Chapter 5
The Evolution of EHR-S Functionality for Care and Coordination

George R. Kim, Krysia Warren Hudson, and Colette Ann Miller

Abstract The purpose of electronic health record systems (EHR-S) functionalities is to improve patient safety by reducing medical errors that lead to harm and to facilitate the measurement of care quality by providing access to process and outcomes data. Through collaborative standards development, the definition and translation of healthcare work into specific system functionalities for improving clinical data capture, communication and coordination has evolved from technical "wish lists" into commercially available products that meet the needs of multiple stakeholders: patients, clinicians, managers, systems developers, payers and regulatory agencies. Important technical drivers in the development and adoption of EHR-S functionalities have been: (a) progressive regulatory requirements for reporting quality measures and (b) lessons learned from deployment of EHR systems and other health information technology. A growing area of attention and challenge for health IT functionality development is in supporting longitudinal care coordination for patients with complex and chronic disease across time, providers and resources. Work in this domain has focused on (a) aligning and connecting Patient Centered Medical Homes and Medical Neighborhoods via data/communication standards to facilitate health information exchange (HIE) and (b) building the information infrastructures to facilitate the collection and reporting of quality measures related to care processes and outcomes.

Keywords Electronic health record systems • Health information technology • Standards development • Clinical information functionalities • Meaningful use •

G.R. Kim, MD (✉)
Division of Health Sciences Informatics and Armstrong Institute for Patient Safety and Quality, Johns Hopkins University School of Medicine, Baltimore, MD, USA
e-mail: gkim9@jhmi.edu

K.W. Hudson, DNP, MSN, RN, BC
Department of Acute and Chronic Care, Johns Hopkins University School of Nursing, Baltimore, MD, USA
e-mail: khudson2@jhu.edu

C.A. Miller, MSN, RNC-Nic
Baccalaureate Program, Johns Hopkins University School of Nursing, Baltimore, MD, USA
e-mail: cmille96@jhu.edu

C.A. Weaver et al. (eds.), *Healthcare Information Management Systems: Cases, Strategies, and Solutions*, Health Informatics,
DOI 10.1007/978-3-319-20765-0_5

Certified electronic health record technology • Patient centered medical home • Medical neighborhoods • Health information exchange • Care coordination • Analytics • Quality measurement • Patient safety • Healthcare redesign

5.1 Introduction

The functionalities of electronic health record systems (EHR-Ss) and other health information technologies are determined by clinical and regulatory needs: to streamline and standardize care delivery, to facilitate access to information across the continuum of patient care and to provide measures of care quality. Rooted in patient safety, EHR-S functionalities have been articulated and realized through standards development processes and guided by the requirements of diverse clinical practice. They have also been shaped by lessons learned from implementation and from the evolution of healthcare science, practice, business and regulation. An important area of ongoing in developing EHR-S and health IT functionality is in care coordination through the Patient Centered Medical Home.

The goals of widespread adoption of electronic health record systems (EHR-S) and other health information technology (health IT) are:

- Assurance of reliable and consistent high-quality (i.e., safe, effective, patient-centered, timely, efficient and equitable) patient care delivery and
- Access to accurate and timely clinically-based measures of the quality and outcomes of care

Together, these support the overall Triple Aim [52] of redesigning and optimizing health care into a highly-reliable [18], continually learning [23] collaborative system.

As the availability of electronic clinical information has grown, health IT functionalities have evolved to meet the needs of multiple stakeholders. Clinical data functionalities have grown from possibilities (what systems can do) to user needs (what they should do) to requirements (what they must do). As the scope of patient care continues to expand to include continuity of care over time and multiple stakeholders (including patients as partners in their own care), EHR system functionalities must also continue to evolve to assure and measure care.

5.2 History: EHR System Functionality, Patient Safety and Standardization

In 2003, the Institute of Medicine (IOM) Committee on Data Standards for Patient Safety recommended key capabilities for EHR systems to promote patient safety, care quality and efficiency [22]. They recommended categories of functionalities (Health Information and Data, Result Management, Order Entry/Management, Decision Support, Electronic Communication and Connectivity, Patient Support,

Administrative Processes and Reporting, Reporting and Population Health Management) that provided a framework for software development, with the goal of increasing reproducibility, completeness and accountability of health services.

The IOM identified overall aims of EHR-S functionalities as:

- Improving patient safety
- Supporting the delivery of effective patient care
- Facilitating chronic disease management
- Improving efficiency
- Feasibility (to be available within a reasonable period of time for purchase/implementation) [22], pp. 5–6.

The IOM recommendations were incorporated into Health Level Seven's EHR-S Functional Model (HL7 EHR-S FM, Fig. 5.1), with an eye to increasing primary use (Care Provision, Care Provision Support) and reuse (Population Health Support, Administrative Support) of health data, incrementally. The FM serves as a base on which to extend functionality recommendations.

Since the 2003 report, the evolution and progressive availability of functionalities for EHR-S and other health IT have been the subject of ongoing collaboration and negotiation among clinicians, systems developers and regulatory agencies to define a framework for clinical IT functionalities and roles within the healthcare infrastructure. This has led to the development of:

- Functional profiles (shepherded by Health Level Seven [43] and other clinical and technical organizations (Integrating the Healthcare Enterprise (IHE) and the Health Information Management Systems Society (HIMSS), among others)) for EHR systems, championed by physician groups, to translate unmet clinical needs into usable technical requirements for implementation and evaluation
- Certification for EHR technologies and products to provide recognition and assurance in meeting clinical, administrative and regulatory functions
- Financial incentives (with subsequent penalties for non-participation) for eligible providers (and hospitals) through the enactment of the Health Information Technology for Economic and Clinical Health (HITECH) Act (of 2009) for adoption and Meaningful Use (MU) of Certified Electronic Health Record Technologies (CEHRT)

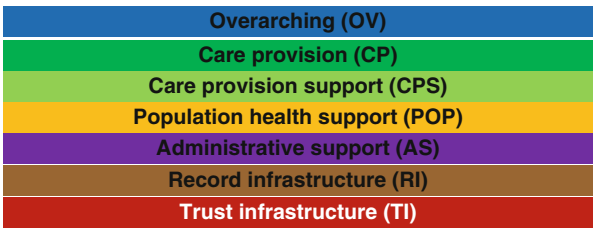

Fig. 5.1 The HL7 Electronic Health Record System Functional Model (EHR-S FM) (HL7 EHR-System Functional Model, Release 2, April 2014; copyright and used with permission from HL7 International. All rights reserved)

- Accountability programs in the form of incremental electronic measures for HIT adoption, performance and clinical outcomes, linked to regulatory reporting requirements, quality/safety reporting and remuneration
- Communications and interoperability standards and networks to connect and coordinate care and information providers
- Collective quality improvement initiatives to measure, support and control care processes and outcomes on patient, service and population levels
- Recognition of the importance of incorporating the adaptive, organizational and teamwork components of care and coordination in safety and quality assurance and improvement and into the development and successful deployment of health IT systems

5.3 Drivers of EHR System Functionality in Patient Care

Health IT functionality is the result of ongoing negotiation among multiple stakeholders: clinicians (physicians and nurses), system developers/vendors, administrators, payers, standards development organizations, regulatory agencies, safety officers, researchers and patients. Success in negotiations requires active leadership and collaboration by the stakeholder groups to manage feasibility, viability and sustainability of health IT development (See [87 plus its associated textbook] for an example). In general, the progression of realizing health IT functionality requires:

- Articulation and specification of what user needs into technical (system and workflow) requirements for design and implementation. This requires organization of and active input by clinicians/users and informed analysis by developers who understand the needs of clinical information work
- Design and implementation of technical solutions into available products for purchase/incorporation. This requires mutual prioritization by customers (practice leaders/clinical users), vendors/developers and other stakeholders (payers, regulatory agencies) to evaluate and make products available for clinical use
- Adoption and incorporation of products/tools into clinical work. This requires acceptance and active use by users/customers, continuous support by developers and systems and reinforcement by organizations and regulators/payers

The negotiation and prioritization of specific functionalities are informed and influenced by:

- Unmet clinician needs
- Experience and lessons learned from implementation

5.3.1 Unmet Clinician Needs

Basic EHR-S functionalities empower clinicians to:

- Organize care
  - Identify patients correctly and link the right patient to the right information
  - Create work lists for session-based clinical tasks
- Document care
  - Capture and store records for reference, communication and coding
  - Provide a reliable legal record of care
- Order and manage therapies and tests
  - Prescribe, dispense and deliver medications/tests correctly and safely
  - Track, review and respond to results (test results, consultations) in a timely and facilitated fashion
- Make informed decisions
  - Use evidence and data to support timely choices, decisions and actions
  - Implement evidence-based guidelines and protocols

Expanding the HL7 EHR-S FM, a growing number of clinician groups and other stakeholders have articulated additional information functionality needs for specialty-based clinical workflows. Some of these needs have been translated into functionalities that have been incorporated into the HL7 model, while others are varying stages of development. In some cases, vendors have implemented special functionalities into standalone "niche" products.

Specific EHR-S functionalities that go beyond the HL7 EHR-S FM have been articulated for different specialties, with each effort being led by a coalition of physicians, IT developers, standards development organizations and regulators. These include:

Behavioral Health:

The HL7 Behavioral Health Functional Profile [46, 62] supports mental health-specific templates that integrate with the medical electronic record to allow documentation and attestation by different provider types (psychiatrists, psychologists, social workers) for full psychiatric (Axis I-V) diagnosis (according to the Diagnostic and Statistical Manual (DSM)) with robust support for coding and billing.

Child Health:

EHR-S functionalities for child health were first articulated in 2001 and updated in 2007 [82] with incorporation into the HL7 EHR-S FM as the Child Health Functional Profile [42] with implementation as a Children's Electronic Health Record Format (as part of the Child Health Insurance Program Reauthorization Act (CHIPRA)). Specific functionalities include:

- Immunization management (point-of-care decision support and forecasting, tracking aids for lapsed vaccines, linkage to office and regional immunization information systems),

- Growth tracking (special charts (such as for premature infants), graphical representation and calculations of body parameters such as BMI)
- Universal weight/surface-area based medication dosing (with pediatric dosing options for age and school-day regimens) for inpatient and ambulatory prescribing
- Standards for handling patient identification at the beginning of life (prenatal and newborn identifiers and clinical data, linkage to mother, name changes, ambiguous gender)
- Connection of EHR-S data among medical homes, hospital nurseries, school health offices, health information exchanges (immunization registries, hearing screening registries) and other child health care stakeholders

Adolescent Medicine:

Adolescent medicine health information functionalities focus on control and maintenance of privacy and confidentiality of encounter data while retaining advantages (tracking, billing, health information exchange) of EHR systems. Inherent conflicts in achieving this include:

- Recognition and preservation of the legal status of adolescents' health information vs. parental rights to access knowledge of services rendered (billing functionality)
- Customization of confidentiality (and access to patient information) according to local jurisdictional law according to patient status (such as for emancipated minors)
- Electronic sharing of adolescent health information and confidentiality issues regarding sensitive health issues (sexuality and pregnancy, sexually transmitted infections, HIV, mental health and substance abuse) and when data must be shared among different services [6, 13]

These conflicts present barriers in articulating needs as technical requirements and pose continuing challenges in successful implementation of adolescent-appropriate EHR-S functionalities [9].

Obstetrics and Gynecology:

Obstetrics and gynecology, characterized as both a medical and surgical specialty and as both hospital and office-based, "requires data fields and image displays unlike any other…discipline…" An effort by the American Congress of Obstetricians and Gynecologists to articulate its special needs [96] has included functionalities for:

- Pregnancy-specific immunization management
- Fetal development tracking with normative growth and laboratory data
- Medication management: Gynecologic oncology dosing
- Patient identification: Assisted reproductive technology (tracking sperm, egg donors) and multiple gestations
- Privacy: reproductive history and choice, contraception, abortion
- Flow sheets:
  - Pregnancy management with trimester-specific screening, medication requirements, laboratory testing and counseling and decision support

  - Chemotherapy management
  - Clinical documentation
  - Guideline-based clinical decision support
  - Displays for fetal age, biophysical profiles and imaging (still, video) management, fetal heart rates, non-stress testing

- Interoperability with specific electronic clinical tools: (biopsies, hysteroscopy, colposcopy, urodynamics, ultrasound, cystoscopy)
- Support for genetic, pre-pregnancy and assisted reproductive technologies, cord blood banking
- Medico-legal records management

As incentives increase the adoption of EHR-Ss in obstetrics-gynecology practice, there are still barriers to implementation of some of these functionalities.

Geriatrics:

The medical care of older adults poses vulnerabilities to errors that may lead to harm for this population of patients. Risks include:

- Multiple chronic and acute conditions of varying complexity and duration with input from multiple providers and caregivers
- Complex care and care transitions [89] related to hospitalization
- Polypharmacy and its co-morbidities [29]
- Functional (cognitive, communication, depression, nutrition, social) status issues that impact on health [16, 32, 33] and that put patients at risk for inpatient readmission and increased morbidity/mortality
- Hospitalization in settings where expertise in geriatric needs is scarce

Many of these functions are served by previously articulated EHR-S functionality, with the principal issue/barrier/problem being the implementation of existing guidelines. Screening tools, such as EHR-S checklists/templates and other decision support can help to identify patients at risk to guide appropriate care and link human expertise as needed [63]. Health IT supports for care coordination may help address geriatric care challenges.

Oncology:

Clinical Oncology Requirements for the EHR (CORE) is a 2009 document created collaboratively between the American Society of Clinical Oncology (ASCO) and the National Cancer Institute (NCI) (who lead in the effort to improve all aspects of oncology care and its safety). A consensus statement outlined oncology needs of EHR-S technology, which includes support for:

- "A treatment plan to be shared with patients and other care providers;
- A treatment summary to be shared with patients and their care teams;
- The use of calendars that patients and their care teams can use to organize the care process;
- Safe chemotherapy administration [94, 95]
- Use of decision support tools, such as ASCO and National Comprehensive Cancer Network (NCCN) guidelines" American Society for Clinical Oncology [5]

Oncology-specific functionalities include:

- Common core data elements to support oncology care and research
- Detailed analysis of functions to support chemotherapy and drug management.
  - Facilitation of electronic chemotherapy orders
  - Interface with pharmacy systems
  - Redundancy of nursing and pharmacy electronic safety checks of chemotherapy orders
- Standardized order sets with dose calculators with clinical decision support based on patient height, weight and test results
- Special features to support patient safety and comfort
- Coordination of care
  - Scheduling functions for physician visits, laboratory and radiology testing, patient education and training, infusions and injections
  - Calendar and reminder functions for patients
  - Patient portals
  - End-of-life care management tools
- Oncology practice and research support
  - Inventory control and billing functions linked to operational bar-coding/RFID
  - Patient matching to prescribed medications and samples
  - Tools for summarization, communication and reporting [5], p. 5–6.

Anesthesiology:

Adoption of anesthesia information management systems (AIMS) has increased because of increased functionality and decreased costs of available systems, but also because of increased regualtory reporting requirements. AIMS are usually standalone systems that must interoperate with monitors, anesthesia machines and hospital information systems. Systems must also be ergonomic with respect to available working space of the operating suite. In addition, anesthesia EHR-S functionalities should include:

- Structured collection and sharing of preoperative data for assessment and risk-stratification
- Manual intraoperative charting and automatic transcription from monitors and ventilators
- Continual real-time access to and organized display of accumulating anesthesia data
- Reminders for intraoperative tasks (drug dose times)
- Provision for tracking performance and practice data for quality and safety improvement [30]

Ophthalmology:

Clinical ophthalmology, as a medical and surgical discipline, is centered on the anatomy and physiology of the eyes (and brain). Clinical assessments are fre-

quently graphical and photographic: anatomic drawings, diagrams and images. Vital signs are ophthalmology-specific: intraocular pressure, visual acuity and examinations are performed by teams, in sequences that employ specialized imaging and measurement tools with unique and sophisticated graphical outputs not used elsewhere. The high level of clinical graphical data requires the use of picture archiving and communications systems (PACS, requiring Digital Imaging and Communication in Medicine (DICOM) standards).

Because care is rendered in parallel by teams, a patient record must be simultaneously accessible by all team members when a patient receives care. The American Academy of Ophthalmology (AAO) promotes best practices ("Preferred Practice Patterns") as templates for clinical data collection and management. The AAO has articulated desired ophthalmologic EHR-S functionalities to guide purchasers and to promote the standardization process. Specific functionality for ophthalmology EHR-S technology includes:

- Seamless linkage and integration of the EHR-S to ophthalmologic instruments and devices using defined standards (i.e., DICOM)
- Standards for interoperability of ophthalmologic and other health data within EHR systems
- Representation of ophthalmologic concepts within a reference terminology
- Summarization of ophthalmologic data for pre-visit review in high-volume practices
- Tools (other than a mouse) that facilitate the creation and annotation of clinical drawings for the record [20]

Dermatology:

Dermatology is also characterized as both a surgical and medical subspecialty with a heavy reliance on clinical images (photographs and diagrams). Its practitioners interact closely with other specialists, such as pathologists and surgeons. Dermatology-specific EHR-S functionalities form an adjunct to larger profiles and include: tools that:

- Facilitate the management and annotation of visual documents (photographs and diagrams)
- Connect the EHR-S to tools that can import such data (dermatoscopes)
- Permit rapid structured communication of skin lesion descriptions and classifications (to surgeons, as in Mohs procedures)
- Allow simultaneous access to records by multiple personnel (such as scribes) and
- Streamline work via connectivity to mobile technology such as tablets [56]

Dentistry and Oral Health:

The information technology needs for dentistry and oral care have been described [11, 75] and several themes which distinguish this field have emerged:

- Dentistry provides primary care to patients of all ages. Payment for services is typically separate from other forms of health insurance which all patients may not have.

- Dental records are separate from medical record, in paper and electronically. There may be other separated documents of care, such as orthodontic records. In addition, data for consultations for some oral surgical procedures may be contained in the medical (non-dental) record in some institutions.
- Dental radiographic technology and the documentation of oral anatomy and pathology have special technical needs and terminologies that are not found or used elsewhere.
- Special relationships exist between dental care and chronic disease (such as diabetes mellitus) that require incorporation into longitudinal care protocols.
- There is variable integration of dental and medical electronic records when both exist.

Emergency Medicine and Trauma Care:

The information technology needs of emergency medicine have been long articulated within the HL7 functionality framework, with a focus on patient throughput:

- Patient tracking and registration
- Task and order management
- Clinical documentation and all stages of patient management
- Management of roles of different workers [44].

The care of trauma patients requires special information workflows that bridge emergency departments to field settings. Use of tools in low-resource settings has been explored to support:

- Checklist generation
- Clinical scoring (for trauma severity)
- Wireless data transfer to electronic registries (i.e., trauma databases) [92].

Other Medical Subspecialties:

Cardiology [90] and gastroenterology (in particular GI endoscopy [58, 91]) are two domains in which clinicians have identified specific workflows, data elements and vocabularies for use in EHR-S and other health IT to meet the needs of practitioners in care, quality assurance and research. With the increasing dependence of patient care on technology to standardize clinical information workflows and to collect information for quality/safety and remuneration of services, the articulation of information functionality needs will continue to expand and evolve.

5.3.2 Experience from Implementation

Standards-based system functionalities are silent as to their implementation. As electronic functionalities are implemented and deployed, they change workflows and may create competing priorities which in turn may require redesign of those workflows or system re-implementation (at additional cost, effort and time).

5.3.2.1 Workflow Conflicts

The standardization of tasks may create non-alignments between user goals and/or organizational performance. Examples include:

- Security practices versus user convenience (timed lockouts after periods of non-use requiring re-entry of credentials)
- Safety practices versus provider efficiency (opening records on multiple patients for parallel work during care) [15]
- Technology versus workspace needs (pharmacy tracking (medication cabinets) may crowd anesthesiologists and nurses occupying the same operating room space around a patient)
- Attention needed for technology versus clinical needs (requirement of clinician to enter orders into a system [34] vs the use of scribes [2]
- Mobile technology used for portable charting that also introduces a vector for nosocomial infections

5.3.2.2 Nursing Workflows

Nursing activities involve direct care and interaction with patients. Workflows are information-intensive, parallel and highly interruptive. In general, health IT functionality, design and implementation do not match nursing tasks well, resulting in unexpected (and frequently unresolved) workarounds [79].

- Patient handoffs ideally are individualized, nurse to nurse and patient by patient, with time for questions and reflection. However, busy units, changing patient loads, time constraints, cross-coverage and management needs make centralized unit reports (away from the patient) the norm.
- Nursing work lists within most EHR-S products omit informal information and tools: nursing assessments, patient summaries, scheduling functions and/or customization (i.e., level of detail of tasks, according to the nurse's experience).
- Bar-coding medication administration (BCMA) decreases nursing errors [74], but increases the number of steps in the process [8]. Workarounds have been observed, such as duplication of patient bar-codes to a common location that reduce the number of steps [26].
- Mobile devices (cell phones and pagers) are used by nurses to reduce noise (overhead paging) on floors, but are not used to their full clinical potential because of institutional constraints and concerns for misuse.

5.3.2.3 Patient Safety

Inpatient patient misidentification rates are an indicator of hospital quality [50] and its reduction is a current (2015) National Patient Safety Goal [54]. The problem of assurance of patient identification becomes more complex as data from multiple electronic sources are combined for direct care and care coordination. The Office of the National Coordinator has a set of recommended safety practices [40] that include adaptive and behavioral practices by users.

5.3.2.4 Clinical Documentation

EHR-S enhanced documentation has resulted in "note bloat" (superfluous negatives and copy-pasting/copy-forwarding) and in increased time spent by clinicians in documenting care. The American College of Physicians has published a position paper that outlines the problems and suggested system functionalities and practices (including physician leadership and user education specifically for electronic documentation) [59].

The implementation of ICD-10 for coding will bring higher specificity to diagnoses, and may further increase the time needed for provider documentation, and pushback by providers and care organizations has delayed its implementation requirement in the US. Recently the Centers for Medicare and Medicaid Services (CMS) stated it would help make the ICD-10 transition less disruptive by not deny claims solely on the basis of insufficient specificity for up to a year to help facilitate implementation of ICD-10 [98].

5.3.2.5 Integration and interoperability

Integrated (defined as combined "software components, hardware components, or both into an overall system" [51], p. 41) single-vendor systems may limit functionality implementation, resulting in failure to meet the needs of some users. Standalone systems may provide solutions, but depend on interoperability (defined as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [51], p. 42) with enterprise and business systems. Some institutions may combine the enterprise and standalone systems with one tradeoff being that clinicians may need to master multiple EHR systems and their interfaces. Governance may be complex with differential impacts on organizational culture [87].

A 2014 KLAS report revealed that 25 % of polled ambulatory practices are considering replacement of current systems due to financial, regulatory or political (hospital affiliation) issues [57]. Although there are efforts to reduce the time and cost of interoperability among systems [45], challenges persist [3].

5.3.3 New Needs

5.3.3.1 New Data Types

In addition to EHR-S functionalities for rendering image and signal data, systems will need to manage genetic/genomic and pedigree data, which pose technical, administrative, legal and ethical issues. EHR-S functionalities for handling personal genomic data include the ability to: (a) store and share it in a clinically computable

and usable format, (b) link to phenotypic information and (c) display and link findings and test results [64] to patient-directed information and decision tools. These functionalities are needed in several clinical domains: obstetrics/gynecology, pediatrics and oncology, among others.

Another challenge (and opportunity) lies in how patients can report and share their personal health data. Stage 3 Meaningful Use will incorporate patient-generated health data (PGHD) [86] into standard healthcare information flows which will pose many implementation challenges: technical, operational, legal, cultural and educational [78, 80]. Such "patient-facing" technologies hold great promise in increasing patient engagement for improving care quality, research and policy [27, 47].

5.3.3.2 Emergent/Adaptive Clinical Systems

A persistent problem of systems functionality development processes is that they are locked into a standards/contracts based "task-artifact" (clinician-to-developer-to-user) cycle which creates a continual lag in meeting user needs in the face of rapidly changing clinical (and regulatory) demands [88]. This results in persistent dissatisfaction and pushback from clinicians and physician groups on meeting initially specified regulatory deadlines for implementation (ICD-10 for example, and Meaningful Use Stage 2).

A recent development has been the pilot of an emergent clinical information system, the design approach that gives clinicians complete control over Web-based systems by providing

- Design tools that do not require programming
- Automatic real-time conversion of designs into executable clinical information systems
- Real-time iteration to facilitate problem identification and solution [12].

5.3.3.3 Usability and Patient Safety

Growing recognition of the importance of cognitive and usability of EHR-S and health IT in clinical workflow, system design and error reduction (especially in critical care [73]) has led to research and new approaches in design, implementation and deployment. Workflows that have been studied include: clinical summarization, problem list management and clinical comprehension [93].

New hazards posed by poorly designed or deployed health IT within the already complex delivery of care has been a concern of the health and regulatory community [53], with the consensus that even with regulation and standardization, safety of health IT is multi-factorial and dependent on human users (i.e., beyond functionality alone) [55]. Unsafe health IT and unsafe use of health IT persist, with barriers to detecting and reporting on such problems [67].

5.3.3.4 Information Assurance

The progressive dependence of healthcare practice on EHR systems and other health IT has made information assurance (confidentiality, integrity and availability) of data, interfaces, applications and networks essential to maintaining healthcare operations:

- Tradeoffs between convenience and security persist as theft/loss of laptops and removable media with protected health information (PHI) remains the leading cause of data breaches [84] with a recent report that the root cause of health care breaches are shifting from accidental to intentional [97]. Concerns for cybercrime involving health data has led to progressive requirements for health data security training for all users and to proactive institutional risk assessment and management [39] as standard practice [31] which may be overwhelming to some organizations [61].
- Poor documentation practices (copy-pasting, over-documentation, etc.) threaten the integrity of clinical content and require training and monitoring.
- The interplay between sociotechnical health information infrastructures and high-reliability IT networks have created lowered tolerances to prolonged system crashes that may paralyze institution-wide clinical work flow [10] (and create additional burdens of data recovery).

5.4 EHR System Functionality in Care Coordination

Care coordination has been identified as a national strategy priority for improving healthcare quality [85]. A 2012 cross-sectional study of US office-based physicians revealed that measures of care continuity (completion rates of consultation requests, hospital discharge summaries and consultant reports) were low, even when practices had an EHR-S. Over a third did not routinely receive needed patient information, with over half not receiving it electronically. EHR-S technology only slightly improved receipt of needed information [48].

Care coordination is defined as "a function that helps ensure that the patient's needs and preferences for health services and information sharing across people, functions, and sites are met over time…[maximizing] the value of services delivered to patients by facilitating beneficial, efficient, safe, and high-quality patient experiences and improved healthcare outcomes" [49]. From a management perspective, it is "the organization of…activities between two or more participants involved in a patient's care to facilitate…appropriate delivery of health care services…marshalling of personnel and other resources needed to carry out all required patient care activities and…managed by the exchange of information among participants responsible for different aspects of care" [66, p 6].

5.4.1 Framework for Care Coordination

5.4.1.1 The Medical Neighborhood

Care coordination (described in the AHRQ Care Coordination Measures Atlas (Fig. 5.2)) bridges gaps between providers (services, goods, participants, information) and requires pragmatic and proactive organization of resources and services with respect to the patient. Centered on the **health care home** (aka "medical home" or "patient-centered medical home" (PCMH) [69]), the **medical neighborhood** includes "the constellation of…clinicians providing health care services to patients within it,…community and social service organizations and State and local public health agencies" [83] that connect and communicate with each other (Fig. 5.3).

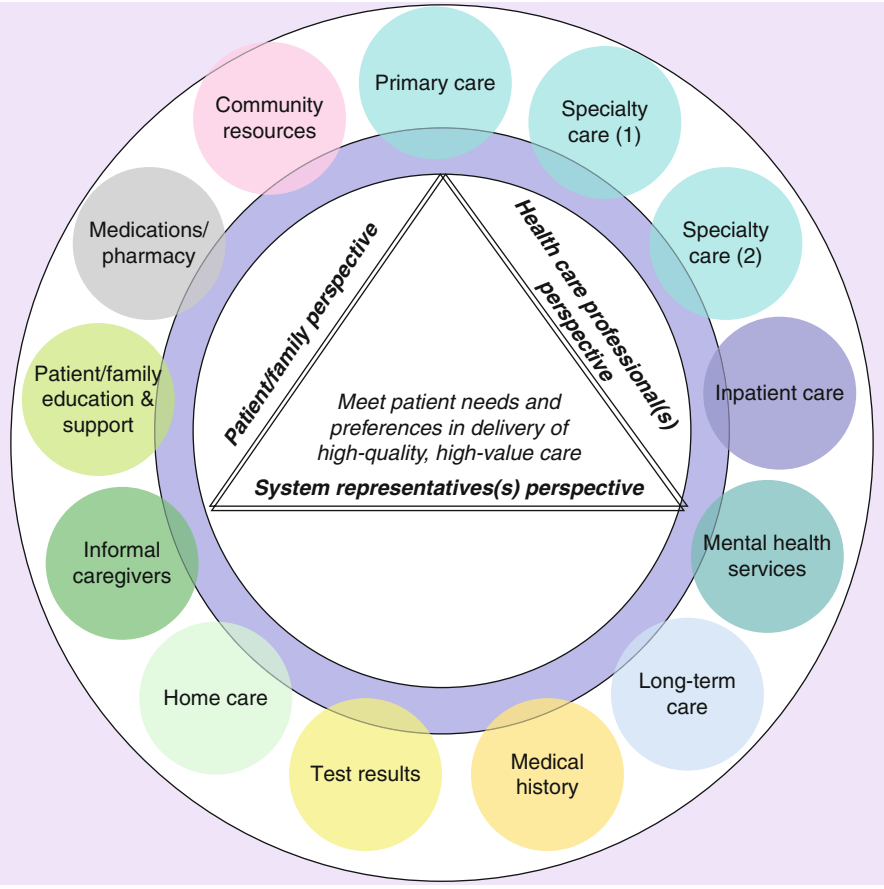

Fig. 5.2 Conceptual structure of care coordination [66] (Reprinted with permission of the Agency for Healthcare Research and Quality)

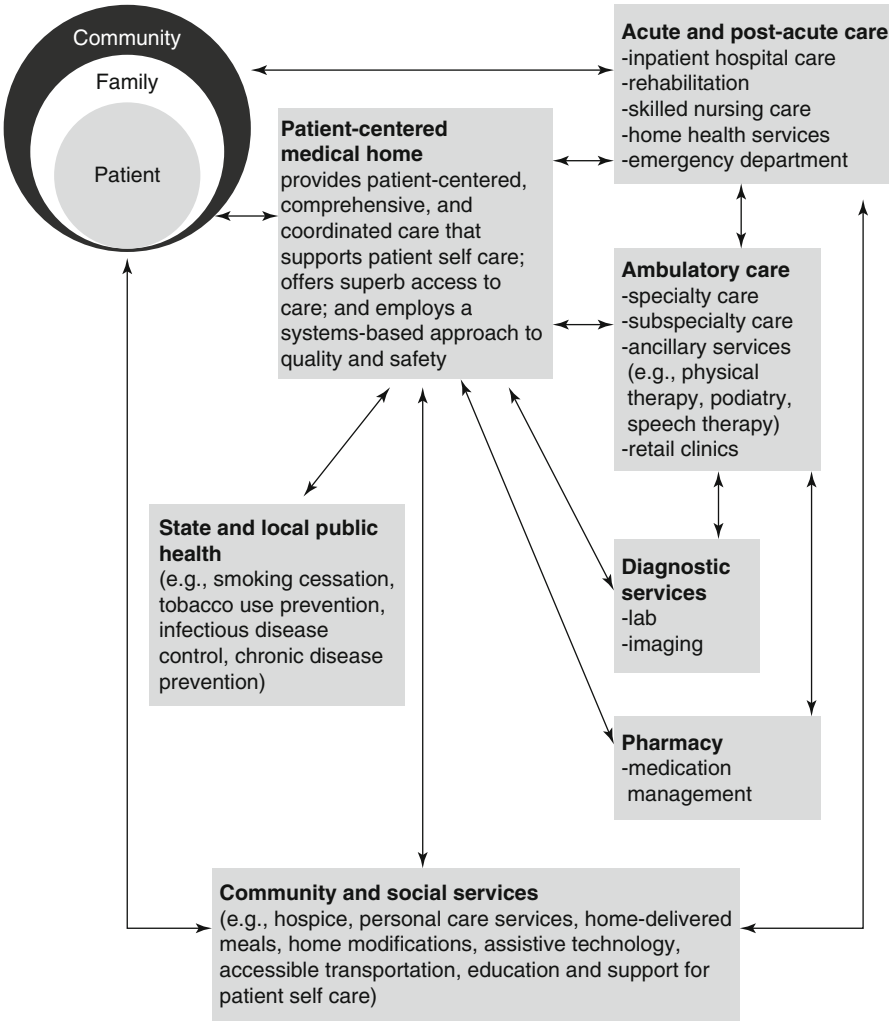

Fig. 5.3 Information Flows in a Medical Neighborhood [83] (Reprinted with permission of the Agency for Healthcare Research and Quality)

High functioning medical neighborhoods encourage collaboration through well-defined (via formal agreements) and shared infrastructures, resources and information (Fig. 5.3) with "regular communication, collaboration, and shared decision-making across various actors in the system" through effective use of information and communication technologies [68]. Care coordination is characterized by:

1. ***Individualized management*** by teams and centralized in the healthcare home, with
2. ***Specific plans*** for tracking and follow-up,

3. ***Well-defined transitions of care***, ***communication***, ***coordination and collaboration*** inclusive of clinicians, patients, families and others involved in ongoing care of the patient, and
4. ***Strongly-linked community services and resources*** that align and facilitate care

Expected outcomes of high-functioning medical neighborhoods include improved patient safety and satisfaction with reduced costs and utilization and improved population health [83 pp. 7, 9.].

5.4.1.2 The Medical Home

To support the IHI Triple Aim (Improve the patient experience, Improve population health, Reduce the cost of healthcare [52]), and other HIT functionalities must support the medical home. Functions that Patient Centered Medical Homes (PCMHs) must provide include: 24/7 access and continuity to care and medical advice by patients, team-based care, population health management, care planning/management (including medication management/prescribing), test and referral tracking and performance measurement and improvement (Fig. 5.4). PCMHs must facilitate communication and collaboration with other members of the medical neighborhood (Fig. 5.3) and with health information exchanges (HIE).

NCQA provides certification to PCMH organizations that meet stringent criteria and to EHR-S and other health IT products aligned to their needs [70].

Still, availability of an EHR-S and patient infrastructure are not enough. Health homes and their medical neighborhoods must themselves be high functioning with dedicated case management in partnership with engaged primary care providers [76]. For patients with complex and chronic health problems, comprehensive periodic needs assessments with updated individualized plans/summaries by a knowledgeable care team that uses HIT optimally are essential [76], pp. 11–12. A framework for coordination support has been described [77, 81] for:

- Coordination within care teams
  - Documentation using structured (and searchable) clinical data for decisions
  - Summarization tools to view and share patient data and trends over time
  - Comprehensive care plan tools to provide accountability over different aspects of care
- Coordination across care teams
  - Interoperability to handle data from multiple sources, reducing the need for multiple entry
  - Tools for medication reconciliation
  - Tracking and loop closure functions for test results, referrals and consultations

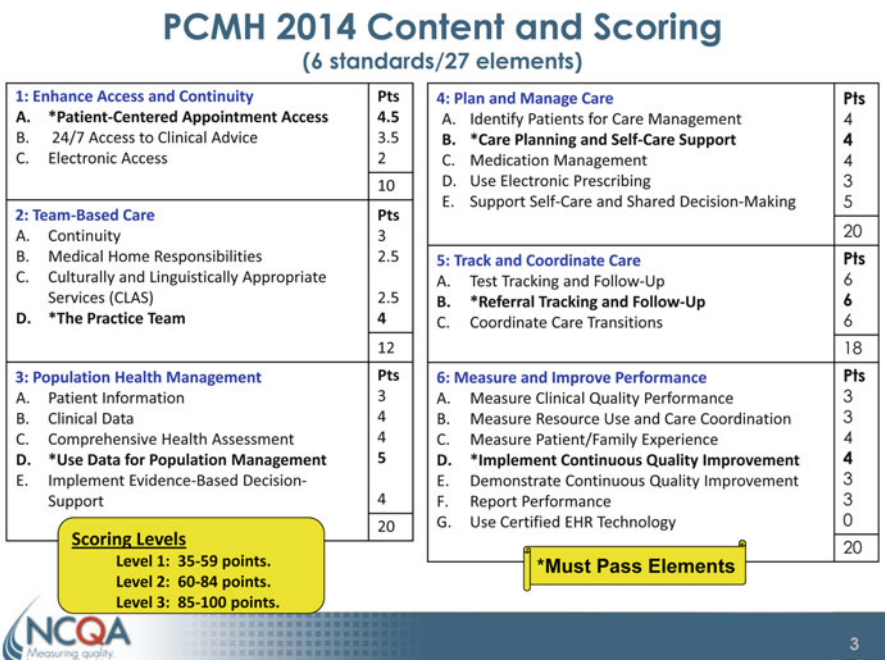

Fig. 5.4 Patient Centered Medical Home Criteria (Reproduced with permission of the National Committee for Quality Assurance (NCQA) [99]

- Coordination between care teams and community resources
  - Tracking patient use of community resources
  - Facilitated communication with community resources
- Continuous familiarity with a patient across time
  - Listing of all members of the care team
  - Ability to share information with the patient and the team simultaneously
- Continuous proactive and responsive action between visits
  - Disease/condition specific decision support (reminders/alerts)
- Patient-centered care
  - Patient portals and personal health records

Other factors important to care coordination success are:

- Active engagement of patients in their own care with direct communication among patients, providers and specialists
- Dedicated teams with stratified approaches dependent on the complexity of care required
- Business models with incentives that support and reward care coordination eHealth Initiative [49, p. 6].

5.4.1.3 The Care Coordinator

The designated individual or team responsible for identifying a patient's care plan goals, coordinating services and providers and helping the patient to navigate the medical system is essential. Ideally, coordination is an integrated multi-disciplinary team that includes one such designee who works in close partnership with the patient, the provider and services [24]. A major aim is to engage the patient in all aspects and decisions of care. The American Nurses Association promotes the training and essential role of registered nurses in providing excellence in care coordination [4].

5.4.2 Health IT to Support Care Coordination

EHR systems and other health IT form the information infrastructure and mechanisms by which:

1. Care coordination activities are documented, communicated, managed and tracked
2. Performance measures are defined, collected and managed

The roles of EHR and other health IT systems are to: (a) assure, simplify and reduce the burden of data collection and sharing, (b) provide access to *clinical* details not available otherwise for care and quality and performance measures and (c) generate views of aggregated longitudinal patient data over time and providers [66, p. 28]. At the PCMH (practice) level, this translates into EHR-S functionalities:

- Decision support (condition-specific reminders, alerts) for clinicians and care coordinators to manage and track tests, results, referrals and consultant reports for individual patients
- Dashboards that facilitate care coordinators to follow up on the care of individuals and groups of patients (completion of prescriptions, testing, referrals, communications, patient reports, seasonal care (i.e., immunizations))
- Report specification and generation tools for multiple users and uses: clinical tracking, practice monitoring and improvement, patient outreach, regulatory measures and research.

5.4.2.1 Health Information Exchange (HIE) and Early Notification

HIE refers to (a) electronic sharing of healthcare information across and among organizations and (b) an organization that provides this functionality to stakeholders. The goal of HIE is to provide timely access to data for high-quality patient-centered care that prevents unnecessary duplication and to prevent abuses.

For definition (a), there are currently three standards [41]:

- The Direct Standard: for secure electronic transfers between providers for care coordination [38]

- The NHIN CAQH CORE X12: for providers to query and request electronic clinical information about a patient between providers [35]
- Consumer-mediated exchange: an example of which is the Blue Button Initiative [21, 37] to empower patients to access their medical information securely from a Web portal.

For definition (b), one example is a collaborative Early Notification System (ENS) Program which provides notification of an admission/transfer/or discharge about patients in Maryland and Delaware [19, 28] to enrolled providers. This program supports transitional care management (TCM) to reduce hospital readmissions [7]. Another example is Maryland's Prescription Drug Monitoring Program (PDMP) [25] using its CRISP HIE (http://crisphealth.org/). The PDMP helps to identify patients seeking controlled substances by prescription from multiple providers, preventing morbidity and promoting appropriate services to patients in need.

5.4.2.2 Care Plan Documentation Standards

Much work has been done by several standards development organizations (HL7, IHE, HITSP) to define a structure for an interoperable electronic document for Care Coordination (the Care Plan, a shared, consensus-driven, comprehensive blueprint of concerns and interventions by multiple providers and the patients). The Care Plan formalizes data fields and values (Fig. 5.5) for use in electronic records and transactions.

5.4.2.3 Performance Measurement Tools

The National Quality Forum (NQF) has endorsed a Care Coordination Framework [71] that identifies an evolving set of coordination measures that includes (but is not limited to): (a) the healthcare home, (b) a proactive plan of care and follow-up, (c) communication, (d) information systems and (e) transitions/hand-offs. In addition, NQF has developed the Quality Data Model (QDM) [17], a formal, standardized framework for enabling structured authoring (via its Measure Authoring Tool, https://www.emeasuretool.cms.gov/) of logically consistent electronic eMeasures (or eCQM). The QDM defines categories of information, their context of use and relationships to other information to allow automated capture of data from HIT such as EHR-Ss Health [36, 65]; http://public.qualityforum.org/hitknowledgebase/Pages/Knowledge%20Base%20Home.aspx.

EHR-based measures, some with formal (QDM) specification, have been identified in Meaningful Use (of Certified Electronic Health Technology) core and menu objectives (Stages 1 and 2) and clinical quality measures [66], pp. 31–34. Current

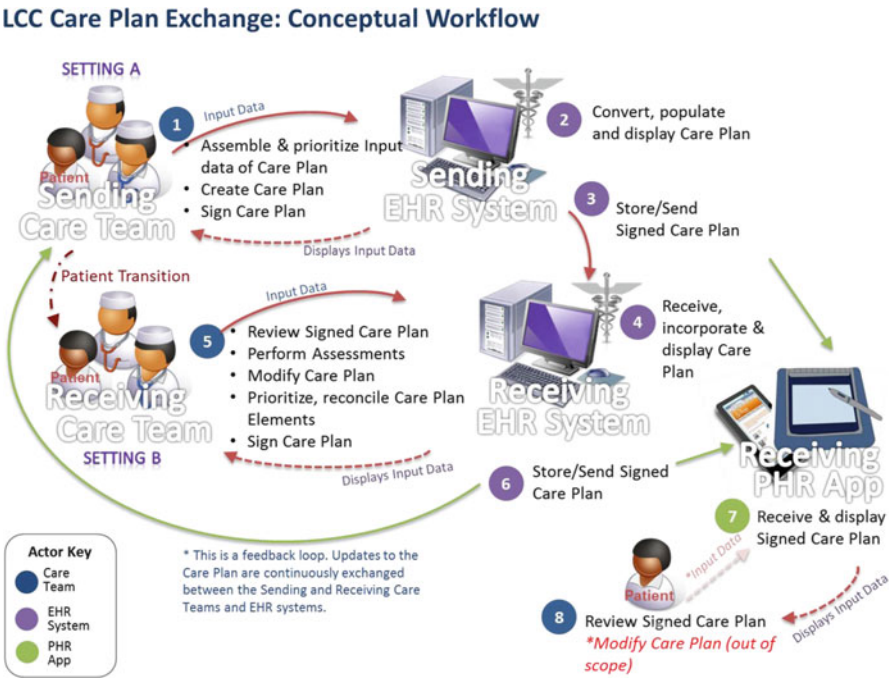

Fig. 5.5 Conceptual Workflow of a Care Plan (Reproduced, courtesy of HealthIT.gov, Office of the National Coordinator) [100]

Meaningful Use objectives for which eMeasures are currently specified (although not implemented) include Clinical Quality Measures:

- Closing the Referral Loop: Receipt of a Specialist's Report
- Follow-Up Care for Children Prescribed ADHD Medication
- Diabetic Retinopathy: Communication with the Physician Managing Ongoing Diabetes Care
- Home Management Plan of Care: Document Given to Patient/Caregiver

5.4.3 Challenges

5.4.3.1 Inclusion of External Care

As more patients receive care in "nontraditional settings" (retail clinics, urgent care centers, school and work clinics), a question that has arisen is: "What is the capacity for these settings to connect with the medical home?" This forms a basis for a recent initiative by NCQA to assess these sources of health care as "visible" parts of the medical neighborhood [72].

5.4.3.2 Management of Inherent Complexity

The challenges of care coordination are long-standing. Even with new approaches, infrastructures and information tools [14], there are inherent complexities in coordinating and optimizing care and health that make success elusive:

- Accountable care organizations' (ACOs') call to engage patients in their care
- Changing patient behaviors
- Medication reconciliation [60] and problem list management [1].

5.5 Conclusion

EHR systems and other health IT technologies are now a part of mainstream healthcare. The evolution of system functionalities has resulted from ongoing negotiations among clinicians and systems developers to meet the growth of clinical information workflow needs. Two important drivers that have increased adoption of EHR-S technology and stimulated development of functionalities are federal regulations (quality measures reporting and Meaningful Use incentives/penalties) and lessons learned from implementation.

Care coordination, as a means to improve transitions and longitudinal care of patients across time, providers and resources, is a national healthcare strategy goal. The management of care trajectories through a medical neighborhood by Patient Centered Medical Homes (PCMHs) requires dedicated nurse-led multi-stakeholder teams and appropriate business models to sustain them. The development of EHR-S and health IT functionalities for care coordination have focused on (a) tools to assure completion of tasks, (b) interoperability standards for health information exchange (HIE) among stakeholders and (c) infrastructures to measure care processes and outcomes.

The starting point and the final arbiter in any functionality of health information tools is how it impacts on the quality of patient care: its safety, effectiveness, efficiency, equity and patient-centeredness.

References

1. AHIMA. Problem lists in health records: ownership, standardization and accountability; 2012. URL: http://library.ahima.org/xpedio/groups/public/documents/ahima/bok1_050158.pdf. Last accessed 11 Feb 2015.
2. AHIMA. Using medical scribes in a physician practice. J AHIMA. 2012;83(11):64–. URL: http://library.ahima.org/xpedio/groups/public/documents/ahima/bok1_049807.hcsp?dDocName=bok1_049807. Last accessed 6 Feb 2015.
3. American Medical Association. 15 questions to ask before signing an EMR/EHR agreement, AMA, 2008-11. URL: http://www.himss.org/files/HIMSSorg/content/files/Code%2093_15%20questions%20to%20ask%20before%20signing%20an%20EMR-EHR%20agreement_AMA.pdf. Last accessed 23 Mar 2015.

4. American Nursing Association. The value of nursing care coordination: a white paper. June 2012.
5. American Society for Clinical Oncology, National Cancer Institute, caBIG, NCI Community Cancer Centers Program. Clinical Oncology Requirements for the EHR (CORE); 2007. p. 2.
6. Anoshiravani A, Gaskin GL, Groshek MR, Kuelbs C, Longhurst CA. Special requirements for electronic medical records in adolescent medicine. J Adolesc Health. 2012;51(5): 409–14.
7. Audacious Inquiry. DHIN launches encounter notification system for two medicaid managed care organizations; (2015). URL: http://ainq.com/case_study/encounter-notification-system-for-two-medicaid-mcos/. Last accessed 15 Feb 2015.
8. Bargren M, Lu D. An evaluation process for an electronic bar code medication administration information system in an acute care unit. Urol Nurs. 2009;29(5):355–67.
9. Bayer R, Santelli J, Klitzman R. New challenges for electronic health records: Confidentiality and access to sensitive health information about parents and adolescents. JAMA. 2015;313(1):29–30. doi:10.1001/jama.2014.15391.
10. Berinato S. All systems down. Computerworld; 2003. URL: http://www.computerworld.com/article/2581420/disaster-recovery/all-systems-down.html. Last accessed 17 Mar 2015.
11. Bertaud-Gounot V, Chaumeil B, Ehrmann E, Fages M, Valcarcel A. Computerizing the Dental Office. In: Venot A, Burgun A, Quantin C, editors. Medical informatics, e-Health: fundamentals and applications. Paris: Springer-Verlag France; 2014. p. 365–403.
12. Bishop RO, Patrick J, Besiso A. Efficiency achievements from a user-developed real-time modifiable clinical information system. Ann Emerg Med. 2015;65(2):133–42.e5.
13. Blythe MJ, Del Beccaro MA, Committee on Adolescence; Council on Clinical and Information Technology. Standards for health information technology to ensure adolescent privacy. Pediatrics. 2012;130(5):987–90.
14. Burns LR, Pauly MV. Accountable care organizations may have difficulty avoiding the failures of integrated delivery networks of the 1990s. Health Aff (Millwood). 2012;31(11): 2407–16.
15. Campbell EM, Sittig DF, Ash JS, et al. Types of unintended consequences related to computerized provider order entry. J Am Med Inform Assoc. 2006;13(5):547–56.
16. Campbell SE, Seymour DG, Primrose WR, ACMEPLUS Project. A systematic literature review of factors affecting outcome in older medical patients admitted to hospital. Age Ageing. 2004;33(2):110–5.
17. Centers for Medicare & Medicaid Services, Office of the National Coordinator for Health Information Technology. Quality data model, Version 4.1.1., September 16, 2014. URL: http://www.healthit.gov/sites/default/files/qdm_4_1_1.pdf. Last accessed 5 Jan 2015.
18. Chassin MR, Loeb JM. High-reliability health care: getting there from here. Milbank Q. 2013;91(3):459–90.
19. Chesapeake Regional Information System for our Patients (CRISP). CRISP Encounter Notification System (ENS). URL: http://crisphealth.org/CRISP-HIE-SERVICES/Encounter-Notification-System-ENS. Last accessed 15 Feb 2015.
20. Chiang MF, Boland MV, Brewer A, Epley KD, Horton MB, Lim MC, McCannel CA, Patel SJ, Silverstone DE, Wedemeyer L, Lum F, American Academy of Ophthalmology Medical Information Technology Committee. Special requirements for electronic health record systems in ophthalmology. Ophthalmology. 2011;118(8):1681–7.
21. CMS.gov. The Blue Button initiative, Jan 2013. URL: http://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/NonIdentifiableDataFiles/BlueButtonInitiative.html. Last accessed 10 Feb 2015.
22. Committee on Data Standards for Patient Safety. Key capabilities of an electronic health record system: letter report. Washington, DC: National Academies Press; 2003.
23. Committee on the Learning Health Care System in America; Institute of Medicine; Smith M, Saunders R, Stuckhardt L, et al., editors. Best care at lower cost: the path to continuously learning health care in America. Washington (DC): National Academies Press (US); 2013 May 10. URL: http://www.ncbi.nlm.nih.gov/books/NBK207218/. Last accessed 1 Feb 2015.

24. Craig C, Eby D, Whittington J. Care coordination model: better care at lower cost for people with multiple health and social needs. IHI innovation series white paper. Cambridge, MA: Institute for Healthcare Improvement; 2011.
25. CRISP. (no date b) The Maryland Prescription Drug Monitoring Program (PDMP). URL: http://crisphealth.org/CRISP-HIE-SERVICES/Prescription-Drug-Monitoring-Program-PDMP. Last accessed 10 Feb 2015.
26. Debono DS, Greenfield D, Travaglia JF, Long JC, Black D, Johnson J, Braithwaite J. Nurses' workarounds in acute healthcare settings: a scoping review. BMC Health Serv Res. 2013;11(13):175. doi:10.1186/1472-6963-13-175.
27. Deering MJ. Issue brief: patient-generated health data and health IT. Office of the National Coordinator of Health Information Technology, Dec 2013.
28. Delaware Health Information Network. Another DHIN "First": DE & MD are first HIEs to exchange ADT information. The DHIN Dialogue, June 2014. URL: http://www.dhin.org/sites/default/files/DHIN%20Dialogue%20June%202014_0.pdf. Last accessed 15 Feb 2015.
29. Evans DC, Cook CH, Christy JM, Murphy CV, Gerlach AT, Eiferman D, Lindsey DE, Whitmill ML, Papadimos TJ, Beery 2nd PR, Steinberg SM, Stawicki SP. Comorbidity-polypharmacy scoring facilitates outcome prediction in older trauma patients. J Am Geriatr Soc. 2012;60(8):1465–70.
30. Ehrenfeld JM, Rehman MA. Anesthesia information management systems: a review of functionality and installation considerations. J Clin Monit Comput. 2011;25(1):71–9.
31. Federal Trade Commission. Consumer information – medical identity theft; 2012. URL: http://www.consumer.ftc.gov/articles/0171-medical-identity-theft. Last accessed 11 Mar 2015.
32. Greysen SR, Covinsky KE. Functional status – an important but overlooked variable in the readmissions equation. J Hosp Med. 2014;9(5):330–1.
33. Greysen SR, Hoi-Cheung D, Garcia V, Kessell E, Sarkar U, Goldman L, Schneidermann M, Critchfield J, Pierluissi E, Kushel M. "Missing pieces" – functional, social, and environmental barriers to recovery for vulnerable older adults transitioning from hospital to home. J Am Geriatr Soc. 2014;62(8):1556–61.
34. Han YY, Carcillo JA, Venkataraman ST, Clark RS, Watson RS, Nguyen TC, Bayir H, Orr RA. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. Pediatrics. 2005;116(6):1506–12.
35. HealtheWay. Exchange specifications; 2015. URL: http://www.healthewayinc.org/index.php/resources/exchange-specifications. Last accessed 10 Feb 2015.
36. Health Information Technology Research Center (HITRC). Continuous Quality Improvement (CQI) strategies to optimize your practice: Primer. The National Learning Consortium, April 30, 2013. URL: http://www.healthit.gov/sites/default/files/tools/nlc_continuousqualityimprovementprimer.pdf. Last accessed 5 Jan 2015.
37. HealthIT.gov. Blue Button; 2014. URL: http://www.healthit.gov/patients-families/your-health-data. Last accessed 10 Feb 2015.
38. HealthIT.gov. Direct basics: Q&A for providers; 2014. URL: http://www.healthit.gov/sites/default/files/directbasicsforprovidersqa_05092014.pdf. Last accessed 10 Feb 2015.
39. HealthIT.gov. Health information privacy and security: a 10 step plan; 2013. URL: http://www.healthit.gov/providers-professionals/ehr-privacy-security/10-step-plan. Last accessed 11 Mar 2015.
40. HealthIT.gov. The patient identification SAFER guide. The Office of the National Coordinator. January 2014. URL: http://www.healthit.gov/safer/guide/sg006. Last 20 Jan 2015.
41. HealthIT.gov. (May 12, 2014). What is HIE? URL: http://www.healthit.gov/providers-professionals/health-information-exchange/what-hie#query-based_exchange. Last accessed 10 Feb 2015.
42. Health Level Seven Child Health Functional Profile Workgroup Pediatric Data Standards Special Interest Group (PeDSSIG). Health level seven. Child health functional profile, final version 1.0. National Institute of Standards and Technology. Functional Profile Registry; 2007.

43. Health Level Seven International (No date). HL7 Standards – Section 4: EHR Profiles. URL: http://www.hl7.org/implement/standards/product_section.cfm?section=4. Last accessed 2 Jan. 2015.
44. HL7. Emergency Department Information Systems (EDIS) Functional Profile, April 2007. URL: http://www.hl7.org/documentcenter/public_temp_A4DB3F90-1C23-BA17-0C1B2021CE42201A/wg/emergencycare/EDIS%20FP%20R1.pdf. Last accessed 17 Mar 2015.
45. HL7 (no date). FHIR Specification. Health Level 7. URL: http://www.hl7.org/implement/standards/fhir/index.html. Last accessed 23 Mar 2015
46. HL7 EHR Work Group & The Behavioral Health Profile Working Group. HL7 EHR behavioral health functional profile, Release 1, 2008 (reaffirmed Apr 2014).
47. Howie L, Hirsch B, Locklear T, Abernethy AP. Assessing the value of patient-generated data to comparative effectiveness research. Health Aff. 2014;33(7):1220–8.
48. Hsiao CJ, King J, Hing E, Simon AE. The role of health information technology in care coordination in the United States. Med Care. 2015;53(2):184–90.
49. eHealth Initiative. Centering on the patient: how electronic records enable care coordination. eHealth Initiative; 2011.
50. Hughes DM. Patient identification. In: Agrawal A, editor. Patient safety: a case-based comprehensive guide. New York: Springer; 2014. p. 3–18.
51. IEEE Std 610.12-1990, IEEE standard glossary of software engineering terminology; 1990.
52. Institute for Healthcare Improvement. IHI Triple aim initiative. 2009. URL: http://www.ihi.org/Engage/Initiatives/TripleAim/pages/default.aspx. Last accessed 1 Feb 2015.
53. Institute of Medicine. Health IT and patient safety: building safer systems for better care. URL: http://www.iom.edu/Reports/2011/Health-IT-and-Patient-Safety-Building-Safer-Systems-for-Better-Care.aspx. Last accessed 17 Apr 2015.
54. The Joint Commission. National patient safety goals. 2015. URL: http://www.jointcommission.org/standards_information/npsgs.aspx. Last accessed 20 January 2015.
55. The Joint Commission. Sentinel Event Alert # 54. Safe use of health information technology. Issue 54, March 31, 2015. URL: http://www.jointcommission.org/assets/1/18/SEA_54.pdf. Last accessed 17 Apr 2015.
56. Kaufmann MD, Desai S. Special requirements for electronic health records in dermatology. Semin Cutan Med Surg. 2012;31(3):160–2.
57. KLAS. One out of four ambulatory EMRs are in danger of being replaced. KLAS Press Room, Aug 2014. URL: http://www.klasresearch.com/News/PressRoom/2014/Ambulatory%20EMR%20Perception%202014. Last accessed 10 Feb 2015.
58. Korman KY, Delvaux M, Bidgood D. Structured reporting in gastrointestinal endoscopy: integration with DICOM and minimal standard terminology. Int J Med Inform. 1998;48:201–6.
59. Kuhn T, Basch P, Barr M, Yackel T, Medical Informatics Committee of the American College of Physicians. Clinical documentation in the 21st century: executive summary of a policy position paper from the American College of Physicians. Ann Intern Med. 2015. doi:10.7326/M14-2128. [Epub ahead of print] PubMed.
60. Lehnbom EC, Stewart MJ, Manias E, Westbrook JI. Impact of medication reconciliation and review on clinical outcomes. Ann Pharmacother. 2014;48(10):1298–312.
61. Levinson DR. Not all recommended safeguards have been implemented in hospital EHR technology, OEI-01-11-00570. Department of Health and Human Services, Office of the Inspector General, December 2013. URL: http://oig.hhs.gov/oei/reports/oei-01-11-00570.pdf. Last accessed 17 Mar 2015.
62. Lopez NI. Implementing a behavioral health electronic medical record. Health information management systems society; 2007.
63. Malone ML, Vollbrecht M, Stephenson J, Burke L, Pagel P, Goodwin JS. Acute Care for Elders (ACE) tracker and e-Geriatrician: methods to disseminate ACE concepts to hospitals with no geriatricians on staff. J Am Geriatr Soc. 2010;58(1):161–7.
64. Marsolo K, Spooner SA. Clinical genomics in the world of the electronic health record. Genet Med. 2013;15(10):786–91.

65. McDonald K, Schultz E, Chapman T, et al. Prospects for care coordination measurement using electronic data sources (Prepared by Stanford University under subcontract to Battelle on Contract No. 290-04-0020--AHRQ SQI-II) AHRQ Publication No. 12-0014-EF. Rockville: Agency for Healthcare Research and Quality; 2012.
66. McDonald KM, Schultz E, Albin L, Pineda N, Lonhart J, Sundaram V, Smith-Spangler C, Brustrom J, Malcolm E, Rohn L, Davies S. Care Coordination Atlas Version 4 (Prepared by Stanford University under subcontract to American Institutes for Research on Contract No. HHSA290-2010-00005I). AHRQ Publication No. 14-0037- EF. Rockville: Agency for Healthcare Research and Quality; 2014.
67. Meeks DW, Smith MW, Taylor L, Sittig DF, Scott JM, Singh H. An analysis of electronic health record-related patient safety concerns. J Am Med Inform Assoc. 2014;21:1053–9.
68. Meyers D, Peikes D, Genevro J, et al. The roles of patient-centered medical homes and accountable care organizations in coordinating patient care AHRQ Publication No. 11-M005-EF. Rockville: Agency for Healthcare Research and Quality; 2010.
69. National Committee for Quality Assurance. Patient-Centered Medical Home Recognition; 2014. URL: http://www.ncqa.org/Programs/Recognition/Practices/PatientCenteredMedicalHomePCMH.aspx. Last accessed 5 Jan 2015.
70. National Committee for Quality Assurance (NCQA) (no date). PCMH Prevalidation Program. URL: http://www.ncqa.org/programs/recognition/Practices/patientcenteredmedicalhomepcmh/pcmhprevalidationprogram.aspx. Last accessed 10 Feb 2015.
71. National Quality Forum (NQF). Preferred practices and performance measures for measuring and reporting care coordination: a consensus report. Washington, DC: NQF; 2010.
72. NCQA. News release: NCQA seeks early adopters for connected care evaluation program, February 5, 2015. URL: http://www.ncqa.org/Newsroom/NewsArchive/2015NewsArchive/NewsReleaseFebruary52015.aspx. Last accessed 11 Feb 2015.
73. Patel V, Kaufman D, Cohen T, editors. Cognitive informatics in health and biomedicine case studies on critical care, complexity and errors. London: Springer-Verlag London Limited; 2014.
74. Poon EG, Keohane CA, Yoon CS. Effect of bar-code technology on the safety of medication administration. N Engl J Med. 2010;362:1698–707.
75. Powell V, Dim FM, Acharya A, Torres-Urquidy MH, editors. Integration of medical and dental care and patient data. London: Springer-Verlag London Limited; 2012.
76. Rich E, Lipson D, Libersky J, Parchman M. Coordinating care for adults with complex care needs in the patient-centered medical home: challenges and solutions. White Paper (Prepared by Mathematica PolicyResearch under Contract No. HHSA290200900019I/HHSA29032005T). AHRQ Publication No. 12-0010-EF. Rockville: Agency for Healthcare Research and Quality. 2012. p. 16–18.
77. Samal L, Hasan O, Venkatesh AK, et al. Health Information technology to support care coordination and care transitions: data needs, capabilities, technical and organizational barriers, and approaches to improvement. Boston: National Quality Forum; 2012.
78. Santana MJ, Haverman L, Absolom K, Takeuchi E, Feeny D, Grootenhuis M, Velikova G. Training clinicians in how to use patient-reported outcome measures in routine clinical practice. Qual Life Res. 2015;24(7):1707–18.
79. Sengstack P. System design supporting workflow vs nursing process: a paradigm shift? ANIA Newsl. 2012;27(3):5–6.
80. Shapiro M, Johnston D, Wald J, Mon D. Patient-generated health data: White Paper. Prepared for the Office of Policy and Planning, Office of the National Coordinator, Apr 2012.
81. Singer SJ, Burgers J, Friedberg M, Rosenthal MB, Leape L, Schneider E. Defining and measuring integrated patient care: promoting the next frontier in health care delivery. Med Care Res Rev. 2011;68:112–27.
82. Spooner SA, Council on Clinical Information Technology, American Academy of Pediatrics. Special requirements of electronic health record systems in pediatrics. Pediatrics. 2007;119(3):631–7.
83. Taylor EF, Lake T, Nysenbaum J, Peterson G, Meyers D. Coordinating care in the medical neighborhood: critical components and available mechanisms. White Paper (Prepared by

Mathematica Policy Research under Contract No. HHSA290200900019I TO2). AHRQ Publication No. 11-0064. Rockville: Agency for Healthcare Research and Quality; 2011.
84. Thomson L. Health care data breaches and information security: addressing threats and risks to patient data. In: Peabody A, editor. Health care IT: the essential lawyer's guide to health care information technology and the law. Chicago IL, American Bar Association; 2013. p. 253–67.
85. U.S. Department of Health and Human Services. Report to Congress: National strategy for quality improvement in health care; 2013. URL: http://www.ahrq.gov/workingforquality/nqs/nqs2013annlrpt.pdf. Last accessed 5 Jan 2015.
86. Van Doornik, W. Meaningful use of patient-generated data in EHRs. J AHIMA84. 2013;10:30–5. http://library.ahima.org/xpedio/groups/public/documents/ahima/bok1_050394.hcsp?dDocName=bok1_050394. Last accessed 11 Feb 2015.
87. Walker JM, Komar MJ. Special purpose software. In: Walker JM, Bieber EJ, Richards F, editors. Implementing an electronic health record system. London: Springer-Verlag London Limited; 2005. p. 134–40.
88. Wears RL. Health information technology and victory. Ann Emerg Med. 2015;65(2):143–5.
89. Weiner M, Callahan CM, Tierney WM, Overhage JM, Mamlin B, Dexter PR, McDonald CJ. Using information technology to improve the health care of older adults. Ann Intern Med. 2003;139(5 Pt 2):430–6.
90. Weintraub WS, Karlsberg RP, et al. ACCF/AHA 2011 key data elements and definitions of a base cardiovascular vocabulary for electronic health records: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Clinical Data Standards. J Am Coll Cardiol. 2011;58(2):202–22.
91. WEO committee for standardization and terminology. Minimal Standard Terminology for Gastrointestinal Endoscopy MST 3.0. Organization Mondiale Endoscopia Digestive (OMED), 2008. URL: http://www.worldendo.org/mst.html. Last accessed 30 Sept 2013.
92. Zargaran E, Schuurman N, Nicol AJ, Matzopoulos R, Cinnamon J, Taulu T, Ricker B, Garbutt Brown DR, Navsaria P, Hameed SM. The electronic Trauma Health Record: design and usability of a novel tablet-based tool for trauma care and injury surveillance in low resource settings. J Am Coll Surg. 2014;218(1):41–50.
93. Zhang J, Walji M, editors. Better EHR: usability, workflow and cognitive support in electronic health records. Strategic Health IT Advanced Research Projects (SHARPC), The National Center for Cognitive Informatics and Decision Making in Healthcare (NCCD). 2014.
94. Shulman LN, Miller RS, Ambinder EP, Yu PP, Cox JV. Principles of Safe Practice Using an Oncology EHR System for Chemotherapy Ordering, Preparation, and Administration, Part 1 of 2. Journal of Oncology Practice. 2008;4(4):203–6.
95. Shulman LN, Miller RS, Ambinder EP, Yu PP, Cox JV. Principles of Safe Practice Using an Oncology EHR System for Chemotherapy Ordering, Preparation, and Administration, Part 2 of 2. Journal of Oncology Practice. 2008;4(5):254–7.
96. McCoy MJ, Diamond AM, Strunk AL, et al. Special requirements of electronic medical record systems in obstetrics and gynecology. Obstet Gynecol. 2010;116(1):140–3.
97. Ponemon Institute. Fifth Annual Benchmark Study on Privacy & Security of Healthcare Data. Sponsored by ID Experts. May 2015. https://www2.idexpertscorp.com/fifth-annual-ponemon-study-on-privacy-security-incidents-of-healthcare-data [Accessed 20 July 2015].
98. Stack SJ. CMS to make ICD-10 transition less disruptive for physicians. AMA Wire, 6 July 2015. http://www.ama-assn.org/ama/ama-wire/post/cms-icd-10-transition-less-disruptive-physicians [last accessed 20 July 2015].
99. National Center for Quality Assurance. Patient Centered Medical Home Criteria, 2014. http://www.ncqa.org/Programs/Recognition/RelevanttoAllRecognition/RecognitionTraining/PCMH2014Standards.aspx [Last accessed: April 2015].
100. Office of the National Coordinator. Standards and Interoperability Framework. Longitudinal Coordination of Care Interoperable Care Plan Exchange Use Case v2.0. 23 July 2013. http://wiki.siframework.org/file/view/LCC%20Care%20Plan%20Exchange%20Use%20Case%20Final.pdf/442230840/LCC%20Care%20Plan%20Exchange%20Use%20Case%20Final.pdf [last accessed 10 February 2015].