications improve, their utility will increase as more real-time data is seamlessly incorporated. **Health information exchange (HIE)** is critical to providing timely access to secure, actionable, and up-to-date patient health information across disparate healthcare settings. By using a **Master Patient Index (MPI)** and **Record Locator Service (RLS)**, an HIE organization can search, match, and retrieve patient records across different systems. Patient data can also be reported and aggregated up to local **patient registries and national databases**, such as the **National Cardiovascular Data Registry (NCDR)**. Managed by the American College of Cardiology (ACC), the NCDR is the most comprehensive outcome-based quality improvement program in the United States, encompassing six hospital-based registries and one outpatient registry. Each registry uses standardized data elements and definitions for patient demographics, clinical variables, and outcomes to facilitate communication and comparison. The measurement of physician performance allows providers to benchmark themselves against regional and national

standards of care, and when made publicly available, supports patients make a decision regarding a procedure, provider, or healthcare organization based on the quality, value, safety, and cost of care reported. While treating a patient, health providers may depend upon **clinical decision support systems (CDSS)** to provide evidence-based guidelines of care such as **Get With The Guidelines®**. Developed in collaboration with the American Cancer Society, American Heart Association and American Stroke Association (AHA/ASA), and American Diabetes Association, Get With The Guidelines® is a national program that regularly provides updated guidelines and in-hospital modules for heart disease prevention, management, and treatment. In a similar joint effort, the American Cancer Society, American Diabetes Association, and American Heart Association joined together in 2011 to create **The Guideline Advantage**, a program that uses data collection, analysis, and feedback to translate prevention and treatment guidelines into practice within the outpatient setting. The Guideline Advantage provides quarterly feedback reports, including both state and national benchmarks, as well as quality improvement resources for specific diseases such as heart failure. Unlike other areas of healthcare, cardiac clinical decision support systems have the unique advantage of harnessing the robust data and backbone provided by the ACC and AHA/ASA. However, although connectivity exists, further standards must be developed to encourage a flexible plug-and-play framework that will allow health IT systems to adopt and integrate guideline changes in real time, and thus enable more seamless care and monitoring.

Patient Disease Management

Patient health records and lab results can be securely accessed via a **patient web portal (PWP)** by an authorized individual or family member. PWPs can facilitate communication between patient and provider, and allow patients to perform routine tasks from home such as scheduling, billing, and processing insurance claims. PWPs also typically provide timely reminders and alerts to patients regarding related events, as well as direct patients towards targeted educational resources. These web-enabled systems have the potential to communicate significant amounts of information to a patient as well as increase the efficiency and productivity of care.²⁶ Whether they are dispensed via PWP or distributed online, educational resources are critical to inform patients about their condition, provide tips on lifestyle and disease management, and ease the process of health-related decision-making.

Following a visit or discharge from the hospital, patients may be remotely monitored via **telemedicine**. Telemedicine has revolutionized the field of cardiology by removing traditional geographic barriers to care and communication by connecting patients and health providers through advanced telecommunication technologies with bi-directional audio and video interaction. Defined as an automated support system for cardiac patients and providers to inform the decision-making process and facilitate disease management, telecardiology can be used in a number of ways to collect, store, and send both objective and subjective data to providers. This can include physiological and laboratory data; general vital signs, symptoms, and behavioral information; medication dosages, interactions and allergies; and sentinel events. Telecardiology tools and systems can improve the quality of information sent to providers, improve the frequency and quality of communication between patients and providers; increase patient education and empowerment; reduce the travel

time and expenses to consult a provider in-person; and create cost efficiencies due to more accurate treatments and necessary adjustments to patients' care plans.

Innovations in telecardiology have been further spurred by the rise of **cardiac implantable devices**, which are placed in one's chest to assist and/or monitor heart activity. Common devices such as implantable cardiac monitors, pacemakers, cardioverter defibrillators, cardiac resynchronization therapy devices, loop recorders and hemodynamic monitoring devices can facilitate the monitoring and evaluation of cardiac rhythm, blood pressure, and the presence of myocardial ischemia or reduced blood flow to the heart. The continuous stream of real-time data allows health providers to improve the monitoring, treatment, and management of heart disease, and studies have indicated that cardiac implantable devices typically receive high levels of acceptance and satisfaction among both patients and providers. Implantable devices can detect adverse events, send safety alarms, provide global positioning system information in the case of emergency, and reduce the overall volume and cost of follow-up visits.²⁷ More importantly, the combination of telecardiology and implantable devices is a safe alternative to conventional care that has been found to improve the provision of care and clinical outcomes while reducing the number of hospitalizations associated with heart disease. Diet, physical activity and heart activity can be monitored through mobile applications on wireless devices and cellular phones to facilitate not only the exchange of electronic data between patients and their respective care team, but also dialogue. Clinical data and outcomes from patients receiving mechanical circulatory support device therapy treating advanced heart failure can be further aggregated up to the **Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS™)**, a prospective North American registry managed by organizations including the National Heart, Lung and Blood Institute (NHLBI), the Centers for Medicare and Medicaid Services (CMS), and the Food and Drug Administration (FDA).

By enhancing the frequency, flow, and accuracy of patient-physician communication, telecardiology is an effective means of improving health outcomes and patient engagement. The recent proliferation of smartphones has reinvigorated the field of **mobile health (mHealth)** and challenged the once clear-cut definition of a medical device to expand the reach of telecardiology and spur patient engagement. The ubiquity of mobile communication devices, in conjunction with the Internet, presents a myriad of opportunities to enhance and extend heart disease prevention and management well beyond the reach of traditional care. Representing an evolution from desktop telemedicine to wearable technologies, mHealth can improve the accessibility of cardiac treatment as well as the ability of patients to actively engage their providers through remote coaching, tracking, feedback, and education. Additionally, the innovations and functionality of mHealth, such as text messaging, smartphone applications and wireless sensor technology, can improve the speed, accuracy, and convenience of diagnostic tests; improve medication adherence and test result delivery; improve interactive, two-way communication; and provide simple methods for data collection, remote diagnosis, emergency tracking and access to health records.

The use of mHealth applications and devices can encourage patients to adhere to their regimens by facilitating self-monitoring efforts with **reminders and alerts**, and serving as simple repositories for information generated by the patient, which can then be shared with the patient's care team. As smartphones have penetrated diverse markets and populations

over the past several years, the number of applications available for direct download onto smartphones has skyrocketed in response to the growing interest of the general population. Currently, there are over 40,000 health-related applications and this number is expected to double as the number of smartphone users increases and the sophistication of the technology improves.²⁸ After conducting an environmental scan of iPhone, Android, and Blackberry applications designed for heart disease management, eHealth Initiative found that applications generally serve one of five critical functions: heart activity (monitor heart rate, cardiograph, etc.), patient-provider communication and education, risk assessment, lifestyle and disease management (physical activity, diet, tobacco, etc.), and vital signs (record blood pressure, cholesterol, weight). However, there is also a plethora of applications that also address related risk factors such as hypertension, wellness, COPD, asthma, diabetes, cancer, and other conditions. As innovations in telemedicine and mhealth continue to expand the reach of data analytics, empowered health consumers are embracing the Quantified Self movement to monitor their own health and submit **patient-reported outcome measures** for ongoing surveillance. While remote disease monitoring has broken down historically significant barriers to care, it has also introduced new challenges surrounding the quality and quantity of data now available.

As health IT continues to evolve, it will be critical to strategically align the adoption and implementation of emerging solutions to integrate with existing systems and products. However, it will be equally important to ensure that health IT tools are also adequately designed and used to support the new directions in which modern healthcare is heading. Over the past several years, new models of delivery such as ACOs and PCMHs have emerged with a heavy emphasis on quality, value, and cost-effectiveness. To support these Triple Aim goals, health care providers and systems at large are harnessing health IT to improve patient-centered care. Discussed below in the following sections are a series of case studies that illustrate how leading organizations around the country are developing and implementing health IT to improve the care and management of heart disease.

Case Studies: Improving the Quality of Cardiac Care

Quality Measurement

Located in central Massachusetts, Reliant Medical Group (RMG) has embraced health IT to improve care at an individual and population level, and ensure that actionable, real-time information is accessible at the frontlines and points of care. As an affiliate of the ACO Pioneer group Atrius Health, RMG works in collaboration with five other non-profit community-based physician groups: Harvard Vanguard Medical Associates, Granite Medical, Dedham Medical Associates, Southboro Medical Group and South Shore Medical Center. Together, the Atrius Health medical groups serve a population of approximately 1 million adult and pediatric patients with over 3.8 million visits each year among the 50 practice locations.

Quality measurement has proven critical to RMG's success, in part due to the long-term strategic investment placed in health IT. As a result of clearly communicating the value of health IT to its teams of providers and working with them to effectively launch health IT initiatives, RMG has enjoyed high adoption and acceptance rates of its EHR system over the years. The integration of claims-based data into a standard EHR system have allowed RMG

to extensively populate their system with relevant patient information on cardiovascular disease management, screening, medical history, immunization, diagnoses, and care that took place outside of the organization with other hospitals and cardiologists in the area that are interfaced with the system. The structure of claims data and the format of ICD-9 codes facilitate the identification of gaps in care at a population level, and RMG tracks high-risk patients to target those in need of further education or outreach efforts. Not only does the system thus permit risk stratification, but it is also customized to check for duplicate information in an ongoing attempt to control the quality of data. Electronic clinical data is also used to support decision-making processes among both patients and providers, routine reminders for services such as echocardiograms, and safety alerts for events such as heart failure.

Reflecting their focus on providing longitudinal care in the community, RMG features an integrated EHR system that provides a complete picture of a patient's health and facilitates coordination of care across the continuum. Through the Improving Massachusetts Post-Acute Care Transfer (IMPACT) program, RMG has benefited from reusing and updating patient data (such as a Continuity of Care Document, or CCD) to facilitate the discharge process from the hospital to a skilled nursing facility. However, because many home health facilities do not have EMRs, RMG is in the process of creating a more basic EMR system that is capable of receiving, updating, and sending a standard transfer document. Given the propensity of high percentage of elderly cardiac patients who seek in-home care following discharge, the electronic CCD has yet to replace the traditional paper form in the context of cardiac care. However, as EHRs continue to be adopted by health providers and CCD standards are further developed to include universal data elements, it is expected that CCDs will be more widely used across healthcare settings such as the RMG and Atrius Health communities.

Population Health Management

Complementing the experience of Reliant Medical Group is another Massachusetts-based organization, Partners HealthCare at Home (PHH), which is the homecare arm of the non-profit Partners HealthCare system. Founded originally by Brigham and Women's Hospital and Massachusetts General Hospital, Partners HealthCare also includes a network of community and specialty hospitals, managed care organization, physician network, and community health centers.

From a homecare perspective, health IT has improved the coordination of care across the PHH network. A robust remote telemonitoring program across PHH and the Partners Center for Integrated Care targets heart failure patients at a high risk of rehospitalization who could benefit from monitoring, but don't meet the criteria for the home care program. To date, over 6,000 patients have been successfully managed through remote telemonitoring and hospital readmissions for heart failure have been reduced by sixty percent. The utilization of dashboards allows real-time data to be collected from disparate sources and respond in a timely manner to reported outcome measures. However, PHH noted that the utility of reported data can be limited when home care providers are not able to fully collect, access, or monitor complete patient information. PHH uses Cerner's Home Health Solutions and a homegrown Partners Healthcare EHR system but because the two systems are not integrated, information is only accessed and shared between home care and physicians on a

limited basis. As a result, Partners HealthCare is currently in the process of integrating Epic across its entire system over the next several years. In the meantime, PHH will continue to use SHP outcome-reporting products for its dashboard by pulling in data from diverse sources that allows providers to drill down and capture elements such as patient medications, hospital history, vital signs trending (e.g. blood sugar to track adherence), and risk factors for assessments. Using dashboards, PHH can engage providers and educate patients with an easy-to-understand display of how adherence or changes to medication can directly impact correlated health outcomes. When it comes to external data however, it can be difficult to improve services in a timely manner based on the outcomes and performance benchmarks of other programs around the country due to the delayed release of publicly reported data. Timely and accessible data is critical not only to the coordination of care across transitions, but also to the application of ACC and AHA/ASA guidelines for conditions such as congestive heart failure in homecare practice. However, transitions of care are not always handled consistently because many providers still receive patient data by fax or phone. As HIEs continue to expand their capabilities and reach across networks of healthcare organizations, it is expected that direct secure messaging will enhance the seamless delivery and exchange of information at the point of care.

Dashboards offer tremendous potential, but they are inherently limited by the quality of data and it is difficult to build products that are sufficiently flexible.

Performance Measurement

The largest integrated health care system in Illinois, Advocate Health Care (AHC) is a not-for-profit system with more than 250 sites of care, including 10 acute-care hospitals and a network of more than 4,000 physicians. AHC is nationally renowned for the quality of its cardiovascular services, focusing on the prevention, education, and early detection of heart disease through programs such as HeartCaring – which provides gender-specific cardiac care and education – and the Risk Evaluation in Action for Cardiovascular Health (REACH®) program to improve the health of at-risk patients through education, behavior change, and medication management. Since being an early adopter of a homegrown EHR system more than 15 years ago to using Allscripts systems today, AHC has extensively used health IT to measure and improve the efficiency and quality of care. In 2005, AHC began using consortium performance measures to give physicians and nurses quarterly feedback that were not tied to financial incentives or penalties. After 520,000 patient visits, AHC providers now fall within the 87%-98% range of compliance with every measure across the board – an accomplishment which AHC largely credits to electronic performance measurement and reporting for realizing behavior change among providers.

Similarly, Fort Wayne Cardiology (now part of Parkview Health in northeastern Indiana) was another early adopter of electronic health records, modeling many of their services and features over the past fifteen years around AHC's approach. Using PINNACLE for quarterly reports on performance and process measures regarding quality of care, Parkview Health (PH) has utilized CDSS software embedded in PINNACLE to directly improve quality at the point of care. Although Fort Wayne Cardiology uses a modified version of WebChart, they

plan to soon install Epic now that they are part of the larger Parkview Health group. Both AHC and PH have significantly modified their EHR systems over the years to accommodate their changing needs in medical care; as technology has improved, more robust functionalities have been designed to further measure, monitor, and analyze outcomes and performance.

Aggregated Data for Reporting and Improving Quality

Provider performance data on outcomes, safety, errors, and efficiency is not only important to review internally within a healthcare organization, but also to disseminate to the general public and patient community at large to promote transparency and encourage wide-scale improvement. From a homecare perspective, public reporting and population health management have greatly improved the coordination of care across the network of Partners HealthCare at Home (PHH). Although the delay between reporting organization-wide data and receiving federal benchmarks can make actionable decisions difficult, the utilization of robust dashboards can allow PHH to collect real-time data from disparate sources, respond to reported outcome measures in a timely manner, and manage care at an individual and population level. However, a common set of standards for public reporting must be adopted to reduce disparate data reported from state to state. Healthcare organizations that cover populations in multiple states are finding it increasingly difficult to integrate systems and report organization-wide data due to the complexity and diversity of state-based reporting requirements.

Continuous Quality Improvement

Clinical registries are essential to improving quality of care and making performance data actionable. By incorporating data points from a registry, evidence-based guidelines of care provide both a benchmark and indicator for quality. In practice, however, guidelines can be difficult to integrate with existing health IT and clinicians must often work with developers to create algorithms that translate discrete data for CDSS. Small practices such as PH stand to benefit the most from using PINNACLE and Guideline Advantage for cost-effective report cards and feedback, given that larger organizations often have the resources to do so with internal data already. The Council advocates for an open-source model of guideline data to be developed by the ACC and AHA, which would allow health IT tools to be further adopted and implemented across cardiology practices with greater ease.

Health IT tools that use data from NCDR and PINNACLE registries need to be more seamlessly integrated into the workflow and delivery of care with a user-centered design that would support, not impede, patient-physician communication.

Organizations such as AHC and PHH use guidelines to alert providers when basic but critical information is not recorded on a chart and/or when patients do not meet expected outcome targets. By keeping critical objectives simple, data becomes actionable. For example, warning lights are displayed when AHC patients report an LDL level below 100. In the first year following the implementation of the warning lights, AHC improved its patient population at goal from 25% to 66%, and today AHC patients are estimated to be around 85 percent. Similarly, PHH has applied ACC guidelines for congestive heart failure and GOLD criteria for COPD directly to the homecare and remote telemonitoring practice.

Clinical decision support systems are being developed around Meaningful Use requirements and pushed by emerging trends and initiatives like accountable care. In the context of cardiology, CDSS have the unique advantage of being driven by the robust guidelines developed by ACC and AHA/ASA. Although connectivity exists, standards must be developed to encourage a flexible plug-and-play framework that will allow health IT systems to adopt and integrate guideline changes in real time, and thus enable more seamless care and monitoring.

Cost-Effectiveness of Health IT Tools

In discussing the arena of cost-effectiveness research and various approaches to measuring cost-benefit analysis, the Council agreed that it remains difficult to quantify many of the indirect costs associated with health IT but more research was needed to guide the field. By efficiently monitoring and sharing electronic information, redundant tests and medical waste can be eliminated, early detection can be provided, and medical errors can be prevented and reduced through health IT. While the cost-effectiveness of the adoption, implementation, and utilization of EHRs and health IT solutions remains a contentious issue today, it is indisputable that overall advancements have been made in cardiac care thanks in part due to innovations in technology that have reduced gaps and barriers to care. For example, between 1998 and 2008, heart failure-related mortality rates were reduced by 30% across the country.²⁹ Systems-level changes have led to better patient recovery time and healthcare costs are being further driven down as the market drives cheaper and better equipment and devices, from pacemakers to coronary stents to generic drugs. Moreover, nurses and nurse practitioners are revolutionizing disease management and follow-up care and lowering overall costs. AHC has nurses at every setting and approximately 10 nurse practitioners in outpatient practice. Given that most of the settings that AHC practices in do not have medical residents or interns, nurses have been critical for transitions of care, follow-up, screening, and overall patient experience across the continuum.

In the context of cardiac care, HIE has been critical for medical imaging to reduce duplication of tests – and possible radiation – for patients. Electronically shared protocols and appropriate use of health IT for specific cardiovascular problems can reduce costs among cardiologists. Cloud-based technology and electronic conferencing are already expanding the reach of telemedicine into remote areas, and reducing the overall cost of HIE. Organizations such as AHC use Merge software to collect and exchange images among cardiology practices, and then subsequently send them elsewhere for second opinions. AHC has reduced costs by standardizing workflow processes with health IT and centralizing disparate systems with a cloud-based warehouse.

Customized solutions were observed to be critical to effectively use health IT and improve care. The installation of large enterprise systems in a health system will not guarantee health information exchange internally let alone on a regional level. Within the 10 hospital and 1,000 physician medical group at AHC, a Cerner system across the organization incorporates Allscripts solutions on the physician side and eClinical Works in the clinical integration network. PH is considering an untethered patient-centric PHR to link with patients' primary physician EHR to allow for data to be pushed and pulled to the patient. As the industry at large continues to move towards a patient-centric model, it is hoped that MU

usability metrics will encourage intuitively useful solutions. Currently, patients often have to be trained by nurses and/or caregivers to use a PHR portal and send/receive information, and the labor-intensive process can place additional strain and burden on understaffed practices.

Patient Engagement, Education, and Access to Care

As much as technology may support the management of heart disease, patient engagement and education are just as important to improving overall access to and efficacy of care. Leading organizations such as Montefiore Medical Center have employed a variety of strategies to use electronic tools and technologies to engage patients and improve the overall quality of care delivered across the continuum. Located in New York City, the 2,400 physicians at Montefiore provide healthcare services to more than two million people in the Bronx and Westchester County. The Montefiore Center for Heart and Vascular Care takes a multi-disciplinary approach towards cardiac and vascular disease with a heavy emphasis on coordination across the continuum of care. Collaborative disease management teams have been established to reduce 30-day readmission rates for heart conditions by incorporating general practitioners, nurses, social workers, psychologists, home care, and psychiatrists. Montefiore cardiologists such as Dr. Ileana Piña have actively sought to not only understand the demographics of admitted patients, but also the origins of how they arrived at the point of care (e.g. emergency department, ambulance, relative brought them in, etc.), and their ultimate destination (home care, hospice, etc.). Over the years, Montefiore has used its EHR to capture critical patient information, achieve quality goals and improve outcomes through a variety of initiatives. By targeting and identifying patients who are frequently admitted for specific cardiac conditions, Montefiore can coordinate and communicate care across disparate settings to improve collaboration through its EHR. However, it is critical to educate providers appropriately about the coding process; for example, to correctly identify the number of patients with primary or secondary diagnoses, Montefiore has been actively engaged in normalizing data and vocabulary employed to reduce the 23 ways in which a heart attack can be referenced. Although health IT systems are not fully connected between inpatient and outpatient care, a heart failure order set was created for clinicians to access pertinent patient information and facilitate appropriate testing, and a discharge form can further pull and populate information from a patient's medical record.

Mobile health technology and text messaging services are not used at the Center for Heart and Vascular Care, but Montefiore utilizes physician alerts to improve coordination and communication among the various care team members across disparate settings. In an effort to use resources more efficiently, Montefiore has begun to offer shared medical appointments with groups of 10-15 patients to simultaneously engage them in education and discussion regarding disease management, nutrition, and exercise, while physicians attend to each individually regarding their condition. Although it's important to engage patients before they're discharged, a hospital bed is not always the most conducive setting to foster adherence given that patients are often sick in an unfamiliar environment. Instead, Montefiore prioritizes an early home visit 7-10 days after discharge for a care team member to spend as much as an hour with patients to review and reconcile medication, balance their diet, and evaluate disease management plans according to patient symptoms and condition.

Educational materials are disseminated in an adapted AHA handbook in both English and Spanish, and Montefiore directs patients to consult the AHA website for further information. In the future, Montefiore hopes to directly embed AHA education portals within its technology solutions.

The American College of Cardiology (ACC) established the CardioSmart platform to equip patients and their care team with tools to empower individuals in the decision-making process and facilitate effective patient-provider dialogue. The CardioSmart website is a comprehensive information and education resource center with content spanning heart conditions, medication and treatment, prevention, risk factors, wellness, and disease management. Upon its relaunch, the portal will encourage and reward healthy behavior through gamification elements around patient-reported information on outcomes such as weight, physical activity, and blood pressure. The CardioSmart portal will also become a digital space for providers to use and prescribe sections for patient education that complement tailored interventions and care plans.

CardioSmart has expanded its platform to also include mobile technology solutions that target CVD prevention, smoking cessation, and post-stent reminder text messaging services. CardioSmart is planning to launch a pill reminder app in partnership with Drugs.com and a Heart Explorer app to display information and graphics on common heart problems and treatment options. These research-driven technology solutions provide risk assessment and education programs for patients to use at their discretion across the continuum of care. As a complement to the aforementioned components of the CardioSmart platform, ACC has also launched CardioSmart TV for use in waiting rooms and office networks. CardioSmart plans to release an API for EHR vendors and providers in the second half of 2013. As envisioned, providers will be able to “prescribe” CardioSmart patient education components to patients in the same way that an embedded blue button functions, using a unique URL to track and monitor patient activity and use.

The Road Ahead

The shortfall of many off-the-shelf solutions is meeting the challenge of effectively providing clinically important information. Health systems often select best-of-breed EHR solutions based on their ability to streamline billing, charge capture, and reimbursement, causing systems to be fragmented across the various practices and settings within an organization. The Council would urge large healthcare organizations and networks of practices to prioritize interoperability and flexibility of systems as EHRs and health IT solutions are adopted and/or upgraded. Electronic data must be useable to improve quality of care, and many EHR solutions are not designed to navigate and interpret information displayed – much less connect and integrate records from inpatient and outpatient care. As technology evolves to process and analyze more and more data, it will be critical to avoid information overload or further straining workflow. Moreover, despite the robust functionality offered by available vendor solutions, the majority of systems today are largely deficient in the domain of usability – particularly in the context and complex workflow of cardiology. Unless user-centered design is more strongly featured in new and/or updated products, it is unclear how successful or sustainable the impact of Meaningful Use (MU) will be down the road. Until

then, organizations will be forced to make adjustments to existing health IT solutions in an effort to achieve both usability and functionality. However, significant movement has been observed around initiatives such as Blue Button capabilities to provide easy access to information; the Council believes that efforts such as these that abide by the KISS principle of design will be the most successful and effective. Emerging technologies and innovations in natural language processing, cloud technology, analytics, mobile health, and personalized medicine are expected to push the envelope of cardiac care by driving further value out of patient data. But ultimately it is a holistic approach towards the design, adoption, implementation, use, integration, and reimbursement models for incorporating technology into daily practice that will revolutionize the field of cardiology and beyond.

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