

Electronic Health Record Usability

Evaluation and Use Case Framework

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HEALTH IT

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Preface

To support research and policy formation in the area of Electronic Health Record (EHR) usability, the Agency for Healthcare Research and Quality (AHRQ) commissioned the “Use of Dense Display and Information Design Principles in Primary Care Health IT Systems” study. This study establishes a foundation of EHR user interface design considerations and proposes an action agenda for the application of information design principles to the use of health information technology (health IT) in primary care settings. The following activities were conducted to further these goals:

1. Existing research and evidence on information design, usability and interface design was assessed. Where available, literature on specific EHR functions and the linkage between usability and the safety, quality, efficiency, and effectiveness of primary care delivery was summarized.
2. A multidisciplinary expert panel was identified and convened to discuss design principles and evaluation criteria and to propose an action-agenda to foster improvements in EHR usability. The members of that panel are detailed below.
3. The information gained through the above activities was used to develop two companion reports:
 - *Electronic Health Record Usability: User Interface Design.*
 - *Electronic Health Record Usability: Evaluation and Use Case Framework* (this report).

This study was conducted for AHRQ by James Bell Associates and the Altarum Institute. We would like to thank the expert panel members for their many contributions to this report. Many disciplines, including medicine, information science, usability engineering, cognitive sciences, psychology, human factors, and others, offer insight into design improvements possible in EHRs. Effective exploration of this field requires expert input from multiple areas and the complete range of stakeholders. As such, a 2-day innovation meeting was held at AHRQ offices on February 26-27, 2009, with the purpose of evaluating the many perspectives and disciplines involved and bringing them together to develop a coordinated and comprehensive policy strategy for AHRQ. A distinguished panel of experts from academia, government, and the provider and vendor communities was assembled for this effort. Participants are listed in the following table.

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Daniel Armijo, MHSA (Presenter)	Practice Area Leader, Information & Technology Strategies, Altarum Institute
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Michael Klinkman, MD, MS (Presenter)	Associate Professor, Department of Family Medicine, University of Michigan; Director of Primary Care Programs, University of Michigan Depression Center
Ross Koppel, PhD	Professor, University of Pennsylvania Sociology Department; Affiliate Faculty Member, University of Pennsylvania School of Medicine; President, Social Research Corporation
David Kreda	Independent Computer Software Consultant
Donald T. Mon, PhD	Vice President of Practice Leadership, American Health Information Management Association; Co-chair, Health Level Seven (HL7) EHR Technical Committee
Catherine Plaisant, PhD (Presenter)	Associate Director, Human Computer Interaction Laboratory; Institute for Advanced Computer Studies, University of Maryland
Ben Shneiderman, PhD (Panel Chair)	Professor, Department of Computer Science; Founding Director, Human-Computer Interaction Laboratory, Institute for Advanced Computer Studies, University of Maryland
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Representing AHRQ and the project team were **Matthew Quinn**, AHRQ Task Order Officer; **Cheryl McDonnell**, PhD, director, James Bell Associates; **Daniel Armijo**, Director of Information and Technology Strategies at the Altarum Institute; **Kristen Werner**, health informatics analyst, Altarum; and **Stanley Chin**, Practice Development Director, Altarum.

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Executive Summary

Electronic Health Record Usability—User Interface Design (a companion report) outlined the need to promote standards in usability and information design in the development of Electronic Health Records (EHRs). As usability and information design are highly correlated with successful implementation and effective use of computer systems,¹ these disciplines should be promoted within the EHR market to ensure the realization of the benefits expected from Federal investments in health information technologies (health IT).²

To begin exploration of improving EHR usability through the application of information design principles, AHRQ contracted with James Bell Associates and the Altarum Institute to:

- Assess existing research and evidence in this area and its linkage to the safe, efficient, effective, patient-centered, equitable, and timely delivery of care.
- Synthesize the information gained into recommendations for ongoing research, implementation, and policy work in this field.
- Develop applicable “use cases” to evaluate how well information design in primary care health IT systems support care delivery processes and clinical decisionmaking.

To support these objectives, the project identified and convened a multidisciplinary panel including experts from the fields of health care delivery, health IT, information science, usability engineering, cognitive sciences, and human factors. Members of the expert panel (listed in the preface to this report) included practicing clinicians, researchers, leadership of care delivery organizations, health IT vendors, broader IT vendors, and health care member organizations. Multiple members of the expert panel serve or have served on the Certification Commission for Health IT.

A continuing theme of this meeting included the call for a framework to evaluate existing and developing EHR systems against proven standards in functionality and design. At the time of this report, very little systematic evidence had been gathered on the usability of EHRs in practice and the implications of their design on cognitive task flow, continuity of care, and efficiency of workflows. Further, the role of EHRs in patient care is evolving significantly as adoption is incentivized, health information exchanges operationalized, and new forms of comparative effectiveness codified and made available for clinical decision support. Given the significant Federal investment in EHR adoption, promoting improvements in EHR usability through development of an evaluation and use case framework are timely activities for AHRQ to undertake.

This document discusses the evolving role of EHRs and the need for a practical, common evaluation framework. Information design principles tailored to EHR considerations along with initial approaches to heuristic usability evaluation and representative use cases are also provided. This document is meant to serve as a starting point for the common evaluation of EHR design. Through a collaborative effort of clinicians, EHR vendors, and usability experts this framework can be further developed and refined to foster and inform a practical and fair process of usability evaluation.

Chapter 1. The Role of the EHR

Electronic Health Record systems (EHRs) are clinical support tools with the potential to reduce strains on clinician memory and cognition while improving efficiency in workflow and effectiveness in care quality and coordination. The safe, efficient, effective, patient-centered, equitable, and timely delivery of health care services requires tools that organize and display information which places patient data in context, synthesizes that information with available medical evidence, and supports the clinician's decision making process.³

The organization and display of information is essential to effectively supporting clinical care and reducing the potential for human error. Medical care is delivered in highly interruptive environments by clinicians operating in heavily tailored (site and provider specific) rules-based decisionmaking modes. The EHR user interface through which the care team enters and retrieves patient information and, in many cases, care guidelines and medical evidence, must be highly efficient, intuitive, and responsive to varying clinical information needs to adequately support the practice of medicine.

EHR-related incentives and penalties introduced through the American Reinvestment and Recovery Act will foster innovation in the EHR market and widespread adoption in the clinical community.² Simultaneously, the role of EHRs in clinical practice is evolving through the incorporation of health information exchange data (aggregating information across organizational boundaries and over time exploring new ways to maintain the context implicit in that information) and new forms of comparative effectiveness are codified and made available for clinical decision support. The increased availability of patient information and decision support at the point of care has tremendous potential for reducing errors and improving the delivery of evidence-based care. The evolving role of the EHR in supporting clinical practice can be organized around four primary functions necessary to achieving this potential and related efficiency gains. These roles include:

- **Memory aid:** Reduces the need to rely on memory alone for information required to complete a task.
- **Computational aid:** Reduces the need to mentally group, compare, or analyze information.
- **Decision Support aid:** Enhances the ability to integrate information from multiple sources to make evidence-based decisions.
- **Collaboration aid:** Enhances the ability to communicate information and findings to other providers and patients.

How well an EHR serves these functions in a complex care environment is the direct result of an interface that is designed to collect, organize, and display patient information in a manner that is meaningful to clinicians at the point of care, consistent, and aligned with cognitive workflows. The specific tasks within these general roles are constantly evolving, as patient information increases in both availability and complexity, as the body of medical evidence and treatment offerings grows and is codified in new ways, as organizations explore new ways of sharing information (e.g., when organizational boundaries no longer impede information flows) and as patients assume more active roles in their care. Table 1 highlights examples of how an EHR may

be used to serve these roles in the context of a clinical encounter. While this is just an illustrative example, it demonstrates the breadth of potential tasks an EHR will be expected to support in this evolving environment of technologically supported care delivery.

Table 1. Expected EHR tasks

Key Tasks	EHR Role			
	Memory	Computation	Decision Support	Collaboration
Review patient history	Displays available history and demographics	Provides contextual view of overall patient health.	Recommend care based on patient characteristics	Incorporate information from outside sources
Conduct patient assessment	Prompt for required information	Compute statistics (BMI etc)	Action oriented clinical reminders	Coordinate across multiple providers.
Determine clinical Decision	Relate assessment to patient history	Display trends, reference ranges	Support based on outside research/ recommendations	Staff views/instructions
Develop treatment plan	Standards of care, care plans, evidence based guidelines	Apply standards of care based on patient characteristics	Evidence based care adjusted by patient characteristics.	Patient summary, educational tools
Order additional services	Review previous services/results	Determine appropriate provider/location	Alignment with insurance requirements	Create referrals, facilitate provider communication
Prescribe medications	Medication history, allergies, formulary	Dose calculation	Interactions, contraindications, effectiveness	Patient instructions side effects and warnings
Document visit	Diagnosis and treatment codes	Prompts/automatic population	Insurance guidelines	Patient education, coordination with multiple providers

Chapter 2. Need for a Common Framework

Given the evolving role of EHRs in clinical practice and the importance of information design and display to meaningful use, further exploration of EHR usability has been identified by the Agency for Healthcare Research and Quality (AHRQ) as an opportunity for innovation in health IT with the potential for significant impact on clinical practice. In our companion report, *Electronic Health Record Usability—User Interface Design*, a number of recommendations were made to promote research and formative policy development to foster improvements in EHR design and usability. The report also identified existing efforts to evaluate EHR systems as insufficient for broad identification of best practices in information design as well as the need for improved EHR evaluation and the dissemination of these results to EHR researchers, developers, and purchasers.

The design of information displays (i.e., user interfaces) is central to ensuring EHRs effectively and efficiently support clinical tasks such as those highlighted in Chapter 1. However, as both the clinical tasks and supporting technologies evolve, it is necessary to develop a basic framework to evaluate EHR design against set standards and guidelines proven to enable high-quality and efficient patient care. It is important to note that both functionality and usability are essential elements of success, as EHRs must provide the correct elements of functionality necessary to support clinical tasks as well as provide that functionality in a way that adheres to proven design principles necessary for efficient and effective use.

Increased observation, measurement, and lessons learned are needed to more accurately describe user interaction with EHRs and the computing devices they run on. The development of metrics to describe an EHR's impact on ergonomic workload, cognitive workload, and data comprehension would all be useful in the evaluation and comparison of currently available EHR products. Measurements specifically focused on usability would provide insight into the ease with which clinicians are able to integrate EHR use into the care setting and patient encounter. While this report does not thoroughly address evaluation methodology it does provide an initial framework of concepts to be considered in design and usability evaluation. The use cases and design principles described in the following sections provide a starting point for the framework necessary to evaluate EHR adherence to information design principles.

Evaluation of EHR offerings is a complex but necessary undertaking. Once practical metrics have been developed, high performing EHRs (in terms of information design and usability) can be identified and direct comparisons can be made which would support end users to make more effective purchasing decisions. New entrants into the market can be effectively compared to existing programs, increasing the ability for promising technologies to enter into clinician use. Done correctly, usability evaluation will provide the vendor community with concise evidence of particular design considerations that would be valuable to product enhancement efforts. Over time, one would expect movement towards more consistency in the design and display of EHR products (which has its own merit for providers forced to use multiple products in multiple settings). This would foster innovation and competition in the vendor community on new features, interoperability, and product implementation, training, and support instead of UI.

Evaluation structure and methodologies could take many forms, and this report does not fully address the breadth of considerations. They range from conducting structured observations of

mature EHR offerings in use through government-supported efforts like Practice-Based Research Networks, to improving the ability to track and evaluate actual EHR use through expanded use of captured audit trail data and structured analysis of navigation patterns. Another structural approach, the creation of a National EHR Usability Laboratory was also proposed in our companion report. Government-funded Regional health IT Extension Centers may also serve as a mechanism to support evaluative efforts and disseminate product comparisons; however, actual product rankings should likely be conducted by the private sector.

Chapter 3. Use Cases

One approach to establishing a foundation for evaluating information design in EHR applications, are “use cases” that categorize and describe discrete functional scenarios and how computer interactions are carried out. A use case is a description of a system’s behavior and appearance as it responds to stimulus and can be used both to define conceptual requirements of a system and to evaluate compliance with user requirements during testing and evaluation activities. Four summary-level use case constructs are included as an attachment to this report (Attachment 1) to improve the overall design of EHRs by providing direct illustration of key functionality and technical principles of effective display of data and UI.

These use cases are not intended as complete illustration of the many interactions that occur between care providers and EHRs as health information is entered, distilled, reviewed, and used to make clinical decisions. They are instead intended to serve as a framework demonstrating and establishing the relationship between high-level clinical functions and related standards in information design and usability. It is expected that these use cases will be expanded to facilitate work identifying best practices in information design which support more discrete clinical functions. Through combining use cases with basic principles of system usability and design, an effective and practical framework for the evaluation of EHRs can be established.

Use Case Scenarios

Most patients’ health needs can be categorized as a mixture of acute episodes, treatment of chronic conditions, and recommended preventative and health promotion activities. In addition, primary care encounters are often the result of a patient presenting with undifferentiated symptoms, a scenario in which the physician must evaluate both presenting symptoms and patient history to determine the most likely diagnosis. For the design of user interface and displays of health information to be effective, the design must promote effective and efficient delivery of care services under all four categories of patient care. As such, separate use case frameworks are defined in this document for each of these care delivery modes.

Acute Episodes

An acute episode is defined by the period of time when injury or illness is at its worst, usually right after the injury or flare-up has occurred. Episodes of acute illness and related hospitalizations are high-risk times that often require speed and accuracy of care delivery. Health data display criterion specific to this situation are critical to positively impact the timeliness and effectiveness of acute care. This use case highlights design principles necessary for the clinician to accurately and efficiently judge patient history, while incorporating the medical knowledge necessary to develop evidence-based diagnoses and treatment plans.

Chronic Conditions

A chronic condition is an affliction that lasts a year or longer, limits what a person can do or requires ongoing management to prevent complications. Some conditions cause few problems, while others cause episodic problems or symptoms that can be controlled with medication, diet, exercise, surgery, physical therapy, counseling, etc. While there are many different types of chronic conditions, they often affect people in similar ways (limits to function, reduced quality of life, requirements for long-term health behavior changes, etc.) and can exponentially increase the complexity of care management as comorbid (two or more) chronic conditions commonly involve treatment trade-offs, concerns about drug interactions, and compounded impacts on body organ systems. Treatment of chronic conditions requires patient monitoring and ongoing assessment of treatment interventions and management. As a result, appropriate health data display criteria specific to this situation (e.g., longitudinal displays of lab values) and to the individual monitoring the health of the patient (including patient-facing views for self care) are important to the quality, safety, and efficiency of chronic disease management efforts in medical practice. This use case highlights some of the design principles necessary for the management of a variety of key chronic conditions.

Preventative and Health Promotion

Preventive care and health promotion activities increase life expectancy, reduce health disparities, and support a state of physical, mental, and social well-being. Actively managing the “healthy” patient population through preventative and health promotion activities reduces the incidence of chronic conditions and acute care episodes in the patient population. From preventative tests (e.g., mammograms, prostate-specific antigen tests, etc.) to immunizations (both childhood and adult) to efforts aimed at changing health behaviors, a significant (and growing) amount of care delivery is proactive. Delivery of preventative and health promotion activities requires population identification and outreach as well as clinical reminders and efforts to bundle these services when a patient enters the office for another reason (e.g., a sinus infection, or other relatively minor acute episode). This use case outlines the functionality and design necessary to both identify patients in need of preventative services and to support physician patient communication throughout the provision of these services.

Undifferentiated Symptoms

Symptoms presented to primary care clinicians are often undifferentiated, multifactorial in origin, and diverse in spectrum. Many of these symptoms may not be attributable to physical or psychological disease, even after thorough investigation. These presenting symptoms are common to multiple potential diagnoses and may or may not be related to previous conditions or chronic disease. One of the core tasks of primary care is efficient evaluation of these undiagnosed symptoms and complaints within the context of patient characteristics and history. EHR displays supporting this role can be of tremendous value in developing our understanding of primary care clinical epidemiology, and will enable novel decision support tools to clinicians at the point of care. This use case highlights design principles necessary for the clinician to accurately and efficiently judge patient history, while incorporating the medical knowledge necessary to develop evidence-based diagnoses.

Chapter 4. Principles for Heuristic Evaluation

Usability can be judged by adherence to a set of established design principles. General principles have been developed for the design of effective information displays. These principles serve as a basis for heuristic evaluation of any system regardless of function or purpose. Usability problems can be observed by evaluators and, with associated use cases, analyzed for expected impact on end users and system performance. Using these principles and evaluation methods for EHR displays is a necessary step in the identification and design of effective EHR user interfaces.

Many methods are available for the heuristic evaluation of information display. Among the most widely used are those introduced by Jakob Nielsen,⁴ Ben Shneiderman,⁵ Bruce Tognazzini,⁶ and Edward Tufte.⁷ The following represents a summary of a framework developed to combine these theories into one Multiple Heuristics Evaluation Table (MHET);⁸ a full table is available in Attachment II. These heuristics represent multiple aspects of usability and design; those most pertinent to display design are listed below.

Pertinent Categories of Usability and Design

Software User Interaction

This category contains heuristics which describe design characteristics which directly support the user-system interaction. Most important to this category is the ability to provide necessary system information to the user when needed. This information includes system status, appropriate feedback and task-based support.

Learnability

Minimizing the learning curve associated with system use is essential to ensuring continued and efficient use of software functions. As users spend minimal time training or consulting manuals much of the burden of system usability is focused on the display and embedded software support.

Cognition Facilitation

A software system should be designed to reduce the cognitive load experienced by users. In alignment with tasks the user is attempting to accomplish, appropriate information should be displayed, graphics and visualizations used effectively, and clutter should be reduced or eliminated.

User Control and Software Flexibility

Effective use of software functions and features is more likely when users feel in control of the system and have appropriate flexibility available to tailor the system to meet their needs. In supporting both the novice and expert user, the system should respond effectively to users' actions, and customization and shortcuts should be supported.

System-Real World Match

System interfaces serve as representations of systems, processes, and items that exist in the real world. As such, information must be presented in a way that naturally represents the expectations and previous knowledge of the intended user. Ensuring appropriate terminology, consistency in icons and functions, and logical representations are necessary to enhance user understanding of the system.

Graphic Design

Graphics are an important part of information displays and design should take into account the visual processing capabilities of users. Color, layout, placement, readability, use of text, numbers, and symbols all contribute to the ability of the user to accurately interpret and use the interface.⁹

Navigation and Exiting

The ability of the user to explore the software and functions depends upon the characteristics of navigation supplied in the display. The system must both support the user's mental model and allow for easy reversal of actions to allow for effective navigation.

Consistency

Internal and external consistency is necessary to improve both learnability and usability of software systems. Maintaining consistency across all screens and functions can be an important tool for reducing the effort required to navigate the system, locate necessary functions, and interpret information.

EHR-Specific Design Principles

The above system characteristics are necessary regardless of the purpose or function of the application. EHRs support a set of specific and often complex interrelated tasks. In addition to supporting many conclusions described in Microsoft's Common User Interface,¹⁰ innovation meeting participants discussed the need to develop design principles which would specifically

improve EHR usability. Some examples of potential design principles are listed below. Together with the broader heuristics for information design, these principles can be incorporated into the evaluation and development of EHR displays.

Design should reflect physician cognition and environmental stressors. Physicians as experts in cognitively demanding, time constrained, and highly interruptive environments operate in what is known as rules-based decisionmaking mode. This method of decision making is fast, economical of effort, and based on well-encoded individualized "procedural knowledge."¹¹ The nature of the clinical care environment puts the physician at risk for information overload errors such as break-in-task¹² or loss of activation.¹³ EHR user interface design should be engineered to support and enhance rules-based decision making by highly practiced experts who do not all use a single or consistent task structure. The form and timing of information presentation must respect the risks of break-in-task and loss of activation events that can be caused by introducing competing tasks and distracting information into the already-saturated workflow.

Displays should support collaborative work processes. Medical care is delivered in a highly cooperative environment where roles and responsibilities are filled by physicians, nurses, support staff, patients, and others. Each of these groups has the potential to have different tasks, goals, incentives, and mental models of the system that occur at differing stages of the care process. The EHR, as an artifact which supports that work, must be designed to support the individual tasks, the collaboration between individuals that exists to support these tasks,¹⁴ and the overall integrated care process.

Displays should facilitate quality care. EHRs hold great promise and in many cases have achieved great successes in improving the quality and efficiency of health care. EHR design, through effective and intuitive displays of information, coupled with appropriate decision support, should make it easier for clinicians to more consistently provide high quality care to each patient. High quality care can be defined as care that is safe, efficient, effective, patient-centered, equitable, and timely.

Information should be action-oriented. Depending on the age and characteristics of the patient and their past experience with the health care system, the amount of information that could be displayed through an EHR is extensive. Information available to the clinician must be prioritized both to reduce cognitive load and increase the ability of the clinician to efficiently locate and act on required information. Decision making is facilitated by having the right information present at the right time and place, and actionability can be defined as not only providing the right information but also providing the mechanisms to act on it efficiently (e.g., click to order). Therefore, action-oriented information displays are aligned with task flow, include altering mechanisms (that action should be taken) which don't cause break-in-task, and incorporate the functionality to easily act on information where it is provided in context.

Displays should adapt to the individual patient. In support of the idea of actionable information, innovation meeting participants discussed the potential costs and benefits of EHR displays which adapt to patient and provider needs. Patient characteristics and past history can have a large impact on the clinical information that should be displayed, as well as the most effective manner of display. EHRs that present views or screens specific to individual patient characteristics can have positive impacts on usability, as long as elements of consistency are not lost.

The source of displayed data should be apparent. All information contained in a medical record is not of equal quality and therefore may not engender the same level of trust or confidence. This is true with paper as well as electronic records. EHRs, however, hold the potential to blend information received from multiple sources, masking indicators required for physicians to determine the source or gain confidence in the accuracy of displayed information.¹⁵ The EHR interface should provide the ability for physicians to easily and accurately determine source and confidence in displayed information.

Design should support privacy and confidentiality. The electronic storage and sharing of medical information brings an added level of complication to ensuring patient privacy and confidentiality. Patients may request for a variety of reasons that aspects of their medical care or condition be protected from view by specific parties or that information be stricken from their medical record entirely. While the medical community has not reached consensus on the breadth of specific policies which should support privacy and confidentiality in the medical record, the EHR interface should be designed to support reasonable needs and patient requests for confidentiality. This includes the ability to mask specific data elements as well as alert providers to the fact that the medical record is incomplete.

Chapter 5. Steps Ahead

Existing efforts to evaluate EHR systems are insufficient for the broad identification of best practices in information design. Further, the recognition of usability as a critical issue varies across organizations responsible for setting standards and not enough objective evidence currently exists for specific design considerations. Developing standards and guidelines for the design of EHR user interfaces is a necessary undertaking to ensure current investments in health IT deliver the expected returns in efficiency and quality. The consistent presentation of well-designed user interfaces by EHR offerings will improve the usability, effectiveness, and implementation of EHRs throughout the country.

Building from this document and its companion (*Electronic Health Record Usability—User Interface Design*), the further development of standards and guidelines for effective EHR displays should be undertaken as a collaborative effort grounded in a community and social structure that promotes evaluation and continuous improvement in this area. There are many ways to promote an action agenda to foster improvements in EHR usability. From workshops and panels at leading conferences to the creation of an annual conference on EHR usability and perhaps even a scientific journal to focus on these topics, there is much that can be done to foster purposeful discussion and stakeholder engagement.

The use cases and evaluation considerations presented in this report serve only as a foundation for the development of a common framework for the evaluation of EHR design. That framework must also incorporate important lessons learned from previous attempts in this country and others to get clinicians to effectively use information technology in clinical practice.¹⁶ Through the collaborative effort of clinicians, EHR vendors and usability experts, this framework should be further refined to inform and foster a practical and fair process of EHR usability evaluation. As these concepts mature and a process is better defined, the Certification Commission for Health IT could then choose the extent to which incorporation of usability considerations should be part of the EHR certification process. This process could be organized around a use case structure and incorporate a National Usability Laboratory coupled with a library of guidance documents (based on the evidence captured through the research recommendations put forth in our companion document) to actively promote improvements in EHR design. Use cases, testing algorithms (to evaluate audit trail data of EHR use in practice settings), and observation methodologies to validate that products actually meet evolving usability requirements are all process approaches in need of further refinement. EHR products designed to more closely reflect the needs and desired work patterns of physicians and other clinical staff would reduce EHR implementation difficulties and improve the long-term efficiency and effectiveness of the application of technology to clinical practice.

Attachment I: Use Cases

Section 1. Overview

The use cases are focused on defining the design elements that facilitate the complete, accurate, and timely transfer of clinical information. The use case description is divided into the following sections:

Section 1.0 Overview describes the sections of this document.

Section 2.0 Background describes the scope of this document, related research, AHRQ research priorities, and the relationship to research priorities.

Section 3.0 Acute Care Use Case describes the scope, stakeholder communities, functional needs and design criteria, data set considerations, and issues and obstacles for the acute care use case.

Section 4.0 Chronic Care Use Case describes the scope, stakeholder communities, functional needs and design criteria, data set considerations, and issues and obstacles for the chronic care use case.

Section 5.0 Preventative and Health Promotion Use Case describes the scope, stakeholder communities, functional needs and design criteria, data set considerations, and issues and obstacles for the preventative and health promotion use case.

Section 6.0 Undifferentiated Symptoms Use Case describes the scope, stakeholder communities, functional needs and design criteria, data set considerations, and issues and obstacles for the undifferentiated symptoms use case.

Section 7.0 Data Set Considerations identifies specific opportunities for identification of information and/or data relevant to this use case.

Section 8.0 Issues and Obstacles describes issues and obstacles that may need to be planned for, addressed, or resolved to achieve the capabilities described in this document.

Section 2. Background

In order to establish a foundation and propose an action agenda for the use of design criteria for innovative information design principles in EHR applications, discrete use cases that categorize and organize user interface and related functional requirements are necessary. A use case is a description of a system's behavior and appearance as it responds to stimulus and can be used both to define conceptual requirements of a system and to evaluate compliance with user requirements during testing and evaluation activities. These summary use cases were created to improve the overall design of EHR user interfaces by providing direct illustration of key functionality, organization, and visualization principles of effective user interface design.

The use cases below were developed as a result of review of current issues in EHR usability and design as well as results obtained from the expert panel discussions held during a 2-day innovation meeting at the Agency for Healthcare Research and Quality (AHRQ) offices February 26-27, 2009.

Scope

The use cases illustrated below are designed to explore common EHR use in the outpatient environment. Most patient health care needs are a mixture of undifferentiated symptoms, acute episodes, treatment of chronic conditions, and recommended preventative and health promotion activities. For the display of health information to be effective, it must be organized and efficient to support the delivery of care services for all four purposes. This document describes the use cases supporting undifferentiated symptoms, acute episodes, chronic conditions, and preventative and health promotion activities.

The use cases are designed to support third party assessment and evaluation of health IT applications' effectiveness in using information design principles in supporting care of the "whole patient." They are based on an assessment and evaluation of the current state of research and evidence of displays of data and other innovative information design principles in delivering primary care with health IT systems.

The identification, development, and harmonization of standards to support the display of data for patients presenting with undifferentiated symptoms, acute episodes, management of chronic conditions, and preventative and health promotion activities requires additional work with standards and professional organizations, care delivery organizations, and organizations providing information technology services and products to the health care industry. These use cases are intended to be used as a starting point to facilitate this work.

Stakeholder Communities

Examples of stakeholders who are most directly involved in each use case include:

Clinician. The stakeholder category that is primarily responsible for the delivery of care services. In this context, clinician includes primary care professionals, specialists, nurses, and technicians.

Clinical support staff. Includes administrative staff within the practice and at any data source facility.

Consumers and patients. Depending on the cognitive state of the patient, this field information design principles and EHR usability as an area requiring innovative research. AHRQ seeks to provide leadership in identifying and building on best practices in this area to improve the ability of health IT systems to positively impact the quality, safety, efficiency, and effectiveness of primary care.

Relationship to Research Priorities

Researching the use of information design principles in health IT systems supports:

- Improving the delivery and utilization of evidence-based care in ambulatory settings by supporting the practice-based health IT demonstrations to improve evidence-based practice, including strategies to improve the technologies and increase adoption.
- Improving the safety and quality of prescription drug management via the integration of utilization and medication management systems by providing research needed for modifications to commercial market health IT products in order to address needs of target populations.

Insight gained from the execution of these use cases has the capability of enhancing the value of past, present, and future AHRQ investments in health IT and provides leadership in an area not currently effectively addressed by the private sector.

Section 3. Acute Care Use Case

An acute episode is defined by the period of time when injury or illness is at its worst, usually right after the injury or flare-up has occurred. Episodes of acute illness and related hospitalizations are high-risk times that often require speed and accuracy of care delivery. Health data display criterion specific to this situation are critical to positively impact the timeliness and effectiveness of acute care. This use case highlights design principles necessary for the clinician to accurately and efficiently judge patient history, while incorporating the medical knowledge necessary to develop evidence-based diagnoses and treatment plans.

Scope

The acute care display use case was developed to provide evaluation criteria for EHR design required to support delivery of care during acute episodes (see Figure 1). The use case is designed to include all events related to care delivery from the point the patient presents, to the determination of a diagnosis, the formulation of a treatment plan, execution of the treatment plan and the implementation of any follow-up care after the acute episode has ended. Each of these major events has specific requirements for display of data to support care of the whole patient.

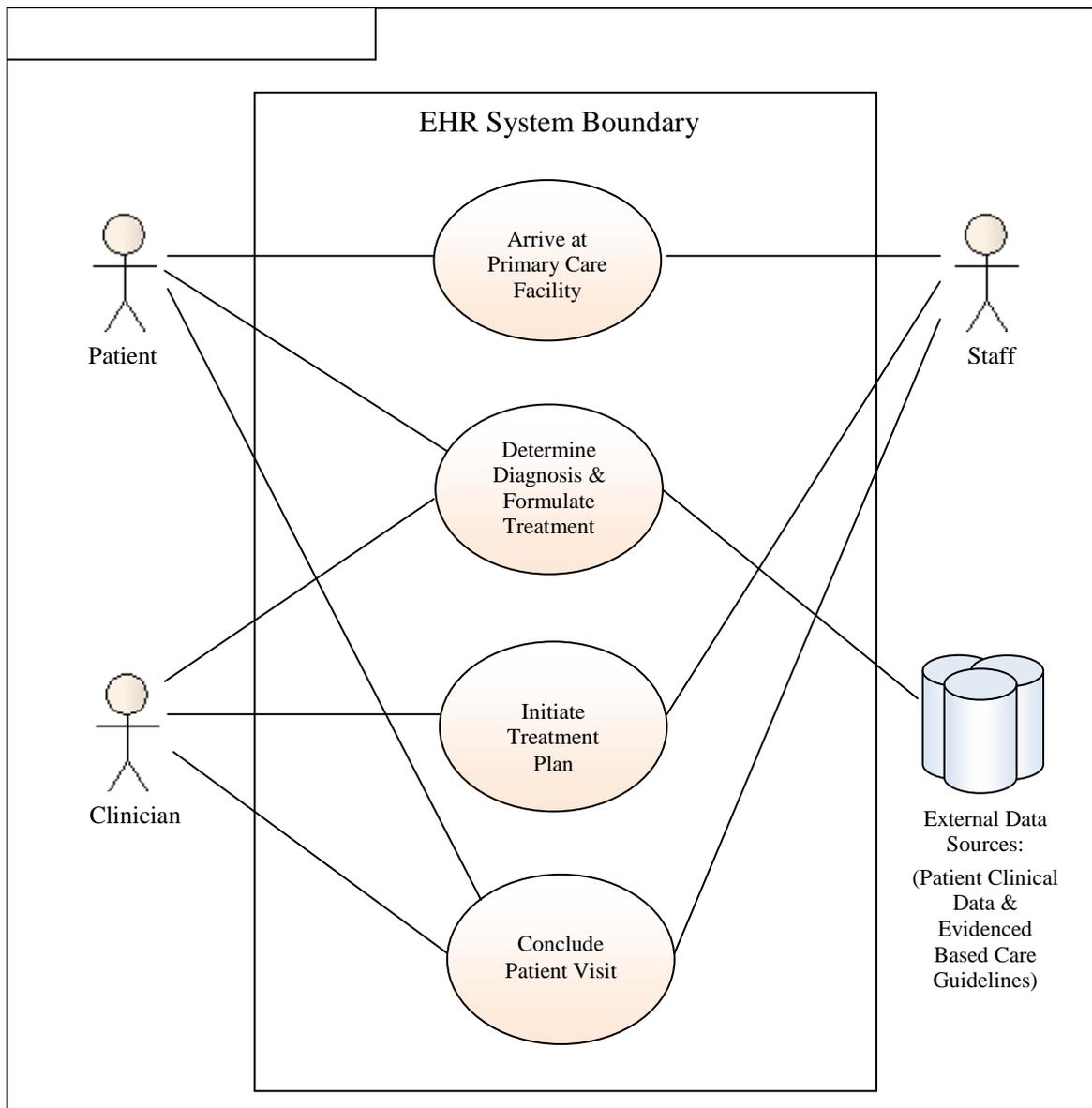


Figure 1. Acute care display use case

Preconditions to this use case include, but are not limited to: the patient’s condition presents as a new event, unrelated to existing conditions or a flare up of an existing condition; and health IT exists with the functionality to support each event and staff and other resources are available and have requisite knowledge and experience to execute their roles.

Stakeholder Roles

During an acute episode, each stakeholder group performs different functions to support the care of the patient. Those roles include:

Clinicians. Enter and review pertinent current and historical information and conduct a physical examination (+/- in-office testing) to determine a diagnosis, reference additional evidence-based information to formulate the treatment plan, instruct staff,

coordinate care, document notes, diagnosis and treatment plan, instruct the patient, monitor progress, and schedule follow-up care as needed.

Clinical support staff. Collect patient historical and administrative data, document results, vital signs, and procedures.

Consumers and patients. Review historical and administrative information for accuracy, describe symptoms, and perform follow-up procedures.

Functional Needs and Design Criteria

This section describes a combination of end-user needs and design elements to support users during an acute episode. Rather than an all-inclusive list of functional requirements, key elements are outlined below. These key elements represent the points at which the EHR display most directly plays a role in the delivery of care. The descriptions in this section are not intended to prescribe policy nor propose architectures required to implement capabilities.

Event #1: Patient presents

A patient presents and gives indication of an acute episode. The clinician and staff must assess current state and confirm eligibility and benefits.

Functional requirements to support event #1. Once a patient presents indicating an acute episode, clinicians require the ability to:

- Enter current vital information into the EHR. This is of particular value during an acute episode that may involve multiple parties such as nurses, clinicians, consulting clinicians, pharmacists, and staff.
- Electronically conduct real-time (i.e., at the point of care) eligibility, benefits checking, and prior-authorization activities. Eligibility and coverage are a consideration for event #2, determine a diagnosis and formulate a treatment plan.

Information required to support event #1. The following nonexhaustive list of data used illustrates some of the information needs when a patient presents during an acute episode.

Patient and clinician identification—Regardless of the nature of the acute episode, standard information is needed to accurately identify the patient and clinician.

Patient administrative data—During an acute episode, administrative information is needed to support the formulation of a treatment plan.

Design characteristics enhancing event #1. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Ease of data entry—When a patient presents for an acute episode, vitals and basic patient information must be quickly entered into the EHR to allow for effective coordination and subsequent decision making.

Effective use of default information—Data entry can be supported through providing default information, however caution must be exercised in this area to reduce occurrence of pseudo data in the EHR.

Proximity of items required for single step—Ensuring commonly needed information and functions exist on a single screen improves provider efficiency and software usability. Functions or information which is repeatedly used in sequence should be reflected in the display.

Consistency in terminology, structures, and look and feel of the system—Patient intake procedures are, in many instances, repetitive and similar events, consistency across screens and between provider views enhances system navigation and team coordination.

Event #2: Determine diagnosis

Once the collection of relevant information is complete, the clinician must synthesize current vital information, relevant history, and decision support information to determine a diagnosis.

Functional requirements to support event #2. A well designed system that provides a comprehensive view of patient data, with the ability to drill down into the detail, and supplemented with reference material is essential to this step in the process. In order to accurately determine a diagnosis and formulate the appropriate treatment plan, clinicians require the ability to:

- Integrate clinical data from multiple sources to form a comprehensive view of the patient’s supporting data and history.
- May require the option to view a summary display that can drill down into specific detail information.
- May require the option to distinguish information received from various sources: clinician’s EHR, other facilities, patient’s PHR, pharmacist, etc.
- Incorporate applicable standards of care, care plans, and evidence-based guidelines.
- Incorporate eligibility and coverage information into decision criteria.
- Review counter-indications and potential interactions of treatment options.
- May require ability to consult outside clinical resources to inform diagnosis and treatment

Information required to support event #2. The following nonexhaustive list of data illustrates some of the information needs when determining a diagnosis and formulating a treatment plan for an acute episode.

Patient clinical history—During an acute episode, clinically-based historical information is needed to support the clinician. This information is supplemented with the vital information gained during event #1.

Clinical decision support information—While a clinician is determining a diagnosis and creating a treatment plan, evidence-based information needed to support decision making.

Medical resources—Diagnosis and treatment plan formulation may require the support of external sources of clinical information and guidance.

Design characteristics enhancing event #2. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics

were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Provide relevant task information and features to the user—Formulating a diagnosis requires appropriate information be displayed and correctly interpreted by the clinician. A focus on actionable information and appropriate use of reminders and alerts will support this role.

Support both overview and details on demand—Appropriate organization and display of overview information on a single screen is most important to reduce the cognitive load on clinicians formulating treatment decisions. However appropriate detail must be available to support all summary information and should be quickly accessible from the main overview screen.

Reduce short-term and long-term memory load—EHRs have at times been characterized as external memory sources for clinicians. In serving this role, EHR displays should minimize memory requirements for its users through ensuring proximity of related information, reducing the number of clicks and scrolls required for all necessary information, and minimizing calculations or computations that the user must perform.

Keep display simple and free of clutter—Locating appropriate information on the screen requires displays limit use of graphics or text which do not add value to the clinician decision making process.

Include appropriate graphics that support and clarify data—Graphics play an important role in reducing cognitive load when interpreting data through quickly displaying trends, comparisons, and relationships.

Support user mental model of the system—In navigating patient history, reminders and alerts, decision support, and external medical references, the system must support the clinicians' ability to maintain an accurate understanding of available options and their location within the system.

Display confidence in information/relevant references—Information supporting this task can originate from a variety of internal and external sources. The display should support the clinician in determining confidence in information displayed as well as providing options to view relevant references for decision support information.

Event #3: Initiate a treatment plan

Once a diagnosis is determined, the clinician must determine and initiate execution of a course of treatment, including immediate orders and follow-up treatment. This may require coordination among multiple parties and care settings.

Functional requirements to support event #3. Initiating a treatment plan requires that all parties understand the plan and know their part in the execution. Clinicians require the ability to:

- Order procedures via a computerized physician order entry.
- Prescribe medications via electronic prescribing.
- Enter staff instruction in EHR.

- Coordinate treatment over time.
- Coordinate across multiple providers and transfer patient information (e.g., transfer to urgent care).

Information required to support event #3. The process of initiating a treatment plan generates new information that must be entered, stored, and shared as necessary.

Design characteristics enhancing event #3. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Ease of data entry—Effective and complete data entry at this step is essential to ensure effective coordination and accurate communication between multiple providers. Screens should support efficient documentation of condition and treatment requirements using language and structure familiar to target users.

Visibility of actions and options—Ordering medications, scheduling procedures, communicating with other providers and other functions required to initiate treatment may exist on multiple screens within the EHR. Options and functions must be visible to the user to ensure their effective use.

Support collaborative work—Patient treatment must be coordinated across multiple providers and at times multiple locations within a single acute episode. The design must support the information needs of and enhance communication between multiple providers. Display should further support the care team in identifying when tasks are complete or who is responsible for completion of required steps.

Event #4: Conclude patient visit

Once the patient is no longer in an acute state, the physicians and support staff must take the steps necessary to conclude the visit and schedule any necessary follow up.

Functional requirements to support event #4. Concluding the patient visit requires that all documentation be complete and parties understand the plan and understand their part in the execution. Clinicians require the ability to:

- Document remaining visit information in EHR.
- Describe instructions to the patient regarding their course of treatment, and support the patient's understanding of and compliance with their role in their treatment.
- Schedule patient follow up procedures and visits as necessary.

Information required to support event #4. The following nonexhaustive list of data used and limited examples illustrate some of the information needs once an acute episode ends and follow-up treatment is formulated and ordered:

Patient clinical history—The patient's medical history needs to be update to reflect the transition to a nonacute stage and the updated course of treatment.

Patient education materials—As necessary the EHR may provide guidance as to available patient education or resource materials which may support their understanding of their condition and personal requirements. Patient's record needs to include self-care curricula they have been assigned and completed.

Design characteristics enhancing event #4. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Support patient/provider communication—Clinicians provide instruction to the patient, such as treatment protocol, self monitoring and testing requirements, and follow-up procedures. Interface design can provide support to both the clinician and the patient to facilitate this transfer of knowledge. Screens which can be easily understood and viewed by the patient can support this role.

Informative feedback of task completion—Clinicians and support staff alike must be able to easily view if any tasks are left outstanding at the end of the visit to ensure a complete patient record.

Section 4. Chronic Care Use Case

A chronic condition is an affliction that lasts a year or longer, limits what a person can do or requires ongoing management to prevent complications. Some conditions cause few problems, while others cause episodic problems or symptoms that can be controlled with medication, diet, exercise, surgery, physical therapy, counseling, etc. While there are many different types of chronic conditions, they often affect people in similar ways (limits to function, reduced quality of life, requirements for long-term health behavior changes, etc.) and can exponentially increase the complexity of care management as comorbid (two or more) chronic conditions commonly involve treatment trade-offs, concerns about drug interactions, and compounded impacts on body organ systems. Treatment of chronic conditions requires patient monitoring and ongoing assessment of treatment interventions and management. As a result, appropriate health data display criteria specific to this situation (e.g., longitudinal displays of lab values) and to the individual monitoring the health of the patient (including patient-facing views for self care) are important to the quality, safety, and efficiency of chronic disease management efforts in medical practice. This use case highlights some of the design principles necessary for the management of a variety of key chronic conditions.

Scope

The chronic care display use case was developed to provide evaluation criteria for display of data design for the treatment of chronic conditions, including the complications that arise when multimorbidity exists (see Figure 2). The use case is designed to include the events supporting care delivery specific to the treatment of chronic conditions: monitoring the condition(s) and adapting the treatment plan. This use case does not include determination of a diagnosis, the formulation of the initial treatment plan, or conclusion of visit as these activities are covered in the acute care use case.

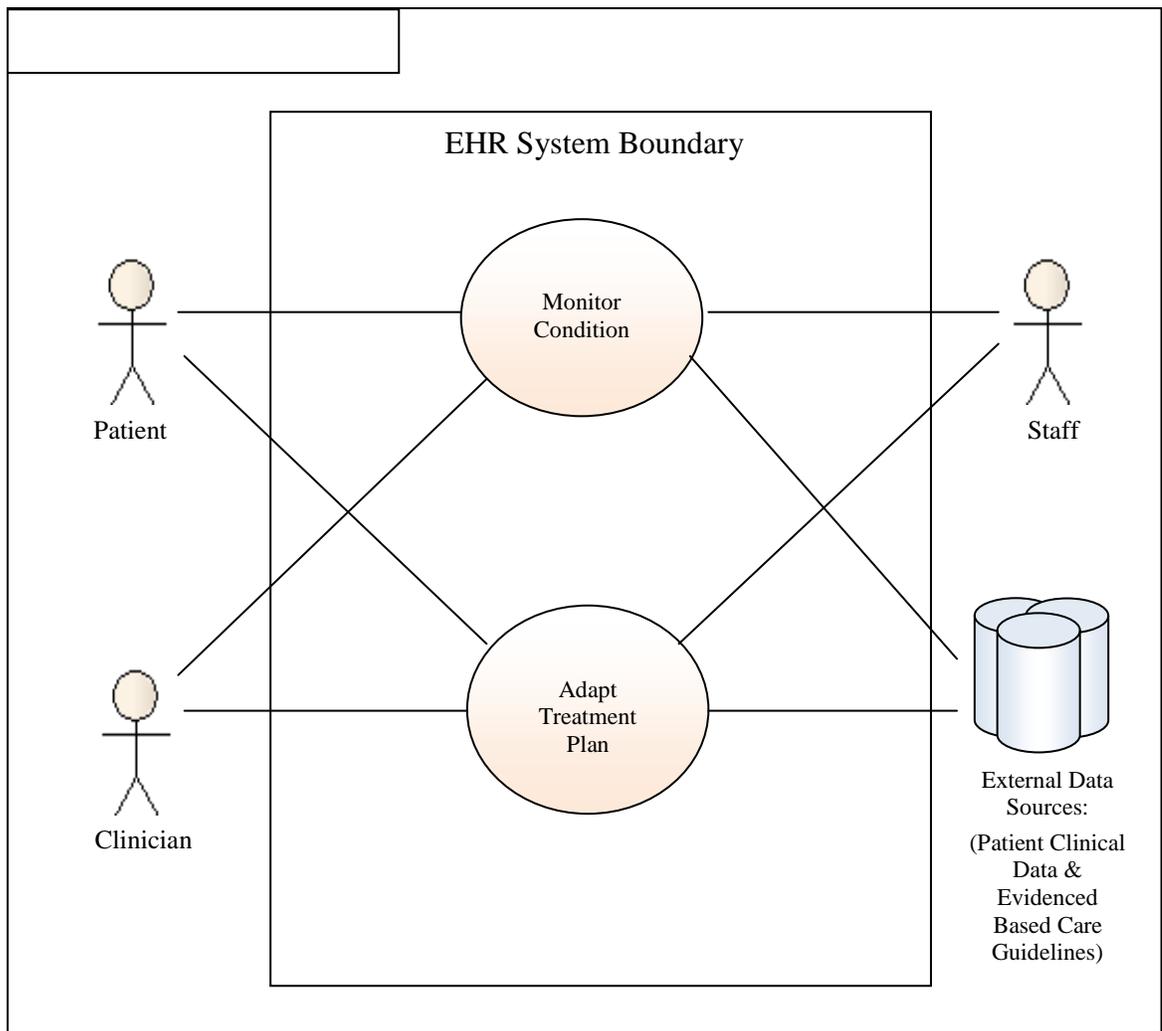


Figure 2. Chronic care data display

Preconditions to this use case include, but are not limited to: the patient’s condition has been previously diagnosed and a treatment plan is in place; and health IT exists with the functionality to support each event and staff; and other resources are available and have requisite knowledge and experience to execute their roles.

Stakeholder Roles

For treatment of chronic conditions, each stakeholder group performs different functions to support the care of the patient. Those roles include:

Clinicians. Responsible for monitoring current and historical patient information, referencing additional evidence-based information, determining the need for referrals, instructing staff, coordinating care, adjusting the treatment plan as necessary, documenting notes and treatment plan, and instructing the patient.

Clinical support staff. Collect patient historical and administrative data, and document results, vital signs, and procedures.

Consumers and patients. Document self-test results, monitor and report symptoms and perform appropriate procedures.

Functional Needs and Design Criteria

This section describes a combination of end-user needs and design elements to support users during treatment of a chronic condition. Support for this exchange includes the development of design standards that are implicit in these functional needs. Rather than an all-inclusive list of functional requirements, key elements are outlined below. These key elements represent the points at which the EHR display most directly plays a role in the delivery of care. The descriptions in this section are not intended to prescribe policy nor propose architectures required to implement capabilities.

Event #1: Monitor condition

Chronic conditions require a level of ongoing observation, both by the patient and the clinician. The patient may be required to self-test and report and must continually observe and report condition and symptoms.

Functional requirements to support event #1. In order to treat chronic conditions, ongoing monitoring of the patient's condition is required. Clinicians and patients require the ability to:

- Integrate clinical data from multiple sources to form a comprehensive view of the patient's supporting data and history.
- May require the option to view a summary display that can drill down into specific detail information.
- May require the option to distinguish information received from various sources: clinician's EHR, other facilities, patient's PHR, pharmacist, etc.
- Enter current information including self-test results and observations into the EHR and PHR. The system should have the ability to highlight or notify the clinician of any significant change in patient condition.
- Access and review current PHR and EHR information.

Information required to support event #1. The following nonexhaustive list of data used and limited examples illustrate some of the information needs to support monitoring a chronic condition.

Patient and clinician identification—Standard information is needed to accurately identify the patient and clinician.

Patient clinical history—To accurately monitor chronic illness and observe trends and changes, clinically-based historical information is needed to support the clinician.

Patient vital information—The treatment of chronic conditions often requires the patient to collect vital information and store it for review by the clinician.

Design characteristics enhancing event #1. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Design should reflect clinician cognition—Chronic care patients, with their increased utilization of the health care system and higher potential for multimorbidity present increased challenges for clinician cognition. Through appropriate presentation

of information, organization of information and effective use of alerts and reminders the EHR should support the clinician in synthesizing the large amount of available information.

Support both overview and details on demand—Appropriate organization and display of overview information on a single screen is most important to reduce the cognitive load on clinicians formulating treatment decisions. However appropriate detail must be available to support all summary information and should be quickly accessible from the main overview screen.

Reduce short-term and long-term memory load—In serving this role EHR displays should minimize memory requirements for its users through ensuring proximity of related information, reducing the number of clicks and scrolls required for all necessary information, and minimizing calculations or computations that the user must perform.

Include appropriate graphics that support and clarify data—Graphics play an important role in reducing cognitive load when interpreting data through quickly displaying trends, comparisons, and relationships. This is particularly important in monitoring chronic conditions to view changes over time.

Provide comparisons to references and normal limits. Lab results and patient vital data should be clearly displayed with references to normal limits to allow clinicians to easily identify potential changes to patient condition that should be addressed.

Display confidence in information/relevant references. Information supporting this task can originate from a variety of internal and external sources. The display should support the clinician in determining confidence in information displayed as well as providing options to view relevant references for decision support information.

Event #2: Adapt treatment plan

Once a treatment plan is in place, based on input from event # 1, monitor condition, the patient's treatment plans must be adjusted as necessary.

Functional requirements to support event #2. In order to treat chronic conditions, the ability to update treatment plans is required. Clinicians require the ability to:

- Order procedures via a computerized physician order entry and prescribe medications via electronic prescribing.
- Enter staff instruction in EHR.
- Coordinate across multiple providers and transfer patient information.
- Incorporate applicable standards of care, care plans, and evidence-based guidelines.
- Incorporate eligibility and coverage information into decision criteria.
- Review counter-indications and potential interactions of treatment options.
- May require ability to consult outside clinical resources to inform diagnosis and treatment.

Information required to support event #2. The following nonexhaustive list of data used and limited examples illustrate some of the information needs to review and update a treatment plan for a chronic condition on an ongoing basis:

Patient clinical history—Clinically-based historical information is needed to support the clinician. This information is supplemented with the vital information gained during event #1.

Clinical decision support information—While a clinician is determining whether to modify a treatment plan, evidence-based information needed to support decision making.

Medical resources—Diagnosis and treatment plan formulation may require the support of external sources of clinical information and guidance.

Design characteristics enhancing event #2. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Provide relevant task information and features to the user—Adapting a treatment plan requires that the clinician incorporate findings from event #1 with standards of care, treatment guidelines, best practices, etc. The EHR should support the clinician in synthesizing this information through information display focused on specific patient needs and characteristics.

Ease of data entry—Effective and complete data entry at this step is essential to ensure effective coordination and accurate communication between multiple providers. Screens should support efficient documentation of condition and treatment requirements using language and structure familiar to target users.

Visibility of actions and options—Ordering medications, scheduling procedures, communicating with other providers, and other functions required to initiate treatment may exist on multiple screens within the EHR. Options and functions must be visible to the user to ensure their effective use.

Support collaborative work—Patient treatment must be coordinated across multiple providers and multiple locations to provide care required for chronic patients. The design must support the information needs of and enhance communication between multiple providers. Display should further support the care team in identifying when tasks are complete or who is responsible for completion of required steps.

Section 5. Preventative and Health Promotion Use Case

Preventive care and health promotion activities increase life expectancy, reduce health disparities, and support a state of physical, mental, and social well-being. Actively managing the “healthy” patient population through preventative and health promotion activities reduces the incidence of chronic conditions and acute care episodes in the patient population. From preventative tests (e.g., mammograms, prostate-specific antigen tests, etc.) to immunizations (both childhood and adult) to efforts aimed at changing health behaviors, a significant (and growing) amount of care delivery is proactive. Delivery of preventative and health promotion activities requires population identification and outreach as well as clinical reminders and efforts to bundle these services when a patient enters the office for another reason (e.g., a sinus infection, or other relatively minor acute episode). This use case outlines the functionality and design necessary to both identify patients in need of preventative services and to support physician patient communication throughout the provision of these services.

Scope

The preventative and health promotion data display use case was developed to provide evaluation criteria for display of data design to support delivery of preventative and health promotion activities (see Figure 3). The use case is designed to include the events specific to delivery of preventative and health promotion activities: determining the target population criteria, querying the patient population, and interacting with patients. Each major event has specific requirements for display of data to support care of the whole patient.

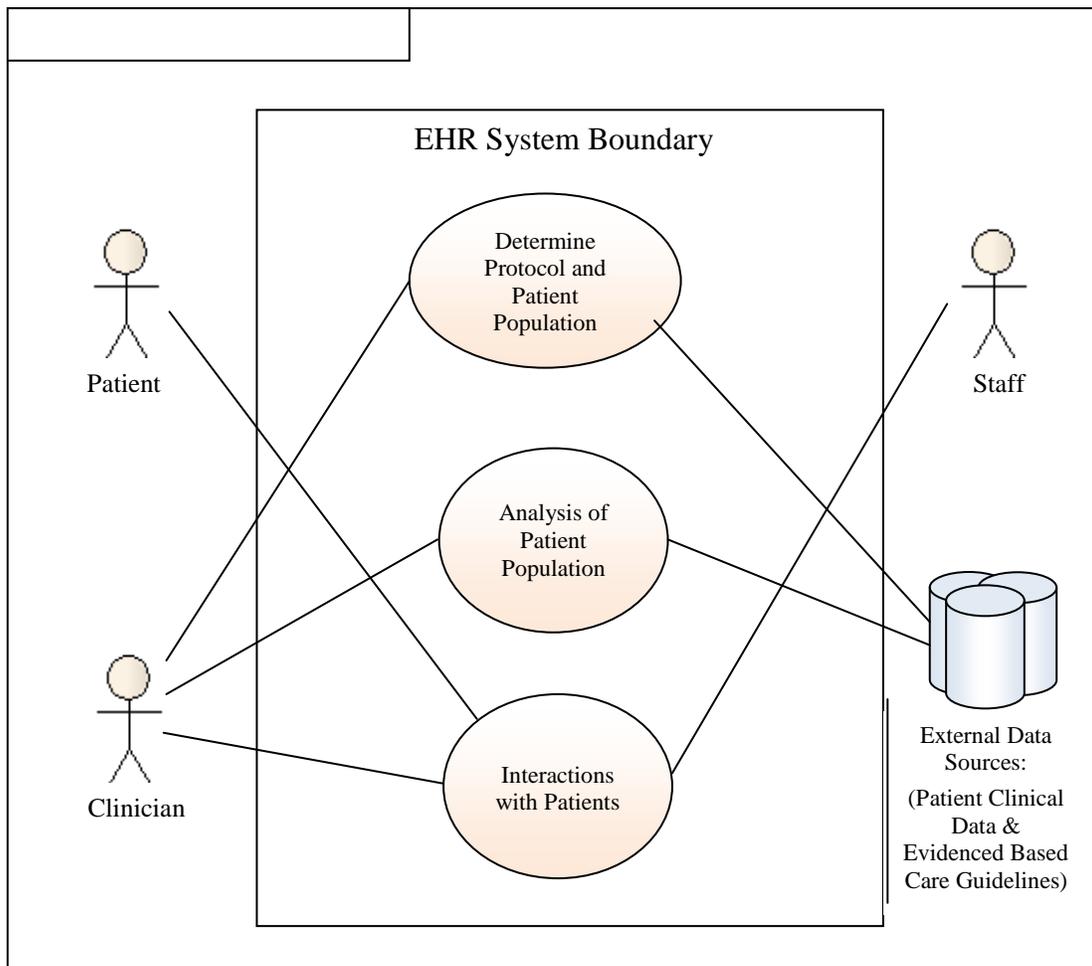


Figure 3. Preventative and health promotion

Preconditions to this use case include, but are not limited to: a robust source of evidence-based reference data is readily available, the clinician’s health IT supports patient population sampling based on discrete criteria, health IT exists with the functionality to support each event and staff, and other resources are available and have requisite knowledge and experience to execute their roles.

Stakeholder Roles

For the delivery of preventative and health promotion activities, each stakeholder group performs different functions. Those roles include:

Clinicians. Reviewing benchmarks, norms, standards, and evidence-based data to determine a target population and protocol for delivery of preventative and health promotion activities.

Clinical support staff. Follow event protocol when contacting patients and delivering preventative and health promotion activities.

Consumers and patients. Determine which population the patient belongs in. Document self-test results, monitor and report symptoms, and perform appropriate procedures.

Functional Needs and Design Criteria

This section describes a combination of end-user needs and design elements to support preventative and health promotion activities. Support for these activities includes the development of design standards that are implicit in these functional needs. Rather than an all-inclusive list of functional requirements, key elements are outlined below. These key elements represent the points at which the EHR display most directly plays a role in the delivery of care. The descriptions in this section are not intended to prescribe policy nor propose architectures required to implement capabilities.

Event #1: Determining protocol and patient population criteria

The clinician and staff query and analyze the patient population to determine the likely beneficiaries of preventative and health promotion activities.

Functional requirements to support event #1. In order to provide preventative and health promotion activities, clinicians require the ability to:

- Access evidence-based reference material.
- Review protocols and criteria in EHR.

Information required to support event #1. The following nonexhaustive list of data used and limited examples illustrate some of the information needs to support preventative and health promotion activities.

Clinical decision support information. While a clinician is determining the activities to execute, evidence-based information is needed to support decision making.

Medical reference resources. External medical resources may support clinicians in determining appropriate preventative care.

Design characteristics enhancing event #1. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Ease of data entry—The design must support the ability of the clinicians or their support staff to easily upload accepted protocols and criteria into the EHR.

Event #2: Analysis of patient population

The clinician and staff query and analyze the patient population to determine the likely beneficiaries of preventative and health promotion activities.

Functional requirements to support event #2. In order to target those activities to a relevant population, clinicians require the ability to:

- Query patient population for discrete criteria indicating preventative health need.
- Review specific patients for appropriateness of identified preventative care and adjust and document the patient care plan.
- Generate contact lists based on the derived patient subset.

Information required to support event #2. The following nonexhaustive list of data used and limited examples illustrate some of the information needs to support preventative and health promotion activities.

Patient population—To create a targeted list of patients for preventative and health promotion activities, clinical and administrative information may be required depending on the type of activity.

Patient clinical history—Clinically-based historical information is needed to determine applicability and severity of condition(s).

Design characteristics enhancing event #2. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson,⁸) and innovation meeting discussions.

Support collaborative work—Patient treatment must be coordinated across multiple providers to identify candidates and define action required for preventative care. The design must support the information needs of and enhance communication between multiple providers. Display should further support the care team in identifying when tasks are complete or who is responsible for completion of required steps.

Support both overview and details on demand—Even with predefined queries some patients identified through the EHR will be ineligible or inappropriate for specific treatments. The ability to view details regarding specific patient supports the clinicians' ability to identify those most appropriate for preventative care.

Visibility of actions and options—When running queries and generating and adjusting patient lists, all actions and options available in the EHR should be easily identifiable to clinicians and support staff.

Provide user with informative feedback required complete tasks—The display should clearly identify what preventative care is recommended for each patient and what next steps are required by the clinician or staff.

Proximity of items required for single step—Ensuring commonly needed information and functions exist on a single screen improves provider efficiency and software usability. Functions or information which is repeatedly used in sequence should be reflected in the display.

Event #3: Interaction with patients

Once the target patient population is identified, the clinician and staff must synthesize contact information to inform and support the execution of preventative and health promotion activities.

Functional requirements to support event #3. In order to target those activities to a relevant population, clinicians require the ability to:

- Describe instructions to the patient, and support the patient's understanding of and compliance with their role in preventative and health promotion activities.
- Enter current vital information into the PHR and EHR.

Information required to support event #3. The following nonexhaustive list of data used and limited examples illustrate some of the information needs when interacting with patients to promote preventative and health promotion activities.

Preventative and health promotion educational media—Information used to inform the patient about proposed activities, including the risks and benefits.

Patient administrative data—Demographic information used to develop contact lists.

Design characteristics enhancing event #3. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Use of terminology familiar to the user group—Instructions provided to the patient must use terminology commonly understood by the patient population, while the EHR must support terminology consistent with that of the medical practice. The EHR and any documentation or communication produced by the EHR must support both roles.

Informative feedback of task completion—Clinicians and support staff alike must be able to easily view if any tasks are left outstanding at the end of the visit to ensure a complete patient record.

Section 6. Undifferentiated Symptoms Use Case

Symptoms presented to primary care clinicians are often undifferentiated, multifactorial in origin, and diverse in spectrum. Only a small proportion of these symptoms can be attributed to physical or psychological disease, even after thorough investigation. These presenting symptoms are common to multiple potential diagnoses and may or may not be related to previous conditions or chronic disease. One of the core tasks of primary care is efficient evaluation of these undiagnosed symptoms and complaints within the context of patient characteristics and history. EHR displays supporting this role can be of tremendous value in developing our understanding of primary care clinical epidemiology, and will enable novel decision support tools to clinicians at the point of care. This use case highlights design principles necessary for the clinician to accurately and efficiently judge patient history, while incorporating the medical knowledge necessary to develop evidence-based diagnoses.

Scope

The undifferentiated symptoms display use case was developed to provide evaluation criteria for EHR design required to support delivery of care when a patient presents with undifferentiated symptoms (see Figure 4). The use case is designed to illustrate how an EHR can be leveraged to support the clinician's diagnostic process when symptoms are not clearly correlated to either an acute episode or chronic condition (see Figure 4). This use case does not include initial patient presentation, the formulation of a treatment plan or follow-up as these are included in the above use cases.

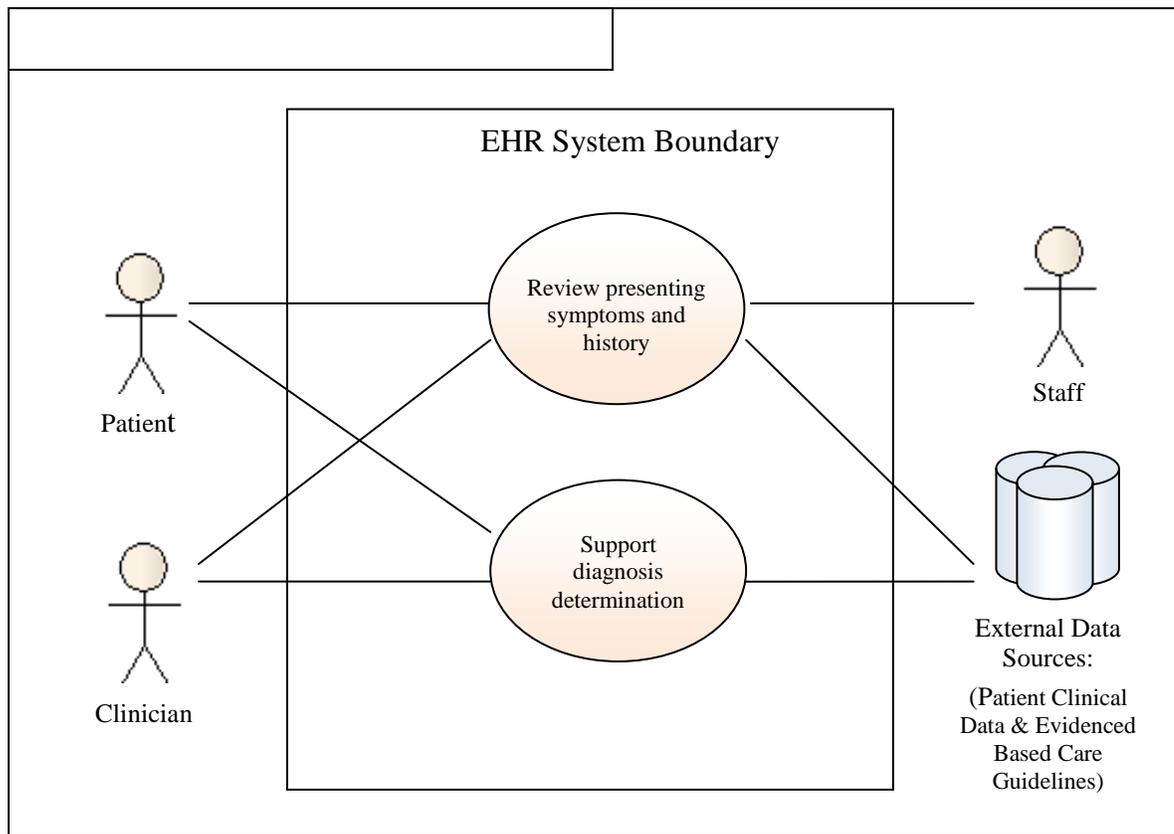


Figure 4. Undifferentiated symptoms data display use case

Preconditions to this use case include, but are not limited to: the patient's condition presents as a new event, and may or may not relate to existing conditions or a flare up of an existing condition, health IT exists with the functionality to support each event, and staff and other resources are available and have requisite knowledge and experience to execute their roles.

Stakeholder Roles

When a patient presents with undifferentiated symptoms, each stakeholder group performs different functions to support the care of the patient. Those roles include:

Clinicians. Interview the patient for pertinent diagnostic information; conduct diagnostic testing (e.g., physical examination, in-office testing); review reference information; create a diagnostic synthesis, including a likely diagnosis and differential diagnosis; create a diagnostic plan; create a treatment plan; create a plan for monitoring the patient's future course; and negotiate these plans with the patient.

Clinical support staff. Collect patient historical and administrative data, document results, vital signs, and procedures.

Consumers and patients. Provide and clarify information (including symptoms); negotiate a diagnostic, treatment and monitoring plan with the physician.

Functional Needs and Design Criteria

This section describes a combination of end-user needs and design elements to support users when a patient presents with undifferentiated symptoms. Rather than an all-inclusive list of functional requirements, key elements are outlined below. These key elements represent the points at which the EHR display most directly plays a role in the diagnostic process. The descriptions in this section are not intended to prescribe policy nor propose architectures required to implement capabilities.

Event #1: Review presenting symptoms and patient history

A patient presents with undifferentiated symptoms. The clinician and staff must assess current state and analyze presenting symptoms in context of patient history.

Functional requirements to support event #1. Once a patient presents with undifferentiated symptoms, clinicians require the ability to:

- Enter current vital information into the EHR.
- View presenting symptoms and vital information within the context of patient history and previous diagnoses
- Integrate clinical data from multiple sources to form a comprehensive view of the patient's supporting data and history.
- May require the option to view a summary display that can drill down into specific detail information.
- May require the option to distinguish information received from various sources: clinician's EHR, other facilities, patient's PHR, pharmacist, etc.

Information required to support event #1. The following nonexhaustive list of data used illustrates some of the information needs when a patient presents with undifferentiated symptoms.

Patient and clinician identification—Standard information is needed to accurately identify the patient and clinician.

Patient vital information—Basic information collected upon patient presentation is needed to develop a full understanding of current patient condition.

Patient clinical history—Clinically based historical information is needed to support clinician decision making.

Design characteristics enhancing event #1. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Ease of data entry—When a patient presents with undifferentiated symptoms, vitals and basic patient information must be easily entered into the EHR to allow for effective coordination and subsequent decision making.

Design should reflect clinician cognition—Undifferentiated symptoms present a challenge to physicians as such symptoms can be indicative of a variety of diagnoses and may or may not be related to previously reported patient problems or diagnoses.

The display must support the clinician in synthesizing the available information to arrive at a treatment decision.

Context of information must be displayed—Through episode or time oriented displays the EHR interface should appropriately organize information to display appropriate context and support the clinician in determining relationships between displayed elements.

Support both overview and details on demand—Appropriate organization and display of overview information on a single screen is most important to reduce the cognitive load on clinicians formulating treatment decisions. However appropriate detail must be available to support all summary information and should be quickly accessible from the main overview screen.

Reduce short-term and long-term memory load—EHRs have at times been characterized as external memory sources for clinicians. In serving this role, EHR displays should minimize memory requirements for its users through ensuring proximity of related information, reducing the number of clicks and scrolls required for all necessary information, and minimizing calculations or computations that the user must perform.

Keep display simple and free of clutter—Locating appropriate information on the screen requires displays limit use of graphics or text which do not add value to the clinician decision making process.

Include appropriate graphics that support and clarify data—Graphics play an important role in reducing cognitive load when interpreting data through quickly displaying trends, comparisons, and relationships.

Support user mental model of the system—In navigating patient history, reminders and alerts, decision support, and external medical references, the system must support the clinicians' ability to maintain an accurate understanding of available options and their location within the system.

Event #2: Support diagnosis determination

Once the collection of relevant information is complete and analyzed by the clinician in context with patient history, the EHR may support the determination of a diagnosis through leveraging available patient information and clinical resources to directly support the clinician's diagnostic decision making process. It is important to note that, in the current EHR market, this functionality is evolving to incorporate new technologies and data sources and therefore represents a process which varies in availability and functionality in current EHR products.

Functional requirements to support event #2. The use of EHRs support the increased availability of patient information and decision support at the point of care. With the use of an appropriate display and underlying data model, the EHR may support the physician in determining the most probable diagnosis and ideal treatment plan given the patient's condition. EHR can be used to:

- Integrate clinical data from multiple sources and multiple patients to support the clinician's diagnostic process.

- Clearly calculate and display probable diagnoses given presenting symptoms and patient history.
- Incorporate applicable standards of care, care plans, and evidence-based guidelines.
- May require ability to consult outside clinical resources to inform diagnosis.

Information required to support event #2. The following nonexhaustive list of data illustrates some of the information needs when determining a diagnosis.

Patient clinical history—When a patient presents with undifferentiated symptoms, clinically-based historical information is needed to support the clinician. This information is supplemented with the vital information gained during event #1.

Clinical decision support information—While a clinician is determining a diagnosis, evidence-based information is needed to support decision making.

Medical resources—Diagnosis formulation may require the support of external sources of clinical information and guidance.

Design characteristics enhancing event #2. The following section outlines a selection of design characteristics most applicable for the event as described above. These characteristics were compiled based on the established design heuristics (e.g., Nielsen,⁴ Shneiderman,⁵ Tognazzini,⁶ Tufte,⁷ and Wheeler Atkinson⁸) and innovation meeting discussions.

Provide relevant task information and features to the user—Formulating a diagnosis requires that appropriate information be displayed and correctly interpreted by the clinician. A focus on actionable information and appropriate use of reminders and alerts will support this role.

Reduce short-term and long-term memory load—EHRs have at times been characterized as external memory sources for clinicians. In serving this role, EHR displays should minimize memory requirements for its users through ensuring proximity of related information, reducing the number of clicks and scrolls required for all necessary information, and minimizing calculations or computations that the user must perform.

Keep display simple and free of clutter—Locating appropriate information on the screen requires displays limit use of graphics or text which do not add value to the clinician decision making process.

Underlying data structure must support diagnostic process—The ability of the EHR to provide probable diagnoses or treatment options is dependent on the ability of the EHR to relate current patient characteristics and history to established guidelines and treatment plans. This depends largely on an appropriately structured and reliable data model in which presenting symptoms and patient history are appropriately correlated and displayed to the user.

Include appropriate graphics that support and clarify data—Graphics play an important role in reducing cognitive load when interpreting data through quickly displaying trends, comparisons, and relationships. Accurate analysis of risks and probabilities can especially be supported through graphical displays.

Display confidence in information/relevant references—Information supporting this task can originate from a variety of internal and external sources. The display

should support the clinician in determining confidence in information displayed as well as providing options to view relevant references for decision support information.

Section 7. Dataset Considerations

In order for all of the events included in the use cases to be realized, a significant increase in the use of health IT is necessary. Adoption of health IT combined with the conversion and storage of paper-based information to electronic and the establishment of shared critical clinical information will facilitate the ability to leverage the data and technology to streamline and enhance these processes.

Adoption of the necessary health IT functionality to support these use cases is still very low. According to a study sponsored by The Office of the National Coordinator for Health Information Technology in partnership with the George Washington University and Massachusetts General Hospital/Harvard Institute for Health Policy the current state of health IT adoption is far short of the tipping point necessary to drive the full functionality of these use cases (see Table 2). As American Recovery and Reinvestment Act investment is expected to increase EHR use, now is the time to address design issues ahead of this significant rise in adoption.

Table 2. Adoption rates*

Setting	2006	2007	2008	2009
Physicians offices (basic)	11%	13%	17%	
Physicians offices (full)	3%	4%	4%	
Hospitals (basic)	N/A	N/A	8%	
Hospitals (full)	N/A	N/A	2%	

* Jha AK, DesRoches CM, Campbell EG, et al. Use of electronic health records in U.S. hospitals. N Engl J Med 2009 Apr 16;360(16):1628-38. Epub 2009 Mar 25.

Section 8. Issues and Obstacles

A number of issues and obstacles require further definition and exploration in the application of technology to the practice of medicine. Examples of specific issues and obstacles related to the design of EHR user interfaces that were not adequately explored in this document or its companion are outlined below.

Design Terminology and Standardization

A standardized clinical design and display terminology vocabulary that supports the needs of clinicians and software designers may be needed. Existing terminology vocabularies may not have sufficient compatibility and clinicians may have unmet needs for describing workflow steps and clinical preferences. Other aspects of clinician information flow would also be served by an improved standard in this area.

Without a standardized clinical design and display terminology vocabulary, many aspects of information exchange related to describing EHR use in clinical settings may be difficult, which may negatively affect communication, data use, and patient health.

Financial Barriers and Incentives

One of the principal obstacles to wider adoption of EHR and other clinical systems is the cost of acquiring and maintaining these systems. Appropriate financial incentives to promote the adoption and use of these may be needed. The American Recovery and Reinvestment Act is expected to provide support in this area. Whether that support is sufficient to foster widespread adoption is yet to be seen.

If electronic systems supporting delivery of care have limited adoption, the benefits to overall health care costs and patient care may not be realized.

Clinician Workflow

Many aspects of clinician workflow rely on the efficacy and efficiency of clinical display. When distractions, such as data that are hard to find or arranged illogically, or multiple tools or systems are required, clinician productivity suffers. Comprehensive, concise, and impactful display of clinical information is needed.

In addition, within a clinician's office, there are obstacles that relate to the communication and workflow handoffs between clinicians and other clinical staff. Where system communications are intended to be directed to one member of the team, there may be instances where another clinical staff member is actually the recipient of a system message.

Finally, if the information displayed is not easily and readily interpreted correctly, the information may be missed or misleading. If the display of data does not enhance, or worse distracts or misinforms clinicians, implementation of EHRs may be limited or important functions may be disabled.

Establishing health IT Standards

Although important steps have been taken, additional effort is needed to define, adopt, and implement comprehensive standards to promote data quality and consistency, exchange, security, and privacy.

Integrating Multiple Data Sources

Data required to establish a whole patient view must be obtained from multiple providers including physicians, hospitals, labs, pharmacies, insurers, and others. Standards must be created and connections established to integrate these data sources into one comprehensive patient view while allowing for an accurate determination of the source and confidence in displayed information.

Collaboratively Developed and Vetted Master Plan

Implementing an extensive, integrated EHR infrastructure in this country is a complex goal that involves a range of stakeholders, various technologies, and activities taking place over time. It is important that these activities be guided by comprehensive plans that include milestones and performance measures, and that these plans are understood and supported by all major stakeholders.

Privacy and Security

A robust approach to privacy protection is essential to establish the high degree of public confidence and trust needed to encourage widespread adoption of health IT and particularly electronic health records. health IT programs and applications need to address core privacy principles while overcoming common challenges such as the diversity of State laws.

Section 9. Dataset Detail

Patient and Clinician Identification

Regardless of the nature of the visit, standard information is needed to accurately identify the patient and clinician. Standard as well as optional identification information may be required depending on the needs of the situation and based on any regulatory requirements. Patient and clinician identification information may include:

Required and Optional Patient Information

Patient identification information

- Name
- Date of birth
- Address
- Email and other message routing information
- Phone number

Required and Optional Clinician Information

Provider identification information, potentially including a National Provider Identifier

- Name
- Location
- Patient and institution privileges
- Credentials/licensing information
- Phone/fax number(s)
- Email and other message routing information
- Phone number

Patient Administrative Data

During an acute episode, administrative information is needed to support the clinician. Patient administrative information may include:

- Insurance coverage
- Formulary
- Encounters
- Consent

Patient Clinical History

Clinically based historical information is needed to support the clinician. Standard as well as optional information may be required depending on the needs of the situation. Patient clinical historical information may include:

- Laboratory results
- Radiology reports
- Medication history
- Allergy information
- Family history
- Personal locus of control
- Health literacy
- Social support
- Preferences

Clinical Decision Support Information

While a clinician is determining a diagnosis and creating a treatment plan, evidence-based information is needed to support decision making information may include:

- Standards of care
- Evidence-based guidelines
- Best practices
- Drug interaction map

Patient Vital Information

The treatment illness or determination of diagnosis often requires the patient to collect vital information and store it for review by the clinician. Patient vital information may include:

- Test results (blood sugar, blood pressure, etc.)
- Subjective measures, (perceived stress scale, etc.)

Patient Population

To create a targeted list of patients for preventative and health promotion activities, clinical and administrative information may be required depending on the type of activity.

- Insurance coverage
- Consent
- Demographic information
- Diagnoses

- Encounters
- Medication history
- Allergy information

Preventative and Health Promotion Educational Media

Information used to inform the patient about proposed activities, including the risks and benefits.

- Educational brochures
- Email templates
- Newsletters

Medical Resources

Diagnosis and treatment plan formulation may require the support of external sources of clinical information and guidance.

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Attachment II: Multiple Heuristics Evaluation Table

Multiple Heuristic Evaluation Table (MHET)

Beth F. Wheeler Atkinson, Troy O. Bennett, G. Susanne Bahr & Melissa Walwanis Nelson

HEURISTICS	DO'S	DON'TS	USER GROUP DECISION FACTOR
<p>Software-User Interaction: Design supports user interaction with the software by providing appropriate and necessary information^{1, 2, 3}</p>	<ul style="list-style-type: none"> • Keep the user informed with status mechanisms and software status displays (e.g., dynamic or animated display for extended delays, message pane and/or history pane, reason for error message, task completion confirmation) • Reduce the user's experience of wait-time (e.g., acknowledge button clicks, display animated hourglass, indicate length of potential wait)² • Provide appropriate feedback (e.g., error message, type of input required)^{1, 2, 3} • Allow mouse-over to trigger additional information such as icon name or description during mouse-over or mouse-hover • Support disabling functions by prompting or user preferences • Provide the user with informative feedback to designate that a group of actions are complete (e.g., clear sequence of dialog actions, feedback that a group of dialog actions are complete)³ • Provide relevant task information to the user • Provide access to features required for task completion 	<ul style="list-style-type: none"> • Do not let user actions occur without a program response^{1, 2} • Do not make the user guess the amount of time still left for an action to be complete • Do not inundate the user with prompts/requests in anticipation of an action (i.e., do not distract them from their current task) • Do not have the user wait without indication that a program is working • Do not make the user guess what is meant by a button or icon (e.g., using uncommon icon representations) • Do not create special functions which cannot be disabled (e.g., auto-correct, auto-format) • Do not leave the user feeling that more actions are required • Do not require the user to search for task relevant information • Do not provide the user with features or dialogs designated for development (e.g., debugging message used for testing) 	User Experience
<p>Learnability²: Design supports timely and efficient learning of features</p>	<ul style="list-style-type: none"> • Minimize the learning curve necessary to use the software (e.g., provide succinct learning aids, quick start to procedures, troubleshooting, references)² • Allow the user time to learn the software • Support user control of information (e.g., mouse-over for additional information to aid recognition) • Make all training embedded in the software • Provide a troubleshooting cheat sheet 	<ul style="list-style-type: none"> • Do not make learning aids too brief or too lengthy • Do not assume the user is ready to move to the next task • Do not make software too difficult for a novice • Do not require training outside the use of the software 	User Experience

HEURISTICS	DO'S	DON'TS	USER GROUP DECISION FACTOR
<p>Cognition Facilitation: Design supports the cognitive limitations of the human user^{1, 2, 3, 4}</p>	<ul style="list-style-type: none"> • Maintain visibility of objects, actions and options¹ • Reduce short-term and long-term memory load^{1, 3} • Store user and state information when appropriate (e.g., cookie, user profile)² • Keep display as simple as possible³ • Keep display free of clutter • Bring all information needed for each step to one place² • Provide the appropriate amount of information for steps to be completed • Provide a continuous GUI display layout from session to session • Provide clear and timely information • Include graphics that support and clarify data⁴ • Provide quality graphics (e.g., high density, necessary information) that aid comprehension⁴ • Use data compression to provide lots of detail in a single graphic⁴ • Use sets of thumbnail sized graphics to allow comparison, demonstrate alternatives, represent motion, overlay images, and permit rapid cycling⁴ 	<ul style="list-style-type: none"> • Do not increase user workload by omitting cues or changing the display • Do not require information to be recalled from previous dialog¹ • Do not require the user to reenter or remember profile or state information • Do not provide irrelevant or rarely needed information¹ • Do not hide relevant or frequently needed information • Do not provide an inappropriate amount of information (i.e., too much or too little) for task completion • Do not change the display configuration including frames and icons between user sessions without user intent (i.e., deliberate changes in preferences) • Do not present ambiguous or overly detailed information that requires additional cognitive effort • Do not use graphics as decorative elements⁴ • Do not use unnecessary graphics⁴ • Do not use low density graphics that do not support easy comprehension⁴ • Do not use data compression to hide or limit the information provided to the user⁴ • Do not include decorative elements in graphics (e.g., legends)⁴ • Do not include embellishments that are context-free⁴ 	<p>User Experience GUI Design</p>
<p>User Control & Software Flexibility: Design provides responses to user actions and is adaptable^{1, 2, 3}</p>	<ul style="list-style-type: none"> • Make the user feel they are in charge and that the software responds to user's actions (e.g., acknowledge button clicks, display animated hourglass, indicate length of potential wait)^{2, 3} • Allow the user to tailor the GUI configuration (e.g., reconfigure panels/windows, add/delete/reorganize toolbar icons) • Develop software to inherit characteristics from existing software code (e.g., features) to alleviate the need for re-coding • Provide access to task accelerator features to support the expert and novice user (e.g., special keys, hidden commands, shortcut keys, abbreviations, macros, toolbar icons)^{1, 3} 	<ul style="list-style-type: none"> • Do not make the user guess if an action was executed because of no program response • Do not hard-code variables, arguments, etc. that may vary throughout • Do not burden user with repetitive input • Do not require a lengthy number of steps for frequent actions 	<p>User Experience GUI Design</p>

HEURISTICS	DO'S	DON'TS	USER GROUP DECISION FACTOR
<p>System-Real World Match: Design matches user expectations based on user community expertise and similar available products^{1,2}</p>	<ul style="list-style-type: none"> • Use terminology that is familiar to the target user group¹ • Provide key words at the beginning of menus and buttons² • Use well-chosen, appropriate and familiar icons (e.g., folders, recycle bin)² • Use well-chosen metaphors (e.g., reference popular programs)² 	<ul style="list-style-type: none"> • Do not use technical jargon or code when providing information to the user • Do not create ambiguous or unnecessarily lengthy menu names • Do not use similar menu options or icons to represent different items • Do not choose icons that are ambiguous or hard to interpret • Do not use a unique design approach unless there is a good reason such as user feedback or usability testing to suggest a change 	<p>GUI Design</p>
<p>Graphic Design: Design uses graphic elements to convey information and create effects^{2,4}</p>	<ul style="list-style-type: none"> • Use color as the main identifier of differences between objects⁴ • Compensate color blindness by using secondary cues (e.g., gray scale, different graphics, different text label) that are associated with each color presented² • Ensure that the design supports easy reading (e.g., use serif fonts)^{2,4} • Reserve pure bright colors for small highlighted areas⁴ • Use small marks and labels⁴ • Use graphics and associated text in close proximity⁴ • Follow Fitts' Law (i.e., the distance and size of a target effects the time to acquire the target)² • Include all important details in graphics⁴ • Ensure that graphic representations are accurate by using appropriate display methods (e.g., provide context)⁴ • Use graphic elements to serve multiple purposes⁴ • User color to label, convey multi-dimensional values and portray reality⁴ • Use solid pastel shades for scroll bars⁴ • Delimit subtle shades with fine contour lines⁴ • Use design concepts such as separation of figure and background, and layering and separation⁴ 	<ul style="list-style-type: none"> • Do not use color as the only identifier of differences⁴ • Do not use gray backgrounds because they reduce font contrast² • Do not use small fonts • Do not use pure bright colors as backgrounds⁴ • Do not make marks and labels so small that they are illegible⁴ • Do not use abbreviations unless necessary⁴ • Do not space out icons or commands that logically go together • Do not closely position commands or icons that cancel each other or cause errors (e.g., high proximity of Delete and Rename can lead to accidental deletion)⁴ • Do not delete details that clarify graphic information⁴ • Do not provide deceptive graphic representations (e.g., dis-information, visual exaggerations)⁴ • Do not use subtle shades (e.g., color, gray scale) that are not delimited⁴ 	<p>GUI Design</p>

HEURISTICS	DO'S	DON'TS	USER GROUP DECISION FACTOR
Navigation & Exiting: Design facilitates software exploration and provides outlets to terminate actions ^{1,2,3}	<ul style="list-style-type: none"> • Provide the user with the means to escape (i.e., cancel option)^{1,2} • Allow the user to easily reverse actions (i.e., undo, redo)^{1,2,3} • Provide easy to identify landmarks (e.g., trail of selected options)² 	<ul style="list-style-type: none"> • Do not force a user to choose an option without the option to cancel • Do not make actions final • Do not use invisible navigation structures² • Do not create disappearing high level menus 	GUI Design System Architecture
Consistency²: Design elements provide standard and reliable terminology, actions and layouts ^{1,2,3}	<ul style="list-style-type: none"> • Use consistent terminology, structures, look and user action/system reaction throughout the program^{1,2,3} • Be inconsistent and employ notably different design elements when functions act differently (e.g., left click to open, right click for menu)² • Have well integrated parts that make up the overall software system (e.g., user should not be aware of multiple systems/parts of a system during normal operation unless specified by the user) 	<ul style="list-style-type: none"> • Do not use multiple or different words to refer to the same thing¹ • Do not randomly require different user actions for the same objective • Do not show multiple systems or parts of a system during normal operation unless specified by the user 	GUI Design System Architecture
Defaults²: Design provides default information ^{2,3}	<ul style="list-style-type: none"> • Make defaults easy to change or delete (e.g., have defaults automatically selected)² • Make defaults descriptive placeholders² 	<ul style="list-style-type: none"> • Do not prevent the user from typing over defaults • Do not use "default" as a placeholder³ 	GUI Design System Architecture
Software-System Interaction: Design supports software interaction with hardware components ^{1,2,3}	<ul style="list-style-type: none"> • Provide a reasonable speed of processing³ • Use multi-threading to support multiple concurrent tasks (e.g., user can continue work while software or system work occurs in the background)^{2,3} • Support portability (e.g., program can handle multiple Operating System platforms and compilers) • Support access to system status displays (e.g., Operating System properties, task manager properties)¹ 	<ul style="list-style-type: none"> • Do not have long delays (i.e., user wait time) for simple processes • Do not create threads (i.e., tasks) to consume Central Processing Unit (CPU) during latency • Do not design software to support a single Operating System • Do not require high CPU utilization for the program • Do not require the software to wait for a computation to complete before continuing to work 	System Architecture

HEURISTICS	DO'S	DON'TS	USER GROUP DECISION FACTOR
Help & Documentation ¹ : Design provides help files and documentation to support use of software	<ul style="list-style-type: none"> • Ensure easy searching of documentation¹ • Provide succinct help messages² • Create a log to track issues requiring help • Provide information that is task oriented¹ • Provide information in an ordered list of concrete steps¹ • Make instructions visible and easy to retrieve¹ 	<ul style="list-style-type: none"> • Do not create a help system that is difficult to search or navigate • Do not make too large¹ • Do not create a help system that is difficult to search or navigate • Do not create a help system that is too generic • Do not embed steps into a paragraph (e.g., create bulleted/numbered list) • Do not hide instructions or make difficult to retrieve 	System Architecture
Error Management : Design prevents, identifies and diagnoses errors and offers corrective solutions ^{1,2,3}	<ul style="list-style-type: none"> • Provide back-ups that limit the loss of user work due to an error or power failure² • Design software to prevent serious user errors (e.g., auto-save for backup, alert and double check before deleting an item, ask to save before closing document or program)^{1,3} • Use plain language when providing the user with messages¹ • Provide succinct error messages • Detect errors caused by software bugs or user issues² • Offer clear and informative messages when errors are detected (i.e., identify the problem or cause and potential solutions)^{1,2,3} • Alert users to repeat errors • Gray out functions that are not currently available 	<ul style="list-style-type: none"> • Do not create a system that cannot save, auto-save or recover files • Do not make recovered files difficult to locate • Do not allow a program to close without notifying user and auto-saving • Do not require user to re-enter data each time software is used • Do not offer cryptic and/or unclear messages • Do not use code alone to indicate what the problem is when providing error messages • Do not use unfamiliar symbols to indicate errors • Do not be wordy, verbose or longwinded when providing user messages • Do not allow user to make multiple errors without notification • Do not allow user to continue without acknowledging error 	System Architecture

USER GROUP DECISION FACTOR	
User Experience	Heuristics related to the subjective experience of the user.
GUI Design	Heuristics that deal with visualization solutions and cognitive user support fall within the category.
System Architecture	Heuristics related to the system characteristics (i.e., hardware, software) that support the optimization of the GUI design and user experience.
NOTE: Because many heuristics address complex design solutions and human-computer interactions, they may qualify for multiple categories.	

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Note: Reference materials used to develop Attachments are embedded within them to allow for their use outside the context of this report.