A CLINICAL DECISION SUPPORT NEEDS ASSESSMENT OF COMMUNITY-BASED PHYSICIANS

by

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ABSTRACT

Background: Community-based practices are being incentivized with Medicare and Medicaid dollars to install EHR systems that include clinical decision support (CDS) technology. This represents a relatively new subject population in biomedical informatics that will be using clinical decision support tools. This research endeavored to understand from community-based physicians' viewpoints what CDS means to them and what it can do to meet their needs. The purpose of the inquiry is to inform the design of CDS tools for these environments.

Methods: The researcher carried out a user-centered needs assessment among 30 primary care physicians and one nurse administrator in community-based settings through in-practice observations and interviews. Interview and observation data was coded using multiple frameworks to explain user needs. First, a grounded method was used to generate themes associated with CDS needs from physicians' points of view. Second, a content analysis was conducted to determine physician CDS needs using an informatics-based taxonomy. Third, a content analysis was conducted to determine users' via a choice architecture framework that has been developed from the field behavioral economics and not associated with medicine and medical informatics. Taken as a whole, the three frameworks enabled the researcher to assess different facets of CDS needs from different theoretical constructs: a bottom-up analysis, a top-down analysis, and an outside-in analysis. Member checks and consults with third-party researchers triangulated data thereby lending greater trustworthiness to the results.

Results: Themes and categories provide insight into the characteristics, goals, tasks, and needs of community-based physicians that can inform CDS design. The CDS taxonomy identified system-specific components and detailing points where users and the system intersected. Grounded theory themes were organized into three facets of community-based care: 1) a self-assessment image, 2) an image of community-based clinical work, and 3) and an image of clinical decision support and the system. Participants provided a physician-based definition of clinical decision support. Additional tools such as "snapshots" were identified as potentially useful CDS functions that supported cognitive work as it applied to community-based care. Choice architecture findings resulted in new approaches to analyzing CDS which is provided in a table of findings, recommendations, and examples.

Discussion: The informatics taxonomy framework provided a simplified view of CDS that did not fully illustrate the iterative and team-based nature of data collection, information use, and knowledge sharing. Interviews and observations provided valuable insights into participants' world views, their views of work, and their views of how the system does and should support their work. The choice architecture provides a useful synthesis that takes a systematic view to integrating culture, human behavior, clinical workflow, and information system operation.

Conclusion: Current CDS tools fall short of meeting the needs of community-based physicians. Users' needs include new tools for safe, reliable, and timely data gathering as well as high-level "snapshots" that inform clinical decision-making and relationship

building. Additional research requires further understanding of the meaning of clinical decision support in order to better meet the needs of users. A user-centered evaluation was a useful, and successful, way to gain insights into community-based practice and how future CDS systems can be of service.

1. BACKGROUND

1.1 CHALLENGES TO PRIMARY CARE: CHRONIC CARE AND MEDICATION SAFETY

The American healthcare system has grown, or careened, itself into a position where 46 million Americans find themselves without insurance, and those Americans that have insurance pay more than double in per capita expenses than the next industrialized nation. In fact, 2005 numbers show that Americans paid $6,401 per capita compared to $2,922 “median per capita expenditure” among 30 industrialized nations. (1)

The comparative difference in per capita costs is just one of many indicators that the American health care system is systemically deficient. At the current rate of growth the American health care system is estimated to account for one-fifth of the national gross domestic product (GDP) in 2018. (2) Projections further out are that health care will account for 31 per cent of GDP by 2035 and 49 per cent of GDP by 2082. (3)

Hoff points to a “troika” (1) of clinical conditions that challenge the delivery of primary care in the United States: obesity, cardiovascular disease, and diabetes. The most recent data on obesity (2007-2008) shows that 34% of adult Americans are overweight, another 34% obese, and still another 6% of Americans are “extremely obese.” The totals represent a doubling in obesity and a six-fold increase in extreme obesity since 1960-1962. (2,3) As scary as those numbers are, since 1971-1974 the prevalence of obesity among children ages 2-5 has doubled, and obesity in adolescents ages 6-11 and 12-19 has increased five-fold and almost three-fold, respectively. (3,4) In 2006, 6.4% of patient visits were due specifically to obesity. (5) Hypertension and hyperlipidemia were the first and third most often chronic diagnoses reported (22.4% and 13%) respectively. (5) Diabetes was the fourth most often reported (9.5%) but the number of diabetics 18 years and older increased by 40% between 1996 and 2006 (See Figure 1). (5)

In addition to above troika of factors, America’s primary care system is burdened by caring for patients who require mental health treatment and assistance with self-managing their mental health and asthma. The two conditions, depression and asthma, comprised 7.9% and 5.8% of all 902 million primary care visits in 2006. (5)

The challenges associated with managing obesity, cardiovascular disease, diabetes, and mental health are all taking place as the American population grows older. Figures from the CDC’s National Center for Health Statistics show that from 1998 to 2008 the proportion of Americans over 65 increased by 15% and Americans between 45 and 64 increased by 37%. (6) Within the same timeframe, patients over 45 increased their total proportion of office visits compared to the general population (49% to 57%), visits in which medications were prescribed (an increase by 31%), increases in the share of imaging tests ordered (26% to 36%), and increases in time spend with physicians (50% to 59%). (6)

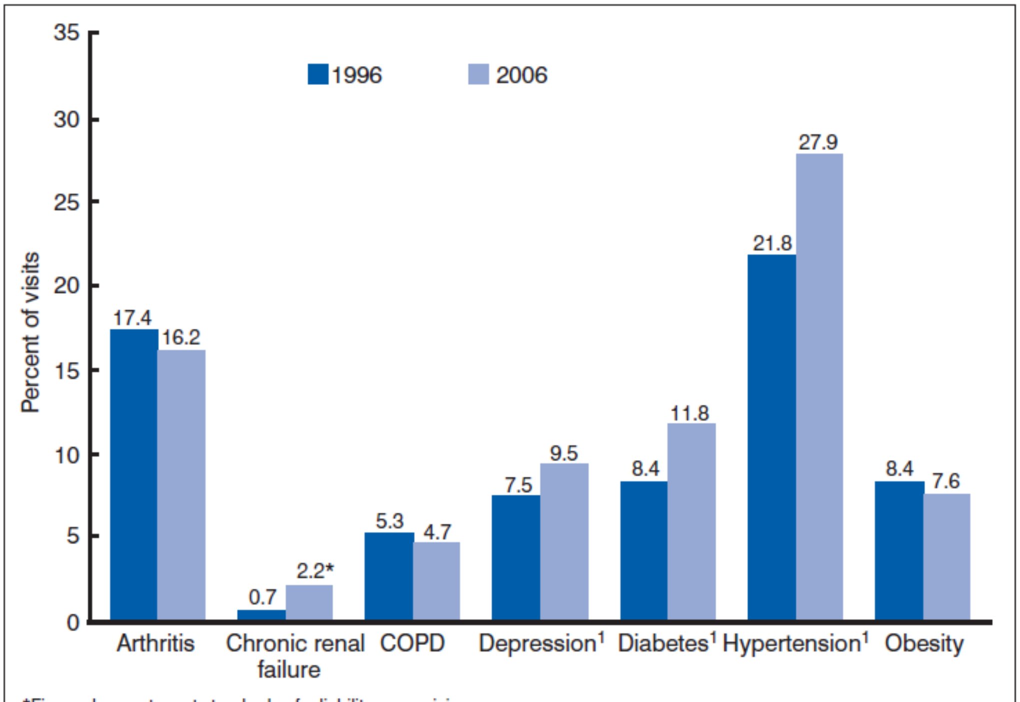

*Figure does not meet standards of reliability or precision.
[1]Difference between 1996 and 2006 percentages is statistically significant ($p < 0.05$).
NOTE: COPD is chronic obstructive pulmonary disease.
SOURCE: CDC/NCHS, National Ambulatory Medical Care Survey.

FIGURE 1: COMPARATIVE PERCENTAGES OF THE LEADING CHRONIC COMORBID CONDITIONS IN THE UNITED STATES (1996-2006)

Population growth has not come with a growth in reimbursement rates for physicians. In fact, Medicare reimbursement rates have not kept pace with private insurance reimbursement rates and the numbers of patients seeing specialists has increased at the expense of primary care. (6) Still, despite the declining numbers, primary care practitioners continue to take on increasing numbers of Medicare patients.

Oft argued is that providers in the United States are incentivized through the fee for service (FFS) model of care, which rewards the provision of *more* health care more than the quality of health care. The two variables, however, have an inverse relationship that may appear paradoxical to many; states that pay more for health care do not receive better quality health care. (7)

As it currently stands, reimbursement levels and health care costs significantly vary by region across the United States but with little to no association with patient outcomes. The phenomenon was famously recounted in Atul Gawande's *New Yorker* article[1] that

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[1] The article had become "required reading" within the presidential administration while advocating for the 2010 health care bill. (8)

described how patients in McAllen, Texas, paid significantly more money for care than did similar patients in Minneapolis, Minnesota, as well as another area within Texas. (9)

Research has shown significant differences in costs of care among regions without correlated benefits or ill-effects that result from those costs. (10-13) For example, Wennberg et al. found that across 306 Hospital Referral Regions (HRR) in the United States, anywhere from 21% to 77% of eligible females received mammograms once over a two-year period as recommended. (10) The authors also found that after adjusting for age, gender, and race fee-for service rates (FFR) in the Miami, Florida region was "nearly two and a half times" greater than FFR in Minneapolis, Minnesota. The authors concluded that "higher" Medicare payments do not result in better quality of health care; and using 1996 numbers, Medicare could have saved $40 billion had high spending HRRs spent at the levels of low spending HRRs.

Recently, June 2010, the Medicare Payment Advisory Commission (MPAC) recommended a model that aligns Medicare payments that address the cost/quality challenge. To drive change in Medicare, the MPAC committee is recommending reimbursement mechanisms that: 1) Award the lowest costs for "clinically similar" services; 2) Link payments to improved "outcomes or the appropriate use of services;" and 3) Demand reimbursement in return for the collection and sharing of clinical data. (14,15) All three mechanisms depend to varying degrees on providers using electronically captured clinical data to inform their decisions around the types of procedures and services they provide.

Medical errors are a costly, and deadly, cause within the American health care system. The Institute of Medicine's publication, *To Err is Human*, brought national attention to the problem by highlighting studies that estimated 44,000 to 98,000 Americans die each year due to medical mistakes.(16) If medical errors were a disease, it would qualify as the eighth leading killer; more than "motor vehicle accidents…breast cancer…or AIDS." (pg. 26) The authors cited Thomas et al.'s (17) estimate that the 1996 costs of adverse events ranged from $37.6 billion and $50 billion, and $17 billion and $29 billion "for preventable adverse events." (pg. 27)

The IOM authors cited James Reason's explanation of slips and lapses as errors of execution as opposed to planning errors[2]:

> "*An error is defined as the failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning).*" (pg. 28)

And they went on to describe adverse events as:

> "*An adverse event is an injury caused by medical management rather than the underlying condition of the patient. An adverse event attributable to*

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[2] Reason J. Human error. Cambridge [England] ;;New York: Cambridge University Press; 1990: pp. 9-18.

> *error is a "preventable adverse event."*[3] *Negligent adverse events represent a subset of preventable adverse events that satisfy legal criteria used in determining negligence (i.e., whether the care provided failed to meet the standard of care reasonably expected of an average physician qualified to take care of the patient in question).*"[4]

The IOM's investigation into adverse events and medical errors focused on hospitals more than on primary and community-based care. The lack of knowledge associated with medical errors and adverse events in ambulatory settings is an often cited limitation throughout the literature.

Noting in their 2007 publication that adverse events in the ambulatory setting had indeed been "understudied," Woods et al. conducted an investigation into how many adverse events are initiated in primary care settings. The authors found that out of 587 adverse events found in Utah and Colorado hospital discharge records, 70 (11.9%) originated in the ambulatory environment and 31 (5.3%) were considered preventable. (18) Extrapolating those results to Utah and Colorado, the authors estimated that every year there are 2608 ambulatory adverse events of which 1296 (44.3%) results in death. Broadening further to include the United States population, the authors estimated that each year 75,000 hospital admits are due to preventable errors in outpatient settings and 2587 result in death. The study also found that most preventable adverse events originated within physicians' offices (43.1%) and that primary care physicians comprised the greatest proportion of hospital admits due to preventable ambulatory errors (31.4%). It is important to note that the authors included day surgery and emergency care numbers in their data. The authors attributed the results to the "distributed nature" of primary care and the lack of shared information that supports coordinated care management. The authors argued that having more readily available patient data as well as improved scheduling, chart management, and lab follow-up information tools could be greatly help primary care physicians. The mix of clinical errors (having readily available patient data) and clerical errors (scheduling and chart management) is another theme that persists throughout the literature on community-based practices.

Prior to the Woods paper, Dovey and colleagues worked to identify the types of errors that most commonly occur in family practice and classify those types of errors to inform future research. (19) They compiled a non-random sample of "reports" from American and then international family physicians to gain an understanding of the types of most common errors. The most reported errors among American family practitioners were, in descending order: 1) improper medication prescribing, 2) following up on labs, 3) losing

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[3] Brennan TA, Leape LL, Laird NM, Hebert L, Localio AR, Lawthers AG, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. N. Engl. J. Med. 1991 Feb 7;324(6):370-376.

[4] Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, Barnes BA, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. N. Engl. J. Med. 1991 Feb 7;324(6):377-384.

or using incorrect patient charts, 4) wrong dose/drug medication dispensing, and 5) not responding to abnormal labs. The findings among American family practitioners had parallels to an international community of family practitioners.

Elder and Dovey developed classifications based on a literature review of primary care-based medical error and adverse events studies. (20) At the time, the authors were able to find only seven studies that addressed errors and adverse events within community-based settings. Elder and Dovey first attempted to reveal "what went wrong" by classifying types of preventable adverse events: 1) *Diagnosis* which described missed or improperly delayed diagnoses; 2) *Treatment* including drug and non-drug treatments; and 3) *Preventive services* that were inappropriate, delayed, omitted, or complications associated with procedures.

In addition to their classification that attempted to answer "what went wrong," Elder and Dovey developed classified types of "process errors" in an effort to answer "why something went wrong": 1) *Clinician factors* including judgment and procedural slips; 2*) Communication factors* between patients as well as fellow clinicians; 3) *Administration factors* which include processes among clinicians with ancillary, pharmacy, and office staff; and lastly 4) *Blunt end factors* that associate preventable adverse events with poor interactions among "insurance company regulations," "funding and employers," and others. The authors criticized the field for not investigating the "prevalence of preventable adverse events and errors in primary care" and argued for including patient perspectives when investigating errors.

Makeham et al. developed the Threats to Australian Patient Safety (TAPS) taxonomy, a three tiered taxonomy that organized reported errors in Australian general practice settings. (21) The authors jointly coded anonymous error "reports" and found, like Elder and Dovey before them, that errors fell into a category around process and two categories around clinical knowledge. (See Appendix D)

Kostopoulou criticized taxonomies like Dovey's and Makeham's for imprecisely categorizing adverse events in non-mutually exclusive categories. (22) She also criticizes Zhang et al's well-known informatics taxonomy for being so domain specific that informatics error types cannot be compared to errors types from other fields. He also criticized Zhang et al's disregard for any environmental and organizational factors associated with medical errors. Kostopolou instead offered a taxonomy based on "psychological mechanisms" that lead to cognitive errors (See Figure XX). Using observations of clinical practices in England and analyzing the data through models from the ergonomics and human factors realm, Kostopolou's taxonomy describes fundamental causes of medical errors in primary care.

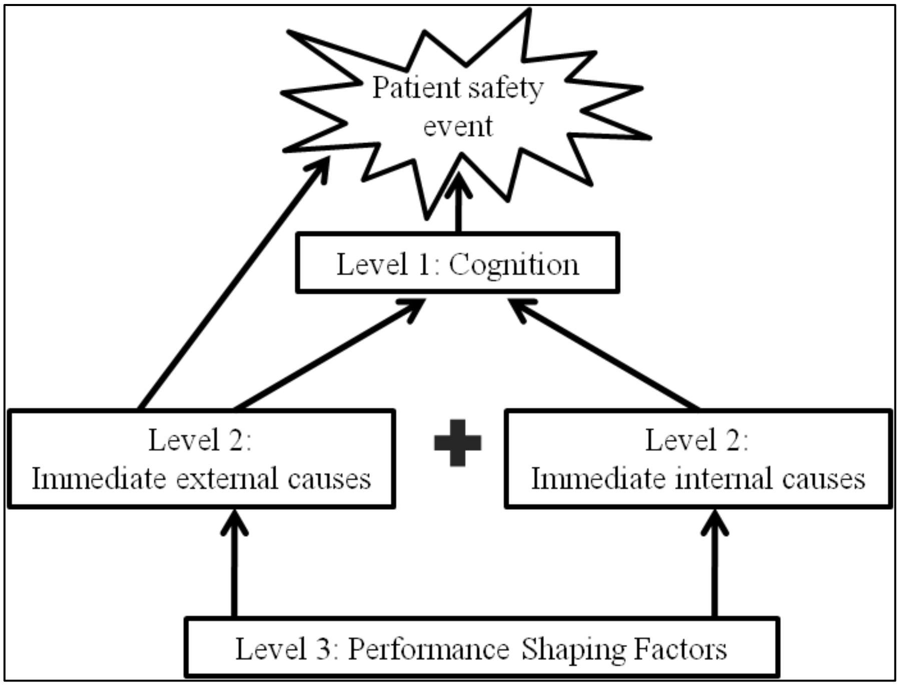

FIGURE 2: KOSTOPOLOU'S THREE LEVEL MODEL OF ERROR IN PRIMARY CARE SETTINGS

Putting it all together, the United States faces challenges associated with an aging population, systematic stressors that result from increasing numbers of patients with chronic conditions, costs associated with inefficient and highly variable care, misaligned incentives within the fee for service model, and new findings about the numbers and types of medical errors that take place in primary care environments. Researchers, policy makers, and clinicians themselves are arguing that electronic information tools in the form of clinical decision support (CDS) technologies can help drive systematic improvement to the health care system in the United States.

Arguments are that EHRs with CDS could, and should, help reduce the variability in health care costs through greater access to best practices and clinical data. In addition, CDS could facilitate shared decision making among patients and providers which, research has shown, leads to “changes in the demand for intensive treatments” that lowers rates of surgery. The Institute of Medicine has consistently advocated the development and use of clinical decision support systems to enhance patient safety and improve the overall delivery of care. (23,24)

1.2 THE AMERICAN RECOVERY AND REINVESTMENT ACT

In its most recent survey, the National Center for Health Statistics (NCHS) reported that 38.4% of responding physicians had “full or partial EMR systems” and 20.4% had “minimally functional” *EMR* systems (including “orders for prescriptions, orders for tests, viewing laboratory or imaging results, and clinical notes”). (25) Those numbers represent nearly 10% and 8%, increases, respectively, over two years. Furthermore, of the physicians who were surveyed in 2008, 17% reported having a basic *EHR* and only 4%

reported having a "fully functional" EHR. Those numbers are quite small when considering NAMCS report found that 85.5% of office visits in the United States had claims that were submitted electronically. (5)

The Health IT Policy Council on behalf of ONC prioritized five areas for improving care delivery at years 2011, 2013, and 2015: (26)(27)

1. Improve quality, safety, efficiency, and reduce health disparities
2. Engage patients and families
3. Improve care coordination
4. Improve population and public health
5. Ensure adequate privacy and security protections for personal health information

Beginning in 2011, the American Reinvestment and Recovery Act (ARRA) will direct $27 billion of Medicaid and Medicare funds to hospitals and eligible physicians to encourage adoption of Electronic Health Record (EHR) systems that meet "meaningful use" standards. (28) Those hospitals and eligible physicians that adopt meaningful use EHR systems between the years 2011 and 2015 will receive bonus Medicare payments to as much as $44,000 and Medicaid payments to as much as $63,750 "per clinician." (29) Providers that fail to adopt meaningful use EHR systems before 2016 will begin receiving diminished Medicare payments. The carrot and stick approach is meant to incentivize physicians to adopt EHRs.

However, as mentioned, it is not enough for physicians and hospitals to only purchase EHR systems. They must use the systems meaningfully which means using the systems to change the way medicine is practiced. To qualify for meaningful use funds community physicians must use an EHR that can perform 15 required functions and out of 10 additional functions, physicians must choose 5. For example, physicians are required report they have implemented and use drug—drug and drug—allergy interaction checking clinical decision support tools, and that over 50% of patients over the age of 13 must have their smoking status recorded in structured format. Optional "menu" choices include drug formulary checks or provide at least 10% of patients with patient-specific educational materials. (29) The 15 required functions and 5 optional functions were reduced from 25 required functions after receiving outcry from the industry. (30)

The United States is attempting to embark on a fundamental realignment of its health care system.

1.3 TYPES OF CLINICAL DECISION SUPPORT IN BIOMEDICAL INFORMATICS LITERATURE

There is agreement within the biomedical informatics field that clinical decision support (CDS) is an important tool that addresses the Institute of Medicine's stated goals: health care that is safe, effective, patient-centered, timely efficient, and equitable. (31) From Clem McDonald's classic paper on "Protocol-based Computer Reminders" (32) to more recent studies, alerts and reminders have repeatedly demonstrated changes to clinician behavior that result in safer medical practice. (33-35) Yet, over the course of informatics history CDS mechanisms such as alerts or reminders have not consistently demonstrated their effectiveness in improving care processes and patient outcomes. For as much as people agree that CDS is an important means for driving improvements in decision making they agree on another thing: doing CDS well is *really* hard. (36)

Greenes argues that the difficulty stems from three inter-related CDS lifecycles that are increasingly difficult to manage as any CDS system is “scaled up” to two or more organizations. (36) The first challenge, according to Greenes, is the difficulty associated with representing clinical knowledge that continually evolves. A second difficulty is effectively delivering CDS to multiple applications across multiple platforms and then keeping up with ongoing changes in those applications and platforms. The third difficulty has to do with building, maintaining, and revising knowledge stored in clinical knowledge libraries. Getting these three areas reliably and sustainably work together requires the cooperative work of people from multiple fields: medical researchers to evaluate evidence-based content, analysts and human factors workers to insure CDS functions fit within clinical workflow, and knowledge engineers who are able to manage content in a world of competing business rules and developing standards.

There are a few “one off” (36) organizations within the United States that are historically known for their development and implementation of CDS: Riegenstrief Institute, Partners Healthcare, LDS/Intermountain Health Care, and Vanderbilt University. These institutions have published extensively on clinical decision support and each is known for their innovations in the field. However, many of the successes that have been reported have had difficulty generalizing their technology and work processes to other organizations.

This touches on a longstanding acknowledgment within informatics that CDS has been evaluated, let alone used, in a limited number of settings. For the most part, CDS evaluations have historically focused on inpatient settings within a small subset of academic medical centers. Shojania et al., for example, found that only 2 of 28 qualifying CDS reports took part in community settings within the US. (37) When CDS results show impressive results, those results were primarily derived from academic medical center studies. In a Garg et al. review of randomized and non-randomized CDS studies, the authors found that 62 of 97 (64%) of reviewed studies showed significantly improved “process outcomes” and auto prompts outperformed manual prompts (success in 73% of trials vs. 47%; $P = .02$). However, 76% of those studies were performed in academic medical centers. Furthermore, the authors found a relationship between successful CDS systems and whether or not the CDS developer was listed as an article author (74% success/developer author vs. 28%/ developer author, $P = .001$) (38) These findings are in line with health information technology literature reviews in general; Chaudhry et al. determined 25% of 257 qualifying studies described derived from four “benchmark” institutions and only 9 studies described commercial systems. (39)

The impact of CDS is widely variable when other settings are considered. For example, literature has shown that alerts are ignored by clinicians 46% - 96% of the time, (40) reminders have limited impact, (37) and alert fatigue is a common end user complaint.

(41) The confluence of ignoring ineffective alerts and reminders, alert fatigue, and end user resistance to such technologies ultimately impairs organizations, *and physicians*, from delivering the safest and most efficient patient care.

Consistent and reliable CDS benefits have been difficult to demonstrate despite years of development. The difficulty stems from a number of factors some of which will be discussed here. First, there is difficulty with controlling confounders such as workflow, users' degrees of experience with CDS systems and/or features, differentiating CDS impact from CPOE or EHR impact, and case severities to name just a few. Two, hospital environments can widely differ from site to site if not department to department. The lack of system uniformity to compare features *in situ* across organizations as well as time, i.e. due to software updates or staffing changes, contributes to the lack apples to apples comparisons. Three, the systems themselves often exhibit different functionalities and layouts which affect user interactions with the computer systems, particularly when those systems are homegrown. (42)

But again, the overall impact that alerts, reminders, and other CDS mechanisms may have on influencing medical practice is less than resounding. For example, from the same Shojania et al. article as listed above, the authors concluded CDS reminders produced "small to modest" improvements in process outcomes such as medication ordering or administering vaccinations. Additionally, the authors found no "specific reminder or contextual features" associated with the improvements. (37) Similar systematic reviews also failed to find drastic improvements in clinician behavior (43-45) and that paper-based reminders could be just as effective as computerized reminders. (46)

Garg et al. once more reported that 62 of 97 (64%) reviewed CDS studies showed significantly improved "process outcomes" but not patient outcomes. (38) The authors also noted that CDS with automated functions outperformed CDS that required users to initiate action (73% success for automated CDS, 47% for manual CDS, p = .02). It was also noted that there was a significant relationship between developer authored articles and reported success and that 76% of the CDS evaluations were conducted in academic medical centers. Kawamoto and Lobach conducted a systematic review of randomized control trials to find any relationships between CPOE systems with any one of fourteen CDS functions and changes in clinician performance. (47) Their meta-regression analysis demonstrated a statistically significant relationship between "automated provision of decision support" and improved clinician performance. However, none of the studies took place in community-based practices. Mollon et al. conducted a systematic review of prescribing CDS. The authors explained that although the identified studies reported improved clinician performance and patient outcomes, statistical evaluation across studies was not possible due to the variability of CDS features and the lack of reported patient data.

A common finding and area of concern as it relates to alerts is that of alert fatigue. As has been mentioned, providers override "drug safety alerts" anywhere from 49% to 96% of cases. (48) Ineffective alerts are so in that the alerts do not change process or disease outcomes for the better. Ineffectiveness is also a result of overexposure in that alerts are ignored. (49) Cash reported an average of 11 alerts per patient per day in a children's medical center. (50) The abundance of alerts was cause for fatigue and ignoring alerts which, because of so many false positives, resulted in missed legitimate adverse drug events (14 out of 700 ADEs).

Krall conducted focus group studies to better understand the nature of alerts on primary care physicians and concluded that for alerts to be effective they must be perceived by users as being useful, efficient, and conducive to clinical workflow. In addition, subjects expressed their desire for decision support that saves time and effort, and if they do get an alert, subjects said they want to know it was time and effort "well spent." (51) When asked their opinions about the factors that are most important to the physicians, the overwhelming response was workflow, more so than alerts. Bates et al. seem to agree and of their informatics "Ten Commandments," the first three were: 1) Speed is everything, 2) Anticipate Needs and Deliver in Real Time, and 3) Fit into the User's Workflow. (40)

Researchers have begun investigating physicians' use of clinical decision support to better understand what, if any, impact it may have on decision-making that is not captured in system logs. As will be discussed in the next section, Weingart et al. found that "ignored" alerts may have a learning effect and therefore alert acceptance rates may not tell the whole story. (52) In an effort to understand what would have greater impact on clinician decision-making than alerts or reminders, it would be beneficial to understand what physicians feel is needed to help them make better decisions. Furthermore, it would be of value to explore the needs of physicians that work outside academic medical centers and beyond the inpatient setting. Yet, a needs assessment of clinical decision support has not conducted among community-based physicians in the United States.

Much more needs to be learned about alerts and other forms of CDS, (53) particularly now that EHRs with CDS are moving out of academic medical centers and into community-based clinics. (*Note: Nationwide, only 4% of outpatient physicians use an EHR coupled with CDS)* (54)

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) provides guidance for ambulatory care information management and clinical decision support. In addition, JCAHO's 2008 standard lists "assess[ing] needs…for knowledge-based information" as one of its standard measures. The standard applies to all ambulatory care health care organizations regardless of whether care is delivered in an EHR, paper-based, or hybrid environments.

JCAHO lists five facets of decision support that encompass clinical care as well as business and financial decision making. First, capturing data and generating reports are required to inform clinical, financial, and business operation decision-making. This relies on the ambulatory care organization to establish "uniform data definitions" that drive data entry, display, and transmission both within and outside organizational boundaries. Second, JCAHO advocates making patient specific and patient population aggregate and comparative data readily available to inform organizational and clinical decision-making. As the standards specify, the data and information are required to be "accurate, complete, organized for data retrieval, and timely (as defined by the organization and specific type of information." A third metric is the degree to which any healthcare organization makes knowledge-based information available to clinicians. Knowledge-based information refers to "clinical, scientific, and management literature" that supports clinical problem solving and "designing as well as redesigning clinical processes." Organizations must insure that knowledge-based information is available during off-hours and in the case of an information system crash. Fourth, organizations should have the means to utilize patient-specific data culled from the EHR. Patient-specific data supports clinical decision-making that helps to meet quality or safety objectives as well as providing secondary benefits such as support legal and financial requirements. Finally, the fifth category that JCAHO identifies as supporting clinical decision-making is making available patient summaries. These decision aids not only benefit patients who may not recall treatment plans once leaving a clinic, but also provides opportunities for clinicians to provide counseling and education.

JCAHO's standards demonstrate that the meaning and purpose of clinical decision support reflects different perspectives and may encompass competing definitions among organizational constituencies. The need to collect financial as well as business data in addition to patient-specific data may present a number of clinical decision support types to physicians. Depending on organizational and clinical requirements, the need to capture, analyze, evaluate, and act upon various forms of information may significantly impact the physician user; especially considering the relatively short duration of time a clinician has with a patient during a typical visit. The JCAHO standards show the criticality of understanding how, when, why, where, and to whom a decision support is offered, in addition to what goal a decision support is intended to achieve.

1.4 CDS IN COMMUNITY-BASED SETTINGS

Bryan and Boren systematically reviewed CDS in primary care settings using seventeen RCT and observational articles from 2000-2006; eight of the seventeen studies were conducted in community-based settings. (55) The authors found a strong majority (76%) of the studies reported improved patient and process outcomes. The authors also reported that definitional variation of "successful" CDS implementations are a barrier to more effective studies, issues around CDS usability's impact on patient outcomes need to be factored, and that much more study of the "ambulatory/primary care setting" is needed.

Publications of alerts and other forms of CDS solely in community-based practices are few in number which is a limitation to current understanding. (53,56-58,52) Yet alerts are a particularly thorny issue that has yet to bring consist changes in user behavior.

Isaac et al. reviewed electronic prescriptions from community-based settings across three states (Massachusetts, New Jersey, and Pennsylvania) to detect patterns and the nature of alert overrides. (59) CDS content was provided from Cerner's Multum product that provides a variety of alert rules including a "three-tier" classification of drug-drug interactions severities. The sample provided "more than 3 million electronics prescriptions" out of which physicians, regardless of specialty, tended to override most alerts. In fact, the range of overridden alerts scaled up to a "20-fold difference" in the types of alerts overridden. The authors discovered patterns in alert overrides and acceptance; for example, physicians were more likely to accept alerts having to do with “interactions between antiarrhythmic agents and antibiotics.” Although physicians seemed to pick and choose which alerts to follow based on levels of severity, “high override rates” were common for variables such as “classes of interacting medications…and patients’ previous experiences with [a] medication.” Isaac et al. concluded that the “utility” of medication alerts in community-based settings “is grossly inadequate” and that “most alerts may be more of a nuisance than an asset.”

Steele et al. looked at drug-lab alerts and compared before and after rates of orders stopped due an alert as well as labs ordered due to an alert. (56) The authors found that the rate of stopped orders significantly increased after the implementation of alerts (5.6% before vs. 10.9% after, p-value = .03); and the number of labs ordered significantly increased, 39% before vs. 51% after, p-value < .001). Although the results were significant, the researchers performed the intervention in only one outpatient setting and carefully wrote the rules with the research clinic in mind rather than implementing an “off the shelf” CDS version. In addition, the researchers performed the 9-month study (16,291 rule firings) in close contact with the CDS developer (Micromedex) and EHR vendor (Siemens). Many community-based outpatient clinics are not likely to have such a close working relationship.

Tamblyn et al. sampled Canadian primary care physicians and compared the prevalence of “prescribing problems” in one group that used computer “triggered” alerts (alerts that automatically care out a prescribed action based on patient data) against another group that used “on-demand” alerts (alerts that require a user to manually take action based on patient data). (53) The authors found that the triggered alerts were viewed more often (10.3%) than were on-demand alerts (.9%), but physicians in both groups ignored large numbers of alerts (75.8% and 90% respectively) regardless of how those alerts were presented. (53) Not only were alerts routinely ignored (that is the physicians felt the benefits to patients outweighed any potential threats, the alerts provided information that was not new or deemed “important”) but the prevalence of prescribing problems between the two groups did not significantly differ. The authors suggested that alerts would have been more effective had they been triggered by patient-specific factors such as age or odds of experiencing an adverse event. Ultimately, the authors concluded that new approaches to “drug alerts,” particularly for commercial EHR systems, are required.

Weingart et al. conducted focus groups and surveys to understand physicians’ impressions of e-prescribing as well as their “perceptions of alerts” and any accompanying behavioral changes due to those alerts. (58,52) The survey responses reported general satisfaction with e-prescribing, i.e. 71% reported “enhanced patient satisfaction,” (52) but in addition, over one-third of physicians reported changing a “potentially dangerous prescription” within the previous 30 days of the survey. However a host of complaints about inappropriate alerts were registered including alerts of “differing severities appearing similar (50%) and “failing to account for appropriate combination use of drugs” (46%). Physicians discussed these alert shortcomings in moderated focus groups. (58) Interestingly, the physicians reported that although they may have “ignored” certain alerts, the posting of the alerts had in fact altered their approach to care such as offering additional patient counseling regarding medication safety. This finding led Weingart et al. to note that rates of "ignored" alerts may wholly reflect the impact alerts may have on behavioral change.

Van Wyk et al reported very different results from a randomized control trial in which Dutch primary care practices were placed in one of three groups: 1) physicians received automated alerts, 2) physicians utilized on-demand alerts, and 3) physicians received no alerts of any kind. (57) The outcome of interest was adherence to published dyslipidemia screening guidelines. The group with automated alerts screened 65% of patients that met the criteria whereas screenings occurred in only 35% of patients in the on-demand alerts and 25% in the control group. The Van Wyk et al. and Tamblyn et al. studies were published in the same year which is likely why they do not comment on each other's results; however, the purpose of the alerts were different (screening vs. prescribing) and the intervention took place in different countries and cultures. Unfortunately, Van Wyk et al. did not provide explanations as to why 35% of physicians in the automated alerts group did not adhere to the recommended screening alert.

As can be seen, VanWyk's randomized control trial is the only study so far that focuses solely on community-based settings yet shows encouraging results. Results aren't as encouraging as VanWyk's even after expanding the cohort of publications to include academic and a mix of community and academic settings. Gandhi et al's concluded that "adverse drug events are common" in ambulatory settings after surveying physicians in academic and community-based practices.

Alerts have not been shown to improve patient outcomes in community-based settings and process-based results have been mixed at best. Aside from the aforementioned studies, clinics with alerts to direct lab orders showed no significant difference from clinics without alerts, (60) clinics with "basic" prescribing technology experienced statistically similar numbers of ADEs as those clinics that used handwritten prescribing, (61) and residents with handheld devices with prescribing CDS performed no better at the end of a study than at the beginning although the control group's performance deteriorated. (62) Only Shah et al.'s development and study of a 3-level classification into "interruptive" CDS and two levels of "non-interruptive" CDS achieved reasonable levels of user acceptance (users accepted two-thirds of interruptive alerts). (63) However, the authors readily acknowledged that the resources required to develop the knowledge base and system are not transferrable to most community-based practices.

To conclude this section, informatics research has some evidence that errors are a "common" occurrence in ambulatory settings. It is critical to develop CDS alerts that people will accept rather than reject. Furthermore, improved communication among providers, their staff, *and* patients may need to support changes to improved decision making. (61,64) CDS developers and implementers should apply interruptive alerts only when interactions of "high severity" occur, provide ways to learn why users override any alerts, and develop systems that allow CDS content to be curated and shared among providers. (63) Finally, the design of alerts require further sophistication so that they account for "patient-specific factors," (53) utilize a mix of default and mandatory options, (61) and allow providers to "suppress" medication alerts for patients who tolerate medications. (65) The current state of EHR-based alerts requires rapid advancement (53,59) and its success depends on understanding “user demands, knowledge base content, and systems design.” (60)

1.5 THE MEANING OF CLINICAL DECISION SUPPORT

As has been demonstrated, it is extremely difficult to fulfill the promise of CDS so that it consistently improves processes and outcomes. (66) Furthermore, the approach to CDS design has been rather limited to alerting and reminding mechanisms. If informaticians are to take new approaches to the design of alerts, reminders, and other forms of CDS, it may be beneficial to revisit what CDS could and should do. That carrying out the implementation of CDS is difficult should not be a surprise to those in the informatics field, but determining what CDS could or should do is perhaps not as simple as one thinks. The *meaning* of the term, “clinical decision support” has had an evolving, if not elusive, definition throughout its history. The following section was submitted to and accepted for publication by the American Medical Informatics Association 2010 Conference.

1.5.1 ABSTRACT

Clinical Decision Support (CDS) is viewed as a means to improve safety and efficiency in health care. Yet the lack of consensus about what is meant by CDS represents a barrier to effective design, implementation, and utilization of CDS tools. We conducted a multi-site qualitative inquiry to understand how different people define and describe CDS. Using subjects’ multiple perspectives we were able to gain new insights as to what stakeholders want CDS to achieve and how to achieve it even when those perspectives are competing and conflicting.

1.5.2 INTRODUCTION

In 1969, Goertzel introduced the concept of a clinical decision support (CDS) system as “a tool to aid the physician in patient care, in data acquisition, and in decision making.” (67) Greenes described CDS as an *action*: “the use of the computer to bring relevant knowledge to bear on the health care and well-being of the patient.” (68) Authors of *Crossing the Quality Chasm* framed their definition by the *types* of decisions CDS is meant to support: “preventive and monitoring tasks, prescribing of drugs, and diagnosis and management.” (31) Shortliffe defined CDS as a “function” of both a *system*, “any computer program designed to help health professionals make clinical decisions,” and its *tools*: “tools for information management, tools for focusing attention, and tools for patient-specific consultation.” (69) Finally, Berner’s CDS definition includes types of potential *users*: “clinicians, staff, patients, and other individuals.” (70)

Any one of the above definitions is not necessarily better than another. However, definitions convey meaning and understanding across constituencies. Based on organizational communication theory, each definition is 1) partial, e.g. “only tells one part of a story;” 2) partisan, reflecting the viewpoint of the author(s), and 3) problematic, generating more questions than answers, and any answers are based on what is known, not on “all that could be known.” (71) How stakeholders interpret the meaning of CDS could impact the way CDS is discussed, designed, and disseminated across research and clinical settings.

The lack of consensus as to what is meant by CDS may represent a barrier to effective design, implementation, and utilization of these clinical support tools. An illustrative example focuses on one type of CDS: clinical practice guidelines (CPGs). Hysong et al. (72) conducted interviews and observations of administrators, middle managers, and primary care providers across 15 Veterans Administration (VA) hospitals to find out if each staff exhibited shared understandings, or “mental models,” of CPGs. Subjects were asked to describe how they interpreted the meaning of CPGs. The authors concluded that each staff within “high-performing” VA hospitals communicated “clear” shared mental models of clinical practice guidelines (CPGs). Conversely, “low-performing” VA hospitals were associated with staff that “lacked clear, dominant mental model[s].” In short, shared understanding of CPGs’ meanings may have facilitated adoption and use of CPGs to improve practice.

Our team explored what CDS means to multiple health IT constituencies, including users, developers, administrators, “bridgers”, and vendors. Using subjects’ multiple perspectives, we were able to gain new insight into what stakeholders want CDS to achieve and how to achieve it, even when those perspectives are competing and conflicting.

1.5.3 METHODS

A multi-disciplinary team of qualitative researchers used an ethnographic method called the Rapid Assessment Process (RAP) (73). RAP relies on a team approach to expedite interview and observation data collection. Audio recorded interviews, naturalistic observations, and questionnaires were collected from a purposive sample of academic medical centers, community practices, community hospitals, and CDS vendors from December 2007 to December 2009. Nine sites (Table 1) were selected based on their reputations as leaders in the development and/or use of CDS.

TABLE 1: TYPES AND LOCATIONS OF ORGANIZATIONS VISITED

Site Visits	**Location**
Regenstrief Institute	Indianapolis IN
UMDNJ	Newark, NJ
Partners HealthCare	Boston, MA
Roudebush VA Medical Center	Indianapolis, IN
Mid-Valley IPA	Salem, OR
Providence Portland Medical Center	Portland, OR
El Camino Hospital	Mt. View, CA
2 clinical content vendors (anonymous)	United States

The research team conducted 183 interviews and observations from December 2007 to October 2009. Forty-six subjects provided either, 1) an explicit definition of CDS; 2) descriptions of CDS; or 3) both a definition and a description. Subjects were classified into one of five roles: 1) Administrators (CIOs, directors, etc.); 2) Technical staff (analysts, IT support, etc.); 3) Clinicians (physician, nurse, etc.); 4) Bridgers (informaticians, content developers, etc.), and 5) Vendors (clinical content vendors). A "best fit" role was selected for subjects with overlapping inter-organizational job titles, roles, and responsibilities. Definitions and descriptions were analyzed using a grounded theory approach. Grounded theory is the process by which data are iteratively reviewed and labels ("codes") are attributed to significant concepts and then organized into themes. (74) Codes and then themes were organized using NVivo Qualitative Software (QSR International, Inc., v.8). We provided written results of our findings to each organization and gathered their feedback. We also conducted a theme analysis to further understand how CDS types may differ according to subjects' roles (Table 2).

1.5.4 RESULTS

We identified the following major themes and issues:

The Ambiguous Meaning of CDS

A number of subjects found that "clinical decision support" is an ambiguous term with an ambiguous definition. One Bridger stated, *"We've wrestled with [CDS definitions],"* and a vendor explained, *"I know personally we're struggling with our definition of decision support."* Some subjects who were responsible for working with CDS asked interviewers for their definition of CDS before they would provide their own. A technical subject said, *"I'd like to ask you to define [CDS] a little bit better...[the definition] depends on what you're using the system for."* A vendor representative specifically responsible for selling

CDS was caught off guard when asked to provide a definition: "*I don't know that I've given it a moment's thought*." The ambiguity that often surrounded the definitions encouraged our team to try to understand how people conceptualize and operationalize CDS within and across organizations.

Decision Support: Alerts, Workflow, Cognition

Subjects defined and described three types of CDS: 1) Alerting CDS such as alerts and reminders that fire to deliver information and interrupt workflow; 2) Workflow CDS meant to ease data entry, documentation, and resource location, and 3) Cognitive CDS that provides a patient management and planning overview.

Alerting CDS was often described as alerts and reminders that are presented at the point of care. A vendor explained, *"I think…an alert is actionable…that fires when certain conditions are met."* Clinical practice guidelines, protocols, or order sets were consistently left out of initial considerations and were discussed only after prompting by a researcher. One administrator told us: *"order [sets]…wouldn't necessarily [qualify] as decision support…they do guide you but they don't give you alerts and reminders."*

Some explained the challenge of alerting CDS is meeting specific user needs: "*over-alerting is a huge problem for us…depending on the practice setting [and] the level of knowledge that [a] practitioner has, they want different levels of information*," and, *"in an ideal world [CDS] would be a system tailored to…individual skills."* Other subjects noted challenges to fitting alerting CDS within specific environments: "*if you're in an oncology clinic, the level of expertise and the doses that are going to be used [is very different than in] a general population.*"

Solutions included recognizing how and when it is best to apply alerting CDS: *"it's that balance between…redundant [alerts] that take time and staying time efficient so that providers will actually use…and value [CDS],"* as well as developing further technical sophistication: *"Decision support needs to become smarter."*

Other subjects viewed CDS less as acute and more as workflow-based in that it provides help for clinical work as well as decisions. Bridgers were aware that CDS can be meant to enhance clinical workflow and they build software tools accordingly. For example, *"once the [physician's] decisions are being made, we actually make it very easy to write patients a letter describing the test results in a patient friendly format."* However, one technical subject described workflow and CDS as if they were different phenomena: *"Workflow is more of a concern [to physicians] than is CDS."*

Clinicians provided descriptions and definitions that emphasized ease of use and workflow. A physician explained, "*…if a patient needs something, I don't want to have to open up another window. As it is now, I have to open up and check the weight; I have to look at their last note to see when that was done. I have to look at the vitals and look at the labs to see when the last lab was done. It takes a long time.*" A pediatrician lamented the emphasis placed on data input: "*Everything is so focused about putting [data] in; nobody talks about what you can get out.*"

Types of CDS that appeared to facilitate workflow included templates and orders sets: "*templates and order sets are 'memory prosthes[e]s' for her…It forces [her] to be clear*," but a physician noted, "*templates limit what you can put in*."

There were also common pitfalls to workflow when using reference materials: "*[The system] lacks a link button to external resources,*" and, "*It is easier for her to use Google*," and this example, "*[the physician walked] across the room to get a copy of 'Facts and Comparisons'…looked up the dose, scribbled a bit on a Post-it note and used a calculator to figure out the volume of elixir that had the same dosage of antibiotic. [When asked] he felt the book was much faster and easier [than Micromedex]*."

A third form of CDS we term cognitive CDS provides users with new insights to the patient's disease state that s/he might not otherwise have. A physician recalled, "*the best tool that I've ever had [was] for follow-up on ordering tests…it create[d] a patient notification form in our system at the same time so if the patient [didn't] get the test…that form pops right up on the desktop and I take whatever action…"* A technical subject provided a counter example, *"some of the practices are taking advantage of [automated] recall letters [and] notifications…That's not really decision support."* The examples illustrate the different perspectives we encountered in our study.

Other process-based support includes functions that facilitate communication. An observer noted, *"his first example was contact with other doctors – this was a form of CDS."* A technical subject included messaging when asked about CDS, *"some clinical staff will go into the system just to do phone notes."* Another technical subject explained how software supported the processes involved with team-based care: *"[Groupware]…not only provide[s]…a focal point for interaction that we can use across time and space…[it] also provides a historical record…"*

Subjects consistently attempted to define and describe distinctions among different types of CDS. One vendor described a categorical view of CDS as either *"actionable"* CDS or "*impact"* CDS. Actionable CDS is *"added into the workflow in such a way that the clinician does not need to stop the basic processes of...assessing, coming to decisions…it's just THERE*." And "*impact"* CDS is *"available, but it does require interruption of the workflow."* Another vendor differentiated between a lower level "*management*" CDS: *"a decision may have been already made to give a medication. And so having…dose checking will tell you maybe you're outside of the normal dose range,"* and higher level of "*leadership"* CDS: *"Are you doing the right thing? Should you have even given that medication to begin with?"*

TABLE 2: NUMBER OF RESPONDENTS SORTED BY ROLE WHO MENTIONED EACH TYPE OF DECISION SUPPORT (DS).

Role	WORKFLOW CDS	ALERTING CDS	COGNITIVE DS
Admin (N=12)	8	10	8
Bridger (N=9)	7	7	5
Technical (N=5)	3	3	5
Clinician (N=11)	8	3	6
Vendor (N=5)	3	4	3

How CDS operates: Explicit vs. Implicit

Subjects described system designs and clinical scenarios that at times called for "*explicit"* CDS that made clinician users aware that the system was offering support. For example, a technical subject described explicit CDS that reacts to a user's order entry: *"something that looks at the electronic medical record…then based on rules determine[s] the answer to certain questions,"* and *"[CDS] assist[s] the provider based on information [he or she] collects and provides them with a list of rule outs, [a] list of possibilities for diagnosis, or treatment plans."*

In contrast, subjects described system designs and clinical scenarios that called for "*implicit"* CDS which subtly supports clinical decision-making. One clinician provided an example of implicit CDS: *"clinical decision support to me means that there [is] some automated process in the background that helps direct me to do a clinically relevant—safe—appropriate task…"*

Some subjects included administrative reporting as implicit CDS. These reporting systems gather data from different clinical systems (e.g., number of patients seen, treatments provided, and hospital outcomes) away from clinician users and present it to healthcare administrators in ways that inform resource allocation. *"I…started getting information from their decision support system to help them make funding decisions for the next fiscal year,"* and, *"sometimes you do clinical decision support on how you bill."* Some administrators felt that *"financial decision support"* is a form of CDS that takes into account aggregate clinical information and is reviewed long after the patient interactions have been completed.

CDS Philosophies: Straightjackets vs. Guardrails

Subjects within individual organizations explained shared meanings of CDS that revealed different philosophies behind the design and development process. An administrator described his organization's philosophy: "*[we] believe in [CDS] guard rails, not straightjackets.*" Furthermore, his organization holds the philosophy that *"CDS [is] neither a carrot nor a stick but a guide for doing the right thing."*

"Straightjackets" represent a view that CDS can restrict clinicians in their decision making, often for the purpose of standardizing care: *"when [CDS] stops you from doing something or it points out something to you that you hadn't thought of…teachable moments."* Straightjackets can represent external mandates that are meant to improve patient care: *"[the] critical lab alert with [JCAHO is] driving everybody crazy…you hav[e] to send out alerts to physicians on critical labs that…are outside of normal but not unexpectedly outside of normal."* And a vendor noted that legal threats result from not following manufacturers' guidelines: "*when [an alert] is not right, then it's an over-message. But all we need is one patient goin' south…[and then] we get into court."*

The "guardrails" metaphor represents a view that whenever possible, CDS design should place bounds around potential decisions rather than alert incorrect decisions. One subject stated, *"I wouldn't say it's necessarily changing [users'] decision[s], it's helping them mak[e] the right decision at the right time,"* and *"decision support that we have is very subtle…[users] see and act on it but they don't really acknowledge it as decision support."* Guardrails may require approaching CDS differently: *"you could give [users] an option to write…an additional dose or you cannot give that option…what you're doing is pushing people toward [a decision]…by making it much more difficult to order a dose…."*

This is not to say that guardrails are useful while straightjackets are not. On the contrary, the two philosophies may complement one another. In fact, a physician described CDS as a combination of the two in that CDS both *"guides me [and] restrains me."*

1.5.5 DISCUSSION

From their multiple perspectives, study subjects conveyed broad definitions and descriptions of clinical decision support which reflect the variety of goals people ascribe to CDS. Paradoxically, subjects appeared constrained by the term itself in that it was not precise enough to describe the variety of goals users wished to achieve.

We discovered that subjects in different organizations had been having internal discussions to define CDS. In our interviews we ran across subjects that had to first ask us to clarify what *we* meant beforehand. The variety of meanings attached to a single term could make it difficult for people within organizations, research teams, and across industry to speak the same language. It is important to clarify what CDS means so that people do not fall prey to competing or conflicting assumptions that may impact CDS acceptability, assessment, and use.

Our findings reveal that subjects from across disciplines and organizations have similar needs to distinguish different types of CDS: acute, workflow, and cognitive. Alerting CDS can be considered "traditional" CDS that is most familiar to informaticians and industry experts. Yet a number of subjects described a need for *workflow CDS* that helps them achieve their day-to-day tasks more easily, efficiently, and safely. Cognitive CDS describes yet another approach to CDS, one that enables a provider to get a snapshot of a patient's disease state in order to support patient management. The field needs to explicitly recognize that different aspects of clinical work that needs to be supported by different types of CDS. The three types work hand-in-hand: the data that drive alerting CDS will not be collected if clinical workflow is significantly impeded; workflow CDS will not be optimized if users lack the tools to timely develop patient plans; and cognitive CDS operates poorly, if at all, without the data that inform it. We also found that distinctions are to be made between CDS that is implicit and CDS that is explicit.

A number of subjects described a CDS philosophy from within the bounds of alerts and reminders. Yet they acknowledged that these mechanisms were not always ideal forms for distributing decision support. The subjects were aware that acute alerting and reminding could be burdensome to users and that care needed to be taken to insure each alert provided value. Administrators expressed opinions that "value" would be gained with "smarter" CDS that accounts for the abilities and experience of users, and that the mark of beneficial alerts and reminders is whether or not they are found to have value by users. For example, an alert that could be considered valuable is one that provides a "teachable moment" to a clinician. Measuring the usefulness of subjective "value," however, brings about unanswered questions of how best to empirically measure it.

External and internal standards were described as a factor that drove the continued use of alerts even to the point of over-alerting. The Joint Commission requirement to alert for abnormal labs, even expectedly abnormal labs, was cited as such an example. Vendors noted the difficulty of managing alerts so as not to cause alert fatigue, yet noted that the presence of alerts provided protection from malpractice suits that could be brought against un-alerted physicians. Of note, the mention of malpractice did not arise in interviews or observations with any of the other groups.

Other subjects seemed to favor a philosophy of decision support that was oriented toward guiding clinicians to "make the right decision at the right time." Designing subtle CDS was held out as a "third way," beyond the common "carrots and sticks" that organizations often use to increase CDS adherence. The philosophy of guidance seeks behavior changes through the use of default options, templates, and order sets.

A limitation of this study is that although all transcripts and fieldnotes were coded by multiple researchers, the subcoding of the "meaning" theme was accomplished by the first author only.

1.5.6 CONCLUSION

A multiple perspectives approach provided valuable insight into how stakeholders have varying definitions and descriptions of CDS. Our research shows that use of the term "clinical decision support" may not adequately describe the types of clinical activities that are practiced in clinical environments and health care organizations that could benefit from computer-based support. Furthermore, through multiple perspectives we describe alternate meanings to CDS that have not been expressed in previous informatics definitions. Further research is needed to understand how people attribute meanings to CDS and the impact they may have on CDS acceptance and use.

1.5.7 ACKNOWLEDGMENTS

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1.6 NOT OF ONE MIND: THE BRAIN'S COGNITIVE INTERPLAY IN DECISION-MAKING

That people attribute competing and conflicting meanings to CDS hints that people are looking for the same tools to address different problems. Rather than attempt to define CDS and attribute the same term to different categories, it may be helpful to first understand human decision-making so that CDS can be built to support particular modes of decision-making.

The goals of medical practice go beyond diagnosis and medical decision-making to practice management, communication, and coordination. To date, however, CDS has been designed primarily for inpatient settings and for aiding diagnostic and ordering activities. Outpatient settings may require different or additional forms of decision support to improve health care quality and safety. For example, de Lusignan argues that primary care is distinguished from inpatient care by "three core activities" (75):

1. A reliance on heuristic decision-making more than deductive decision-making
2. Application of a "biopsychosocial model," not a "biomedical model," of patient care
3. Primary care scientific evidence guides the practice of patient-centered care

If the practice of primary care has different goals and utilizes different decision-making skills than inpatient settings, then it is important to gain an understanding of what those differences may be and how they impact decisions. Our understanding of clinical decision support and how it should be designed will be enhanced by a greater understanding of human reasoning and decision-making in general; it relates to the issue of what aspects of medical care is clinical decision support designed to support. Therefore this section provides a high-level overview of human reasoning and decision-making. With greater knowledge we will be able to investigate distinctions among decision types and how people utilize those types to achieve different goals.

Traditionally, philosophy, economics, and even medical informatics have modeled the human brain as a cognitive organ that is in conflict between the "rational" and irrational. (76) The bias has been to improve human performance through rational, thoughtful, or contemplative thought. For over thirty years, however, cognitive scientists have been finding that the brain is not composed of rational and irrational forces. Furthermore, people naturally do not innately digest information, weigh potential costs and benefits, and then choose the option that is most beneficial for them. This may appear counter-intuitive to those who have for years touted the benefits of evidence-based medicine and that if providers are shown evidence of successful or unsuccessful treatments then those physicians will change their practice accordingly. As has been shown, alerts, reminders, and other forms of CDS have had mixed results in changing clinician behavior. Cognitive scientists would argue that the results should not be all too surprising given how the brain operates.

1.6.1 THE NEUROLOGY BEHIND MAKING CHOICES AND DECISIONS

Bernard Balleine from UCLA describes decision making as a complex interplay of cognitive processes. (77) Actions and consequences are "encoded, retrieved, and maintained in working memory." In addition, motivators include any associated "value…of actions or a sequence of actions." (77) What stands out about this description is how complex cognitive processes are carried out in working memory, and that working memory is further taxed by simultaneously, and/or in parallel, weighing the value associated with an action or actions. This appears like quite a lot of brain work occurring in isolation; let alone the sensory and cognitive demands of a dynamic clinical environment.

Neuroscience is endeavoring to understand the complex processes involved in human decision making. Whereas past models focused on "structural" challenges, which I take to mean research into physical structures and anatomy, the contemporary approach is to investigate the "functional" processes that go into decision making. Certainly new tools such as functional magnetic resonance imaging (fMRI) have impacted how neurological researchers approach decision making, but so too has a recognition that the human brain does not rely on any one cell type or region for decision making. Rather, the brain relies on a system-wide network to manage the variety of cognitive-based and value-based motivators that go into decisions.

Researchers have begun to focus on particular regions of the brain, both human and non-human, to understand its workings. For example, some researchers are beginning to look into the orbito-frontal cortex (OFC) and its ability to not only use "predictive cues" to make judgment values but also the OFC's ability to weigh "values across distinct event categories." (77) Another area of research concerns itself with the "corticostraital circuits" and their dopaminergic effects. Other researchers have been discovering interesting connections between basal ganglia that go beyond their import in sensorimotor learning to contributing to reward systems by enabling humans to take goal-oriented actions.

Within medicine and informatics, Cohen describes how the complex interplay among the nucleus accumbens, OFC, hippocampus, and neurotransmitters regulate emotion and memory to drive rapid ("phasic") or deliberate ("tonic") decision-making. (78) Further still, Martinez-Selva and Sanchez-Navarro point out that emotion is a powerful force that alters the brain's perception of risk, reward, and uncertainty. (79) Sittig observed that computer-provided order entry (CPOE) systems cause primarily negative emotional responses that endanger CPOE installations (80) and warranted the inclusion of "emotion" questions in future CDS implementation surveys. (81)

Cognitively it may be a misnomer to describe many CDS tools and functions as "decision support" because, what some neuroscientists would argue, those tools do not account for fundamental differences between decisions and choices. Choices are actions that can be explained when presented within a context of alternatives. Perhaps it's better to directly quote Schall who explains, "a choice at the most fundamental level is an overt action performed in the context of alternatives for which explanations in terms of purposes can be given." (82) Choices aren't deliberated or debated, choices are just made. And provided that a human is given a set of alternatives in a specified context, a set of choices can be predicted.

In psychology and economics, a choice is instead termed a "utility". Choices that provide an actor a reward are described as "positive utilities" and choices that deliver punishments are described as "negative utilities". (79) Different areas of the brain respond differently to positive and negative utilities. The OFC is described as the reward center of the brain and humans as well as primates often seek out or manipulate their actions to satisfy the OFC.

Unlike choices, decisions are more difficult to predict; in fact, Schall argues decisions are distinguished by the fact that their results can't be predicted. The difficulty associated with decisions stem from the lack of available information available that in turn hinders a person from choosing between a known set of alternatives…or, "choices". Decisions require deliberation, perhaps debate, but most certainly judgment before taking action. So essentially, choice is about action and decision is about the process before an action is, or can, be taken. Schall notes that once a person says he or she can make a decision, then a decision has already been made.

Finally, Schall distinguishes *actions* from choices and decisions because action is the physical manifestation of intentions and achieving goals. Actions can be segmented into "basic actions" which humans "do" but can't explain. For example, humans may point to something on a list to indicate a preference. The human can't explain how they moved their finger, they just moved it. "Purposeful actions" are carried out when performed within a certain context so that the actor may achieve a particular goal. An action that happens by happenstance, such as bumping into someone, is not an action but is rather termed an "event". This paper, however, will not wade into the argument of what constitutes a choice or decision as it relates to CDS and so will continue to refer to decision making throughout.

Research from neuroscience reveals that the human brain uses a variety of systems to arrive at decisions that lead to actions (or inaction which is itself an action). Although fMRI studies have not given us an ability to peer into the world of the brain and its ability to make decisions, enough has been learned to show that the mind works very differently than philosophers, economists, and perhaps informaticians have assumed. To simplify the analysis, one can consider the brain as an organ that relies on three different systems to make decisions: reason, emotion, and morality.[5]

1.6.2 REASONED DECISION-MAKING

When people think of the human brain and how it differs from brains of other species, they perhaps point to its ability to reason. This is undoubtedly true, for humans are able to plan ahead to consider ultimate consequences, and reason to solve problems from landing a rover on Mars to developing safe and effective clinical decision support technologies. These capabilities and qualities are unique to human beings and set us apart from other species in the animal kingdom.

The ability to reason comes from one remarkable source: the pre frontal cortex (PFC). The PFC is larger and more developed in humans than any other species and it is that advanced development that makes us who we are today. The PFC is the great thinking machine of the brain that enables humans to reason and think through their actions both as events are taking place and just as importantly, if not more so, envision actions *before* events occur. The PFC carries out its responsibilities by coordinating and at times commanding the other parts of the brain to do its bidding. This “top-down control” (84) is possible because of a special set of brain cells called prefrontal neurons.

Prefrontal neurons enable humans to engage in “volitional” thinking that helps us think through actions. I will use a hypothetical scenario as an example. Say that during a surgery the carotid artery is accidentally severed, one response a surgeon could have is panic and unsettle others on the surgical team by dropping her instruments and screaming, “Aaaaaaaah! The carotid artery is severed! Oh no!” (or some other expletive). Such would be an “automatic” response (84), driven by her parietal neurons, and likely would not do much to help solve the problem of repairing the severed carotid artery. Fortunately, many surgeons are trained and have the experience to not react in such a way. Our surgeon would utilize her prefrontal neurons to calmly state what occurred, what is happening, and what next step should be taken to rectify the situation. The purposeful use of volitional thinking and not automatic thinking in highly stressful situations is referred to as, “‘deliberate calm’.” (83) It is encouraging that this skill is teachable and that it is being taught through programs such as the Crew Resource Management (CRM) protocol which encourages problem identification and solving (“see it, say it, fix it”). CRM has been expanded and studied in multiple health centers and has shown “meaningful” changes in performance and staff communication. (85)

It is the calm, deliberate thinking that many think about when thinking about “reason” and “appropriate” decision making. Unfortunately, as many know, the PFC is not all powerful and all knowing. If it were, there would be little need for clinical decision

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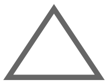
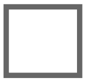
[5] This approach to understanding human cognition is nicely laid out by Jonah Lehrer in *How We Decide*. (83)

support. The PFC benefits each of us in that it directs us in purposeful thought. However, purposeful thought can be interruptive in and of itself when one tries to carry out repetitive tasks and/or tasks that need to be conducted without mental effort. For example, Chuck Knoblauch was an all-star second baseman in Major League Baseball. He was for a time considered one of the most reliable second baseman in the league when unexpectedly his throws to first base (a routine play for a second baseman) became consistently errant. This cognitive phenomenon is referred to as "choking" and describes how conscious thought can interfere with "automatic" performance. (83,86,87)[6]

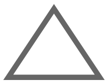
The PFC also demands quite a bit of energy to function at its best. Gailliot et al. found that blood-glucose levels regulated a person's ability to "override one's thoughts, emotions, urges, and behavior." (88) Given the finding perhaps a physician's drink of choice should be sugar water and not coffee. The brain falls prey to a host of other shortcomings if its PFC is not properly calibrated with other sections of the brain: a person can make two different decisions on the same data depending how those data are presented ("framing"). (89-91) It can be fooled into eating more depending on the size of the portions presented ("mental accounting")[7]. (92,93) The PFC can be tricked in thinking that more information always leads to better decision making but in the process become overloaded. This phenomenon is a well-known limitation of human "working memory" which Miller showed that the "amount of information" the brain can store averages seven "chunks" plus or minus two. (94) Johnson-Laird's work supports Miller by theorizing humans use mental models in the interest of using as little working memory as possible. (95) He posits that humans are "parsimonious" in that they try to fit as much information in as few mental models as possible. Perhaps this explains professions' love of acronyms (biomedical informatics included). Johnson-Laird's work over the course of his career has demonstrated that humans do not innately rely on formal logics to understand the world to arrive at decisions. Laboratory experiments have shown results that support his model theory. For example:

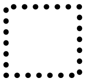
Conjunction says "there is a triangle *and* a square" (p26) is one model





Disjunction says "there is a triangle *or* a square" is two models.





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[6] See Lehrer, "How We Decide", pg. 138.

[7] Interestingly, nutritionists' intake of ice cream at an ice cream social increased as serving sizes increased

Model theory provides "corroborative evidence" that conjunction statements are easier and faster for people to process because they can be explained using one model instead disjunctive statements which contain two. Also, "negative premises" (95, pg. 26) are harder and slower to process than affirmative premises, i.e.

Negation: "It is false there is not a triangle"

Affirmation: "It is true there is a triangle"

Furthermore, model theory demonstrates another model to consider when dealing with negation:

"it is not true there is a square and a triangle"

Accuracy of subjects found that model theory could predict the rank degree of difficulty for "connections" based on the number of explicit models required by each (p27-28).

TABLE 3: TYPES OF INFERENCES THROUGH FORMAL LOGIC

Inference Type	**Examples**	**Level of Difficulty**
Conjunction	And, If	Easiest
Disjunction	Or	Difficult
Negation conjunction	Not both…and…	Most difficult

Other types of reasoning include "relational" and "quantifying"

TABLE 4: TYPES OF INFERENCES THROUGH MENTAL MODELS

Branches of Deductions	
Propositional	Connectives
Relational	On the right of, Father of
Quantification (syllogisms)	None, Any, Some

Research shows that mental model theory better explains deduction than formal theory. This has the following implications: 1) People correlate deductive reasoning to their real-world experience(s); 2) people require models in order to reason about them (they have to have a "vision" of something before they can assess that something; 3) Beliefs and prejudices can impact deductive reasoning because people look for more alternatives to propositions/models that conflict with their beliefs and prejudices than if these beliefs and prejudices agree ("deductive satisficing"). It is important to consider or remember that the importance of models is that they provide structure on which to base deductions, ("their structure corresponds to that of situations") and not that they may produce visual representations.

Syllogistic inference research has demonstrated that "one-model problems are considerably easier than those that call for multiple models." (p36) Mental model theory also explains why subjects make propositional errors: they fail to consider all possible logical outcomes because the reasoning process typically ends once a model satisfies a proposition.

Furthermore, Johnson-Laird describes the differences between the types of reasoning humans are able to undertake: deductive reasoning (make information-based, evidence-based decisions, monotonic reasoning) and inductive reasoning (real-world experience, general knowledge of the world). (96) He argues that in the absence of deductive reasoning to commit action, humans fall back on inductive reasoning (real-world experience, general knowledge of the world, non-monotonic reasoning). Both types of reasoning have historically been used within science.

TABLE 5: COMPARING DEDUCTIVE AND INDUCTIVE APPROACHES TO SCIENCE

	Scientific Laws (Induction)	**Scientific Theories (Deduction)**
Specific	Describes a specific instance of a phenomenon	Explains specific instance of a phenomenon
General	Develops a generalization that describes a phenomenon	Develops a generalization that explains a phenomenon

Johnson-Laird declares there are three general stages of induction that parallel the three stages of deduction. The first stage "is to grasp some propositions, some verbal assertions, or perceptual observations." (pg. 64) The purpose of the second stage is to take the data that has been grasped and to "frame" hypotheses or a hypothesis that explains the data "in relation to a background of general knowledge." (pg. 64) The hypothesis is truly a result of induction if the conclusion's semantic information "goes beyond" (pg. 65) what is contained in the premises. If a conclusion results from valid premises *and* background knowledge then the conclusion is a form of deduction call, and "enthymeme." An enthymeme is a deduction that contains premises; it's just that those premises are unstated. Third, a person "evaluates" (pg. 65) that conclusion and revises it, maintains it, or does away with it. Those are the general principles of inductive reasoning, but Johnson-Laird goes further and describes distinct induction types.

Johnson-Laird notes that an explanatory model is a valuable and powerful tool for inquiry because it goes beyond describing something which, in itself, is a form of simulation. He states, “You can describe a phenomenon without understanding it, but you cannot explain a phenomenon unless you have some putative understanding of it.” (pg. 66)

As Johnson-Laird points out, the rules of formal logic are so restrictive and limited that computer scientists have looked for other methods of “machine reasoning”. (pg. 12) Johnson-Laird comments, “If human beings are to perform more skillfully, and if machines are to be clever enough to guide them, then we need a better theory of both the strengths and weaknesses of human inductive competence.” Furthermore, Marvin Minsky, a leader in the field of artificial intelligence (AI) said, “’logic’ is the word we use for certain ways to chain ideas. But I doubt that pure deductive logic plays much of a role in ordinary thinking.” (pg. 12)

So if not with logic and reason alone, how do humans make decisions?

1.6.3 EMOTIONAL DECISION MAKING

It turns out that the PFC is not the brain’s ultimate decision-maker. Other sections of the brain are responsible for the “automatic” thinking that guides much of human daily life. Automatic thinking is rooted in emotion. As previously noted, Martinez-Selva and Sanchez-Navarro describe emotion in medical decision-making as a powerful force that can alter the brain’s perception of risk, reward, and uncertainty. (79) Emotion is a consideration when implementing computerized provider order entry in clinical settings. (80,81)

Sites in the orbital frontal cortex are generally referred to as the limbic system of the human brain, and it competes with the PFC for a person’s attention. The limbic system comprises the “central dopamine (DA) systems” (97) that use dopamine to communicate with one another and other parts of the brain, including the PFC. The brain uses dopamine to generate the feelings we feel: pleasure, disappointment, sadness, ecstasy. If for some reason the PFC is damaged but the limbic system is intact, a person will be ruled by his or her emotions and chase after whatever whim comes into mind.

At the heart of the limbic system is the Nucleus Accumbens (NAcc) which generates dopamine when it perceives that a reward, or risk, is imminent. Its spurt of dopamine traverses pathways to the anterior cingulated cortex (ACC) where particular neurons pick up on the levels of that dopamine. (98) Recent research shows that the neurons in the ACC are sensitive to the amounts of dopamine and are particularly sensitive to stimuli that are novel. (99) Depending on the level of excitement, the ACC sends signals of varying ranges to the thalamus where the PFC consciously associates the reward or risk with a salient experience. (83) The ACC also signals the hypothalamus which creates a somatic response, i.e. increased pulse and sweaty palms. Working against the NAcc, which begins the cascade just described, is the insula. If the insula perceives a loss is imminent, and not a reward, then it will act to suppress whatever rewards the NAcc may be so excited to share. In the brain, the insula is the police to the NAcc’s fraternity party.

The brain uses dopamine and its associated emotions to dictate a how a person responds to events in the world. It is a highly sensitive system in which the ACC continually adjusts expected rewards. If the ACC is disappointed that the reward isn't as great as expected, it downgrades expectations for the next time that same reward is offered. In short, the systems that drive emotions are systems that enable people to learn.

The limbic system provides human beings with a number of advantages. First, it is fast. The limbic system allows humans to carry out tasks quickly with reasonable expectations those tasks will be rewarding or rewarded. That leads to the second advantage of the limbic system, it is always learning and gauging. This enables humans to evolve over time as personal or environmental circumstances themselves evolve. Third, humans benefit because the continuous learning takes place on an unconscious level, for the most part, and frees the PFC to use its limited working memory to go about making conscious decisions. And lastly, although perhaps most importantly, the limbic system provides humans with insights into events or scenarios that just don't "feel right." If a patient presents with normal labs and an unremarkable history, yet the doctor feels that something's amiss, it is his limbic system that is telling him so.

As may be expected, though, the parts of our brain that drive our emotions can be manipulated if not hoodwinked. One example of this is termed the "endowment effect" in that people endow value to an item they might lose more so than the objective value of the item itself. (100) This phenomenon repeated in different circumstances with different subjects even after subjects were given "learning opportunities" to develop a better sense of value among items. Unlike rational economic theory which predicts purchasing behavior modulates around supply and demand, cognitive scientists find that people hold onto what their possessions even when offered more than the possessions are worth. (101,102) Another effect is termed the "status quo" bias in which people consistently agree to stay with options that are pre-selected. People determine there are costs to changing from the status quo and therefore resist change to avoid those costs. (103)

The aforementioned biases are common traps for human emotions and make up what a class of biases termed "loss aversion." (104) Kahneman et al. explain this behavior as a result of two influences: 1) rather than being motivated (or not motivated) by perceived value, people are cognizant and hyperaware of change, and 2) People are much more protective against potential losses then they are open to taking gainful risks. These behaviors run counter to rational economic theory which predicts human decisions are motivated by costs or pricing alone. Instead, subjects take into account social and psychological factors when making their decisions. The research lends intriguing insights into how people make decisions when interacting with one another and the world.

1.6.4 MORAL DECISION-MAKING

Moral decision-making is a third facet of decision-making that Lehrer singles out. (83) Human beings are intensely social animals. The physiological need to establish and maintain human contact is a powerful force that has a logic all its own. What helps people maintain relationships a certain code of ethics; Lehrer argues that the human code of ethics is founded upon humans' advanced ability to sympathize with one another.

Therefore, moral decision-making is not centered on the self but rather on how other people feel.

The brain that feels sympathy is furnished with particular areas that enable humans to connect socialize with one another: the superior temporal sulcus, the posterior cingulated, and the medial frontal gyrus. (83) These systems together with the chemicals vasopressin and oxytocin drive humans to seek out and maintain relationships. The drive is so strong that to deprive someone contact with other humans is a form of abuse. Social isolation leads to behavioral difficulties, substance abuse, and death. (105) Given humans' desire to be connected is perhaps no surprise; but what may be unsettling is that the decisions that guide morality are *first* driven by emotions and *second* by rationalizations. In this case, rationality is used to that explain and justify that what was first felt. This is very unlike what philosophers, religious theorists or social scientists have argued throughout history; that the moral brain pauses to weigh evidence and consequences before deciding what action to take.

The takeaway at this point is that the brain is hard wired to first feel good and performing moral acts often makes a brain feel good. This phenomenon has been observed in primates (106) as well as humans. Moll et al. found significant mesolimbic activity in the human brain when making donations while being recorded by an fMRI. This area of the brain also happens to be the area that reinforces rewards for "food, sex, drugs, and money." (107) The authors concluded their findings support the presence of linkages between "social cooperation" and "culturally shaped moral beliefs." (107) Walter et al. review a number of social cooperation studies using fMRI including one often-conducted study that demonstrates reciprocity among players in both western and "non-western" societies. (108,109)

There are limits, however, to the humans' moral decision-making abilities. First is that to sympathize requires one to read and understand, within varying degrees of proficiency, the expressions of others. Humans who lack the ability to read others' expressions often have difficulty with moral decision-making. People with these difficulties most often have underdeveloped amygdalae.

In a study Brotman et al. claimed was the first of its kind, adolescents with ADHD, bipolar disorder, and severe mood dysregulation were compared to healthy adolescents in their abilities to interpret facial expressions of fear and hostility. (110) Based on previous research, the authors hypothesized that fMRI readings would show amygdala hyperactivity in bipolar subjects relative to those with healthy subjects, and amygdala hypoactivity in those with severe mood dysregulation relative to healthy subjects. Previous studies like Brotman et al. had not been conducted on those with ADHD. The researchers verified their hypothesis that children with severe mood dysregulation would exhibit hypoactive amygdala activity when presented with facial expressions of fear and hostility. However their hypothesis that amygdala hyperactivity would be significantly different among the bipolar disorder did not pan out; instead, it was the ADHD subjects that exhibited amygdala hyperactivity. Despite its limitations, the study showed significantly varying levels of amygdala activity among subjects traditionally known to have difficulty with social interactions.

When taken to the extreme, those with amygdala that are so damaged as to not work at all become sociopaths. Sociopaths lack the ability to feel sympathy of others and therefore have no qualms making immoral, abhorrently immoral, decisions.

A second limitation of the moral brain is that its altruism comes to bear mostly when it comes face-to-face with another individual in danger of being harmed. (111) People have been shown to donate money more readily when presented with the case of a single person going hungry than nations going hungry. (112) It is this quirk that we sympathize with the few and not the many that has such devastating consequences on charitable giving. Humans are spurred into action by the prospect of helping one particular person but become overwhelmed when faced with a mass of statistical data.

1.7 UNDERSTANDING THE USERS

Software engineering concerns itself with knowing users in order to develop the most effective software possible. Software engineering is a "discipline" concerned with the design, development, and maintenance of software (See Figure 3). (113) Its concerns are different than computer science, which is focused on "themes and methods" (113) behind software; and systems engineering which is a longstanding discipline concerned with higher level aspects of system use, such as policies that define a system's use within the greater environment. Software engineering focuses on software and its real-world design, development and use.

Software engineering employs models that structure the design of software. These models inform and communicate capabilities of current software and requirements for new (hopefully improved) software to software developers. This is a stage in software development referred to as "requirements engineering," and takes place early in the overall software development process (although it may iterate throughout that entire process).

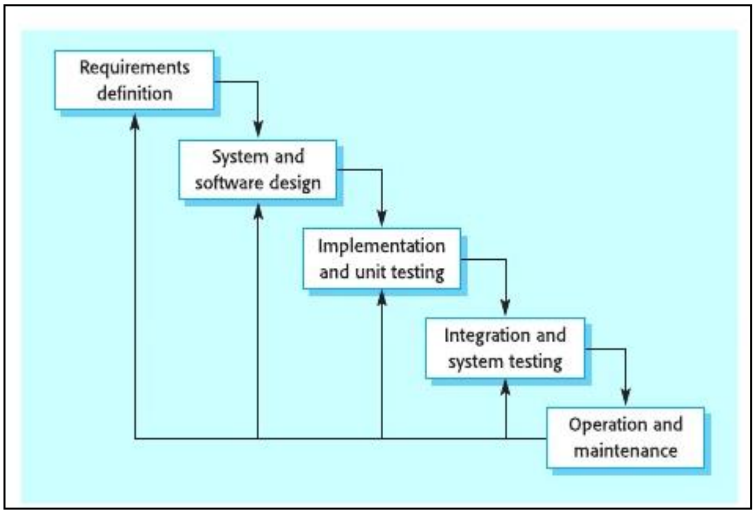


FIGURE 3: WATERFALL SOFTWARE DEVELOPMENT MODEL

In short, requirements engineers endeavor to understand the state of current software, learn what is needed from any new software, and then synthesize and translate what is known into understandable and *actionable* aspects of new software development. The challenges of the work is developing software that often operates within larger and complex socio-technical systems, must be design in ways that are economic and achievable, and wins the trust of its ultimate end users and purchasers (most often not one in the same).

Software engineering generally consists of four stages: 1) Feasibility study, 2) Requirements elicitation and analysis, 3) Requirements specification, and 4) Requirements validation (See Figure 4). (113) In general, feasibility studies attempt to conclude whether or not current software meets ser and organizational goals. Although the background section of this dissertation is not a textbook feasibility study, it has demonstrated to a large degree that current CDS software does not meet the requirements of end users and organizations. Therefore, requirements elicitation and analysis (REA) is warranted. REA's purpose is for engineers to gain understanding of how people work and try to achieve end goals.

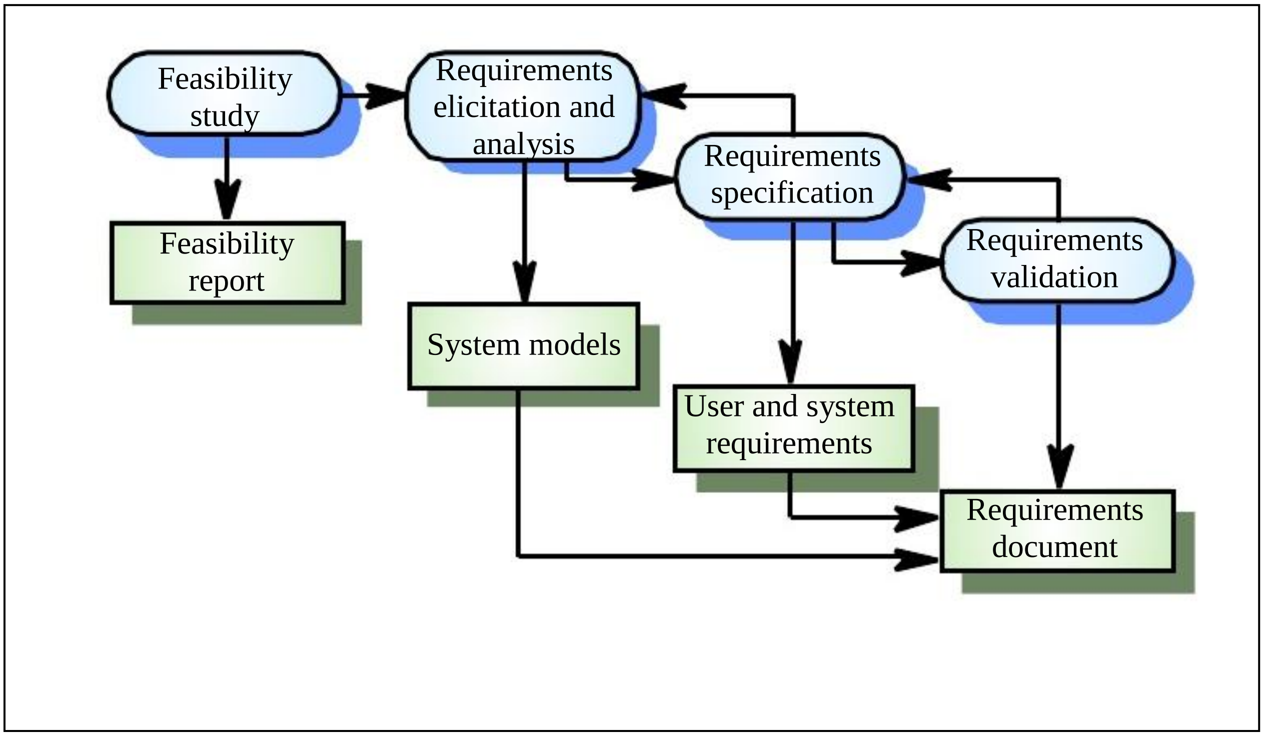


FIGURE 4: SOFTWARE DEVELOPMENT WATERFALL MODEL

Interviews and observations (ethnography) are often-used methods for gaining understanding about work and whatever software could, or should, do to support that work. Toward this, software engineers face two overarching challenges: 1) How best to elicit user-needed software features, and 2) How best to communicate users' needs to software designers and developers.

1.7.1 ELICITATION THROUGH INTERVIEWS AND OBSERVATIONS

Sommerville highlights two strategies for each method to help engineers gain that insight.(113, pg. 153) The use of scenarios in interviews is one way that interviewers can get subjects to discuss the shortcomings of current software as well as any ideas for bettering future software. Interviewees may find it difficult to think about new system features without grounding comparisons to a current system, in this respect scenarios can be quite beneficial. Scenarios themselves can also help communicate needs to software developers and help structure all phases of the software lifecycle including implementation prioritization. Observations and interviews may employ a strategy that accounts for multiple perspectives (113) of a system's use. Comparing and contrasting viewpoints from different system users can help engineers identify varieties of system requirements or how competing interests may place unexpected, and unintended, demands on software.

Grounded theory methodology is a well established observational technique within the biomedical informatics field. The overarching goal of the method is to investigate meaning within the world through subjects' perspectives through the researcher's own acknowledged perspective. By exploring meaning qualitative researchers delve into hidden assumptions associated with a bounded phenomenon such as what is it like to be a first-year resident, or phenomena like how do people conceive CDS. The qualitative researcher uses inductive reasoning in the attempt to create or derive understanding out of that which is unintelligible. (114, pg. 148)

The approach was developed by Glaser and Strauss (115) in an effort to shift the researcher's focus away from preconceived theory and to generating theory from the data itself. Also, frustrated with the perception that quantitative work was the sole valid approach, Glaser and Strauss argued that qualitative work provides useful and reliable theory. (116) Taking what were implicit practices among sociologists, the authors developed a methodology that systematically collects and analyzes data, and then from that process, generates "rigorous" theories. (115, pg. 243)

Addison provides an excellent overview of the grounded approach he took to develop theories around the experiences of first-year family practice residents. In short, the researcher first must identify a problem and "frame" (115, pg. 151) that problem in such a way that makes qualitative study an appropriate method for addressing that problem. Next, the researcher prepares materials for data collection: interview guide, observational strategy, sample identification, and plans to validate the data collection and analysis that is to be performed. In addition the researcher strives to make explicit as possible any and all assumptions so as to acknowledge and consider one's own biases. This process, also known as reflexivity, helps the researcher understand where he or she may encounter "blind spots" in their observations or to discover areas that require further study and preparation.

Once preparations are complete the researcher goes into the field to collect data. Considerations while in the field include carrying out the data collection such as developing observation notes that include appropriate location and time information, notes that are written in present tense format, or employing interview techniques that are meant engage interviewees and give them the space to fully express their responses to questions. The researcher is responsible for recording as soon as possible any impressions, thoughts, or feelings that resulted from an interview or observation session.

Editing and interpreting the data is carried out by "immersing oneself in data" (117) and focusing analysis around that data. Approaches can differ according to what the researcher strives to discover: a phenomenological approach looks to identify underlying philosophical structures; a constant comparative approach looks to identify recurring patterns within the data. (117,118, pg. 117)

Throughout the research process the investigator should be consulting and testing findings with others inside or outside the project. This confirmatory step, often referred to as triangulating, is carried out by collecting feedback and critique from peers. Feedback and critique are also expected from the subjects themselves and this step is referred to as, "member checking."

All of these steps are carried out iteratively. The researcher may revise data collection strategies, expand or retract the study sample, or revise theories as analysis is carried out. Miller and Crabtree like the process to a "dance" that oscillates from editing to formulating ("crystallizing") theory as the research project develops. (119)

1.7.2 COMMUNICATING REQUIREMENTS

The second challenge REA engineers face is how best to communicate discovered needs to software developers. The most common way is to model the existing system or the idealized system, whichever is the focus. (113) Sommerville states that models are traditionally driven by any of one of four "perspectives":

1. External
2. Behavioral
3. Structural
4. Object

The external perspective attempts to define the bounds of any system and its place within the physical environment. Defining the bounds can be difficult because a system may cross geographic, legal, and/or organizational boundaries. For example, the bounds of an EHR system extend outside the patient room to the clinic, the healthcare network, and (perhaps one day) a National Health Information Network.

The behavioral perspective models systems and how they carry out their operations. Two behavioral models include the “data flow” and the “state machine models. Data flow models represent systems and how they pass data along longitudinal pathways to carry out a process. State machine models structure systems as entities that respond to internal or external stimuli, such as power up a computer. The models represent systems that differently handle data.

The structural perspective describes models view systems through the structure(s) of the data they handle. The Entity-Relationship-Attribute (ERA) model is the most well-known data model. It represents components as objects (entities) with defined interactions (relationships) and possesses certain qualities (attributes) of those objects and interactions. ERA models have been useful because their object-oriented approach fits well with object-oriented programming. Another advantage with modeling data rather than a system is that data can be stored and organized in a data dictionary that can be useful for knowledge management.

Finally, the object-oriented perspective represents a hybrid of behavioral and structural perspectives. Models of this sort (inheritance, aggregation, and object behavior) represent not only data structures but also provide an understanding of how those data are operated on within a system.

Each of the aforementioned perspectives help to organize software requirements into a synthesized whole that can effectively communicate requirements to software programmers and engineers. However, a common quality of all four perspectives is that they model aspects of a *system*. Certain developers and designers over the last 15 years have been arguing that relying solely on system-based perspectives and models discount the most important actors of any system, the people that use the system. It is with a user-centered perspective in mind that REA has begun to model users, their characteristics, behaviors, and goals. This shift in perspective has resulted in models referred to as, “personas.”

1.7.3 USER-CENTERED DESIGN AND PERSONAS

Leading informaticians have argued that attaining user input in a software design process produces increased chances that that software will be meet the needs of those users, increase the likelihood users’ intent to use the software, and be open to changing their behavior. (120)

Effective software design, development, and implementation are aided by knowing end users and their tasks, behaviors, and goals. Many from the field of human-computer interaction (HCI) argue that user models are pivotal component of successful technology use. Models in general provide a mental framework around which large amounts of data can be formed into concepts, and relationships among the concepts can then be analyzed, visualized, and communicated. User models have been developed to help organize data gathered from user interviews and observations, and then explicate user characteristics, behaviors, and goals. (121)

Early in HCI history, Rich described an electronic version of a reference librarian, named Grundy, which could surmise patrons' reading interests. (122) She argued that ideal human-computer interfacing could not be achieved if the computer did not have means for modeling the user it was to interact with. Rich attempted to model humans by accumulating a library of human *stereotypes,* "clusters of characteristics", that could be enacted when set off by an appropriate *trigger*. (122)

Since the Rich article a variety of user models have been put into practice with the goal of providing software engineers an understanding of the end users. Aquino and Filgueiras (123) outline a number of user modeling techniques that are meant to inform software engineering teams about end users; such as, "user roles, user profiles, and user segments." First, u*ser roles* are abstractions of human populations and their "characteristics, needs, and behaviors", with the understanding that any one person can play multiple roles or many people can play one role at the same time. Its application in modeling clinical users could be, for example, a doctor who plays the role of "authority figure" with some patients and of "caretaker" with other patients. The different roles could be cause for alternative design considerations. Alternately, *user profile* models combine categorical demographic information such as age, gender, and education, along with fictitious personal information layered over. User profiles rely on stereotypes which are distinguished by categories defined by the researcher rather than characteristics defined and described by the user. Lastly, *user segments* model user interactions with "a system" and how the system should react in kind. Aquino and Filgueiras explain that each of the three models are informed by some form of human data yet the models' results are often so highly abstracted that their reliability can be questionable, particularly for developing and describing user scenarios meant to inform software engineers. (123)

Designer and author, Alan Cooper, makes the counterintuitive argument that highly abstracted user models that describe a broad segment of users ultimately impair usability and software design. (121) He argues that designing technologies for broad swaths of users only complicates the final products with increased cognitive load on users being a main result. For example, an electronic health record (EHR) interface that is designed to target pediatricians, OB/Gyns, and family practitioners is bound to satisfy none or dissatisfy all three groups of users. Each group has specific characteristics, behaviors, and goals. Cooper argues that the most effective approach would be to "design for *specific types of individuals with specific needs* [emphasis in the original text]." (121) Rather than spending effort designing technologies for everyone, designers and engineers should spend energy doing the following: 1) understanding the *needs* of representative users of defined constituencies; and 2) prioritizing design elements that address the *needs* of primary users while not significantly burdening "secondary users". (121) The *persona* user model, commonly referred to as "personas", addresses both of those points.

Personas are a type of evidence-based user model primarily derived from qualitative data as well as a mix of qualitative and quantitative data. (124) Personas attempt to provide "a precise descriptive model of the user, what he [or she] wishes to accomplish, and why." (121) A persona is a model of a particular user, an archetype, which provides greater in-depth background of the end user than would a workflow or organizational model. The development of *personas* is universally attributed to Alan Cooper (125) who had originated the use through his experiences in software development. However, precursors to the persona model were born out of the design and marketing communities as far back as 1955 with Henry Dreyfuss writing about "human engineering" for stereotypical end users, Joe and Josephine. (126) However, these fictitious users in decades past often lacked the depth and detail that personas provide. As Adlin and Pruitt note, "personas…seem like real people." (127) HCI researchers are rapidly adopting personas to inform those with who have few interactions with end users (software engineers, administration, project managers) and guide the development of new technological tools.

The purpose of personas is to communicate user requirements and needs to software developers and stakeholders. Personas are neither meant to describe quantitative averages of populations nor user self-descriptions transcribed verbatim from interviews. Personas are rooted in data collected through interviews and observations, with perhaps supplementary quantitative summary data, and expanded to describe user characteristics, behaviors, and goals. The power of personas is that they convey to developers stories of how end users live and work. The narratives are intended to paradoxically dispel the notion of the "end user" and instead demonstrate to developers that technology is being built for a range of humans who have different needs.

Design researchers argue that better understanding of the end users results in software tools that meet the needs and goals of the end users. People have invented different approaches such as participatory design (128) and contextual design (129) attempt to tap user insights to identify needs. Software engineers may assume that they are "user centered" in their design but often lack the data to support their assumptions. Assumption-based design causes many difficulties including: 1) conflicting goals among designers and developers that can reduce a focus of effort in not efforts that are at cross purposes, 2) software tools and technologies that meet the needs of the designer more than the end user, 3) end products that do not meet end user needs and/or wants.

Only one study was found that empirically tested the use of personas. (130) Already assuming that personas were of some value, a classroom of design students were split into three teams within three groups that were given specific materials to inform a project design: 1) an image board and a brief, 2) a brief and a picture-based persona, and 3) a brief and an illustration-based persona. Outcomes of interest were usability heuristic scores across the three groups, and between the two persona teams, scores from a persona recall test were compared. The results showed that teams using photo-based personas met four times as many heuristic requirements than the teams without personas, but the recall scores between the persona teams were not statistically significant (average score 20.6 vs. 18.4). Follow-up focus groups revealed that teams using personas felt they were able to develop consensus quickly because if questions arose around design then they could use the persona as the ultimate arbiter.

Personas tell fictional, yet meaningful and memorable, stories that convey end user qualities and needs to designers and developers; the very people who are tasked with developing technologies and tools yet often have little, if any, opportunities to meet with or interact with end users. Adlin and Pruitt argue personas provide advantages to the design and development process: 1) Personas reduce the amount of guesswork as to how users would or would not appreciate functionalities designers want to offer, personas "make assumptions and knowledge about the users explicit; 2) personas help designers focus their efforts on design elements meant for a specific segment or segments of users; 3) personas appear to "engender" empathy among designers for the end users. (127) Cooper argues that personas protect against three errors designers make: 1) conforming the "user" to designers' assumed or "presupposed" opinions, 2) developers or designers "self-referencing" themselves by thinking users share a similar, if not the same, mental model; 3) designing according to what users are capable of doing as opposed to prioritizing design decisions based on what users want to do. (121) The potential benefits of personas are that they provide precise user-centered information that ground design decisions in terms of, "what would user X think about option Y?"

Given the history of informatics and clinical decision support, personas may represent an important armamentarium in the researcher's toolbox. A number of well-known applications were written with the developer in mind or the with the developer's conception of end user needs. A plethora of tools such as Shortliffe's MYCIN or Miller's ATTENDING anesthesia critiquing program met the needs of the researchers but were unsuccessful when transferred to "real world" users. This phenomenon may be reflected in Garg et al.'s (38) systematic review of clinical decision support applications. Those authors found that over 75% of clinical decision support tools were deemed "successful" when the software developer was also an author of the very article that deemed the outcomes successful. Garg et al. surmised that the involvement of the developer with the subjects could have impacted how well the system acted. However, when developers were not one of the authors (I'm assuming that means the developers were not part of the analysis) their CDS systems fared much worse. The gap might be due to developers providing assistance and context for users of successful systems, and not being able to provide assistance and context for users of unsuccessful systems. The difference in results may be explained by developers not having accurate enough understanding of the end users, and so when the developer is not with the users providing guidance, the users fail in carrying out their tasks.[there are many potential sources of the bias between developer and non-developer evaluated systems]

Personas are amalgamations of end users who have been interviewed and observed. Those that might be considered to be interviewed or observed are who the researcher finds represent intended end users of a technology. Ideally researchers identify their research subjects based on preliminary data gathering that can include all or parts of the following: background literature research, introductory interviews, discussions with stakeholders, discussions with experts, and discussions with organizational sponsors.

McGinn and Kotamraju argue that quantitative methods develop "families" of personas more cheaply and authoritatively than qualitative methods. The authors surveyed identified users of interest and used factorial analysis to bunch the data into groups of prospective personas. They then conducted phone interviews to validate their quantitative models and revised their personas accordingly. Although McGinn and Kotamraju felt the personas provided faster and cheaper results that were based on "real customer data", the authors did not address the fact that their initial survey was developed without interactions with the end users. Therefore, it leaves the question as to whether the personas were reflective of the users' needs or reflective of the researchers' needs.

Personas are primarily developed through interviews and observations. The ethnographer translates his or her experience with and among the subjects to inform software developers, stakeholders, and others involved in the design of clinical decision support tools. Cooper argues that personas must reflect a range of users ["similar enough" users for each persona?], rather than average users, in order to understand behaviors when given a technology within a prescribed context. Just as a qualitative researcher may want to recruit a range of subjects for maximum variability among users, Cooper calls for developing a "cast of personas".

Holtzblatt (131) points out that after interview and observation data are analyzed, researchers are often intimately familiar with the subjects and have developed rich insights into how those users "tick". It can be difficult translating that rich information to others outside the circle of researchers such as software developers or external stakeholders. Researchers can use their intimate knowledge of subjects to "bring [the,] alive" (131) through stories about users that remain grounded in data.

Holtzblatt also explains that persona building first occurs by identifying typical user "practice roles" (132) based on the different ways in which different people carry out similar tasks. Second, the researcher identifies the subjects that best exemplify each persona. Third, the researcher finds other subjects that appeared similar to the core persona and fills in the story with tasks, values, and "life story elements". Fourth, the researcher rounds out the persona by including a representative photograph of the user and by attributing "typical tasks, roles, goals, and other practice characteristics" (132) that were collected through interviews and observations.

If seeing and watching user behavior is the basis for personas, then understanding user goals is the basis for understanding user behavior. Cooper expands on Goodwin's (133) three goals that should be included in persona models. First, "life goals" such as a physician wanting "to make a difference in Americans' health," may not have direct application to EHR or CDS design but it does provide a context to understand broad user goals. Cooper compares "life goals" to the "deep drives" a person may have. Second, "experience goals"

Personas are introduced to the development team, or teams, during the requirements analysis phase yet can provide an anchor throughout the entire development process. Proponents point out that personas provide common understanding to developers at times when it is not certain what software tools should be developed and how those tools should work. Rather than the designer assuming or trying to guess what the end user desires, personas provide a data-driven representation of user qualities, behaviors, and goals. Such knowledge acts as a guide throughout the software development process.

1.7.4 IDENTIFYING AND DESCRIBING THE USERS

Hoff conducted a qualitative inquiry of 95 primary care physicians in New York to understand from their points of view the state of primary care, “their careers, everyday challenges, work experiences, and adaptations as a group of professionals working with an evolving model of service delivery.” (1) The investigation covered how the changing landscape of health care is placing severe demands on the ground in primary care clinics among those with whom Hoff spoke. An overriding theme in the book is that primary care physicians are more and more often finding themselves having to conduct more care coordination activities, more paperwork, and meet more guidelines in fewer minutes every day. The problem is further compounded in that physicians are only reimbursed for their “procedural work” and not the “cognitive work” (pg. 30) that frequently goes into helping patient navigate a treacherous health care landscape.

EHRs had become common among subjects in the midst of all this rapid change. Subjects, even once-enthusiastic adopters, however, had become jaded about EHR systems and what they represent. According to Hoff, many physicians resented EHRs’ use of templates that are not specialty specific and perceptions that they degraded the quality of notes. Clinical decision support and its frequent alerts and reminders were also considered a nuisance. Furthermore, physicians complained that the systems with ill-designed data capturing mechanisms required them to take more time out of their days (and nights) to chart. Participants resented the expectation that they take on the additional work because it was considered just a part of their job, even if compensation did not accompany that additional work. Subjects felt the use of EHRs increased documentation demands as well as patients’ demands for more rapid and more frequent communication.

The changes that EHR systems represent were coupled with the developing model of the “medical home” which positions the primary care physician as a liaison between the patient and the health care system. Hoff explained that the physicians were leery of the model and considered it another “fad” (pg. 178) rather than a fruitful restructuring of primary care on behalf of physicians.

Bagley and Kibbey argue that EMR systems, in combination with a “computerized practice management system” (CPMS), improve practice management and workflow. EMR clinical and billing data can be integrated for “improved accuracy and timely submission of bills to appropriate payers.” (134) It is interesting to note that the authors note the primary advantage of an EMR system is that it streamlines the billing process. Secondarily, the authors note that EMRs can capture “additional useful information.” The secondary benefits are listed as: “inventory control” and “efficiency” and “productivity” measures that reduce patient wait times and track practice outputs.

Bagley and Kibbey point to CDS as an enabler of medication reconciliation, drug-allergy, drug-drug interactions, as well as providing additional prescription information a doctor may require “at the touch of a screen or with a single keystroke.” (134) However, the authors allow that not all EMR alerts are “clinically significant” but still the alerts give clinicians the ability to make their own judgment about the severity or correctness of the alert. The authors also explain that EMR systems provide more accurate and thorough record keeping for prescriptions and office visits than with paper records. Another benefit the authors describe is the shareability of EMR-based records which provides coordination with pharmacists, patients, staff, and "subsequent care providers." (134)

Rakel notes that the "decision aids" are valuable because "questions about drug dosages, side effects, indications, and interactions are among the most common questions the family physicians have a point of care." (134) Of note, though, that Rakel never uses the term "clinical decision support."

FAMILY PRACTICE

As far back as the 1920s arguments for a generalist approach to medical care was advanced in contrast to decades of increasing medical specialization.[its only worsened since then] Mills and Willard published their report on the "Rise of the Generalist" in the 1950s and the growing trend eventually led to the founding of the World Organization of Family Doctors (WONCA) in 1972. (135) Perhaps it was at this point that the field diverged from: 1) "Internists" medical practitioners that were geared more towards laboratory-based studies and focused on adult as well as OB-Gyn issues; and 2) "Family Practitioners", those more geared towards clinical observational studies, behavioral population studies, and family focused issues including pediatrics. (136)

Family practice is "a field of medicine that provides care regardless of "age, sex, race, religion, or social circumstances." (pg. 4) Rakel views the FP as a specialist who takes in all patients regardless of condition and uses a variety of clinical, psychological, and sociological to meet the healthcare needs of patients. Furthermore, he argues that physician satisfaction has an important relationship with patient satisfaction. (pg. 4)

The family practitioner's (FP) model of care may significantly differ from "traditional" medical teaching that often derive from teaching hospitals. According to McWhinney and Freeman, the "biomedical model" (136) is an "old model" of medicine that unnecessarily constrains the medical decision making process into a reductionist process that utilizes differential diagnosis to isolate an organ system for treatment. Although the biomedical model may have advantages in identifying acute conditions, the model isn't as useful when dealing with chronic or systemic disease. The FP supposedly finds that a more "holistic" approach to patient care is required; an approach that accounts for a patient's social factors and social, familial, and physician relationships. This viewpoint is labeled a "biopsychosocial model" (136) to patient care.

Behavioral science has had an important role informing health care delivery in family medicine. It has made the practitioner "the objects of study" (pg. 8) and places focus on the decision-making and prescribing practices of family practitioners. In addition, behavioral sciences have lent insights into "doctor-patient relationship[s], family relationships, and the behavioral aspects of medicine such as…concepts of health, disease, and illness, the role of the physician, and the ethics of medicine." (pg. 8) In addition, behavioral sciences brought into light considerations of environmental and societal impacts on disease and, ostensibly, patient outcomes.

McWhinney and Freeman argue that one, if not the most, distinguishing characteristics of Family Medicine is the “transcendence [of] the mind and body” duality. (136) The transcendence of physical and psychological is an outcome of relationship-based care. Blurring the mind/body dualism also requires family practitioners to take account more for patients’ emotional needs than other medical practices; and furthermore, the mind/body synthesis also directs attention of the emotions back on the physician himself or herself; “attention to emotions is a requirement.” (p 17) As such, a high premium is placed on the relationship between the FP and patient to engender trust.

Hjortdahl (1992) studied continuity of care as it relates to the development of patient-doctor trust and discovered the duration and “density” (frequency of contact) logarithmically increased doctors’ sense of responsibility over a span of five years (sense doubled in one year and had a 16-fold increase by the end of five years). (137) Continuity, or the sense of continuity, is an important factor for both patient satisfaction and physician decision making. (138,139)

Rakel provides a brief overview of how FPs utilize evidence-based medicine through electronic resources. The resources appear geared more towards addressing general information needs rather than patient or context specific information. InfoRetriever and DynaMed are the only two noted commercial resources electronic repositories commonly used by FPs. However, other resources are available. For example, the Family Physicians Inquiries Network (FPIN) is a resource through which FPIN members can pose clinical and practice management questions to the community on a case-by-case basis and receive answers and suggestions. FPIN’s mission is to provide evidence-based answers to 80% of physician questions within 60 seconds. FPIN provides two resources to its information. First, it provides access to all physician questions and evidence-based answers via its publicly accessible online library named, “Clinical Inquiries” library Second, FPIN provides a commercial product named Portable Electronic Physicians Information Database, Primary Care Plus (PEPID PCP) which combines “Clinical Inquiries” [what about UpToDate, available at OHSU?]

INTERNAL MEDICINE

The American College of Physicians, the largest organization of general internists, distinguishes internal medicine from family medicine in that the focus is solely on patients who are adolescents and adults. Neither do general internists treat children nor do they “deliver babies.” (140) As far back as the turn of the twentieth century the field combined an attention to adult care and laboratory science. (141) During the 1950s, as previously noted, internists’ foci deviated from a general need to focus on general family and pediatric health issues which family practitioners began to address. This trend was accelerated during deliberations throughout the 1960s as to how to grow the medical field in light of population needs, workforce challenges, and instituting Medicare. (142)[internal medicine focus seems to be on chronic disease]

McWhinney and Freeman see any distinction between the fields of internal medicine and family practice as one rooted in “administrative and political differences.” (136) Yet internists see themselves set apart in part because of their focus on the adult population but also in part because of their training. Internists spend a minimum three years of their post-residency training in adult medicine. (141) Furthermore, internists may not only provide general patient care but also subspecialize: cardiology, endocrinology, and gastroenterology, and more. (143) One may say that any distinction between internists and family practitioners is that internists tend to specialize within the patient whereas family practitioners tend to expand beyond the patient to family and relationships.[good!]

Research does not convincingly demonstrate that the different approaches to patient care impact diagnosis and referral practices[what about outcomes or quality of life?]. In 1987, family practitioners and general internists' diagnosis patterns were directly compared across three test cases: dyspnea, abdominal pain, and syncope. (144) The authors found that internists utilized more data than family practitioners which accounted for greater numbers of hypotheses. However, the accuracy of final diagnoses was not statistically significant among the groups of internists and family practitioners. More recent research has shown that likelihood of referrals tends to rely in part on specialty and also physician gender and, perhaps most importantly, patient-case mix. (145,146) Doroodchi et al. compared family practitioners and internists' answers to cardiovascular disease (CVD) "vignettes" to understand the use or non-use of guidelines. The authors found that guideline adherence was primarily driven by years in practice or if the provider estimated 25% or less of their patients had CVD. The only significant difference internists and family practitioners displayed in relation to the CVD vignettes was to not apply anti-platelet therapy (internists followed the guidelines more than family practitioners). (147)

Family practitioners and internists take different approaches to practicing medicine as well as the types of patients they typically see. Although there may be subtle differences in how diagnoses and referrals are carried out, or how information tools are used, the two specialties have much in common. Both family practitioners and internists approach patients with a goal to treat the whole person and both provide patients with coordinated and longitudinal care.

OBSTETRICS AND GYNECOLOGY

The practice of OB/GYN has over time developed into its own subset of primary care. Dr. Douglas W. Laube argues that there is a clear distinction between OB/Gynecologists and family practitioners in primary care (pg. 3). His argument is that because family practitioners provide services to all members of a family regardless of age, condition, or gender; they therefore don't have the expertise in providing women-specific services. OB/GYNs possess specific knowledge and skill to address female health within the primary care setting. It is an interesting argument because the case is made that the OB/GYN arena of primary care demands a generalist who is also a specialist.

The needs of women vary according to high risk factors and variables associated with age (pg. 5). The Guidelines for Women's Health Care divides age ranges into four groups: 1) 13-18, 2) 19-39, 3) 40-64, and 4) 65 and older. (148) Clinical needs such as patient screening or counseling evolve as women grow from one group to the next. The focus on age ranges is used to inform clinicians as to the particular requirements for screening, immunization, and counseling. This represents a shift in care away from episodic and acute treatments to long-term patient management. And as the patient population grows older, there will be an increased need for preventative care, and perhaps a reduced need for obstetric care. (148)

Gynecological care is focused on women's reproductive faculties and therefore requires gynecological and non-gynecological considerations. For example, as Laube notes, the thyroid is not in the direct purview of gynecology but thyroid problems can change hormone levels that ultimately impact menstrual cycles. (149, pg. 18) In such a case, a systemic assessment accounts for particular difficulties.

OB/GYN in primary care is an "official designation" (149, pg. 18) that was sought to insure appropriate payment levels from insurance companies. In addition, OB/GYN organizations are developing a fourth-year medical school curriculum designed to introduce students to women's health.

There are certain topics of interest to consider in the OB/GYN field. First, domestic violence impacts women disproportionately to men. Women experiencing domestic violence tend to use health care services more frequently than women free from domestic abuse (149, pg. 22). Screening guidelines such as "HITS" (Hurt, Insult, Threaten, Scream) have been developed to assist provider assessments. Any physician should have at their disposal any and all resources to local support systems. Second, substance abuse such as excessive use of alcohol and inability to quit tobacco is an important issue in OB/GYN. However, the authors fail to distinguish how OB/GYN practitioners may or may not detect and diagnose problems any different than other primary care practitioners.

PEDIATRICS

Pediatrics developed over 100 years ago when there was recognition that children have particular health needs that often do not fit within the models of care for adults. The stated mission of the American Academy of Pediatrics, which represents approximately 60,000 pediatricians and is the predominant professional organization in the field is "to attain optimal physical, mental, and social health and well-being for all infants, children, adolescents, and young adults." (150) As Stanton and Behrman point out, pediatricians look beyond particular "organ systems and biological processes" and address the social and behavioral needs of children and their families irrespective of "culture, religion…or national boundaries." (151)

1.8 CDS NEEDS ANALYSES IN BIOMEDICAL INFORMATICS

Royse describes needs assessments as "process[es] that attempt to estimate deficiencies," and a method "that attempts to 'determine need. (152) In addition, needs assessment provides "estimates or sophisticated guesses about perceived needs…an appraisal of some kind of community or group." The purpose remains of needs assessments require "action" or "activity" on the part of people.

Need is a "relative term," (152, pg. 7) in that it changes depending on a person's perspective. People's needs change over time as perspectives change; therefore, one person’s need at a point in time can be different at another point in time. At one point in time a physician may need a telephone to be successful and at another point in time a physician may need a cell phone. The “needs” changed. There can be points in time when needs are “nonexistent” (152, pg. 7) say until a new technology is developed and then a need is created, i.e. iPhone, iPhone apps.

Royse et al. argue that needs assessments strive to find answers and develop knowledge that can be directly applicable to organizations (See Table 6). (152, pg. 17) Basic science, for example, differs in that any knowledge and answers that are produced in answering a question may not be immediately applicable.

Needs assessments are conducted because someone feels that a perceived need must be met. A longstanding issue in biomedical informatics is attempting to understand why CDS interventions do not succeed as much as developers (or users) expect they would. Understanding perceived needs of the users can help designers build software that better addresses physicians’ challenges in clinical work.

Needs assessments can consist of quantitative analysis such as how many people are X, or the number of people that do Y is Z. Needs assessments can also be qualitative and uncover what people want, what they would do with it, why and then how. Royse et al. note that some may consider the qualitative component a “feasibility study” or a “’front-end assessment.’” (152) Those in business may be more familiar with the qualitative methods as a form of market research.

TABLE 6: FOUR APPROACHES TO UNCOVER NEEDS

Needs Assessment Focus	Description
Awareness	Degree to which users are aware that functions and services exist
Availability	Degree to which users feel known functions and services are available
Accessibility	Degree to which users perceive functions and services are accessible
Acceptability	Degree to which users feel known or available services are acceptable for use

Time, funds, and resources are often lacking to conduct a full formal needs analysis that includes background literature search, observation and investigation, and the analysis itself. This has consequences on the effectiveness, or lack thereof, on any intervention meant to address needs.

Royse et al. note four ways that needs assessments can be beneficial. (pg. 17-19) First, assessments can identify problems not previously considered or brought to others’ attention. The conclusions from a needs assessment can guide stakeholder decision making such as deciding one large initiative or multiple small initiatives is required to address a new-found problem. Second, the information gleaned from a needs assessment could identify an organizational need to “modify [its] policies” to better address the challenges of its customers or end users. Third, needs assessments can inform stakeholders if and how to alter services that better meet the needs of organizational constituencies. Finally, a needs assessment can spotlight opportunities to develop new partnerships or strengthen already existing partnerships.

When designing a needs assessment it is important to identify those who are “primary stakeholders” from those who are “secondary stakeholders.” (pg. 24-25) Primary stakeholders are those people that the research is meant to benefit whereas secondary stakeholders are those that “provide a program” (pg. 24) or who oversee resources. For example, a study on Computerized Provider Order Entry (CPOE) may define physicians entering CPOE orders as the primary stakeholders and hospital administrators as the secondary stakeholders.

Needs assessments can be derived from both quantitative and qualitative means, as well as a combination of the two. Like in other areas of research, the qualitative and quantitative methods each have strengths and limitations: 1) Qualitative approaches provide in-depth, contextual knowledge about a particular group or groups of people that can be quite informative; but the results cannot be generalized to a population. 2) Quantitative approaches allow results to be generalizable to populations and can make strongly infer relationships between variables and outcomes; but the results can be too general to be applicable to specific groups or subsets of populations.

Biomedical informaticians have utilized needs assessments across range of study subjects. Public health informaticians look to needs assessments to inform national policy, budget allocation, and resource spending that impact regional and local information and workforce development needs. Chauvin et al. conducted a workforce needs survey in four southern states in the United States. The authors found that the significant proportion of the surveyed workforce had a felt need to receive training and an expressed need to retain industry “core competencies”. (153) Another needs assessment study among public health workers used a two-phase approach of first a survey and second in-person work groups. The researchers found the subjects valued “core competencies,” but also expressed additional needs for training including practices for managing personal health information. (154) Nursing informaticians have written needs assessments for the development of training and educational programming. (155-166) Health science librarians too conduct needs assessments of patrons to guide programming (167-179), understand user communities, (180) as well as define librarian workforce training. (181,182)

Physician needs assessments within biomedical informatics literature appear to be fewer in number than nursing and library literature; and fewer still, physician needs assessments in regards to clinical decision support.

Lloyd argued in 1984 that too much focus at the time had been placed on designing CDS systems that attempt to mimic human diagnostic decision-making as opposed to focusing on clinician needs based on clinic work life. (183) Gaps between diagnostic systems and fulfilling physician needs, Lloyd claimed, were particularly unhelpful for primary care physicians and that decision support should be based on effective "administrative applications" over all else. Primary care physicians need systems that are unobtrusive, time saving, and inexpensive. Despite the successes achieved by Miller's Internist system and McDonald's GOPHER system among others, Lloyd believed diagnostic systems had little applicability in primary care practices and that the marketplace would have to develop solutions because researchers had not and would not.

Lloyd's critique, although harsh, may have been appropriate. CDS systems developed and tested in labs were often evaluated for their ability to offer assessments and diagnoses like physicians. Yet comparing a CDS system's decisions to a human's decisions within a lab environment is a much different problem than understanding if a CDS system will be or is accepted and useful in a clinical environment. The evaluation component for CDS systems needed to be more robust in order to meet the needs of the users.

But biomedical informatics researchers had long been aware that CDS systems did not readily carry over from testing labs to clinical settings. (184) Friedman and Gustafson, for example, criticized the field in 1977 for not doing more to understand the issues around human-computer interaction. (185) Years later in 1992 Wyatt and Spiegelhalter reasoned that clinical decision support was not generally accepted in clinical settings because the systems did not address "real world problems" and was likely due to the lack of resources required for effective evaluations. (186, 187) The authors argued efforts needed to be taken to learn how physicians use CDS systems in the "real world;" and suggested the undertaking of CDS field tests to identify: 1) Structure: understanding how the CDS system fits within the structure of the overall clinical environment and how well users like the CDS system; 2) Process: understanding how the CDS system impacts processes that results in "accuracy of decisions" or changes in treatment patterns; and 3) Outcomes: accumulating evidence of in primary or surrogate patient outcomes brought about by process changes. The three areas are still influential in health care quality initiatives such as the Plan-Do-Study-Act (PDSA) framework. (188) The authors rightly outline the difficulties associated with CDS system evaluation and lay out a number of considerations in any evaluation such as the "Global Hawthorne Effect" and placebo effect.

1.8.1 QUANTITATIVE METHODS FOR NEEDS ASSESSMENT IN INFORMATICS

In 1981, Teach and Shortliffe were motivated to conduct a physician needs assessment because the acceptance of computers in medicine "depends on improving our understanding of the needs, expectations and performance demands of clinicians." (184) The authors discovered that previous informatics studies had not sought about information physician satisfaction as it related to clinical IT systems. Teach and Shortliffe developed an informatics tutorial and asked participants to complete a survey before the tutorial began and then complete the same survey after the tutorial was complete. The authors hoped to gain an understanding of physicians' attitudes on three aspects of clinical consultation software applications: 1) *Acceptability* of different applications; 2) *Expectations* how the applications would change medical practice; and 3)

Demands regarding the performance of different consultation applications. The survey was designed to get answers to understand, “how computers *will* affect medical practice,” and, “what computers *should* be able to do.” (184) Teach and Shortliffe concluded that physicians were more accepting of software applications that were perceived as tools rather than as “replacements” for clinical work, and that were perceived as *assisting* the physician’s decision making rather than *advising* the physician. Interestingly, after taking the tutorial physicians expressed a significantly higher demand for the software applications’ capabilities. Some of the study’s final recommendations were to cause as little impact as possible on clinical workflow and “consider the concerns and demands that physicians express.” These lessons could have significant impact on how systems are designed and developed today.

McGowan and Richwine described a project named SHELSI, the Shared Hospital Electronic Library of Southern Indiana. (189) The authors conducted a survey to understand the information needs of rural practitioners as related to clinical decision-making. The needs assessment revealed that many subjects rarely, if ever, searched the MEDLINE database (61%) and another 50% stated they did not ask others to mediate MEDLINE searches. McGowan and Richwine were able to develop an intervention that included bundles of knowledge resources as well as in-person training seminars. The authors claimed the SHELSI program reduced hospital admissions by 14% and a reduction in mortality by 12.5%; although, they do not explain their basis for making claims of the intervention’s causality.

Mihailidis et al. reported conducting a nurse needs assessment regarding “assistive computing devices.” (190) CDS was one aspect of the inquiry and the nurses expressed a high degree of acceptance that met certain needs such as anticipating needs, providing visual and auditory alerts and reminders, and provides users with patient trend lines. The study provided the researchers with thirty “mandatory features” that would be included in a prototype device for future testing.

Most recently, Sintchenko et al. had convenience samples of general practitioners (GPs) review clinical test cases and then rate their information needs as they related to CDS. Results revealed preferred CDS types were dependent on any one of three patient care models: acute, chronic, or preventative. For example, GPs preferred having patient histories and calculators for preventive and chronic care but less so for acute care. Also, when posed with a chronic care case the GPs expressed preference for having CDS that shows treatment costs for the patient. Finally, the GPs noted that CDS would be most applicable for preventive care (81%) than for acute care (54%) or chronic care (45%). In conclusion, the study found that GPs scored CDS needs differently according to the model of care required to treat a patient.

1.8.2 QUALITATIVE METHODS FOR NEEDS ASSESSMENT IN INFORMATICS

Qualitative methods are commonly used for needs assessment in biomedical informatics. Kinzie et al. conducted a needs assessment in their design of a web site for patients and primary care providers. (191) Kukafka et al. conducted a needs assessment among HIV counselors and concluded that informatics tools could help “bridge” gaps in training and support evidence-based practices. (192) Morris et al. determined needs among elders and posited how “ubiquitous computing” technologies could address barriers and facilitators to social connectedness. (193) Furthermore, qualitative methods have been used to understand user needs in relation to information needs (194-197), EHR systems (198-200), and care coordination (201) in primary care settings.

Qualitative methods have often been used to determine user needs as they pertain to CDS. In 1983, Bischoff et al. published their experiences installing a chemotherapy protocol management system, ONCOCIN, into an oncology clinic. (202) The researchers were interested from the outset how they could make the system implementation meet the needs of the clinician users. Purposefully sought physician feedback revealed design shortcomings the researchers had not considered during the design phase: implicit workflow not documented in flowsheets, and dosing recommendations that were too “stringent” for real-world use. The authors concluded, “It is clear that in order for a computer-based consultant to be effective in a clinical setting, the overall system design must take into account both the needs of the intended users and the constraints under which they function.” Looking at it another way, Bischoff et al. were calling for informaticians to assess and address user needs when designing informatics applications.

A variety of needs assessment studies in primary care settings have been published in biomedical informatics literature. Siden conducted focus group-based assessments to understand physician and patient needs as they pertained to a proposed telehealth program. (203) He found users expressed positive and negative views of *uncertainty* in both the telehealth technology and practices, and *trust* that the technology would adequately support medical practice. Weingart et al. also conducted focus studies but focused on primary care physicians’ opinions of electronic prescribing. (58) Some of the authors’ findings revealed usability concerns, ambivalence on the part of physicians, and frustration with the number of alerts. However, the physicians explained the alerts often prompted discussions with patients about potential drug interactions and side effects leading the researchers to conclude that alerts may have secondary functions that had not been considered.

Needs assessments have contributed to understanding factors associated with CDS adoption and design. Rousseau et al. conducted semi-structured interviews to understand adoption factors of electronic evidence-based guidelines within a general practice in England. (204) Subjects rejected the CDS system because the guidelines were presented an inopportune moments, provided already known information, and were not easy to use. Short et al. conducted fifteen interviews in nine practices and reported lack of physician training, “time pressures”, and “infrequent use” were barriers to adoption. (205) Wilson et al. interviewed patients and providers in regards to a CDS system meant to support and manage “cardiovascular risk”. (206) Patients appreciated the system but providers did not appreciate the additional time required to incorporate the CDS into workflow. The authors encouraged software designers and developers to better understand user needs. None of these studies, however, looked at CDS within community-based settings.

Although not a needs assessment of clinical decision support, a multi-disciplinary committee of biomedical informaticians, computer and social scientists, as well as human-factors engineers touched upon the subject when assessing needs of health care information technology (HIT) that meet future health care needs. (207) The Committee conducted eight site visits to some of the "best" health care organizations in the United States known for development, implementation, and use of HIT in clinical settings, and routinely asked site representatives "what the site needed but did not have." (pg. 91) Although the focus was on HIT, the committee identified decision support as a critical component. In addition, the panel noted current CDS limitations and recommendations for improvement.

The committee identified CDS as one of "four domains" of HIT focus. CDS was presented as a spectrum of technologies that ranged from "simple rule-based alerts" to using "statistical and heuristic" logics to recommend patient treatments given the capabilities of the organization from which services are being provided. (pg. 28) The committee focused on a particular need from clinical decision support: "patient-centered cognitive support." (207)

According to the committee, the "fragmentation" of medical data in electronic health records leaves users, primarily physicians, devoting "precious cognitive resources" to sifting data in an effort to develop a "model" of a patient. The committee argues that a primary reason for this may be because much of health care data is collected within the context of a "transaction" (ordering a medication, ordering a lab, referring a patient) rather than the context of the patient. The result leaves physicians and other providers very little context with which to conceptualize the patient as a person and strategize how best to approach that person's condition. In short, having a patient model help providers "formulate a plan" (207) with which a transaction, i.e. a medication order, may be carried out. Development of patient-centered cognitive support was considered a "grand challenge." (207)

The committee also pointed to the need for improved HIT functionalities that enable more robust data sharing using common data repositories that use "mediated schema" along with "semantic mapping." (207) Another need was for tools that reduce the amount of manual data entry using technologies such as voice recognition and automated real-time record summarization.

Of note is the committee's use of "vignettes" that illustrate how proposed HIT functions could address needs. The vignettes synthesize observed findings and place them within a context so that readers might better understand how specific solutions could be implemented to improve a particular aspect of care. The authors provide one such example (207):

> "Suggestion: Instruments and tools that allow providers to manage a portfolio of patient and to highlight problems as they arise both within individual patients and within populations.

> *"The computer of an outpatient care provider displays the summary health status (a "dashboard") of her 300 diabetic patients with color-codes and carefully designed graphical displays for clinical measures of the disease (blood sugar levels, A1C counts, and so on) that provide rapid assessment, at a glance, of the status of all patients: those who are managing illnesses successfully, those requiring intervention, and those who are marginal cases. When a diabetic patient visits her, the system reviews applicable guidelines, customizes an order set to the patient's state and insurance plan (e.g., picks the preferred drug from the drug class), and reminds the physician to discuss the selected drug with the patient. Feedback indicating success is provided when the provider sees the display indicators of her patients show successful management. The clinical significance of a summary health status display is that it gives the provider prompt feedback about where her attention is most needed in time to take corrective action."*

1.8.3 MIXED METHODS FOR NEEDS ASSESSMENT IN INFORMATICS

Biomedical informatics literature contains examples of CDS needs assessments that used both quantitative and qualitative methods. Carlson et al. developed an Internet and library use needs assessment that focused on diabetes within African-American communities in South Carolina. (180) Using both focus groups and a survey the researchers "confirmed" that older and less educated community members were the most likely to need training for accessing and effectively using the Internet to find reliable health information. In another library-associated needs assessment, Perley et al. developed a survey, structured telephone interviews, and focus groups to learn that physician patrons most desired timely point-of-care information while non-patrons desired more library outreach. (208) Barrett et al. identified needs for effective personal digital assistant (PDA) use among a purposive sample of specialist and primary care residents. (209) The authors discovered that both specialist and primary care residents not only used PDAs on a daily basis, the subjects self-promoted the use of PDAs among each other. An interesting qualitative observation was that medical faculty did not qualitative appear to use PDAs as much as residents. The study also found that heavy reliance on PDAs caused concerns about PDA failures as well as the capturing and storing of patient health information.

Christensen and Grimsmo conducted two mixed methods studies to understand primary care physicians' needs in Norwegian community practices. Their first study used observations, interviews, and a survey to learn how EHR systems impacted physicians' work and doctor-patient relationships. (210) The authors found that although physicians had greater access to EHRs than in previous studies, physicians had difficulty finding information within the EHRs. One result was that observed physicians asked patients for medical histories rather than finding the information within the EHR system. Their conclusion was that physician needs revolved around usability and that EHR systems need to present sometimes expansive patient records in more easily readable formats. In a second study the authors also used interviews, observations, and a survey to identify primary care physicians' current EHR needs and potential future EHR improvements. (211) Through their interaction with physicians and their survey the authors concluded that future EHRs should use a problem-oriented format (as opposed to source or time based), (212,213) and support dialog among physicians and patients as a function of decision support.

1.8.4 EHR USABILITY AND CLINICAL DECISION SUPPORT IN PRIMARY CARE

Like the HIT needs assessment committee, a multi-disciplinary committee of usability experts assigned to assess EHR usability needs also included clinical decision support as a consideration. Their definition of CDS, however, was not forthcoming and the committee was vague as to its relationship to usability. For example, the committee referred the need for alerts and reminders in "cognitive support" that helps users "synthesize large amounts of available information." (214) However, the committee distinguished CDS as providing information either "while determining whether to modify a treatment plan," (214) or, while determining "activities to execute" (214) a decision. Further unexplained distinctions were made such as "patient administrative data" containing formulary information (traditionally considered CDS) or "patient vital information" such as test results (also a traditional CDS concern).

The committee did, however, distinguish "decision support" as one of four "roles" that assist users by synthesizing data and placing it within a defined context. Toward that, decision support was described as, "enhancing the ability to integrate information from multiple sources to make evidence-based decisions." The other three roles were listed as (214):

- 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.
- Collaboration aid: Enhances the ability to communicate information and findings to other providers and patients.

Yet despite some of the vagaries already described, the committee's links between decision support and usability are significant in that: 1) it is noted that "little systematic evidence" (215) describes how EHR systems are used in primary care practices and how those systems "integrate with clinical decision making" (215); 2) that there is a pressing need to understand how systems are used in primary care practices (214); and 3) that the committee chose "use cases" as the means to communicate current primary care activities and propose EHR usability improvements (214).

To the first two points above, the committee noted the particular difficulty vendors would have gaining entry into primary care setting to observe EHR use in situ. Therefore the committee called for the government to sponsor entities such as the Practice-Based Research Network to conduct standardized usability evaluations and promote research that documents patterns of information seeking in primary care.

To the point about use cases, the committee developed four use cases to "provide direct illustration of key functionality, organization, and visualization principles of effective user design.” (214) Each use case described a visit type: acute care, chronic care, preventative and health promotion, and undifferentiated symptoms. Each case was furnished with a graphical interaction model of clinicians, staff, and a patient/consumer. (See Figure 5) Each case was furthermore broken down into “events” which acted as stages of a patient visit which then had “functional requirements”, the activities that are carried out, “information requirements,” the information needed to support the related activity or activities, and “design characteristics,” suggestions as to what the system should do or look like to best support users. The functional requirements are not exhaustive but rather provide “key elements” within a prototypical primary care workflow. The committee consistently notes the needs for EHR tools that support users’ abilities to sift and summarize large amounts of data, ease the burden of data entry, and reduce both “short-term and long-term memory load.” (214)

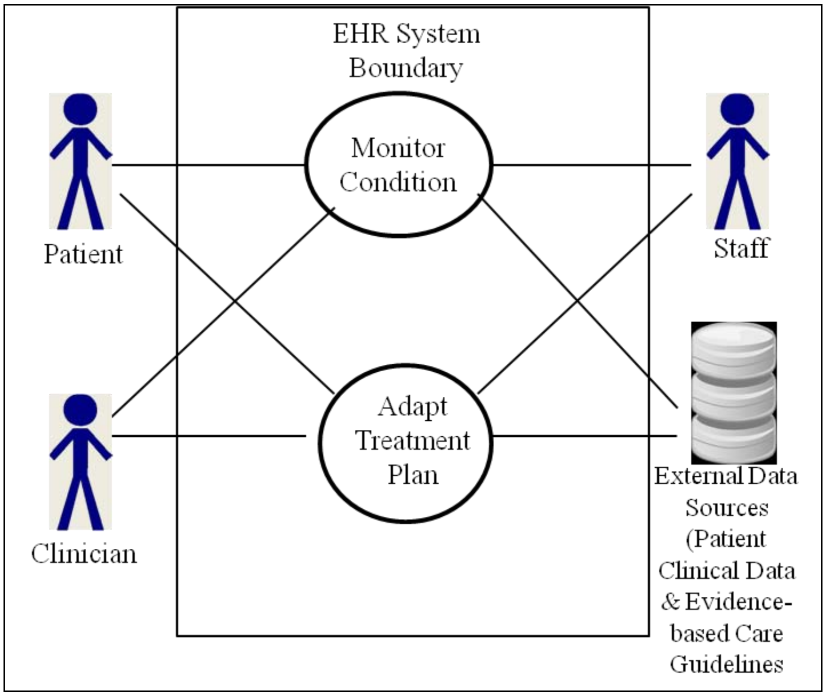


FIGURE 5: STEAD ET AL'S "DATA DESIGN" MODEL FOR CHRONIC CARE

It should be noted that the use cases were developed out of literature reviews, of which there were reportedly few, as well as committee discussions. The use cases were not informed by user observations and/or interviews. The use cases also excluded actors from the scenarios such as clinicians and staff outside the clinic, or patient representatives such as family members or friends. The committee’s reports represent an important first step to integrating CDS and EHR usability but remain relatively simplistic when compared to Stead et al’s barriers and challenges that were described in the previous section.

1.8.5 PATIENT-CENTERED MEDICAL HOME: REDESIGNING PRIMARY CARE TO ADAPT TO A NEW ENVIRONMENT

When considering issues associated with primary care at this time it is valuable to understand clinical decision support in the context of the "patient-centered medical home" (PCMH). The patient-centered medical home model has been offered as an improvement on the current model of primary care in the United States. The National Committee for Quality Assurance (NCQA) describes PCMH as a model whereby providers partner with patients and their families to support coordinated, longitudinal care via information technologies whenever appropriate. (216) Rittenhouse and Shortell describe "4 cornerstones" to the PCMH model: "primary care, patient-centered care, new-model practice, and payment reform." (217)

The four cornerstones together support a new framework for delivering and maintaining patients' health as well as the health of the provider practices. In short, Rittenhouse and Shortell argue that primary care has been an effective means for supporting and maintaining patient health while "lowering costs." The authors call for changes in the ways doctors and patients interact toward "patient-centered care" where practitioners and patients share decision-making and utilize new information communication technologies (including clinical decision support) to improve the efficiency and effectiveness of care. The authors are vague about the final cornerstone, "payment reform," calling for a mix of "fee-for-service, pay-for-performance, and…care coordination." The authors readily acknowledge that it is "not known" at this time how best to structure payments so that individual practitioners and care teams are adequately compensated for online consultations and team-based care that keeps patients well and out of the hospital. The PCMH model heavily relies on information technology to tie together communication, coordination, measurement, and reimbursement to ideally incentivize patients and practitioners to attain and maintain wellness.

Dr. Ronald Dixon has argued for a "technology-enabled" EHR will provide a new model of care and ways in which physicians interact with patients. (218) He touts information and communication technologies that connect providers and patient using asynchronous, synchronous, and remote monitoring tools. Although not referring to "clinical decision support" by name, he touts technology's abilities to support patients in self-care, particularly those with chronic diseases.

Based on the literature of the few "published studies" associated with PCMH, Bates and Bitton note there are gaps in current knowledge that are foundational to any successful PCMH initiative. (219) The authors point to the lack of knowledge around clinical decision support in medical homes as a significant knowledge gap.

1.9 RESEARCH QUESTIONS AND RESEARCH APPROACHES

The question that the researcher will set out to answer is the following:

1. How do community-based physicians conceptualize clinical decision support?
2. What do community-based physicians needs from clinical decision support

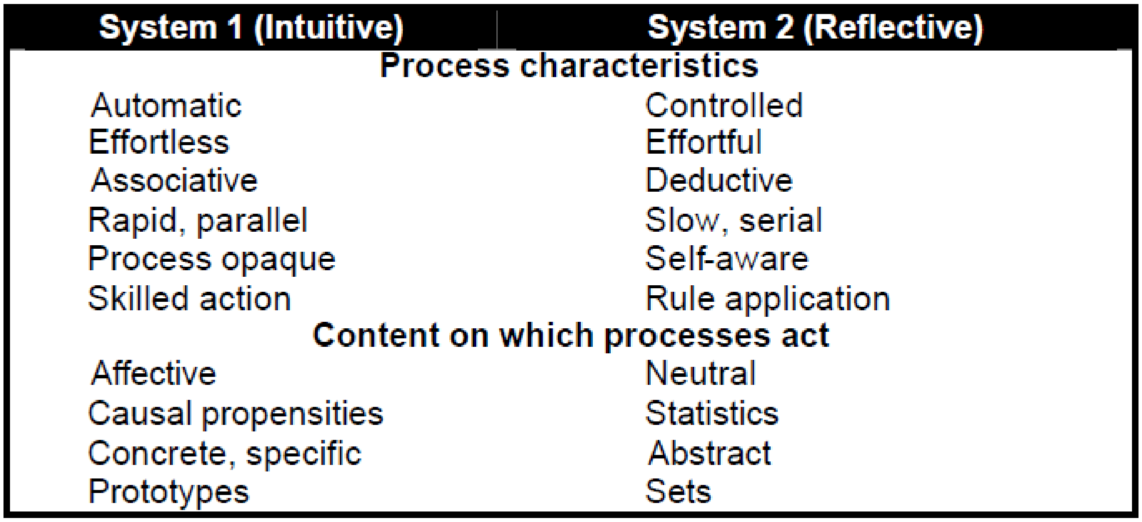
1.9.1 A CHOICE ARCHITECTURE FRAMEWORK: NUDGES AND PERFORMANCE SUPPORT

Behavioral economics researchers have been investigating how the brain’s physiology affects human economic behaviors. These researchers tend to question the historically predominant theory of economic decision-making which is that economic actors (people) take actions based on rational decision-making. As was previously discussed, the rational view in economics conceives of human beings as primarily input and output processors. Human beings take in information, process that information, make a decision that provides the greatest probability of success, and then act on that decision.

Behavioral economists account for the degrees of difference between that which makes up a decision and that which makes up a choice. Like those in cognitive science and neuroscience, behavioral economists acknowledge that the human brain acts in different modes, inductive and deductive, according to the goals the particular human wants to achieve. The approach recognizes that people make different types of decisions to function in the real world; therefore, some organizational and technological systems more than others better support the different modes of human decision-making. As it applies to biomedical informatics and this project, it means that “issues of technology design need to be considered alongside psychological limitations, team dynamics, and organisational cultures if the full potential of technology is to be realised.” (220)

Inductive and deductive reasoning has been discussed as well as their corollaries:, choices and decisions. Thaler and Sunstein introduce another categorization meant to explain the same distinction: System 1 and System 2 cognitive systems. (221, pg. 20) System1 thinking includes facets of passive, automatic decision making that humans carry out without much thought (See Table 7). (222)

TABLE 7: THE DUAL PROCESS MODEL REFLECTS DIFFERENT MODES OF HUMAN COGNITION



System 1 (Intuitive)	System 2 (Reflective)
Process characteristics	
Automatic	Controlled
Effortless	Effortful
Associative	Deductive
Rapid, parallel	Slow, serial
Process opaque	Self-aware
Skilled action	Rule application
Content on which processes act	
Affective	Neutral
Causal propensities	Statistics
Concrete, specific	Abstract
Prototypes	Sets

A clinical example of System 1 thinking may be to provide a five-day dose regimen of azythromycin to a child with a routine case of otitis media. The physician knows what treatment to provide and just wants to quickly write a prescription. System 1 thinking ("effortless, associative, and fast") (221) takes over. In such a case, the physician would most likely appreciate CDS tools that support System 1 decision-making. However, if the child has a known allergy to penicillin, then CDS would ideally post an alert to wake the physician out of System 1 decision-making mode and into System 2 decision-making mode. Unlike System 1 decision-making, System 2 decision-making is "effortful, deductive, and slow" (221) and therefore beneficial when the doctor needs to be more deliberative about his or her actions. However, CDS that unnecessarily imposes System 2 decision-making will likely cause annoyance and alert fatigue among physicians when System 1 decision-making is best.

What Thaler, Sunstein and others are advocating is recognition that humans are susceptible to routine cognitive errors. This occurs in part because the human brain has its natural limitations but also because the brain must filter and synthesize the inordinate amount of stimuli that exist in the world around us. Humans rely on System 1 and System 2 systems to make decisions in the real world. Referred to as the "dual-process model," (222) it is a well established theory whose originator garnered a Nobel Prize. (223)

What Thaler and Sunstein describe closely mirrors what subjects had described to POET when detailing different kinds of decision support. (224) Subjects had described a need to balance the need for optimal decision-making based on evidence and the need for decision-making that fits within the time and contextual. However, given the choices between System 1 and System 2 thinking, physician subjects would consistently choose System 1. This finding is also supported by Krall's focus groups with primary care practitioners. (51) Therefore, building on Friedman's theorem (225) perhaps models a more appropriate way to approach CDS: physicians want the computer to support human cognition so that it can reduce time and cognitive load than by the human alone, whereas CDS designers want the computer to support human cognition so that human can make better decisions than the human alone.

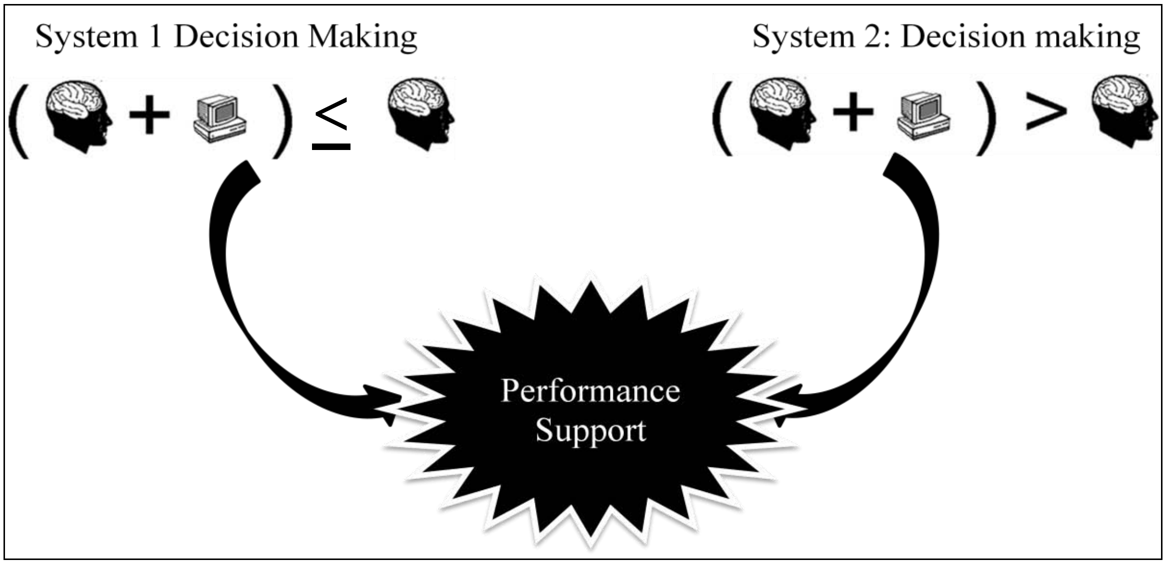


FIGURE 6: RICHARDSON'S MODEL OF PERFORMANCE SUPPORT

So rather than try to eliminate cognitive errors by forcing people to be more “rational”, Thaler and Sunstein argue the aim should be to design systems in ways that leverage the strengths and weaknesses in both System 1 and System 2 decision-making to promote safe, flexible, and measurable changes in human behavior. The authors suggest organizational and technical design approaches that “nudge” users to carry out desired behaviors while facilitating, and respecting, users’ intended goals. The authors lay out their proposed design strategies using the acronym NUDGES, and describe their process of design as “choice architecture.” (221)

Thaler and Sunstein define choice architecture as, “A structure designed by a choice architect to improve the quality of decisions made by homo sapiens. Often invisible, choice architecture is the specific user-friendly shape of an organization's policy or physical building when homo sapiens come into contact with it.” (226) Thaler and As it relates to the design of clinical information systems and CDS, the goal is to “harness technology to better serve human purposes, rather than requiring people to become super human users of complex technology.” (220) The six categories (“NUDGES”) are described in detail:

N – INCENTIVES

First, the ‘N’ in “iNcentives” directs choice architects to align incentives in ways that people see benefits or feel rewarded for taking certain actions. For example, collecting accurate data in clinical settings is critical to track patient outcomes. Yet clinicians have less incentive to collect data if they do not see the benefits of data collection through reports or displays that they consider valuable to them and their work. Choice architects must work to discover and apply “salient” incentives and avoid conflicting incentives.

U – UNDERSTANDING MAPPINGS

Understanding mappings ('U') refers to assisting users that must make a decision "that are difficult and rare." (221) Humans have applying rational decision-making to scenarios in which they lack previous experience. For example, a patient given a diagnosis of prostate cancer is given three options for treatment: surgery, radiation, or no action. Potential morbidities that result from prostate treatment include impotence, incontinence, and tissue damage. Yet patients that lack experience with having a prostate cancer diagnosis will have difficulty mapping the decision to the consequences of their decision.

D – DEFAULTS

Defaults are akin to using the power of suggestion to influence behavior. Johnson and Goldstein conducted a study to see if computerized default values influenced whether or not subjects would be organ donors. (227) Subjects were randomized into one of three groups: 1) default opt-in to be a donor, 2) default opt-out of being a donor, and 3) no default option. The opt-out and neutral groups significantly chose to be organ donors whereas subjects in the opt-out group chose not to be organ donors (See Figure 7). (227)

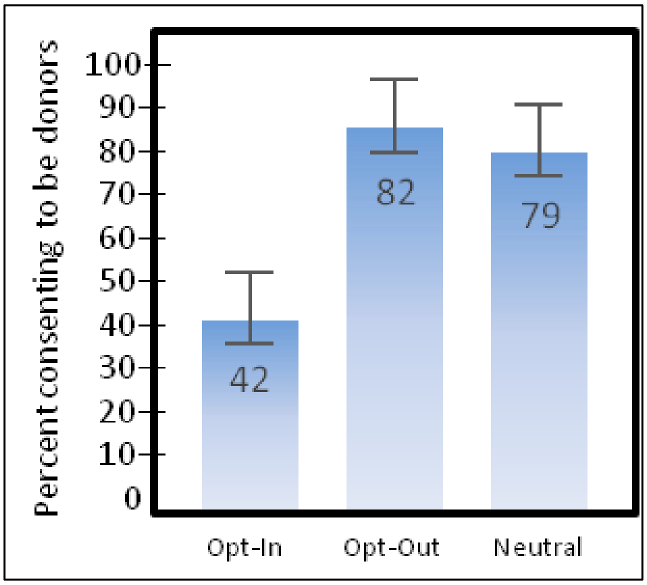


FIGURE 7: DIFFERENCES IN ORGAN DONOR RATES BY DEFAULT OPTIONS

The authors extended their study (see Figure 8) by reviewing the rate of agreement among European countries that either have opt-in organ donor programs (explicit consent) or opt-out organ donor programs (presumed consent). (227) The null hypothesis would be no significant difference across countries' organ donor programs based on default options. The results, however, were significantly different. Donor rates in countries that relied on explicit consent were much smaller than rates in countries that relied on presumed consent.

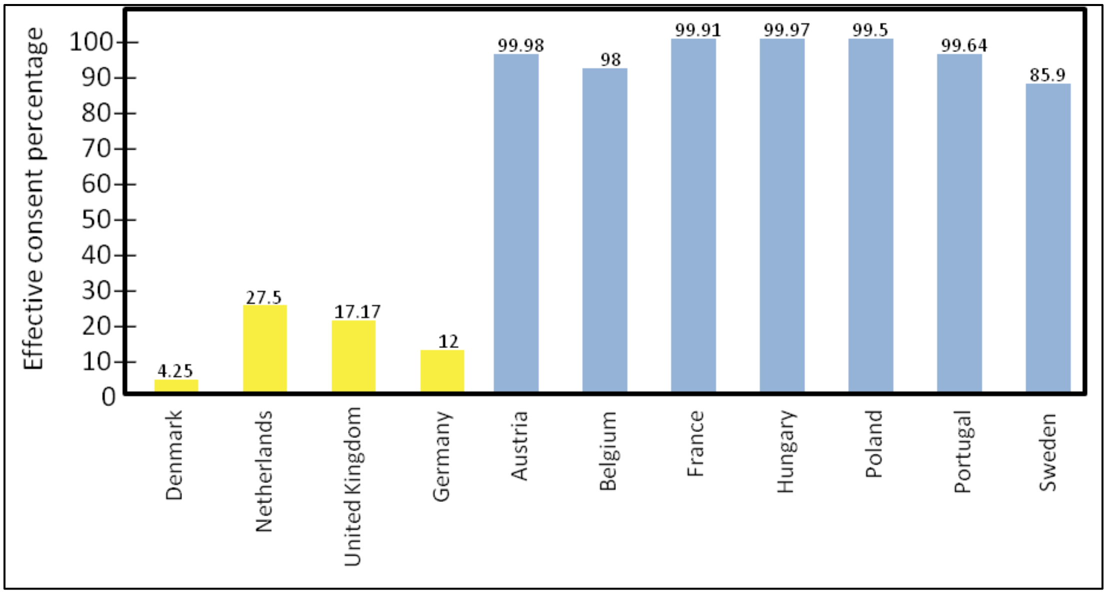


FIGURE 8: DIFFERENCES IN ORGAN DONOR RATES BY DEFAULT OPTIONS ACROSS EUROPEAN COUNTRIES

Eslami et al. compared clinician prescription patterns among ICU clinicians whether or not they were given default levels of tobramycin and gentamycin (240mg/day). They found clinicians accepted the default values significantly more than not, (58% vs. 43%, n=392, $p < 0.0001$). Moreover, default dosages were included in 86% (113 of 132 of prescriptions to renal insufficient patients compared to 53% (66 of 124) of prescription that were not given a default dose ($p < 0.0001$). Although the high rates of prescriptions errors in both groups bring into question some underlying questions about the study environment, I feel the differences between groups' process outcomes are hard to ignore.

Thaler and Sunstein lay out different applications of defaults: 1) Explicit consent requires a user's action to opt-in; 2) Presumed consent requires a user's action to opt-out; 3) No consent acts as a mandate that users must follow; 4) Mandated choice requires users to note their choice with an explanation for their preference; and 5) Promoting Norms tries to influence choices by giving users information about what other users choose most often.

G -- GIVE FEEDBACK

Giving feedback is critical to allowing users to complete their tasks and, if those tasks are repetitive, to do so with greater speed and efficiency over time. Choice architects should be mindful to tie immediate feedback mechanisms to immediate goals. For example, some EHR systems provide an active list capability which brings up drug names or other keywords as a physician types in a search field.

E – EXPECT ERRORS

Thaler and Sunstein describe how errors thrive on cognitive complexity and therefore system designers need to be ever mindful. The authors' approach, however, is to not require more user training but rather understand user behaviors and design systems that fit those behaviors. Because repetitive human behaviors tend to evolve into routines, systems would do well to take advantage of those routines.

Birth control pill hormones, for example, are to be taken once every morning for 21 days and then skipped for 7 days for menstruation. Assuming that a woman wants to insure a proper regiment, it would be beneficial to support the habit of taking one every morning regardless of menstrual cycle. Birth control pill companies solve this by providing 21 days of hormone pills as well as 7 days worth of placebos. Designers that expect human errors can iteratively look for new ways to mitigate those errors and future errors.

S – STRUCTURE COMPLEX CHOICES

Lastly, Thaler and Sunstein argue that choice architects should design choices such that they account for humans' innate needs to simplify large amounts of data. Tversky demonstrated this quality by demonstrating how people cognitively identify characteristics of selected facets to arrive at a small group of choices or one choice. He termed this strategy as "elimination by aspects." (228) Given this tendency, people would be expected to perform more effectively if given only a few choices from which to select rather than being given as much data as possible. This idea could also be summed up by the idea behind "information overload."

Forcing doctors to use one form of decision-making when it may help to support different forms of decision-making; limiting decision-making to one type overplays the strengths of that type and undermines the strengths of alternate types of decision-making.

1.9.2 CDS TAXONOMY FOR OUTPATIENT CLINICS

In 2003 Sim and Berlin published a CDS taxonomy which in 2004 was applied to outpatient CDS systems; it was the first clinical decision support taxonomy applied to outpatient settings. (229) (Note: since beginning this writing Wright has since applied an inpatient-centered taxonomy to inpatient and outpatient settings (230)) The authors' goal was to develop a classification of CDS systems and their "contextual, technical, and workflow features" that could identify generalizable features of successful CDS. Using the MeSH definition for CDS they searched for descriptive and randomized control trial articles published between the years 1975 to 2002 and arrived at 150 qualifying articles. Using an iterative review process they developed a taxonomy comprised of five categories and 25 axes (See Figure 9). Wright notes that the taxonomy "provides an insight into the design and intent of clinical decision support systems." (231)

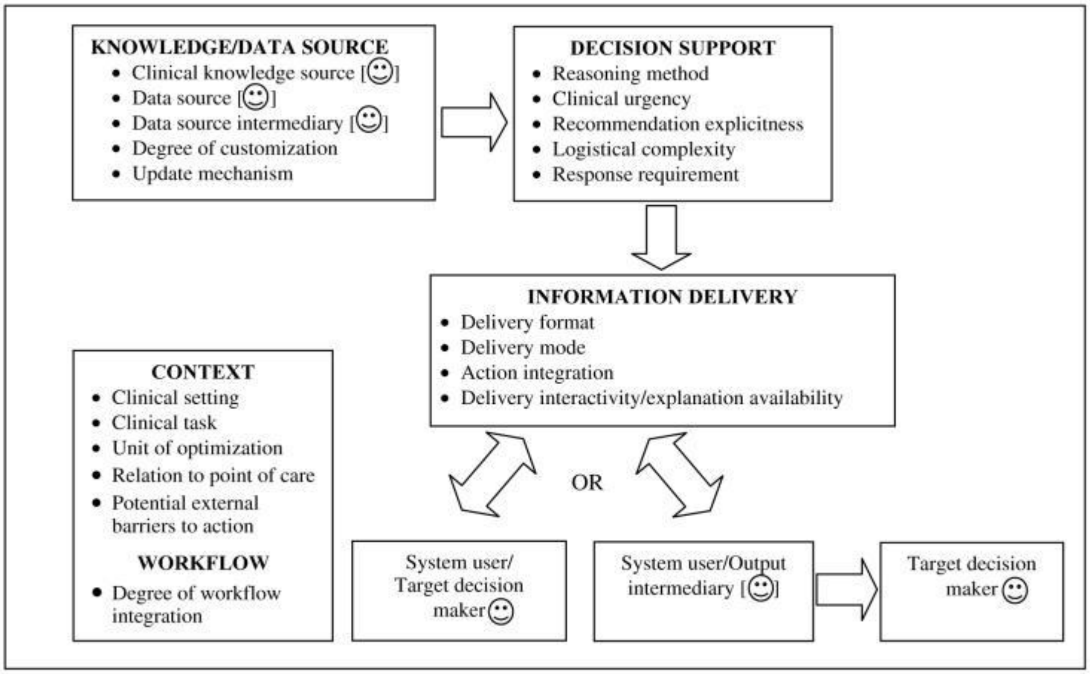


FIGURE 9: THE SIM AND BERLIN CDS TAXONOMY (SMILE FACES INDICATE HUMAN-CDS SYSTEM INTERACTIONS)

For their 2004 paper Berlin et al. they applied the same taxonomy to a set of outpatient 42 CDS systems reported in 31 randomized control studies between 1998 and 2002. (232)

The literature search took a broad interpretation of CDS and therefore the taxonomy included a wide range of articles including physician and patient targeted systems. The authors found that CDS systems in outpatient settings were highly heterogeneous. Furthermore only 31% of the systems delivered CDS during a patient visit and CDS tended to be targeted at one user rather than support team-based decision making. They concluded that the use of published RCTs may lend bias to the effectiveness of the reviewed systems, and that the published literature provided “poor” overviews of CDS functionality, user interfaces, and descriptions of workflow. Although the CDS taxonomy of outpatient CDS systems is limited, its novelty makes it a useful tool for gauging outpatient CDS capabilities.

2. METHODS

2.1 STUDY SUMMARY

Those in the field of biomedical informatics have conducted comparatively few studies of physicians using CDS in community-based settings. Understanding the behaviors, tasks, goals, and needs of these users is essential for the following: 1) to learn how community-based physicians conceptualize CDS; 2) to reveal the barriers and facilitators to the use of CDS from the perspectives of community-based physicians; and 3) to uncover any limitations of current CDS design, particularly related to alerts, reminders, and guidelines.

The researcher carried out a user-centered needs assessment among primary care physicians in community-based settings through observations and interviews with physicians in their practices. Interview and observation data was coded using multiple frameworks to explain user needs. First, a grounded method were used to generate themes associated with CDS needs from physicians' points of view. Second, a Content Analysis was conducted to determine physician CDS needs using an informatics-based taxonomy. Third, a Content Analysis was conducted to determine users' via a choice architecture framework which has been developed from the field behavioral economics and not associated with medicine and medical informatics. Taken as a whole, the three frameworks enabled the researcher to assess different facets of CDS needs from different theoretical constructs: a bottom-up analysis, a top-down analysis, and an outside-in analysis.

A PhD doctoral candidate sought to conduct semi-structured interviews with, and observations of, a minimum of thirty primary care physicians, including: 1) family practitioners; 2) internists; 3) OB/GYNs; and 4) pediatricians. All were to be users of an EHR system that contained CDS components and who used the system within their practices. Subjects were to be recruited from three community-based health care systems located in different geographical regions of Oregon: ten subjects minimum from the Mid-Valley Independent Physicians Association (MVIPA) based in Salem, Oregon; ten subjects minimum from Central Oregon Physicians Association (COIPA) based in Bend, Oregon; and ten subjects minimum from Oregon Community Health Information Network (OCHIN) based in Portland, Oregon.

2.2 RESEARCH QUESTIONS AND SPECIFIC AIMS

The questions that the researcher set out to answer were the following:

1. How do community-based physicians conceptualize clinical decision support?
2. What do community-based physicians need from clinical decision support?

The first aim of this study was to develop a physician-centered model of electronic CDS. The study was to employ a model derived from the field of human-computer interaction to create a physician-centered model (See Figure 10). (233) The physician-centered model is meant to develop and communicate user models through the use of “personas”; which are accepted tools in the human-computer interface (HCI) and usability fields. As described above Personas provide archetypes of “model end users” by conveying data-driven user requirements via interviews and observations. (118, 234) Therefore, this study aimed to conduct a contextual task analysis that was to focus on physicians’ views about CDS and how CDS impacted the practice of medicine in community-based settings. Interviews and observations would be used to gain the insight necessary to analyze community-based physicians’ tasks with their natural work environment. (129)

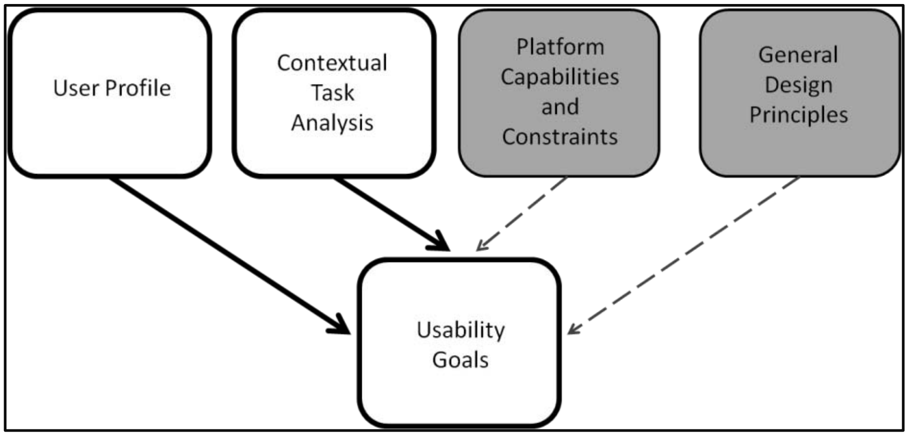


FIGURE 10: MAYHEW'S HUMAN-COMPUTER INTERACTION MODEL: A FOCUS ON THE "USER PROFILE" AND "CONTEXTUAL TASK ANALYSIS”

Limitations due to time and resources would prevent this study from embarking on the other two areas of Mayhew’s model: 1) Platform capabilities and constraints, and 2) General design principles. It is hoped those two areas will be conducted in the future based on the information gleaned from this study.

The second aim of the study was to analyze CDS from different analytic frameworks so to explore CDS from a multi-disciplinary viewpoint. To achieve these ends the researcher was to employ three frameworks. First, a user-centered framework based on a grounded theory approach using study participants’ own words and actions. Second, a user-centered framework based on a CDS taxonomy developed within the biomedical informatics field. (235) And third, a user-centered framework based on a choice architecture framework developed in the field of behavioral economics and neuro-economics. (70,221)

2.3 PRELIMINARY RESEARCH

The project is an extension of an AHRQ-funded contract that tasks biomedical informatics researchers to investigate and explore CDS knowledge management best practices in leading informatics institutions around the United States. The interview and observation techniques are well established within the field and the researcher is experienced with the proposed research methods and protocols. The researcher has trained with a leading team of informaticians whose work was recently given a distinguished paper award for its method design. (73) The observations were designed to not intrude on physician interactions with patients or staff. The interviews were to provide a voice for physicians who could share their perspectives on current applications and needs of CDS.

Training on each health care system's EHR platform took place before site visits to any one of the networks commenced. The researcher received training on the NextGen EHR system (used by MVIPA) and viewed it in clinical settings between November and December 2008. A Central Oregon IPA employee conducted user training on the eClinicalWorks platform (used by COIPA) on December 29th, 2009. The researcher trained and passed a basic test on the EpicCare Outpatient platform (used by OCHIN) February 1st, 2010.

2.4 SETTINGS

The MVIPA, COIPA, and OCHIN health care organizations were purposefully selected based on their geographical locations and use of varying EHR platforms {and primaryu care delivery}. The three systems are based in cities deemed, "urban areas", and support clinics included within areas deemed, "urban clusters". (236) The United States Census defines urban areas as having "[population densities] of at least 1,000 [people] per square mile" along with "surrounding census blocks" with a minimum of "500 people per square mile." (236) Rural areas are those that fall outside of what the U.S. Census deems urban areas and clusters. (237) According to the Oregon Office of Rural Health, rural clinics are those that are located ten miles or more outside of areas populated by 40,000 people or more. For this study, study participants from urban areas and clusters were targeted. However, to achieve greater variability in perspectives, special consideration was made to include participants located in rural areas.

In addition to the varying geographical locations, each health care system was selected because it uses a different EHR platform. First, MVIPA oversees the installation and maintenance of the NextGen EHR platform (NextGen Healthcare; Horsham, PA) on behalf of its independent practice members. However, it should be noted, some clinics within MVIPA already had their own EHRs prior to the NextGen implementation. Non-NextGen clinics are allowed to keep their systems yet receive lower levels of service and support. Second, COIPA employs the eClinicalWorks EHR platform (eClinicalWorks; Westborough, MA). The EHR platform is supported through an external organization named, eFormatix (Bend, OR), which was formerly an internal IT department within COIPA. Lastly, OCHIN oversees the installation and maintenance of the Epic Ambulatory EHR platform (Epic Systems Corporation; Verona, WI) within clinics both in and outside of Portland. Including multiple EHR systems and their accompanying CDS technologies allows the researcher to investigate physician needs that extend across any one technological platform.

The researcher gained permission to interview and observe MVIPA and COIPA physicians after conducting discussions and gaining verbal approval from organizational representatives. Permission to interview and observe OCHIN clinicians was applied for and granted by the organization’s governing IRB, SafetyNet West (SNW). The researcher requested for access using a written description of the proposed study and by presenting the study’s aims to SafetyNet West oversight board. The researcher also obtained IRB approval from Oregon Health & Science University’s Institutional Review Board (IRB) and all three study networks agreed to defer to the OHSU IRB as the acting oversight entity.

2.5 SUBJECTS AND SAMPLING

Purposive samples of subjects were identified with the assistance of organizational sponsors at each network. Sponsors at MVIPA and COIPA nominated a range of subjects based in part on core demographics (age, sex, role, years of experience working with and Electronic Health Record (EHR) system with CDS); as well as based in part on a spectrum of the liaison's working knowledge of physicians: known user champions, known user skeptics and users in between.

MVIPA invitations were sent from the site liaison beginning March 23, 2010. Official COIPA invitations were sent out April 6, 2010, although the site shepherd had been informally communicating with select physicians the possibility of this study being approved. The informal conversations helped prepare doctors for my official contacts on and after April 6, 2010.OCHIN invitations were emailed to EHR-supplied clinics beginning in mid-March.

OCHIN subjects were first contacted with a letter emailed to prospective clinics: clinics that possessed Epic Ambulatory EHR systems with basic CDS. (see Appendix E) Selection of clinics included both university-affiliated (OHSU) and non-university-affiliated clinics; although, care was made as to not select university-affiliated sites located on the OHSU campus. Interested subjects were encouraged to contact the researcher directly to schedule interviews and observations.

Potential subjects were contacted by one or more of the following means: email, phone, letter, and personal introduction between one physician participant to a potential physician subject. If a subject tentatively agreed to participate in the study, the researcher entered that person’s name and contact information on a confidential list. The list was kept electronically in a password protected file on a password protected machine. Additional informational materials were then provided to prospective subjects. If subjects agreed to participate, then they and the researcher negotiated dates and times for interviews and observations.

In addition to purposefully selecting healthcare networks, the researcher focused on physicians in particular roles: family practitioners, general internists, obstetrician-gynecologists, and pediatricians. These four roles were selected because they represent the four largest primary care specialties in the United States (See Figure 11). (5) This study focused on the physicians and not patients. Vulnerable patient populations were not targeted.

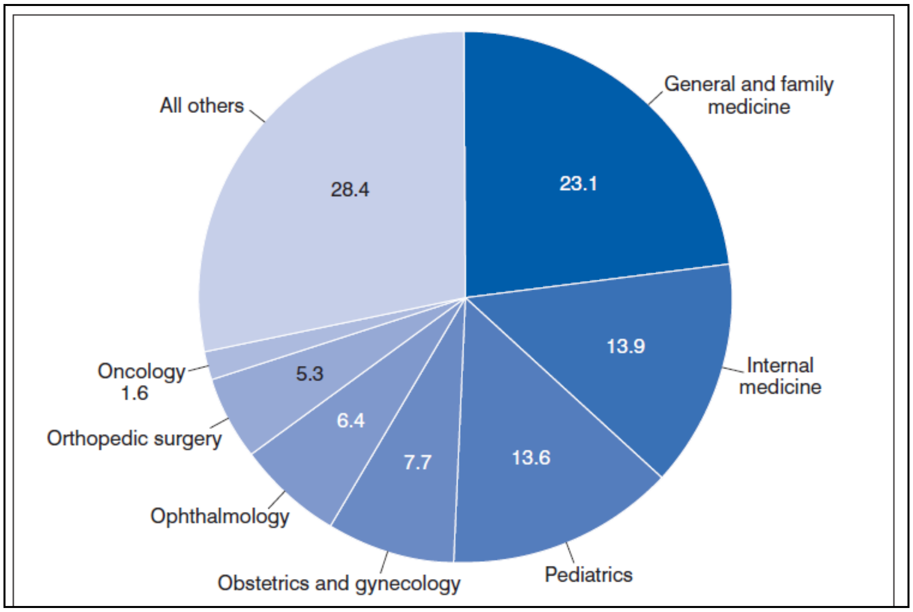


FIGURE 11: "PERCENT DISTRIBUTION OF OFFICE VISITS BY PHYSICIAN SPECIALTY" IN THE UNITED STATES, 2006

The researcher found it challenging to recruit community-based physicians and ask them to donate time and effort toward the study. Inroads with OCHIN clinics were made through physicians' professional relationships. MVIPA clinics were considered unexpectedly challenging despite the valuable assistance of its site liaison. COIPA clinics too, with the valuable guidance of its site liaison, were slow to recruit. Midway through the study, the researcher developed a strategy to deal directly with clinic managers rather than physicians. That strategy generated more responses and feedback and eventually became the primary recruiting strategy.

The strategy to work with clinic managers, and in some cases medical assistants (MAs), did indeed prove to be more fruitful than working directly with physicians. Clinic managers and MAs were more responsive to emails and phone calls. And although these people were very protective of clinic doctors' interests and doctors' time, they appeared more open to learning about the study than were doctors. The increased openness provided me additional opportunities to gain entre into clinics. Clinic managers and MAs are community-based physicians' gatekeepers through whom access is often gained or lost.

Physicians, though, ultimately proved to be powerful voices for recruitment. A family practitioner who was the study participant from the COIPA network provided a brief reference "letter" in nothing more than simple e-mail text. (Appendix B) The brief letter provided an imprimatur to the study and may have allayed any hesitations reluctant COIPA study participants might have had. With that I {the researcher} worked to attain letters of reference from one physician participant in each of the other two systems: MVIPA and OCHIN.

Participating physicians, clinic managers, and MAs were not remunerated for their time and effort that went into scheduling and hosting a researcher at their place of work. Yet experience from conducting fieldwork in other projects had --- on me the importance of expressing gratitude beyond words. Therefore I prepared packages of brownies, each presented in red wrapping paper and a bow. Participants appeared sincerely grateful for the gesture of thanks and good will, some commenting that the brownies were a welcome snack during a long work day. The brownies turned out to provide another way to maintain contact for follow-up communications, questions, and additional subject recruitment.

2.6 DATA COLLECTION

Approval from all three health networks and IRBs was gained by January 2010 and recruitment efforts began soon thereafter. Interviews and observations took place over three months beginning in March 2010 and ended in May 2010. The entire study may take up to four months to gather and analyze appropriate data from each health care organization (MVIPA, MRIPA, and OCHIN). However, data collection within each organization may be completed in one work week. The length of time required to gather data from each organization depends on how well physician schedules can be coordinated and accommodated.

Prior to interviews and/or observations, a consent form was presented to each study participants. The researcher went over the consent form with participants and addressed any of their questions or concerns. Specific mention was made that participants had the option remove themselves from the study at any time during the study and before any publication of the results. Consenting participants and the researcher jointly signed two forms, one for each of the party's records.

OHSU IRB approved information sheets were handed to patients whenever the researcher conducted observations in patient rooms. The researcher allowed the form to be presented in ways that each provider felt was most helpful for their patients: 1) The researcher handed out the form to patients upon entering the patient room, 2) The physicians handed the form to patients before the researcher entered the patient room, or 3) Nurses and MAs handed out the form prior to either the doctor or researcher entered the patient room. The information sheet summarizes the study and informs patients that they have the power to ask the researcher not be present within the patient room. The researcher left the patient room if the patient opted out of the study. In cases where sensitive patient consults were being conducted, primarily for OB/Gyn visits, the researcher waited outside the patient room or in a designated "neutral" spot, i.e. the physician's office. There were instances where the researcher entered the patient room to observe physician use of an EHR and any appropriate CDS and then left the room before a sensitive consult began.

A minimum of thirty community-based physicians were being asked to allow the researcher to observe any use of CDS within the setting of a community-based practice. The observations and semi-structured interviews were designed to focus on aspects of physicians' goals, work, and environment. The duration of each physician observation was estimated at a minimum of one hour. Participants were also asked to provide follow-up feedback after preliminary analysis was conducted (see Data Analysis below). Physicians were informed they would be donating an estimated two to three hours of their time over the span of the entire study. Minimal staff time was required to situate the researcher to the environment and staff at each community-based clinic. Monetary compensation for physicians' time was not available but a small token of appreciation was given to each subject for his or her participation

The observation strategy was to be unobtrusive and was not expected to impact the physician's ability to treat patients. Opportunistic questioning did occur during moments when there were breaks in clinical workflow such as patient visit cancellations.

Observations were performed with the purpose of observing and noting the users' experiences of work and workflow within the community practice environment. Observations were recorded using pen and paper. Physician observations took take place within office areas as well as patient rooms. Patients' health information was not collected; rather, the researcher focused on physician activities. Any and all patients were asked for their permission to allow the researcher enter any patient room. In addition, any physician identifiers that might have been collected were eliminated from all transcribed observation notes. Physician subjects were given the opportunity to review observation notes at the end of a session and edit any information deemed too sensitive to be included in this study.

Physicians were asked to follow observations with semi-structured interviews approximated at twenty minutes in length. The ordering of observations and interviews was intentional so that the researcher could ask follow-up questions if an observation needed further clarification or explanation.

Personal names were not asked of the subjects during any interview and no direct identifiers were kept on any written notes made during any interview. Digital recordings were transcribed and entered into NVivo 8.x qualitative research software. Digital recordings and written transcripts will remain in a secure, locked location for up to three years. Only the researcher and members of the researcher's dissertation committee will have access to recordings and transcripts.

The researcher developed an interview guide in consultation with his advisory chair and members of the dissertation committee. A preliminary interview guide was tested on a primary care physician in a network not included in this study (Salt Lake City, UT). The researcher and physician discussed strengths and weaknesses of the interview guide and notes were taken. The researcher used the notes to refine the semi-structured interview guide, presented the revised guide for committee feedback, and then received committee approval for IRB submission.

The interview guide contained five questions of primary interest (see Appendix F) for entire semi-structured questionnaire):

1. Why did you decide to become a [physician role]?
2. How could the system support your work?
3. What problems could the system solve?
4. What things could it do to help you perform better?
5. What types of decisions could it help you make?
6. What tradeoffs would have to be made to get the system you want?

Subjects were asked additional questions to acclimate themselves to the interview process and so that the researcher could probe and explore topics that arose during observations. The interview guide evolved as the study progressed and subjects revealed concepts themes that were not considered in the original interview guide.

Interviews took place in dedicated spaces at each of the study sites: a conference room or an office, apart from clinical areas or general office areas. In cases where private space was not available the researcher confirmed with the subject that they were comfortable to continue with the interview. In such cases participants stated they felt comfortable to proceed. During those interviews the researcher paid attention to physical cues and changes in tone that could reveal the participant was withholding information due to the perceptions of others; such occurrences were not noted. Interviews were digitally recorded for future transcribing.

2.7 DATA ANALYSIS

The researcher transcribed written observation notes into Microsoft Word documents. The researcher noted when subjects emphasized words by using capital letters. Long pauses during a subject’s answer were also noted. However, the transcriptions did not include brief pauses or “ums” and “ahs”.

Digital recordings of interviews were transcribed into Microsoft Word documents. The researcher transcribed three interviews whereas the remainder of interviews was transcribed by Wordcrafters Northwest (Bellingham, WA). The use of an outside transcription service was approved by the OHSU IRB. Transcription guidelines were provided to the transcription service so that file names and structures would be standardized.

All digital transcriptions were imported into and then analyzed with Nvivo 8.x qualitative analysis software. Paper-based notes were stored in a locked cabinet within a locked office. Digital recordings remain on a secure, password protected network drive.

2.7.1 CODING

Open coding is the means by which interview and observation data reveal physicians' understandings of, and their needs associated with, CDS. Codes were organized and synthesized into larger themes around CDS. This bottom-up approach provides an alternate perspective to our understanding of CDS. In addition, the same interview and observation data were coded using two aforementioned frameworks: the Sim and Berlin taxonomy from biomedical informatics research and the choice architecture framework from behavioral economics.

Personas

Personas are means by which a researcher can translate his or her experience with and among end-users to inform other researchers, developers, and stakeholders of those end-users' needs and goals. Interview and observation data provides user-centered perspectives that guide the design of clinical decision support tools. Based on Cooper's framework (121) personas were designed with three goals in mind:

1. Life goals: Provides broad context to user goals such as the reason why a physician likes CDS is because, "I want to be the best doctor I can be," as opposed to, "it helps me get through the day so I can get home in time to eat dinner with my family." Life goals explain *why* physicians perceive CDS may or may not help achieve overarching goals.
2. Experience goals: Provides an understanding of users' experiences when using CDS such as, "I don't like alerts because I get angry when I make mistakes." Experience goals explain how physicians want to *feel* when using CDS.
3. End goals: Lends insight into physicians' goals that CDS could or should provide, "I just wish the patient's labs would come up with each condition." End goals explain what physicians *want* CDS to do.

With the committee's urging, these goals were expanded to place the goals within the context of the grounded theory themes.

2.7.2 STRATEGIES FOR TRUSTWORTHINESS

In addition to using both observations and interviews to gather and triangulate data, the physician subjects were asked to review and comment on the researcher's preliminary conclusions. This feedback process, referred to as member checking, lends greater trustworthiness of a study's results. The amount of physician's time required for review and comment will depended on how much subjects agreed or disagreed with the researcher's results; however, ten to fifteen minutes to review the results was a reasonable estimate of time commitment.

Member checking was conducted by creating a "feedback report" and emailing the report to study participants as well as any of their office contacts. Care was taken to follow evidence-based practices that have demonstrated increased likelihood of attaining subject responses. (238) The following criteria were acted upon:

- Avoiding the word “survey” in email subject line
- Inclusion of a “simple header” in the form of a picture
- Use of a white background in the email content section
- Included a description that attempted to make CDS an “interesting topic”
- Provided a deadline written in bold font

Criteria that the researcher did not or could not act upon were:

- Personalize each email for each recipient
- Included a statement of how many had responded to the study (although the email included the number of total study participants)
- That the email was sent from a male

Study participants were asked to return any feedback on or before 5pm the following week (7 days) while acknowledging the short duration of time provided. After six days two responses were provided. The researcher sent a reminder email on the sixth day using the same email criteria that were acted upon as above; the only exception was an added statement that only two responses had been received at the time.

Health system liaisons were written questions about the EHR and CDS systems that arose during interviews and observations. The questions sought to clarify if user difficulties with CDS stemmed from system limitations or other mitigating circumstances such as functionality not used due to a need for training.

2.8 METHODS SUMMARY

Results from this study were expected to contribute to the field of biomedical informatics in a number of ways. First, the study would inform biomedical informaticians how community-based physicians perceive CDS thereby making explicit certain unknown or implicit knowledge and communication gaps. The understanding would help stakeholders optimize CDS functions that meet the needs of physician users in community-based settings. Second, the study would contribute to understanding the types of decisions community physicians want supported. Third, the results would help identify challenges faced by community-based physicians that CDS could or should address. Fourth, the study would identify aspects of clinical performance that community-based physicians value and how CDS should (or should not) impact performance. Finally, the study would detail barriers and facilitators to CDS use that have not previously been identified or explored in biomedical informatics research literature.

3. RESULTS

3.1 STUDY PARTICIPANTS

The purpose for conducting physician interviews and observations was to perform a “contextual task analysis” of physicians in community-based settings. The aims were to focus on activities in these settings, probe users’ views on current CDS, and gain insight into desired CDS functionalities.

I recruited and interviewed 31 subjects from three health provider systems: 30 primary care physicians and one nurse administrator with informatics experience from a previous employer. I observed 25 total observations that included shadowing physicians in and out of patient rooms as well as clinical workflow from nurses’ stations. (a target number of observations was not pre-determined). Twenty-three observations took place in and out of patient rooms, one observation occurred in the physician office only (OB/Gyn), and one other observation occurred from two nurses’ stations in the same clinic (OB/Gyn). A minimum of 10 participants from each network were recruited and interviewed (See Figure 12). During the recruiting process, 3 potential participants (identified by organizational liaisons) actively declined participation, and 3 potential participants did not respond to recruitment communications.

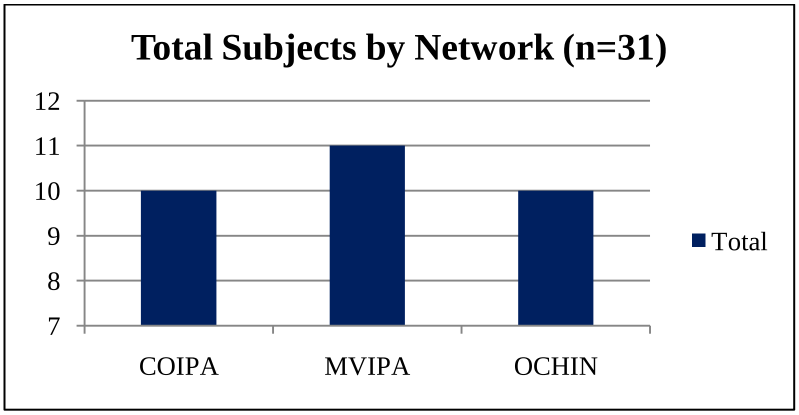


FIGURE 12: NUMBER OF STUDY PARTICIPANTS BY NETWORK

The recruiting target for each network by role was three family practitioners and three internists (solid line), and two pediatricians as well as two OB/Gyns (dotted line) (See Figure 13). It is of note that a family practitioner for OCHIN (Multnomah County Health Clinic) said she and other family practitioners in that clinic are essentially internists since their patient population is strictly adult care.

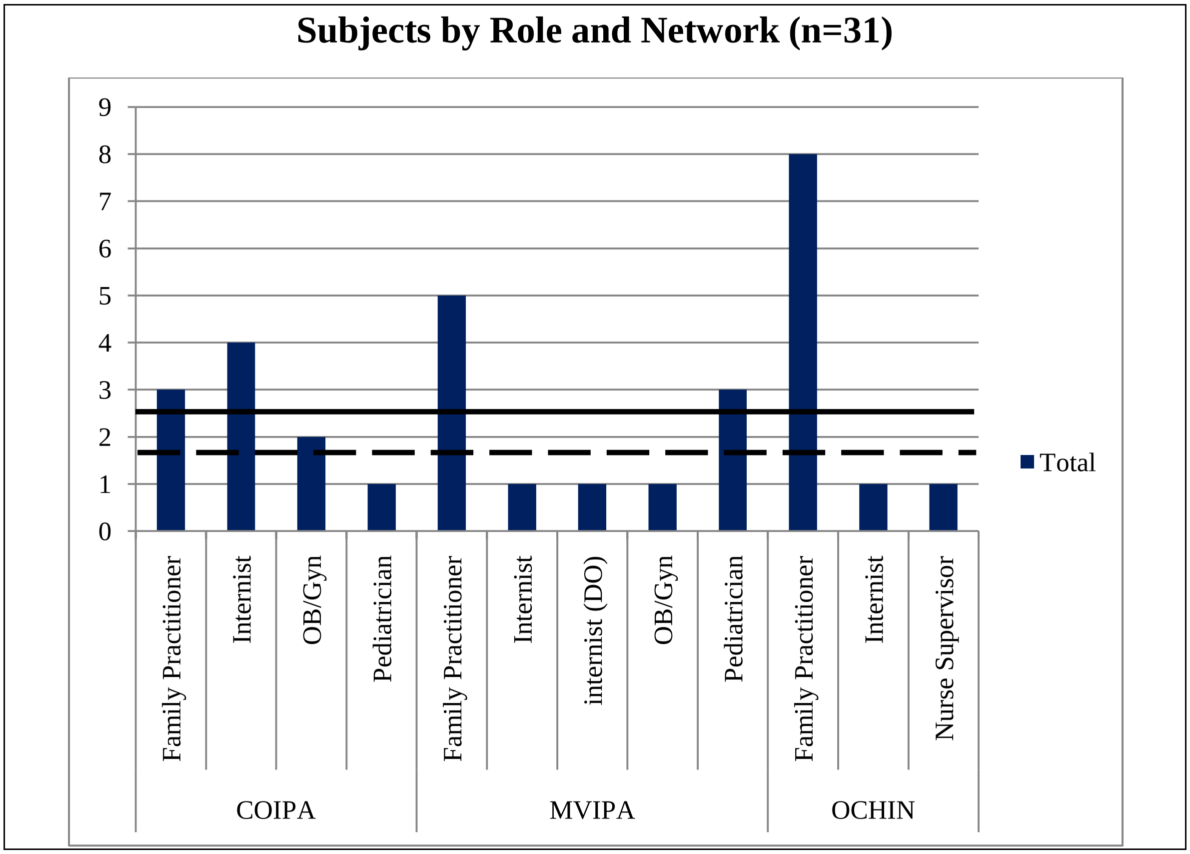


FIGURE 13: TOTAL SUBECTS BY ROLE AND NETWORK

Solid Line = Family practitioner and internist target;
Dotted Line = Pediatrician and OB/Gyn target

Participants were recruited from a total of 15 clinics throughout Oregon (See Table 9, also see Appendix G for a map).

TABLE 8: COMMUNITY-BASED CLINICS' CHARACTERISTICS

Clinics	**Data**
Count of clinics	15
Average doctors/clinic	8 (7.333)
Median doctors/clinic	7
Range of doctors/clinic	1—21
Rural clinics	5
Urban clinics	10

Subjects averaged close to 50 years of age, although there were a wide range of ages (31-63 years), and they were more often men (See Table 10). Subjects on average had been practicing medicine (post-residency) 18 years with a mix of physicians just out of residency and more experienced physicians (range: 2.5 – 33 years). Users averaged approximately 3 years experience with their existing EHRs and most considered themselves "average" level users (n=16) with others self-describing as "advanced" (n=10) or "novice" (n=4).

TABLE 9: PARTICIPANTS' CHARACTERISITICS

Participants	Data
Total subjects	31
Women	14
Men	17
Average age (years)	48 (range: 31-63)
Years practicing medicine (post-residency)	18
Average time using the current EHR (years)	2.7
Subjects who'd used another EHR system	9
Level of EHR proficiency self-assessment (current EHR only)	4 novice 16 average 10 advanced

Interviews averaged 26 minutes in length and ranged from 11 minutes to 38 minutes in duration (See Table 11). A total of 25 observations averaged 90 minutes in length, not counting the six participants who declined observations. One observation was conducted from two nursing stations within an OB/Gyn clinic in place of direct observations. Interviews and observations occurred in all three networks (See Figure 14).

TABLE 10: INTERVIEWS AND OBSERVATIONS

Interviews and Observations	Total
Total Interviews	31
• Average Interview Duration:	26 minutes
Total Observations	25
• Physicians observed	24
• Patients Seen	94
• Patients Observed	85
• Average Observation Duration	90 minutes
• Median Observation Duration	87.5 minutes
• Observation notes	112 single spaced pages

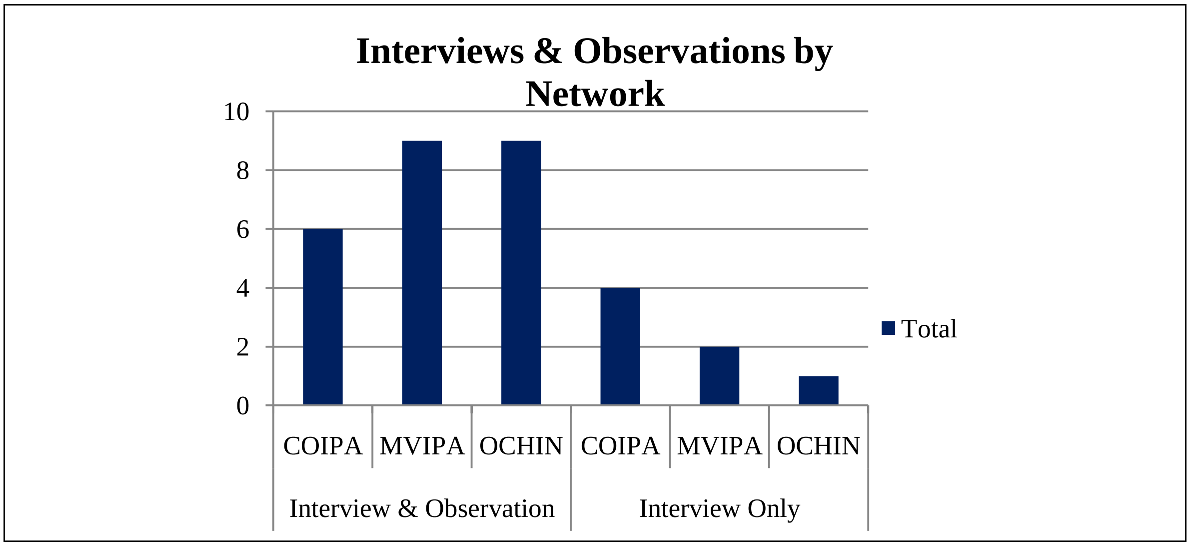


FIGURE 14: INTERVIEWS AND OBSERVATIONS OCCURRED ACROSS THREE HEALTH SYSTEMS

The following sections will provide results of how users conceived CDS based on each of the frameworks in the following order: 1) The biomedical informatics taxonomy which provides a informatics-based analysis; 2) A grounded theory approach which provides themes not beholden to any one predetermined framework; and 3) The choice architecture framework that utilizes research findings based on cognitive science and economics. Looking at the same data through three different lenses allows one to compare and contrast data which therefore adds an additional layer of triangulation and attributing greater trustworthiness to the data. Users' "felt needs" will be interspersed with the results to more effectively relate what users feel they currently have to what they say is needed and wanted. A subsequent section will summarize then users' needs.

3.2 BIOMEDICAL INFORMATICS TAXONOMY

Sim and Berlin provide a taxonomy based on their literature search of CDS (229) which was then applied to literature in outpatient clinics. (232) The taxonomy is the only framework found in informatics literature that was applied to primary care settings. Sim and Berlin define clinical decision support systems (CDSS) as the following, "All CDSSs by definition support decision making: the commitment to an action that allocates resources." (229) I will provide a summary of results based on the five categories of Sim and Berlin's taxonomy: context, decision support, information delivery, knowledge and data source, and workflow. In this section, each category's axis will be written in bold italics.

3.2.1 CONTEXT

Context is intended to categorize CDS literature based on their healthcare settings: inpatient, outpatient, or no clinic at all, i.e. a web site in place of a clinic. According to their notes, outpatient clinical settings include clinics and private practices of which this study included both.

Other aspects of context are evaluating ***clinical tasks*** based on “target tasks,” more commonly referred to as process outcomes, and ***units of optimization***, more commonly referred to as patient outcomes. Dr. Bustamante’s was the only clinic that was observed having close to such a program. Run charts of depression screening rates across three teams were marked in felt pen and taped to the wall by the nurse’s station. A pediatrician suggested that sharing rates of immunizations among his practice partners would be an effective way of changing clinician behavior because they are *“a TRIBE of high achievers that want to do the right thing, and [they] don’t feel good when [they are] below the bar.”* Although few clinics appeared to have defined ***clinical tasks*** and ***units of optimization***, participants expressed the need to have tools available to help them do just that. And participants within OCHIN explained that their system is taking steps on their own to develop such tools.

CDS’s ***relation to the point of care*** pertains to whether a decision support is presented to the end user synchronously (at the point-of-care) or asynchronously (outside the point-of care). When it appeared, CDS mostly did so synchronously alerting a physician of a potential drug-allergy or drug-drug alert. As has been previously discussed these alerts were not appreciated because of inaccuracies, timing, or method of presentation. In interviews, participants liked the idea of having alerts prevent unsafe ordering and other practices but not always at the point-of-care and particularly if those alerts were needlessly going to interrupt their train of thought and/or workflow. A challenge around CDS’s ***relation to the point of care*** is that a number of physicians did not chart in patient rooms opting instead to do so after a patient visit or at the end of the day. Reasons for doing could be discomfort of typing in front of the patient or concern that something the patient says will be missed while inputting data. Such concerns could in theory impact data accuracy although such concerns were not raised in interviews nor validated in observations.

A final context axis concerns ***potential barriers***, whether they are patients’ socioeconomic status or psychological status that may impact any final decision. Dr. Rowland encountered such a scenario in which one of her CHF patients who lived in a care facility was non-compliant on his medication. The inability for Dr. Rowland’s system to interact with the care facility’s system posed a barrier to better managing the patient and tracking his use, or non-use, of medication.

3.2.2 DECISION SUPPORT

The decision support category focuses on aspects of CDS reasoning. In short, CDS reasoning implicitly or explicitly recommends an action that can either be logistically simple or complex, may require action within "hours" or later, and may require the user to indicate acknowledgement that an action was or was not taken.

The ***reasoning method*** behind any CDS available among study participants is unknown and was not a focus of this study, but from what users expressed, further technical sophistication is required for CDS to be considered useful. Some subjects expressed a desire for clinical algorithms integrated into EHRs so that best practices could be easily followed. Observed interactions showed there was a lack of applicable knowledge around the probable outcomes associated with a heart valve replacement or the potential impact of taking Fosamax for an extended period of time. Advanced reasoning methods could help inform decisions around these considerations.

Whatever powers the CDS reasoning method, ***recommendation explicitness*** refers to the "degree" that a recommendation itself specifically states what is to be done or not done. Sim and Berlin do not provide a metric for explicitness and so qualitatively one could conclude CDS within the three observed systems was not explicit. CDS did show itself during drug-drug and drug-allergy interactions but because many users had turned off their alerts (rightly or wrongly) reduced the degree to which CDS recommendations could be made known. Health maintenance prompts in red font, thereby signifying that a screening or test of some kind were due, were routinely ignored because of either physician time constraints or because the prompts were knowingly not patient-specific.

Logistical complexity and ***clinical urgency*** are related in that one refers to degrees of effort required to carry out an action while the other bounds those actions within certain time constraints. ***Logistical complexity***, although not quantified, increases as the number of required actions and/or participants increase. Participants were well aware that the health care system which surrounds them was frustratingly complex and that completing a task, such as completing a lab or reaching a patient, required effort. There were not any examples where ***clinical urgency*** of a life and death nature arose, but coordinating activities with specialists, labs, and missing patients generated an urgency of their own kind. CDS systems did not provide particular support in these areas although remote access to data was considered an advantage, particularly for OB/Gyns called to the hospital late at night.

Finally, CDS ***response requirements*** are a way to confirm whether or not physicians knew of an allergy before ordering a contraindicated medication. Dr. Spell, a pediatrician, noted that the NextGen system required an acknowledgment whenever a contraindicated medication was being ordered.

3.2.3 INFORMATION DELIVERY

A third category of Sim and Berlin's taxonomy looks at how CDS is delivered to end users. Information delivery focuses on the ***mode*** and ***format*** of information; that is, whether any information is pushed to or pulled from users and how any information is presented. The taxonomy terms ***action integration*** as any information that is delivered during prescribing, test ordering, referrals, or consultations. And finally, ***explanation availability*** accounts for whether a CDS tools provides explanation as to its reasoning and if there is any *delivery interaction* tools that enables an end user give CDS feedback.

The ***delivery mode*** is similar to CDS that has passive alerts ("pull") or active alerts ("push"). CDS was described and observed as predominantly passive which meant patient-specific clinical data did not trigger events. For example, eClinicalWorks presented general screening "alerts" in a sidebar to the right hand side of the screen.

Participants decided whether or not to access the sidebar. As may be expected, push CDS presented information using pop-up windows that stopped workflow.

Delivery format refers to the modality by which CDS is pushed from the system to users or pulled from the system by users. Any CDS was predominantly delivered to users from within the EHR at the point of care. Participants also accessed online references through the EHR directly or by separately using a web browser. PDAs were common means to access drug information. Only one physician was observed receiving a text page while at work and it was not documented if it was CDS related or not. Last but not least printed reference materials were consulted to address clinical questions.

Referring back to Dr. Spell and the example of NextGen's response requirement for contraindicated medications, she had gone on to explain that the CDS *"does an annoying thing"* by not only alerting her of the allergy but then informing her what not to prescribe: do not to prescribe *"Albutorol for wheezing [or]…Zythromax for pneumonia."* There was no explanation to inform her why these common medications would not be prescribed for such indications. Not being presented the reasoning behind a CDS rule is referred to as *explanation availability*. Dr. Spell questioned the CDS recommendation and wanted to know who gave approval.

Furthermore, to communicate her question Dr. Spell would require some form of ***delivery interactivity*** such as an online form. Dr. Spell was not asked if she was given such an opportunity but from her tone it was assumed that she did not. However, it may be that she could contact information support to get clarification or that there was a means but unknown to her. For cases like this example what would be needed is an easy and effective way to attain an answer to her question.

Lastly, Sim and Berlin made a special distinction for tools that facilitate actions associated with recommending prescribing, test ordering, referrals, and consultations. Examples given would be to make a single click or mark a check box to carry out a clinical action of some kind. Instances of this sort were not recorded in interviews or observations.

3.2.4 KNOWLEDGE AND DATA SOURCE

The knowledge and data source category focuses on a number of axes related to knowledge management of CDS. It seeks to specify the person who is the primary data source, the person with clinical knowledge is tasked with coding that data, the degree that data are customizable within CDS, the person or organization that sources clinical content, and the process for curating data.

Data sources are the data that drive CDS. They can be collected directly from users via CPOE, or imported from third parties such as labs or hospitals, or perhaps imported using "medical instruments." According to interviews and from what was observed, data were primarily captured manually in EHR workstations located both in and out of patient rooms. Capturing data and the means of capturing data were concerns of many participants. Physicians expressed frustration with the process of capturing data due to its impact on workflow and time spent with patients. Doctors often did not lament that data entry and documentation were required but they lamented the amount and the time it took away from patients. Dr. Hellman stated what many other participants expressed about capturing data, *"If I'm clicking I'm not seeing people."*

Participants were very well aware when their systems did not share data with other systems both within and outside their networks. One clinic was documented as having a lab on the premises that could not share data with the EHR. Physicians across found accessibility to data to be an urgent need and one doctor pointed out that doctors themselves are going to have to open up to one another. Two other participants cited HIPAA as the cause for not being able to share data.

Finally, no medical instruments were seen to capture and transfer patient measures and/or readings into CDS. Although subjects did not express a need, observations include notes where a medical device that wirelessly transfers data to EHRs would be valuable.

As physicians were the exclusive focus of this study as well as the only observed users to enter any CDS-related data, any distinction between a ***data input intermediary*** and ***data source*** is for the most part moot. As physicians were most often the person to collect and enter data they were most often both the data source for themselves or data input intermediary between patients and the system.

Observations and interviews did not record data describing patients entering data in lobbies or via PHRs. Furthermore, staff was not observed as data input intermediaries although it is a role that was likely fulfilled at many clinics by MAs. Doctors made it known that they would like to shift certain data input tasks to other intermediaries. Dr. Rowland went even further by suggesting that the certain sources themselves, i.e. patients, enter data into the EHR. What doctors then saw as being needed was CDS that was directed at those people, lower level staff, to support routine and structured data collection.

Two participants described being familiar with an emerging clinical role, that being data input intermediaries known as "scribes". Scribes were reportedly being hired in some clinics, not participating in this study, to shadow physicians into patient rooms, collect visit data, and then enter that into an EHR. This reported development was the only finding that a new "role" was being developed as a result of community-based EHR use, if not the use of CDS.

How any CDS data were coded falls under the purview of ***data coding***. This axis starts to get at a challenge participants described which was what manner should be used to get data into the system. To address free text participants used a number of means to capture data most often of which was keyboard typing. Epic Ambulatory offers typing shortcuts known as "dot phrases" to enter common phrases to clinical work. Physicians also employed other technological means to reduce the amount of typing which included using self-made templates saved in text files as well as using a third party software called, FastFox. Another tool that was found in clinics was Dragon Speak which is voice command software that enables users to verbally enter data into a system.

Sim and Berlin include ***clinical knowledge sources*** as an important aspect of CDS. Users were aware, sometimes hyperaware, that intra- or inter-clinic standards of practice were administered. Participants were also aware of third-parties, such as Cerner Multum, that provided clinical content.

The ***degree of customization*** and knowledge related to data ***update mechanisms*** appeared largely hidden from users. However, participants appreciated the automated manner of medication lists which improved reliability of a patient's current regiment. Yet the ***degree of customization*** in regards to CDS was at a level far below what participants wanted. They often wanted to develop CDS around how they thought and that fit their particular cognitive and physical workflows.

3.2.5 WORKFLOW

A fifth category addresses the workflow pertaining to CDS. Four axes encompass workflow which is the system user who uses a computer within the system, the target decision maker for whom CDS is intended (not necessarily the system user), the output intermediary who is the intended person to processes whatever decision is made, and any external factors that may impact a clinical decision.

System users are individuals who directly interact with the CDSS output. System users may include data output intermediaries, and target decision makers. There were no direct observations of system users who were other than physician users. Same goes for ***target decision makers*** for whom this study CDS was intended. There were many instances when physicians with patients engaged in shared decision-making but this was often aside from specific CDS tools. Some doctors stated they wanted to hand off structured decision-making to certain staff members, and the one non-physician hinted that staff is anxious to take on some of the work around documentation and panel management. Ultimately this would mean shifting some of the documentation and management burden away from the doctors.

When patients were the ultimate decision-makers then physicians play the role of ***output intermediary***. Few instances were recorded where CDS may have directly led physicians to turn to patients for ultimate decisions. Those examples were previously mentioned: a physician leaving a decision about a Fosamax prescription up to the patient, and a physician leaving it up to a patient as to consider reasons for and against heart valve replacement.

Finally, ***workflow integration*** describes CDS systems that "push" unrequested information at users who work in clinics. The CDS systems observed and described provided very few opportunities understand how, or if, these technologies were used. This could be largely due to the fact that any push technologies such as alerts were turned off. In fact, one reseller advised doctors to turn off the alerts once the system was operational.

3.2.6 NEEDS SUMMARY

The Sims and Berlin taxonomy provides a multi-faceted view of decision support as it moves from the system to the user. It also provides means for documenting the relationships between CDS and any contextual factors and workflow. The taxonomy places a system-centered focus on rule creation, generation, and presentation. Multiple system-user interactions are interspersed throughout the taxa thereby framing people's interactions around CDS. As such, user needs centered around improved interactions with the system including ways to provide feedback, defining who captures data, when, and how, as well as perhaps providing means to informing end users how the system derives any CDS that is presented to the end user.

3.3 GROUNDED THEORY

THEME 1: THE USERS

A critical component of user-centered design is to understand the users: who they are, how they view the world, and what they want to accomplish. This section will provide self-descriptions and interpretations of study participants' characteristics. Participants' quotes will be written in italics.

THEME 1.1: SELF IMAGE: PERSONALITIES & PERSPECTIVES

As the study developed over time, subjects began being asked why they chose to specialize in their field of primary care and the goals that they aim to achieve when practicing medicine. Study participants chose their specialties because they highly value working with a *"variety"* of patients and enjoy the challenges associated with their care. Participants described being *"bored"* by specialty care and enjoying the challenge of caring for a *"spectrum"* of patients and conditions.

They are puzzle solvers who thrive on using their wisdom and expertise to address difficult health issues. They are energetic even after 10-hour workdays meeting with 20 – 30 patients, with few lunches and breaks, and working mornings through late nights finishing a day's paperwork. In addition, someone on staff would be assigned to be "on call" to cover others physicians. This meant being at the ready to attend to a late night call about something like a patient going into labor and being rushed to the hospital. Within this demanding schedule, participants find time to have hobbies and attend school; one participant even graduated from OHSU's biomedical informatics program.

As previously noted, primary care participants described themselves as a *"tribe"* that in a rapidly changing field is not always valued (professionally and economically) by the larger health care system. To that, Dr. Harter lamented the cause of the primary care practitioner, *"...we're a dying breed."* Still, they take extreme pride in their work and their work on behalf of their patients and communities.

That pride showed itself through the demands that PCPs placed on themselves as well as the CDS and EHR system. Participants saw themselves as *"compulsive"* which brought both benefits and costs, benefits for patients and the care they receive, but costs that could result in additional work. In their need to be prepared as well as feel prepared, physicians explained they may chart the night before or prepare notes the morning before patients arrive. Dr. Cowden explained that she is *"a little OCD,"* and that having notes prepared *"...takes [her] ANXIETY level down."* Aspects of working with EHR systems could also make the participants defensive such as likening clinical data entry to a job that has them *"wear a hair net [or] a name tag."* But working with CDS and EHR systems could bring out honest frustrations that led to self-criticism:

> *"...I feel kind of DUMB when parents will say: 'And you'll see we were in three weeks ago. We saw Dr. so-and-so, and he diagnosed MRSA.'...I didn't KNOW that because there's nothing [in CDS to] really TRIGGER. I have to go SEARCH*

> *for that information. In a paper chart that didn't HAPPEN as much, I don't think. I guess I'd like the information to be in a better, more usable, more understandable form, and more readily at my fingertips."* [Dr. Bracey, Pediatrician]

A common thread among this group of primary care physicians was their appreciation and respect for the relationships they'd built among their patients as well as staff. Building and maintaining strong relationships with patients not only provided the physicians job satisfaction, they were also critical to the ongoing and highly personal partnership between a patient and doctor. Participants were energetic, possessed good social skills, exhibited curiosity, and were personable; all characteristics they used to solidify the bonds of the patient-doctor relationship.

Stated goals of primary care practitioners included providing good care to the *"whole patient."* This philosophy put onus on the participants to have a strong grasp of the biological as well as the psychological, social, and spiritual needs of their patients. Dr. Steward provided his goal that sums up what many others discussed:

> *"[my goal is] to provide good care for my patients, and build a level of TRUST that we can discuss things honestly, and they feel comfortable, [with] my recommendations."* [Dr. Steward, General Internist]

Good care, trust, and relationships were often discussed and so are interpreted as central concerns of primary care practitioners.

Each role primarily focused on a particular patient population, with some overlap, which necessitated different relationships. Family practitioners, for example, provided care to children, teens, and adults of all ages whereas predictably pediatricians cared for newborns to teens. The type of care these populations receive meant having long standing relationships with their family practitioners and pediatricians, which meant patients and doctors had a history with one another which could provide broader context to any one visit. But pediatricians' and family practitioners' information needs were divergent to certain degrees, the former relying heavily on weight and growth charts while the latter needing access to height, weight, blood pressure and other data.

General internists, like family practitioners and pediatricians, worked with patients over extended periods of time but those patients tended to be older. Having an older patient population could mean having longer medication lists with complicated polypharmacy. In addition, as Dr. Hatter pointed out, caring for retirees could result in longer visits because the patients are not rushed to get back to a job. This is an important consideration in terms of workflow, patient flow, and information flow. General internists and family practitioners in this study both described goals of treating the *"whole patient"* which meant being attentive not only to clinical needs but also meeting psychological and social needs.

Obstetrician-gynecologists, unlike their primary care counterparts, could expect a very different patient population. Dr. Altamirano explained that the difference is more than just having a female patient panel, the age of patients tends to be younger and therefore medication lists are not as daunting as might be for older patients. In addition, the nature of relationships are different in that OB/Gyns may only see patients for short stretches of time while a pregnancy progresses before referring patients back to their family practitioner. Or, an OB/Gyn may not have contact with a patient for years and then meet again to discuss options associated with a uterine disease.

During interviews participants could be asked, or they offered on their own, opinions as to *"what constituency"* or whom CDS is designed for. Physicians felt that the EHR systems were built for billing purposes and as such benefitted people other than themselves: *"lawyers"* and *"billers."* One participant grumbled that the systems were "designed by people who AREN'T busy Internists." The feelings expressed were that EHRs in general and CDS in specific was often another barrier to practicing primary care medicine:

> *"You know, medicine's COMPLICATED and so I don't even know that that's gonna be that ACCURATE, ALWAYS. But I do feel that this is pushed down our throat quite a bit by people who wanna analyze the event, and then wanna be able to get a REPORT that looks PROFESSIONAL, without having to actually read CHARTS or figure things out."* [Dr. Rathbun, General Internist]
>
> *"I would be able to just, you know, rattle off that chart, and some PERSON, not a MACHINE, because transcription, I mean, they've now used automatic transcription, in the hospital first, and then a Transcriptionist reads it second, and there's all sort of errors all over it, and embarrassing."* [Dr. Harter, General Internist]
>
> *"It's unprofessional. Just, I mean, you know, if you look at the letters that I write NOW, and the prescriptions that I print and hand the patients, they look AMATEURISH."* [Dr. Hellman, Family Practitioner]

In conclusion, participants were exceedingly busy and often stretched for time, giving themselves or being given few breaks for lunch or coffee warm-ups. However they were social, gregarious, curious, and appeared to truly enjoy the variety of cases that waited in patient rooms.

THEME 1.2: RELATIONSHIPS

Community-based primary care practitioners highly value the relationships they develop and nurture with patients, patient families, caregivers, and clinical staff. As such, there is a need for decision support to work within the context that decisions are made to support a variety of relationship types. This requires designing a system that ultimately gives physicians a sense of a patient's story. For example, one physician described an advantage of paper records was that their format (a heavy chart vs. a light chart) alone could convey a patient's personality and history. Another aspect concerned the need for tools that do not detract from the physician-patient interaction. These needs represent a higher level of clinical decision support: quickly giving a physician a sense and a feel for a patient's needs that inform how to approach the patient visit.

To build and maintain relationships requires trust between the patient and physician (as well as the physician's team). Physicians consistently described their need for a system that engenders trust in the physician-patient relationship. There were a spectrum of needs that spanned from having accurate and ambulatory-based alerts and notifications to generating more professional looking patient letters.

THEME 2: THE PERCEPTIONS OF CLINICAL WORK

Despite their efforts to build and support relationships, physicians often find themselves strapped for time and resources. Much of this is influenced by the larger economic environment within which they work, but they look to clinical decision support (CDS) tools to enhance their decision-making and clinical efforts in ways that enhance relationships. Excessive documentation requirements and inefficient data collection were viewed as barriers to patient-physician interactions. And although physicians did not feel poor EHR navigation affected their ultimate clinical decision-making, interviewees revealed examples when procedures either were or were not performed in order to avoid *“klunky”* EHR navigation and documentation. Physicians also described and expressed in observations the cognitive work associated with EHR navigation and data collection while trying to focus on clinical decision making.

THEME 2.1: ENVIRONMENT

Physicians described challenges associated with clinical decision-making while navigating and documenting within the EHR, often times running behind schedule with few breaks. Observation notes contain passages where the researcher described being hungry, tired, or both. Within this context, physicians described their mental processes when working with CDS in the EHR and explained of ignoring health maintenance flags, reminders, and alerts due to lack of time or inappropriateness. When asked physicians did not believe cognitive limits did not affect their clinical decision-making, it just slowed their ability to make those decisions. However, one physician described one instance when not having patient-specific data caused her to perform unneeded clinical tasks; she referred to this as having wasted her *"brain power."* The doctor's concept conveys to some degree that *"brain power"* is a resource that is of finite capacity.

Categorizing clinics as merely *“clinical settings”* or *“private practices”*, however, does not fully describe the context within which participants worked. The physical aspects of work in community-based practices were demanding. I felt exhausted at the end of just one full day of interviews and observations. My feet were tired, my brain was sluggish, and I was hungry. I gained the sense as to why medical mistakes could be made in community-based practices; the workdays are long and there are few breaks. Lunches were often abbreviated and hastily eaten while catching up on paperwork and charting. By the time mid-afternoon arrived my body wanted to lie down and my mind wanted a breather. The pace of work was consistent for both community clinics and private practices.

Also the variety of patients spoke to the variety of demands to which physicians are accustomed, and to which CDS must adjust. Pediatricians interact with new mothers walking around the patient room with infants in their arms and screaming children scared of what an otoscope might do. Family practitioners and internal generalists work with patients who purposefully avoid check-ups or who might not have bathed for two weeks while living on the streets. One moment they may be celebrating a patient's lowered blood cholesterol and another moment revealing a diagnosis of malignant melanoma. Or OB/Gyns who may see patients for brief periods of time during pregnancy. The clinical setting axis doesn't leave room to capture the variety of physical demands, joys, and stressors that accompany the many clinical decisions that are made in community-based practices.

THEME 2.2: TIME

To understand the practice of primary care is to understand that time is always looming and restraints are omnipresent. Observations noted multiple instances when participants were behind schedule if not pressed for time; the act of decision-making occurred under sever time constraints. These constraints were a significant factor in whether or not CDS-based recommendations would be accepted or not. Dr. Steward boiled it down to effective and accurate decision-making needing to occur with scheduling burdens:

> *"It's a matter of TIME. For instance…I were to go into [a patient's] exam, and click on the EXAM, instead of clicking HERE, and then clicking HERE, and then clicking HERE, I have to either NOT click that, or click in the EYES, and say: 'Well, generally, they were OK. Sclera was OK. PUPIL was OK.' And then click OK. And then go BACK. So it's simply a matter of TIME."* [Dr. Steward, General Internist]

Clinical decision-making was not made in a vacuum; it took place within the context that decisions about proper medications and treatments needed to be made quickly so that the patient visit could be completed to move onto the next waiting patient. Decisions particularly at the point of care had to fit within the scope of the doctor-patient interaction; otherwise there was a higher likelihood that CDS will be ignored. Dr. McBurney also noted the precious need for time:

> *"You'd have to actually go look it up…somewhere and read about it which you don't have time to do in the middle of prescribing."* [Dr. McBurney, Family Practitioner]

The feeling that time was a precious resource caused participants to perceive that any system, and those who might design it, was working against them:

> *"I feel FRUSTRATED that my time is so squandered. And I FEEL somewhat RESENTFUL that people who don't take care of PATIENTS have decided [CDS in and EHR] is a good idea."* [Dr. Rathbun, General Internist]

Time constraints were ever present and were a primary cause for ignoring alerts or reminders. As Dr. Nations noted, health maintenance reminders were not of foremost importance under the constraints of the average visit:

> *"I mean in a fifteen minute visit with all the stuff patient[s] have. Y'know, they come in [and the chief complaint] says 'nausea' but…you [consider] alcohol abuse, and falling, and…follow-up with the cardiologist and a whole bunch of other stuff; that the flag that tells you they're due for a mammogram seems less important than making sure they're actually going to get home safely. And so it, it's…there and you see it, but…I don't know I just ignore it then unless they're here for a health maintenance or I have extra time."* [Dr. Nations, Family Practitioner]

Waiting for the system to provide appropriate CDS, let alone flip screens or process orders, was a *"painful"* experience that caused outbursts of frustration. In addition, time constraints meant that participants had few, if any, opportunities to remove themselves from patient workflow and review literature or weigh the options of their decisions. Rather, doctors judged the effectiveness of their work by the speed at which they were able to provide patient care and relished strategies that, as Dr. Rowland said, *"carve[d] off MINUTES"* from data entry and ordering. Physicians looked to CDS to improve their efficiency as much as any decision making.

In addition, time restraints were further weighted by thoughts that to do less than what was clinically required could be met by litigation. Therefore the completion of records and documentation of decisions taken were of particular concern to a certain few participants, those that had been taken to court for accused malpractice.

Experience with the paper chart was the measure of effective and timely decision support. Physicians wanted CDS that allowed them the perceived flexibility of a paper chart supplemented by technology that prevented errors. At baseline, participants wanted a system that they perceived did no worse than paper charts:

> *"I just don't want it to HURT me."* [Dr. Rathbun, General Internist]

…and

> *"I would feel like it's HELPING me instead of hindering me in terms of [laughs] I'm spending less time looking for the right diagnosis, like you saw me doing there a few times."* [Dr. Bustamante, Family Practitioner]

Interestingly, participants wanted the system to help them save time not just because they could be on schedule or get through their day faster; instead, doctors wanted to redirect any saved time to patients. When asked what it means to have the system slow him down, Dr. McKean equated slowing down with taking time away from patients:

> Interviewer: "By slowing everything down, what does that mean to you?"

> Dr. McKean: *"It means that you spend more time taking care of the chart and less time taking care of the patient. So you have to -- if you have to read through 22 interactions, then to find out that none of [the alerts] are really significant or important, then you just spent time in [the office] doing that and you haven't spent time in [the patient room] with your patient taking care of [them]."* [Dr. Mckean, OB/Gyn]

The above example is demonstrates not only the perception that time with the chart is time away from the patient but also that participants' time is separated into office time and patient time. CDS is often viewed in physician offices, away from the point-of-care. Clinical decision making in community-based practices is consistently pressed by a schedule that forced participants to make fast and time-appropriate decisions. Of course, this is a justification for having CDS but it is also a reality as to why CDS must fit within the context of its potential use.

THEME 2.3: COGNITIVE WORK

A complaint about the work of community-based practice was the amount of uncompensated *"cognitive work"* that went into patient care. Cognitive work was referred to as the work that occurred away from the patient visit: planning for the patient visit, researching potential patient care plans, communicating with the patient, and coordinating health system players, and more. Unlike billable "procedural work" that compensates primary care physicians for their face-to-face care with patients, cognitive work is uncompensated. To community-based physicians, much of their effort involves cognitive work for which doctors must take on as a cost.

The concept of cognitive work and procedural work was introduced by Dr. Rathbun, a general internist, who provided the insight. She gave an example of procedural work, work for which she gets paid:

> *"Some things are so straightforward. There's a skin cancer. You know, most of them you just cut it out and you're done."* [Dr. Rathbun, General Internist]

Dr. Rathbun then contrasted that with the effort that goes into the cognitive work of a primary care physician:

> *"I have a complicated [case] with multiple medical problems in the hospital right NOW. This morning her labs showed new abnormalities. So for me to understand WHY her kidney function and potassium are UP, I had to go to her OLD record, and see what medicine she was on, and compare them to the medicine she's on NOW, looking for toxic effective of a medication. I had to REVIEW her fluid status in complete detail Ins, outs, did she have post-void residual? Is there anything volume-wise? I had to think about obstruction. So then…this one's complicated, and lots of doctors, lots of tests. I had to look at her radiology records. Did somebody else happen to order a kidney ultrasound or CT? Is there some radiological information that I need to look at to help me understand why her kidneys aren't working well today? [A]nd then I had to consider the reason*

> *she is in the hospital. She has urinary tract infections. Is that contributing? I had to access Up ToDate.com to kind of, you know, refresh on certain things. And that's just ONE of her problems this morning. She, of course, has OTHER problems. And so then, kind of thinking about that, I have to go into the hospital system and order…the tests I WANT. Repeat the tests later. I have to REMEMBER to look those up later TODAY. Then I have to TALK to the patient and explain this to her, and then I have to synthesize this and write a note that FOR MY PURPOSES, gives me my thought process, and so if it turns out this way, I do this, and X if it turns out THAT way, I do THAT. So I want THAT in the note. And then of course, for BILLING purposes, you wanna reflect the complexity of that process. In the HOSPITAL you can charge for work on the FLOOR. But as an OUT-PATIENT, you can't charge for any of that process. That's completely NON-reimbursed."* [Dr. Rathbun, General Internist]

In order to feel prepared and dutifully maintain the relationships and trust with their patients, physicians may conduct much their cognitive work before the start of the workday, minutes between patient visits, or even at home. They may go to great lengths to prepare themselves for work. Dr. Cowden, for example, reported she initially spent three months of after-work time, each night, entering patient histories in the EHR to be prepared for patient visits. In an understated manner, Dr. Cowden admitted, *"It was an inordinate amount of effort [laughs]… NOW I've got most of [the patient histories] in there, and [patient visits] flow better."*

Understanding that participants were hyper-aware of cognitive work provides further understanding as to why they are protective of their energy for decision making. Dr. Spell, a pediatrician, used the term "brain power" to explain mental energy. To her, "brain power" was a resource of limited amount that required protection.

> *"…last night I was on call, and I saw a kid…I flipped to the medication history, and I saw a page full of antibiotics. And so I said to myself, 'Wow, this kid's had a lot of reason for antibiotics and probably given the age, it's all ear infections.' And the dad TOLD me he's had a lot of ear infections. So I went back into the room saying, 'Gosh, you know, we really need to get an ear, nose, and throat doctor referral.' And he's like, 'Oh, yeah, we have an appointment for blah, blah.' You know, they already KNEW all that they needed to know. I didn't even need to…waste brainpower or time or THINK about, 'Well, whom I'm gonna REFER them to?...I would have known they were already referred IF [CDS] popped up in the chronological flow, but it DIDN'T."* [Dr. Spell, Pediatrician]

Instances of brain power were described in interviews and evoked in observations like this one:

> *"There's been no break from patient to patient, "c'mon brain," she says as she reviews the values and opens UpToDate. "Hang in there [doctor name]," encourages another doctor in the office."* [Dr. Nations, Family Practitioner]

Participants communicated a clear sense that they wanted to reduce the amount of cognitive work to spend more time with their patients. This need was sometimes communicated by differentiating “doctor work” from other kinds of clinical work. Doctor work was not only something other than cognitive work, it also described something beyond “routine” procedural work:

> *“[Patients] don’t need me to check…more AICs. They need me to either finally convince them to go on insulin or . . . help ‘em figure out how to do somethin’ different… Are you exercising, and why? And do you understand why we check your feet every time? Did you have Aqua Socks for when you go to the beach? And tell me about how nutrition’s going. OK, well, we should, you know, be thinking about makin’ these food substitutions. You know, is your husband supporting you better in your nutritional plans? Or do you still feel like he’s undermining you? You know . . . that stuff. The stuff that I think actually makes the NUMBERS…”* [Dr. Tarver, Family Practitioner]

Much of cognitive work and effort revolved around physician sense-making at times outside the patient visit. Sense-making provided participants a big picture view of any one patient so that decisions around care plans and strategies could be carried out. Physicians lamented anything in systems that slowed them down or caused them to spend additional *“effort”* clicking through windows in their EHRs to develop a sense of their patients before patient visits occurred.

> *“…right now when I see someone with diabetes, I have to go to the lab when their A1C was, and go to the D.I. and see when they had their eye exam, and I have to go about FOUR places, and be checking off in my MIND what I know they NEED.”* [Dr. Tarver, Family Practitioner]

Participants believed that CDS could help them by piecing together disparate data and quickly provide them with a sense of a patient, a patient’s status, and a patient’s history. This form of CDS would ideally save time, reduce their amount of cognitive work, and save their brain power. Participants explained that when using paper charts there were a number of artifacts that helped them piece together data. These artifacts were termed summary sheets and medlogs (medication logs):

> *“We don’t have a MEDLOG. We don’t have a good way to look at the whole PICTURE of medications. It’s so crazy. You can only click one at a time…I really miss having, you know that piece of paper that had all their drugs, and one was stopped, and one was started.”* [Dr. Rathbun, Internist]

An instance of how cognitive work usurped clinical work was when Dr. Nickel, a family practitioner, spent twelve minutes (almost a full 15-minute patient visit) trying to rearrange when refills of a controlled medication would occur.

> “The doctor tries to mentally calculate when to start giving the medication given a new timetable. It’s likely critical to be very accurate since the drug is a controlled substance. He and the patient stare at the wall calendar in silence. The patient asks if he can get meds on the 20th of every month and the doc scratches his head. “I think I can figure this out,” says the doctor.

> The doctor pulls the calendar down from the wall and begins to count the days on the calendar with his finger, “23-24-25,” laughs and starts again. I think he lost his place. The doctor hypothesizes that the patient will from now on get his meds on Tuesdays (he thinks). But the patient wants to pick up the meds on the same date number (the 20th), not the day of the week. The doctor goes back to working it out manually and his math tells him the patient will need 180 pills for the next three months. The doctor enters 180 in the med quantity; but then the doc opens the windows calculator to figure how many total pills the patient will require. The calculator shows 168. With 168, the doc revises the 180 in the order form. Furthermore, he writes out the med (in text) as 168/28 days and so proceeds to fill out the next series of orders just to get this out of the way. The doctor counts out a period of 28 days, bouncing his pen on the calendar and determines when the refill will be needed. The doctor slowly types that refill into the new (estimated) date of pick-up. The computer pop-up prevents the doctor for entering the drug instructions because he used brackets instead of parentheses. The doctor then repeats this process three times more so that the patient can pick up three more refills at the 28 days as expected. This was comical yet painful to watch. I haven’t done the math but I’m not surprised if the numbers are wrong.” [Observation of Dr. Nickel, Family Practitioner]

Another paper-based artifact that participants appreciated was post-it notes. Post-it notes were high value, low cost reminders because they were non-intrusive, highly visible, and could be easily discarded when no longer needed or wanted. Post-it notes were one example of providing physician reminders without taking much brain power.

> *“…a Post-It note [would be] in a different color than the whole PAGE. It was clearly something foreign to the chart. It didn’t BELONG there, and you’re like, ‘I wonder what that’s there for?’ So your brain automatically said, ‘Hmm, I wonder what that’s there for?’ And you READ it.”* [Dr. Spell, Pediatrician]

Participants expressed a need for CDS to help them their cognitive work more efficiently and effectively. This would not only help them save time and effort associated with non-billable activities, it would help direct work toward higher level activities directly related to patient care. Furthermore, it would also help them gain a better understanding of their patients and support relationships with their patients.

THEME 2.4: COLLABORATION

Participants described a number of issues related to collaborations. Whereas relationships addressed longer term bonds between physicians and patients, collaborations represented actions that were meant to address short to intermediate term needs. Participants described four constituencies with whom they often collaborated: patients, patients’ family and friends, clinic staff, and entities within the larger health care system.

Collaborations put focus on decisions in that whatever clinical decisions are made involve at least two parties: a doctor and a patient. Examples of shared decision making included patients recommending they themselves receive immunizations and the doctors agreeing, physicians laying out options regarding surgical procedures or medication regiments that patients were to consider, and both patient and doctor that tried to decide what to do about a bad case of insomnia. Observations were valuable in that they noted how interactions between the system and physicians, and any needed decision support tools, might also need to account for patients as well.

Collaborations during the brief 15 to 20 minute visits were intimate dialogues that took place in patient rooms. Dr. Durfee, a general internist, explained what many physicians expressed which was the quality of a patient-physician interaction was a critical component of a successful patient visit: *"Well, it's UNMEASURABLY (sic) important. When people come in to see you, they want to SEE you."* Participants expressed reservations about the presence of a system when talking with patients, particularly if the system was mounted between a physician and a patient. Participants furthermore conveyed concern about typing and addressing any CDS in the middle of the patient interview for two primary reasons: 1) that a physician's eyes focused on a monitor prevented collection of important data through physical communication; and 2) that verbal data would be missed while the doctor attempted to chart the visit at the same time conversing with patients.

> *"... the OPTIMAL system would be a way for me to JOT notes, while I'm sitting, knee-to-knee with patients, and able to, you know, TALK to them CLOSELY, in a somewhat intimate way that you're, you know, in a relationship with a patient, and to be able to WATCH what's going on in their face while only intermittently glancing down to put a note on a SCREEN, and to QUICKLY pull ORDERS off of an order set or something like that."* [Dr. Vela, Family Practitioner]

A barrier to collaborations was patients and doctors going into visits having competing agendas. Despite having a documented chief complaint for any visit, patients brought up additional concerns that diverted discussions away from documented foci. In such occurrences valuable time was used up as both patient and physician as they negotiated their needs around the visit.

> *" [patients] come in because their back's hurting, or their knee's hurting. And that's THEIR agenda. And MY agenda is: Hey, your blood pressure's not quite optimal. You know, your diabetes needs a little more work. We need to make sure you've established THIS, accomplished this, etc. And having a system that supports THAT, I think would be helpful."* [Dr. Dehart, Internist]

Collaborations tended to follow one pattern: information needs of the physician (primarily) led to what I will refer to as *"data dialogues"* then opportunities for patient education and physician advocacy. Many observed participants throughout this process utilized the data displayed in the EHR to emphasize points about patient status or to justify proposals and decisions a physician would make. Physicians often started patient visits by gleaning information from patients about the medication lists. At this stage mounted monitors or laptops on patient room sink counters arms were often turned toward the patient with the physician clicking down the list confirming each (if any) medication. Epic Ambulatory, for example, displayed large green checkmarks that could more easily be seen than the other systems when shown from across a patient room. The discussion of medication lists then often moved to doctors and patients exchanging data such as patient blood pressure measures written on lined pieces of paper or going through Ziploc bags of over-the-counter medications. Physicians would also use this stage to present data back to the patients about their health status.

> *"I can pull up information and show it to the patient and…that's valuable; to…see trends."* [Dr. Nations, Family Practitioner]

Lastly, data dialogues would inform a plan that often involved patient education and physician advocacy. Patient education took place by handing off printed information from the Mayo website, hand drawn pictures, or shaking medications to reinforce learning. Physicians described disappointment with the applicability of patient education literature due to length and level of literacy:

> *"I would like to be able to USE my Electronic Health Record to be able to EDUCATE the patients. And as it is right now, I think that's IMPOSSIBLE…[P]atients…that are willing to pick up [a patient handout] sheet and actually get started, are gonna fatigue…[Patient handouts are] full of information that's DISTRACTING, and actually OFF-PUTTING…CANNED statements and stuff…"* [Dr. Nickel, Family Practitioner]

Physicians also used data in the EHR to justify and support decisions to remain on or change care plans. Participants were observed taking time and spending effort to advocate healthy behaviors to patients that were hesitant to change.

> *"This is a negotiation between doctor and patient. 'I want to work with you,' says the doctor as she tries to convey again and again the condition and its consequences. The patient complains about the edema but the doctor again has to reinforce the need for compliance of meds; to not do so is to leave the edema unresolved."* [Dr. Rowland, Internist]

THEME 2.4.2: COLLABORATING WITH PATIENTS' FAMILY MEMBERS AND FRIENDS

Many times patients had family or friends accompany them on patient visits and were involved with collaboration. Presentation of data also was a valuable communication tool to patients that did not speak English and so had family members act as interpreters on their behalf.

This phenomenon was quite ordinary, and expected, among pediatricians who technically were serving patients who happened to be infants. In such cases, sharing data was also an important way to justify clinical decisions. Presentation of growth charts to uneasy mothers was pointed to as valuable decision support tools.

> *"I don't want [the system] to interfere with the flow of me talking to a patient. But yet I wanna have data at my fingertips so I can just whoop, put it up on the screen, and say, 'Well, you know, you're worried about your child's growth but here's what I see on the growth chart, and it looks really NORMAL.'"* [Dr. Spell, Pediatrician]

THEME 2.4.3: COLLABORATING WITH STAFF

Collaborations among staff was as should be expected an important component of providing clinical care. In that respect, how decisions were carried out and communicated to a team were of interest and concern. One consideration was how decisions were communicated to staff. Two participants working in the same system (Epic Ambulatory) had very different impressions as to how the system supported intra-clinic communication.

> *"Well I mean it's very easy to send people charts and notes, you know, and write little things as, you know, update people on what's going on. And so the communication is much easier than it used to be."* [Dr. Serra, Family Practitioner]

> *"the…LPN or RN will come and sit there and take most of the phone calls because they can give advice, and [a patient call] may be marked as a high priority but no one may actually tell …because I'm going back and forth seeing patients. [T]hen I'll look at it at 5:30 at night after the LPNs are already gone and I think, 'Oh my god I should've addressed this five hours ago!' There's a lot less verbal communication and I think a lot more electronic communication between people all sitting within 100 feet of each other in the same building."* [Dr. Nations, Family Practitioner]

Physicians from different health systems approvingly described the concept of working at *"the level of the license."* The idea is that systems should support people to work within teams and at appropriate skill levels. Clinical decision support was pointed to as a means for task shifting *"routine"* and *"menial"* responsibilities away from physicians to lower *"levels"* of support staff. This idea caught the imagination of physicians because they saw it as a way to potentially relieve them of some of the data collection and care coordination activities. With proper clinical decision support tools in place, medical assistants or nurses could receive a majority of alerts that insure appropriate and safe practices are carried out. Physicians would have ultimate sign-off responsibility. Participants had ready examples of task shifting already occurring within their clinics and outside clinics.

> *"…one of our providers here… works out of a clinic that has Centricity, that she felt like had a much more robust kind of an automatically updating thing that could, you know, take in the lab result, or take in the Echocardiogram results, and would kind of give you a, you know, a gridded or a table big picture thing of here's what [patients] HAD, here's when [patients] had it, here's what the result*

> *was, and here's what [patients are] due for, based on frequency. [H]er Medical Assistant was able to get the labs ordered, get going on whatever the person needed, as part of sort of the ROUTINE predicable stuff…we don't have it set up in a place where it's able to help us do that right now."* [Dr. Tarver, Family Practitioner]

Segregating tasks among different levels of care was part of clinical workflow prior to implementation of EHR systems. Flowsheets and what one clinic termed a *"risk management sheet*" would guide medical assistants through the process of collecting data for health maintenance.

One clinic had begun building patient care teams that worked as a team; physical and organizational barriers were being torn down to facilitate team decision making, knowledge sharing, and communication. Each team would be situated in one of three "pods" and consist of one or two doctors partnered with specific MAs, a nurse, a "panel manager" who tracked the care of multiple patients, and a "referral clerk" that would track appointments and route questions and patient issues through appropriate channels. In addition, a "pathfinder nurse" who was a certified care manager was "embedded" in a team and engaged patients in the field. Collaboration occurred across the team yet one participant felt they could be doing more through task shifting. Interestingly, the participant argued that the MA was a key person to collecting patient data:

> *"the relationship with the patient is that CMA [medical assistant]. The person who greets them, who brings [patients] out [from] the lobby, who hears about their grandkids, who knows if they've got clothes today in our clinic,...who can confidently get out of that patient how much they've been drinking, what drugs they've been doing. I mean I don't ever see that patient. But that CMA can tell me if [patients are] higher than a kite and different than they were last week. I mean that's the knowledge person. And even though they're not in a power position, they hold a tremendous skill at getting information and putting it in the record. And if they're given a space to record it, they'll do it."* [Nurse Zamudio, Nurse Supervisor]

Physicians described taking on other clinical tasks that they deemed more appropriate for their level. Examples of those activities included training residents, developing treatment plans (for others to carry out), keeping abreast of current research literature, and supporting healthy patient behaviors. As previously mentioned, these tasks were considered in line with *"doctor work."*

THEME 2.4.4: COLLABORATING WITH THIRD PARTIES

A fourth facet of collaboration is working with people outside the clinic. Physicians were keenly aware of limitations associated with having systems that did not interface. Participants wanted to be able access records from other clinics, have medication lists automatically update when a specialist added or took away a medication, and have labs automatically (and synchronously) update. Lacking access to data in these multiple ways hindered physician decision making. When attributing any blame to the lack of interfacing, physicians pointed to HIPAA as the primary factor. One physician looked to physicians themselves blocking access to each other’s data. Interestingly, not one participant specifically used the term health information exchange (HIE).

THEME 2.5: WORKFLOW

Observations of participants’ workflows found that they tend to follow a basic pattern regardless of role or EHR system: reviewing patient records before entering the patient room, reviewing patient records while a patient undresses, and charting the patient’s record at the conclusion of a visit (See Figure 15). Early on in the study it was noted that the workflow of meeting a patient, making initial notes, and then charting further after the visit seemed time consuming and *“energy draining.”*

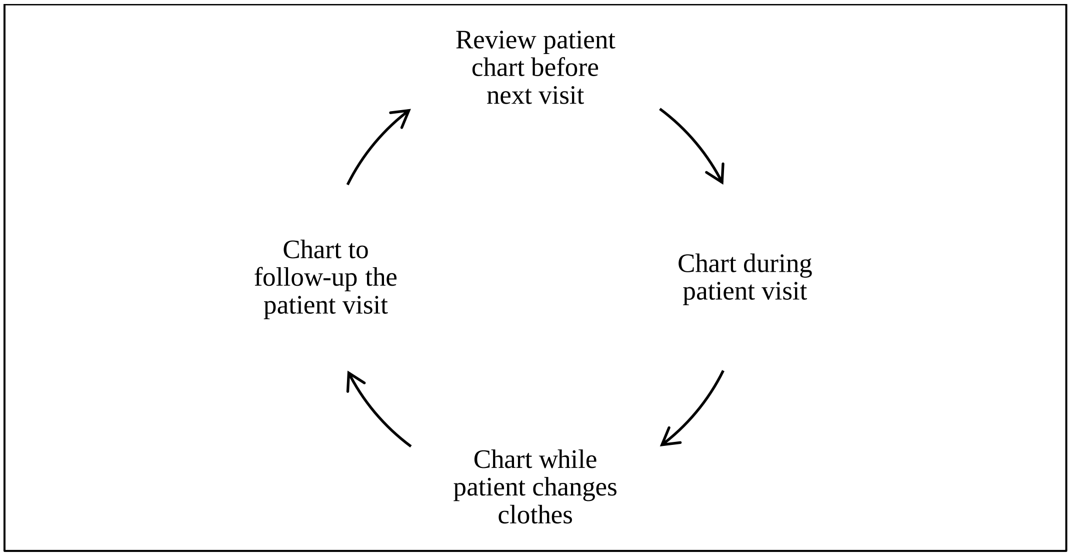


FIGURE 15: COMMON POINTS FOR CHARTING WITHIN COMMUNITY-BASED CLINIC WORKFLOW

Participants commonly reviewed patient records before meeting with a patient. The duration reviewing or preparing charts varied from seconds to hours beforehand, and the review could take place in hallways, offices, or even at home. Dr. Bills, for example, is a family practitioner and said he *“previews”* charts the night before to see what he needs on the day he practices. Dr. Rathbun, a general internist, developed observably “intense” and “extensive” SOAP notes during her lunch breaks to feel prepared for her visits and to better insure the visits were “seamless.” Dr. Cowden took a “few minutes” per patient at the beginning or end of a day to review patients and their circumstances. And Dr. Vela took a couple minutes reviewing Effexor medication dosages just minutes before entering the patient room. Reviewing charts before visits gave participants opportunities to prepare data, reacquaint themselves with a patient, and reflect on a patient care plan. However, the process could be very time consuming when considering that participants met with multiple patients daily.[how many per day on average?]

Physicians also followed similar patterns once they entered the patient rooms. After greeting the patient and any accompanying friends or family, the physician would most often sit at eye level with patients, log into the system if need be, and either bring up the history of present illness (HPI) or the medication list. More often than not, participants would try turning the monitor or laptop so that both the patient and doctor could see the screen together. After confirming medications, the process predictably moved through a SOAP note where the physician would try to steer the meeting along a trajectory from subjective to the plan. If documenting with the system rather than on paper, the physician would attempt to navigate the system and/or type as the patient spoke. This process appeared cumbersome and distracting at times. If the patient required a physical exam of any kind the participant would step away from the system or put the laptop aside, wash his or her hands, address the patient, and then return to the system. If paper notes were being taken, then the participants would jot down notes or scribble pictures. Some participants did both; Dr. Kepler for example balanced her laptop in her left arm and took paper notes with her right hand. She would move back and forth between taking paper notes and entering data on her laptop with a stylus.

Should a patient require undressing for an exam, the physician would leave and often use the few minutes to catch up on another patient's chart, e-mails, or telephone messages. During this time physicians might hurry to their offices or work from a laptop at a nurse's station to approve orders or review incoming labs.

Finally, participants would most often have a prescriptions prepared on their patients' behalves. Participants would leave the patient room and meet with the MA to address follow-up work and instructions. Depending on available time, or if the schedule was not too lagging, physicians would document the visit by rounding out their notes. The detail of patient notes varied from doctor to doctor and various strategies were used to speed the process: dot phrases in Epic, copying and pasting text, recording notes for dictation, or entering data using Dragon voice recognition technology. If participants found themselves far behind schedule then they would save their charting for the end of the workday, either at the office or at home.

Four out of thirty-one participants discussed workflow and its application to clinical decision support. Those that brought up the issue did so in the context of automated or improved data entry into the system. Dr. McKean liked the flexibility of the eClinicalWorks system and how it could accommodate individual idiosyncrasies off work: *"people have a lot of choices how they want to [use the system]."* Subjects also referred to the *"flow"* of a patient visit in terms of interaction with patients and wanting to successfully navigate the system in the course of those interactions. Dr. Bills noted that the *"flow"* of the system did not accurately map to how he collects and synthesizes data:

> *"a lot of things are written by programmers who are SMART, but they may not . . . they may have an overall CONCEPT of the flow of how medicine information is gathered, and digested, and treatment is done, but they . . . oftentimes it really isn't quite as smooth as it COULD be."* [Dr. Bills, Family Practitioner]

Taken together, workflow was more than the system or CDS fitting within the physical element of workflow but also fitting within the flow of thought and interactions with other people such as patients.

THEME 3. PERCEPTIONS ABOUT CDS AND SYSTEMS

Physicians in community-based practices described six themes of current *"clinical decision support"* that informed the following definition: "clinical decision support is made up of tools that are intended to inform clinical decisions by way of electronically delivered medication safety alerts, health maintenance alerts and prompts, best practice prompts, and access to accurate and timely reference materials." I will provide analysis of individual themes within that given definition.

THEME 3.1: CLINICAL DECISIONS

The most important take away from the definition is that study participants distinguished *clinical* decisions around patient care very differently from other types of decisions that, although related to care, are not directly related to patient care. The distinction is salient because community-based physicians conduct a number of activities are tangentially related to patient care and therefore considered clinical decisions.

Dr. Wooley, a family practitioner, made a fine distinction between types of decision support: *"decision support…is… knowing what drug to PRESCRIBE, or drug-drug interactions,"* and furthermore, *"[it] prompts you that certain labs are – needed to be ordered…are not up-to-date for whatever reason…or a certain… need for general health maintenance…'you don't have any [outstanding] orders.'"* Yet ideally a different kind of decision support would help with care coordination and patient activities such as submitting labs prior to any clinic visit: *"…it's a decision support in its own sense, but I think it would just be a DOCTOR support, or care management support, is how I would phrase it."* Separately Dr. Hellman described an idealized automated patient appointment tool as *"decision support for patients,"* not clinical decision support.

The distinction is made that decision support reminds the physician that a lab is due or data is missing but decision support does not address how the lab is collected or how to collect any missing data. This connotes that community-based physicians see clear distinctions between clinical and clerical work even though their workflow often require conducting both. Dr. Rowland, an internist, distinguished between support for clerical decision making and clinical decision making: *"I don't WANT to be answering phone calls…inputting medication in lists. I don't wanna DO that…[That is] just* ***CLINCAL support****, utilizing the computers.* ***[Clinical] decision support*** *is…the algorithms. You know, give me an algorithm that I can use, and populate the field with, 'The patient has a thyroid nodule. What do you do NEXT?'"*

Physicians from all four specialties expressed and confirmed their general consensus as to what did not constitute CDS. In addition to the above examples, EHR navigation, a common frustration among study participants, was not considered a form of CDS. Clear distinction was made between navigating the EHR to find information and ultimately deciding what to do. Dr. Beckett noted, *"I don't know [EHR navigation] affects my CLINICAL decision…The ultimate outcome is the same. I just take a lot more steps to GET there."* The sentiment that poor navigation merely delayed inevitable clinical decisions was shared by others:

> Interviewer: And how do you feel like when you're in that piece of interaction, and you're having to click these buttons, and you're not sure of which folder to select?
>
> Dr. Spell: *Well, it just takes more time.* [Dr. Spell, Pediatrician]

And another example:

> *I don't think I do or don't do anything because of the number of clicks. It just takes more time and ending in more frustrating with a system is not efficient.* [Dr. Suarez, Family Practitioner]

However, physicians provided a number of examples when poor usability impacted their *"ultimate"* decision. Documentation, another common source of frustration, was specifically counted out as clinical decision support although again, examples of poor documentation procedures impacted clinical decision making.

> *"I have to go in and look at each different note until I find a foot exam…And so rather than DO that, I just do another foot exam." When asked, Dr. Beckett said he was unsure whether or not he would charge for that foot exam."* [Dr. Beckett, Family Practitioner]

As well as…

> *"It's just because the [lab] information isn't available to me at the time I need it. Or else I'm stuck -- I just sometimes get frustrated and say, you know, it's gonna take forever to get that -- forget it. I'm just gonna reorder it."* [Dr. Serra, Family Practitioner]

Dr. Rathbun, an internist, recalled a time trying to access her office's EHR from a hospital:

> *"…for me to ACTUALLY DOCUMENT that, I would have had to do a remote access to my OLD system, log in, password, you know, click, click, click, click, click. It would have been just so HARD for me to tell you what her [inaudible] was a year ago, that I just didn't DO it."* [Dr. Rathbun, General Internist]

If physicians see so many alerts to the point of fatigue then they similarly expressed a kind of EHR navigation fatigue as well. Issues related to navigation fatigue and documentation will be discussed further in upcoming sections.

THEME 3.2: ELECTRONIC CDS

The purpose of the study was to understand how electronic clinical decision support technology indeed supported community-based practitioners, yet interview questions were open-ended enough to allow participants to describe other means of decision support. Observations too noted times when non-electronic means were used to alert or prompt clinical decision making. For example, Dr. Bracey is a pediatrician who during observation pointed out she uses a paper-based immunization schedule as her *"alert,"* and other participants gave examples of paper-based artifacts they would like to see as electronic CDS. However, participants mostly focused discussions on their experiences with *electronic* CDS. It provides a bit of insight into how the study participants were focused on tools integrated into the EHR.

THEME 3.3: MEDICATION SAFETY ALERTS

Medication safety alerts were a common topic of discussion among study participants. Opinions of alerts ranged from accepting to *"silly"* to *"just atrociously BAD."* Community-based physicians felt that alerts were an important part of decision support but underwhelmed by the low level of clinical reasoning, the accuracy of the alerts within clinical and patient context, and the presentation of those alerts. Before Dr. Beckett started using, and soon turning off, decision support alerts he "imagined" they would work much differently:

> *"I imagined that if I had a patient who was on a medicine, and I wanted to give them another medicine that interacted with it, it would say, you know, [inaudible] and Seldane, one of the old…medicines that you're not supposed to do it. It's Black Box warning that I would see there. And I imagined that it would just automatically tell me when mammograms were due, and when colonoscopy was due, and there'd be a separate screen to keep track of that. That was real. And we HAVE that, but I don't USE it because it seemed too cumbersome. It's just easier to go from…memory."* [Dr. Beckett, Family Practitioner]

Turning off medication alerts was an occurrence that unfortunately was all too common. In part this was due to doctors feeling they were being overwhelmed with alerts. More than that, doctors believed those alerts were questionable at best and wrong at worst. Like Dr. Beckett, Dr. Kepler, a pediatrician, had high hopes for CDS and considered it *"one of the reasons [she] wanted a computer"* in her practice. Her examples were familiar over the course of the study: 1) It could not distinguish levels of intolerance or allergy, *"if my patient's allergic to ANYTHING, it has an alert that comes up, every single time;"* 2) Its accuracy was unreliable, *"It always says there's something the patient is allergic to;"* and/or 3) The presentation was ineffective, *"the medication alert, it's always RED."* Dr. Kepler like others *"just turned [alerts] all OFF."* Dr. Bills boiled his concern down: *"the issue is I can't trust [the CDS]."*

As opposed to turning off medication alerts, turning on medication alerts could also be troublesome. Dr. Altamirano, an OB/Gyn, said he was unsure how to turn on *"preventive reminders"* and chalked it up to a need for retraining. Dr. Bills attempted to turn on the system's CDS functionality but was unsure where the option lied. He found the option after one to two minutes of exploring but then expressed difficulty knowing which of three levels to turn on; and after selecting "moderate", he had to reboot the system to turn on the CDS. The time spent waiting to reboot was not appreciated.

There were instances when clinical decision support altered physician behavior around clinical care. CDS to augment or reinforce processes were perhaps the most common. Templates and flowsheets were well-used tools that structured process and flagged data entry opportunities. Some of these tools were vendor developed (pediatric templates) or developed within the health system (immunization flowsheets). Dr. McBurney, a family practitioner, appreciated the immunization flowsheet because he felt he followed up on immunizations more often but within the flow of patient visits.

CDS also provided support around medication interactions and ordering. For example, Epic ambulatory users used abbreviations, such as "HCTZ" for hydrochlorothiazide, to quickly and reliably order medications. This feature was available in other platforms as well. CDS also informed a user of an out of stock medication, Anacin, and so she was able to quickly revise her order to aspirin. Despite users' complaints of *"klunky"* interaction checking, alerts did cause physicians to modify orders. Dr. Bills, for example, was warned that a lithium cytalopram order put a patient in jeopardy of serotonin syndrome.

Physicians relied on self-made, paper-based flowsheets to track immunizations. Dr. Bracey went as far as to call it, *"her alert."* The paper flowsheet was a half-sheet long with different numbers of checkboxes for each type of immunization, depending on how many make up a complete immunization

Unfortunately CDS was rejected more than accepted due to three primary reasons: 1) physicians reported *"alert fatigue"* from the abundance of alerts and reminders, 2) they reported frustration with the lack of discernibility, and 3) those inaccuracies gave an overall sense that alerts and reminders were not trustworthy. Alerts, when turned on, occurred so often that physicians literally blocked them out of their minds. Dr. Hellman, for example, was writing follow-up lab letters to patients and before final printing an alert would display. This was pointed out and Dr. Hellman at first did not believe an alert existed. We agreed to complete a second letter to see what the alert was addressing and on the second time Dr. Hellman clicked through the alert without seeing it. We had to work through two more letters before the doctor could finally stop to see the alert. Dr. Hellman's mind was working so fast he never took the time to see, let alone read, the alert. Participants reported turning off medication safety alerts within hours of using CDS for the first time, and that EHR vendors had even recommended turning off alerts before a system go-live.

Medication safety alerts also lacked appropriate ability to discern which also led to physicians' alert fatigue. Users' words that described CDS content included, *"obtuse," "not helpful,"* and *"silly."* Medication alerts lacked real-world ability to weigh the likelihood that an alert would be patient-specific and valuable. One physician, after turning on a "moderate" level of medication alerts was observed receiving multiple alert recommendations for patients to take "fish oil" whether the prescription was for warfarin, cortisone, or other drugs. Dr. Shuler provided a colorful example as to CDS's inability to discern pertinent clinical differences, *"...it's kinda like if you put a warning label on everything, people don't know the difference between sulfuric acid and vinegar. They're both acids. But one of em'll eat your face off. You know, and you can drink the other one."* The problem associated with one drug is that its relationship to other drugs is interwoven to the point that there is likely to be an interaction with any number of possible drugs. One participant confirmed that the interconnectivity of drugs is something akin to *"six degrees of separation."*

With so many shortcomings some participants explicitly expressed a lack of trust in CDS medication alerts which capture a sense shared by a larger portion of the sample. Dr. Bills tested the system by seeing if an alert would present after typing in a prescription for accutane to a pregnant patient (a category X contraindication). After an alert failed to fire Dr. Bills stated, *""the issue is I can't trust it [the CDS]."* This sentiment was shared by Dr. Suarez. Furthermore, participants questioned the ability of CDS to improve on clinical decision making and even exhibited frustration that people thought computers could do the work of doctors. To that point, Dr. Harter stated,

> *"I think it's a little bit INSULTING in a way, to think that your medical training doesn't really MEAN that much. If you just have a computer program that had all the bells and whistles, all doctors would be GREAT doctors, no matter who you are, or where you came from? And that's just FALSE. You know, you can't MAKE people good DOCTORS because of the bells and whistles in the computer system. Either they HAVE good training, good judgment and good awareness of where their areas of deficiency are, and the humility to ADMIT that, but they DON'T."* [Dr. Harter, General Internist]

But even though users expressed frustration with medication alerts, they also expressed frustration that the alerts did not work to expected potential. CDS may be trying to do the work that community-based physicians have long been trained to do but the users still want the alerts to be accurate and contribute to their medical practice. Dr. Hermann preached patience and that it will take time to build enough clinical data in the system's repositories in order to make CDS more of an asset.

Participants expressed the need for formulary CDS because it would primarily save time. Dr. Tarver noted that her version of eClinicalWorks had a formulary module but that it was not *"robust"* enough for and her colleagues' her needs. Dr. Harter explained that she was reviewing E-Scripts for her office and that the formulary was *"burdensome"* and *"not ready"* for clinical use. Her reasons were one, users had to exit out of the system to use the formulary; and two, when searching medications the system returned results by brand name rather than by price. This also means that the results were not color coded for easy browsing: green for generic, yellow for higher cost, orange and then red for even higher costs.

Interestingly, interviews consistently steered toward medication alerts. Yet participants were hard pressed to provide alternate mechanisms as to how medication safety could be achieved without the use of alerts.

Other functions of medication safety that users needed were auto-calculation tools. Pediatricians in particular, across the three systems, desired the tools so that they would no longer require manually calculating adult-child dose conversions. In one clinic, the pediatricians wore small bags that carried calculators with which to convert dosages. An general internist desired a calculator that would generate medication-by-medication dosages based on *"renal or hepatic function declines."*

THEME 3.4: HEALTH MAINTENANCE ALERTS AND "PROMPTS"

Physician looked to alerts and *"prompts"* to notify when patient health maintenance activities were warranted; yet like medication safety alerts, study participants yearned for greater technological sophistication. One facet of health maintenance that required attention was manual maintenance of patient course and required procedures. Dr. Tarver, a family practitioner, said disappointedly, *"my nurse needs to remember to ASK [patients] when they had their last tetanus shot… it probably would be handy if the system would REMIND us that…'Hey, this person is due for a tetanus shot.'"* Dr. Tarver further explained the limited nature of clinical reasoning that drives health maintenance alerts prevented the system from rounding up procedures. For example, the CDS logic could not alert that a tetanus shot had been provided given a person received either a tetanus-diphtheria (TD) or a tetanus-diphtheria-pertussis immunization (TDAP).

Participants described *"prompts"* and their potential to help physicians meet desired clinical outcomes. However, general prompts of this sort were uncommon and patient-specific prompts were not observed. Dr. Dehart described an idealized type of health maintenance CDS that would not only prompt the physician but also be used to align physician and patient goals:

> *"…it can definitely support the patient – clinician interaction by REDUCING the amount of time SPENT on doing this sort of mundane, trying to EXTRACT data, and make sure the patients are there. If there were PROMPTS that sort of said: Here's patient X with these diseases, and here's the DISEASE-specific GOALS that are set up, that are agreed upon. And if we have a system that POPULATES, and if we have a LIST of goals to accomplish, and if you have a system that POPULATES those goals, so that a SIMPLE look at that, and say: 'All right. We've accomplished, you know, ALL of the goals that we set with the exception of these THREE.'"* [Dr. Dehart, General Internist]

Dr. Dehart's description was one of only a few descriptions of any kind of CDS that explicitly incorporated patients into the equation. In practice, however, medication lists appeared to be used as a kind of prompt that physicians and patients went over together. In particular, physicians who used the Epic ambulatory system many times turned monitors toward patients and invited the patients to review the medication lists together, noting each line item with big green checkmarks as they went.

As it stood most health maintenance CDS was ignored in all the variety of forms: alerts, reminders, prompts, and flags. When asked, the most common reason for not taking action upon health reminders had to do with perceived time shortages. Dr. Nations stated that she notices on-screen pneumovax reminders in the Epic Ambulatory system but ignores them unless health maintenance is specifically *"on [her] agenda that day."* She explained further,

> *"I mean in a fifteen minute visit with all the stuff patient have. [The chief complaint] says 'nausea' but ...you [there's] alcohol abuse, and falling, and [them] follow with the cardiologist and a whole bunch of other stuff…the flag that tells you they're due for a mammogram seems less important than making sure they're actually going to get home safely… I just ignore the [CDS flag] then unless they're here for a health maintenance or I have extra time."* [Dr. Nations, Family Practitioner]

The lack of time throughout the typical workday was a common refrain as to why CDS was not acted on. In another example, Dr. Hermann routinely ignored health maintenance "HM" flags which were written in red font. At one point of the observation I asked Dr. Hermann HM meant after seeing a patient with the flag. She replied that "HM" did indeed refer to "health maintenance" which then reminder her to order the patient a pap smear. However, in this case, it was I who reminded Dr. Hermann as opposed to the health maintenance flag.

THEME 3.5: BEST PRACTICE PROMPTS

Physicians expressed a need for systems that prompt best practices for care. Prompts were described as being in the form of alerts or flowsheets. Flowsheets would provide physicians with an algorithmic, step-by-step guide for how a physician should carry out a particular plan of care. Dr. Serra, for example, recalled having received a positive RPR (a positive test for syphilis) but not being certain what to do since it had been some time since she last carried out such a treatment. As the doctor lacked easy access to best practices she had "to go out of the system, look it back up, call somebody, try to remember [the procedure]…this kinda thing comes up all the time where you see something that you haven't seen in a couple of years." However, Dr. Serra's and other participants' systems did not contain this type of CDS.

When thinking about integrating best practices into CDS, physicians acknowledged that a challenge would be deciding which best practices to use? Discussions on this topic provided interesting insights and revealed tensions in the manner in which different primary care specialties practice medicine.

A challenge some participants described was developing consensus around which best practices (guidelines) physicians might use to inform medical practice. Although personalized CDS was a highly valued trait, participants explained that consensus would have to be achieved at some level: within clinics, across clinics, across systems, or some other constitutional factor. In an interview with Dr. Hermann, a family practitioner, we explored some of the ramifications for integrating best practices in CDS systems. At the first level, practices with two or more physicians could decide which guidelines to follow. One way would be to carry it out by a clinic director's mandate whereas another way would be to have dialog and gain consensus among physicians. The latter approach would most likely be amenable to practices with equal partners. A third approach could be to use a *"least common denominator"* approach that has an alert fire at the lowest age of all recommended ranges. For example, a breast cancer screening prompt would display for a 40 year-old female patient yet also explain the U.S. Preventive Services Task Force recommends screening at 50. The decision would be up to the physician. At a level above individual clinics, a health network could have an oversight board or quality committee hand down decisions as to which guidelines participating practices will follow. A question would then be would the clinics agree to go along. Taking that yet another level higher, a question would be what malpractice issues, if any, might arise when a patient develops a disease in a system that follows "best practice A" and not "best practice B". Dr. Hermann ruminated that to protect oneself the physician might leave the decision up to the patient and document which guideline *the patient* chose to use.

Although the discussion was an exercise in "what if" scenarios, it illuminated some of the struggles that some practices are already facing. An internist named Dr. Steward recounted an anecdote that physician friend of his was happy with his EHR to which Dr. Steward attributed to his friend being a solo practitioner. Study participants work in medical groups described having to negotiate which templates and flowsheets to use in daily practice. This led to additional effort not only in developing a clinic standard but also adjusting one's practice to adhere to that standard, and sometimes that required adjusting to unfamiliar practices.

Subjects explained how rudimentary best practices for one specialty could be considered idiosyncratic in another yet all had to work from the same page, so to speak. For example, pediatrician participants highly valued access to growth and weight charts not observed in family practice platforms. In addition, pediatricians bemoaned not having CDS that automatically calculated pediatric dosages and so instead calculators had to be pulled out any time a prescription was written. Family practitioners did not note these issues as areas of interest. Internal generalists Dr. Durfee and Dr. Steward pointed out that their system templates included a field for head circumference size (a pediatric metric) and that the system recorded generic eye exams as scopic exams. The former was considered a minor nuisance whereas the latter was of more concern because to correct the documentation meant to make manual changes 30 times over during a course of a workday. In the case of the eye exam, the doctor made a conscious decision to never revise the documentation so to save time.

THEME 3.6: ACCESS TO ACCURATE AND TIMELY REFERENCE MATERIALS

Community-based physicians placed a high-premium on timely access to reference materials. Being able to access online materials within the patient room was considered a boon despite the occasional awkwardness of searching in front of patients. Reference materials often provided physicians with valuable information that informed decision making and care plans (See Table 12).

Doctors primarily used online resources during times of observations (See Table XX fix numbering). Observation notes also include comments of being impressed at the number of iPhones and PDAs that could be seen within clinics. Subjects were observed using PDAs when reference materials were unavailable through the EHR or when access to an online reference was unavailable due to a technical malfunction (EHR error attempting to access UpToDate). Subjects also seemed to express feelings of relief that they had access to reference resources should they be contacted while away from the office.

TABLE 11: NUMBERS OF TIMES REFERENCE MATERIALS WERE OBSERVED BEING USED OR DESCRIBED

Reference Resources	Observed Use	Described Use	Total
Up To Date	4	6	10
ePocrates	2	2	4
Google	2	1	3
Mayo clinic	2	0	2
MPR Reference	0	1	1
Bing	1	0	1
CDC travel website	0	1	1
Diagnosaurus	0	1	1
MD Consult	0	1	1
Medline/MedInfo	1	0	1

Subjects expressed satisfaction with the availability of resources through their PDAs but also a desire for greater access to reference resources through the system. This included having links to search engines like Google and Bing as well as a desire for any resources that are current and succinctly present information.

THEME 3.7: CDS USER KNOWLEDGE: ALERT CENTEREDNESS

Subjects exhibited an impressive degree of understanding of clinical decision support when describing their definitions and descriptions. They ably expressed successes and shortcomings of the technologies. Participants’ knowledge of decision support often came from self-tutorial, interest in computers, personal experience with other systems, or through discussions with friends and colleagues. Interestingly, subjects occasionally commented, often after the recorder had been stopped, that they had little sense as to how colleagues in their own practices and fields were using EHRs in general and CDS in specific. They expressed curiosity and eagerness to receive the findings from this study.

Discussions around electronic clinical decision support tools tended to gravitate toward the limitations of, and frustrations with, alerts. Alerts also seemed to evoke the strongest emotions from physicians, most often negative emotions. Concerns about alerts, both observed and described, had to do with: 1) accuracy, 2) appropriateness, 3) frequency, 4) timeliness, and 5) presentation. A challenge associated with alert centeredness is its tendency to dominate conversations about clinical decision support and makes it difficult to conceive of alternate CDS approaches.

The primary care physicians I interviewed and observed desired tools that supported decisions that doctors and patients make together which means depending on strong relationships and high degrees of trust between the doctor, patient, support staff, and patient caregivers a patient has (or does not) have available.

Despite their efforts to build and support relationships, physicians often find themselves strapped for time and resources. Much of this is influenced by the larger economic environment within which they work, but they look to clinical decision support (CDS) tools to enhance their decision-making and clinical efforts in ways that enhance relationships. Excessive documentation requirements and inefficient data collection were viewed as barriers to patient-physician interactions. And although physicians did not feel poor EHR navigation affected their ultimate clinical decision-making, interviewees revealed examples when procedures either were or were not performed in order to avoid *“klunky”* EHR navigation and documentation. Physicians also described and expressed in observations the cognitive work associated with EHR navigation and data collection while trying to focus on clinical decision making.

THEME 3.8: USABILITY: BARRIERS AND FACILITATORS

COMPARTMENTALIZED DATA

Barrier: Compartmentalized data impacted decision-making

Compartmentalization within the EHR represented a barrier to effective use if not a barrier to effective clinical decision-making. Subjects distinguished CDS from EHR navigation stating that slow navigation did not impact their ultimate decision-making on patients' behalves. However, physicians (sometimes the very same ones) also provided examples in interviews when they either provided or withheld procedures in order to avoid documenting and/or navigating the EHR. Physicians felt the time it took to navigate the EHR took time away from their ability to interact with the patient and address patient-specific concerns.

Another barrier that was widely criticized was that some systems did not allow users to tab through multiple windows for the same patient. This prevented users from moving back and forth between results screens and referral letters, for example, and significantly slowed workflow. Users developed workarounds that included having multiple sessions of the same patient simultaneously open. One physician described using two monitors and a laptop just to review data for one patient.

Facilitator: Physician terms used for synthesized data

Physicians used a variety of terms to evoke how they would like to feel the system presented data. Terms included:

- Clean
- Linear
- Familiar
- Skim
- Fast
- Flow
- Seamless

DEVELOPING A SYNTHESIZED VIEW OF THE PATIENT

Barrier: Compartmentalization of patient data detracted from the big picture view

Compartmentalizing data and requiring navigation through multiple tabs hindered physicians' ability to quickly get a sense of the patient before, during, and after the visit. Compartmentalization slowed the *"flow"* of the patient visit by requiring drilling down to find data hidden away. Epic Ambulatory and eClinicalWorks exacerbated compartmentalization by disallowing users to toggle between multiple windows in the same patient records; this was done so in the spirit of patient safety. Compartmentalization required participants to waste time piecing together data. And compartmentalization led to navigation fatigue which, as previously noted, ultimately impacted clinically-related actions. Current systems fragment medications, conditions, diagnoses, and more throughout the EHR thereby eliminating a physician's ability to scan a patient record to develop a picture of the patient. Not having a snapshot slows the flow of care because physicians must navigate multiple windows to arrive at a high-level understanding of the patient.

Facilitator: Snapshots and stories were described as effective means for data presentation

A pervasive need expressed by participants was to have a *"snapshot"* patient summary that quickly conveyed an understanding of a patient's history. The snapshot also represents a moment in time, for the snapshot would be viewed before the workday begins or just before entering the patient room. One participant remarked that physicians are specifically trained to provide a patient snapshot by way of presenting a patient. For example,

> *"Mrs. Smith is a 62-year-old gravida 5 para 5 woman, went through menopause about ten years ago, and she's here for this REASON. She's had these past surgeries, she's on these medicines, she's allergic to penicillin."* [Dr. Altamirano, OB/Gyn]

This window of time provides a moment of reflection during which physicians may be more amenable to flags, prompts, reminders, and/or alerts. What to include in snapshots varied by the information needs of each role. The following are potential snapshots based on the results from observational and interview data.

Family practitioners value more than just the biological needs of their patients, they also value and are trained in attending to the psychological, social, and spiritual needs of the patients. Therefore it is of value to include a photo or photo gallery and brief biographical patient sketch that may include items of personal interest to the patient and physician, i.e. pet names, hobbies, work environment, religion, etc. Genograms that visually display familial relationships would help physicians quickly get a sense for connections, and family medical history could be accessed if the physician wanted. A medication list is essential. Patient views should ideally be longitudinal that is centered on the current date. Current screenings of interest should be front and center, i.e. chlamydia screening in women between 18 and 25, with upcoming and past screenings available for viewing. It would be helpful to filter any previous visits on the physician viewing the snapshot. (See Appendix I for data)

Obstetrician-gynecologist participants also valued gaining an understanding of the patient prior to patient visits and so would likely enjoy the aforementioned biosketch data. Because OB/Gyns are referred to often it may do them well to have a contact list of family practitioners that most often refer patients. A patient's snapshot could have their family practitioner's name as well as full contact information. The longitudinal patient view could be abbreviated to the patient's course of pregnancy centered on the current date but positioned within a nine month timeline. Additionally, OB/Gyns must have easy access to patient age, gravidy, and parity as well as other information such as surgical history and OB history. (See Appendix J for data)

General internists in this study made it a point to view a snapshot history of medications and transitions from one medication to the next accompanied by when, why, at what point in a patient's care, and brief explanation of problems. The drug information must be listed on one page so that the physician is able to have a *"big history."* Additional personal information could include patient drug tolerances and/or intolerances. Finally, a one-click sign-off sheet would be an asset. (See Appendix K for data)

Pediatricians relish quick access to weight and growth chart information as well as immunization history. Therefore a graphical display of immunizations administered and yet to be administered would be beneficial. Weight charts could go one step further by automatically calculating the amount of weight gained from the previous visit. Pediatricians often see patients for ear infections and so it could be beneficial to track patterns around such cases. Pediatricians enjoy knowing their patients and maintaining supportive relationships with the parents so parent it would be good to include parents' biographical information in addition to a child's biographical information. Finally, cluttered medication lists need not be apparent so long ago medications could be relegated to the background for a physician to view if they so desire. Otherwise, the medication list should contain recently added or changed medications. (See Appendix L for data)

POOR DATA ENTRY CAPABILITIES

Barrier: Data entry hindered data collection

Related to navigation, physicians described their concerns regarding excessive and inefficient documentation tools. Again, although physicians felt documentation in itself was not clinical decision support, they explained that slow documentation tools hindered their ability to: 1) interact with patients and build relationships, 2) getting to a point in the patient visit when patient care plans required dialog and decision-making, and 3) getting to the *"doctor stuff"* in a patient visit.

Facilitator: Shortcuts and workarounds were used to support data collection

Participants used functions provided by the systems the hasten data collection. Epic Ambulatory employed the use of “dot phrases” that enabled physicians to use keywords that inserted large chunks of written text into charts. Even though physicians complained they lacked the time to develop personalized dot phrases, they appreciated the few they may have created as well as the ability to do so. Other shortcuts included using abbreviations that brought up templates and forms. For example, an eClinicalWorks user brought up a “patient note” form just from typing the letter “p”.

Physicians also developed their own tools and strategies to capture data. One NextGen participant purchased a product called FastFox which enabled abbreviations to insert phrases into a chart. For example, typing in “URI” brought up the phrase, ““Encouraged rest and fluids [and check back in a week].” Another NextGen user developed standard phrases and had them saved them in a text document. When it came time to chart the user copied the text and pasted into the record.

DIFFERENT DATA CAPTURE MODALITIES

Barrier: Multiple data collection modalities added time to workflow and may hinder CDS

Participants often took paper-based notes during patient visits to capture data for eventual entry into the system. Note taking was interspersed with system use to varying degrees. In addition, some participants prepared paper notes prior to patient visits and used them as prompts during the visit. The time invested in developing, creating, and transcribing data from paper-based notes into the system added to workload. In addition, use of paper may open room for errors in that there is a temporal gap between note taking and final documentation. Data gathering that is not taking place at the time of the patient visit may prevent optimal use of CDS.

Facilitator: Multiple data collection modalities promoted interaction and synthesis

Paper-based artifacts and notes provided flexibility in how participants collected and synthesized data. The paper-based notes were used as a substitute for poor or absent EHR health maintenance functions or modules. Using paper-based prompts provided physicians the feeling that they were better able to engage patients than if they were typing and navigating an EHR during a visit. Separating electronic data collection from the patient visit may be cognitively less burdensome to physicians than typing, talking, and developing care plans at the point of care.

TEMPLATES AND FLOWSHEETS

Barrier: Templates and flowsheets standardized data collection that lead to homogenous documentation

Some participants did not appreciate the use of EHR templates and expressed concerns they it led to *"boilerplate"* and *"checkbox"* medicine. Physicians described the importance of capturing nuance and richness in the medical chart that contain pieces of information which provide valuable clinical insights. Dr. Suarez felt that template charting also led to a *"dangerous [trend of] documenting by exception"* which could result in misinformation.

Facilitator: Templates and flowsheets standardized data collection that lead to efficient documentation

Some participants appreciated how templates could guide practice and act as static reminders throughout the flow of the patient visit. Dr. Tarver commented it helped her remember to *"hit the high points"* in a patient visit. Dr. Altamirano described a homegrown flowsheet enabled him to easily capture data and that NextGen inserts text into charts when ICD codes are checked. A facilitator observed in the NextGen pediatric system was having one checkbox at the top of a list that, when selected, checked all the systems subcategories.

THEME 3.9: PATIENT PANEL MANAGEMENT TOOLS

Whereas health maintenance alerts and best practice prompts cover aspects of CDS from the point-of-care, participants described another form of CDS unavailable to them: panel management tools. Dr. Vela described panel management tools as *"population-based decision support tools"* and would allow a doctor, clinic, or an entire system to identify patient populations ("panels") with specific needs and then reach out those patients for offers of assistance. Such tools would enable community-based physicians to have a firmer grasp on overall health of their patients and the specific needs of certain patient segments, i.e. diabetic men over 50. The information gleaned from these tools would most often come from a monthly report.

Interestingly only family practitioners and internists described a need for having panel management tools. For OB/Gyns, the absence of discussion on this need could be attributable to their tendency of providing mainly episodic care among younger patients (pregnant women). For pediatricians, it could be due to the tendency of parents bringing growing infants and sick children on routine bases. Family practitioners and general internists may be more likely to require follow-ups with adults who require routine care, or only sporadic care, whatever the case may be.

Study participants described the value of panel management tools as a way to better meet the clinical requirements of their patients. Dr. Suarez, a family practitioner, explained that lacking the knowledge of who needs to be, or at least should be, seen leaves doctors with very little means to follow-up with patients. Besides sending mailers as only some clinics do, using patients’ needs for medication refills is perhaps the only other mechanism a doctor has to getting a patient with a chronic illness to visit the practice. A panel management tool would be more efficient than relying on refills and enable doctors to proactively manage disease. In addition, doctors expressed individual interest in particular disease states. Having a tool at their disposal to track those diseases of interest could be a motivator for physician (or clinic) follow-up.

THEME 3.10: DATA AVAILABILITY

Physicians were well aware of their inability to share data within and across practices, health networks, and the health system at large. The lack of data reduced physicians' trust in patients' clinical data. Doctors expressed frustrated patience with the development of systems that exchange patient data. In the meantime, physicians bemoaned waste and inefficiency due to inconsistencies in medication lists, lab data, and health maintenance. Having access to data across systems also means physicians must decide how to operationalize that data. The processes associated how to collect and share data required adjustments in roles (general internists having to use family practice templates), as well as considerations around what best-practice guidelines will be followed (whether or not to conduct mammograms at 40 years of age). The lack of data availability also reflects shortcomings in how and when data from labs are collected. Patient visits were observed when patients had not provided specimens prior to patient visits, as requested, thereby *"wasting"* a patient visit. Although the coordination with patients and labs was not considered a type of clinical decision support, it ultimately posed a barrier to deciding on a patient plan.

3.4 NUDGES CHOICE ARCHITECTURE

As discussed in the background section, authors Thaler and Sunstein developed a framework that synthesizes research from cognitive sciences and behavioral economics into one acronym: NUDGES. Each letter in the acronym refers to an area Thaler and Sunstein argue should be considerations for any person designing systems meant to influence others' decision making. The work that goes into designing how those decisions or choices and their options are presented ("framed"). "Choice architecture" is the term Thaler and Sunstein use to describe the process of designing, implementing, and presenting decision or choice systems to intended users.

The fundamental impetus behind the choice architecture is recognizing that humans have particular cognitive limits and therefore designing decision tools with those limits in mind. This is in contrast to another approach which might be to prevent people from falling victim to their cognitive limits and so instead provide alerts that an error is, or is about to, be made. Of course the down side to this approach is that users feel inundated with alerts and consequently turn those alerts off or ignore those alerts. Choice architects believe they can have it both ways: inform decision making without always requiring users to stop their physical and/or cognitive workflow.

The issue of "brain power" was raised in a previous section but it will be helpful to revisit it here as well. Study participants often alluded to cognitive processes that were affected, most often negatively, by the EHR and any accompanying CDS. Dr. Bustamante provided an excellent example of this when he described shifting his mental process:

> *"...MY decision-making, it SCREWS IT UP [laughs]. I'm gonna have to use a certain part of my brain to navigate through the system, and then the other part of my brain is thinkin' about what meds I need, or what the diagnosis is. And it's interesting you ASK that 'cuz definitely the first few months of getting USED to it, you kinda felt like you had one side of your brain trying to do the medical part, and there's this whole OTHER side, trying to figure THIS out, and it's really hard to do both at the same time."* [Dr. Bustamante, Family Practitioner]

Other participants described similar experiences when navigating EHRs. The switch between *"one side of the brain"* to the other was particularly jarring for users when switching was caused by alerts, only to see that those alerts were inaccurate at worst or rudimentary at best. Yet when the alert was successful, which participants did provide, then they were happy the alerts made the appropriate recommendation.

3.4.1 INCENTIVES

Incentives (the "N" in NUDGES) reminds choice architects to seek out salient rewards for dependent parties expected to give effort as well as those who expect reward for whatever effort. Participants in this study let it be known that they felt CDS and EHRs in general are not currently designed with physicians in mind. Of those who were asked, the incentives for using EHRs in medical care were *"lawyers," "billers,"* and even people *"who don't require complexity of information."* Those who were asked made believed another constituency benefitted from doctors using EHRs and CDS.

Another form of incentives participants raised was the need to exchange clinical data among physicians, local and state entities, as well as third party vendors such as labs. Statements included acknowledgement that physicians themselves, in general, need to be more open with their data because availability will ultimately benefit patients. Participants also singled out HIPAA as a reason for slowing, if not preventing, clinical data sharing. Dr. Brockway looked to Oregon's immunization data sharing service as an excellent way to keep on top of children's vaccinations, and other doctors made it known they wanted similar access whether through individual patient cards or *"cloud computing"* infrastructures.

A third area for consideration is that participants appeared particularly incentivized to build and maintain strong relationships with their patients. The desire for strong relationships was often cited as reasons these people decided to go into primary care practice. Although not one of their definitions of CDS, participants did describe how relationships with patients guided and informed clinical decision making. Relationships with patients were so highly valued that it was often cited as a reason for frustration with EHR-related documentation and navigation; participants viewed clumsy documentation and poor navigation as barriers to *"doctor work"* which involves counseling, education, and encouraging behavioral changes. Wanting to discuss these issues with patients generated an overall consensus that particular aspects of clinical work, with the help of CDS, could be directed at lower level staff. Citing the phrase, *"work at the level of your license,"* doctors felt CDS tools could and should do just that: enable doctors to take on high level functions of patient care with appropriate documentation and hand off *"routine"* data collection to others.

Promoting patient-physician relationships were exhibited in the ways that doctors incorporated EHR systems into patient rooms. Many participants sat down with patients and either turned the computer monitor or laptop so that the patient could watch the physician navigate the record. In many respects the physicians used the opportunity to prompt patients about current medication lists, which in Epic Ambulatory could be checked off line-by-line with big green checkmarks; or alleviate fears that an infant was not eating, which Dr. Spell could do by showing an anxious parent a growth chart graphic. Participants often used the technology to engage patients in conversation and begin to develop or maintain care plans. The process appeared to support joint decision making.

Physicians also felt that EHRs missed a vital component of paper charts, the ability to convey qualities of patients. For example, while Dr. McKean lauded the EHR for its *"clean"* layout he expressed some sadness that it did not convey the information that a 12-pound paper medical chart would have in the past. To him, the weight of the chart itself communicated something about the patient, information that perhaps the patient has been through a lot, and so he would likely take one or two minutes more review the chart's contents. Other participants said they missed or wanted more patient *"stories"* from the EHR. They explained that stories not only provided a fast and effective means to getting reacquainted with a patient, just before entering the patient room, but that stories also conveyed important information that could be used to inform clinical decision making. CDS could be designed in such a way as to fulfill needs for such information and perhaps incentivize physicians by reconsidering the value of certain documentation or be used to drive decisions around patient-physician relationships.

Participants appeared to be disincentivized to use CDS and EHRs because it interfered with clinical preparation and detracted from physicians' self-images. Physicians expressed frustration that the system was not helping them appear professional to patients. Examples ranged from fear that limited typing skills may be preventing physicians keep up with patients' subjectives, to stress that one might not remember a child's surgical history, to the feeling of *"flailing around"* the EHR looking for an EKG while the patient talked. The participants were accomplished, highly motivated, and were self-described *"high-achievers."* There appeared to be feelings on the part of physicians that they may be losing face or, worse yet, trust of their patients. When coupled with feelings that primary care practitioners are *"a dying breed,"* ineffective CDS could perhaps stir extra emotion. CDS developed and delivered in ways that help physicians show improved performance to themselves as well as patients could provide a powerful incentive for driving CDS acceptance and use.

The final, and perhaps largest looming, incentive to address is time. Time is the one thing that doctors consistently felt they did not have enough of and it may have been participants' most valuable commodity. When viewed within the context of time and how few any free minutes are available in a day it becomes clearer that slow documentation, data capture, data entry, and EHR usability promote cognitive load and stress.

Challenges associated with capture was perhaps the most often noted phenomena in observation notes and was a theme of discussion throughout the study. Efficient data capture and data entry is critically important to effective CDS functioning. CDS is more likely to fail if the data that drive CDS are inaccurate. Participants employed a number of different strategies to capture and enter data: written notes, dictation for transcription, voice recognition, self-made templates, typing in patient rooms, typing away from patient rooms, during lunch or after work. However, physicians did not completely bemoan data entry on its own, rather, physicians bemoaned data entry because they felt it took time away from the patient-doctor interaction. Once again, participants wanted to speed the process of data entry so that they could have more time conducting patient checks and educating.

As such participants yearned for more effective EHR usability that fit the *"flow"* of clinical care. COIPA participants, for example, criticized eClinicalWorks for disallowing more than one window to display at a time. To adjust for the limitation, doctors opened multiple sessions of the same patient so that they could view reports and labs on two different monitors; sometimes even two monitors and a laptop. Repeatedly participants criticized their platforms for not being intuitive, inflexible, and just confusing. But most of all, participants criticized the technology for gorging on precious time between patients and doctors.

Many participants described the need to redirect work so that staff worked at *"the level of their license."* This, in participants' opinions, would mean having support staff take on *"routine"* data gathering activities but supported with CDS technology. Physician CDS would be then be geared more towards literature reviews on patients' behalves, educating, counseling, and supporting care plans. Task shifting was viewed as a way to streamline data collection, insure greater data quality, enable physicians to spend more time with patients, and dedicate themselves to the aspects of clinical care they find motivating.

3.4.2 UNDERSTAND MAPPINGS

To understand mappings is to better understand (map) actions to expected results. A simple example would be flipping a light switch up to turn a light on ("powering up"), and flipping a light switch down to turn a light off ("powering down"). Mappings, however, can differ according to culture. Understanding mappings among community-based physicians may help to inform CDS design.

One form in which mappings can inform CDS design is in the user interface. Two examples are illustrative of how understanding mappings might improve the amount of data that are captured and the speed by which they are done so. A participant lamented that when documenting a review of systems (ROS) that the systems were listed in alphabetical order. She, on the other hand, had documented an ROS since medical school from head-to-toe. For her, listing systems in alphabetical order *"reflected the mindset of an engineer."* Another doctor wondered aloud why the lab order sheet was in alphabetical order and not grouped by common labs. So when it came time to order a Fecal Occult Blood (FOB) sample, listed under 'F', and a stool test, listed under 'S', he had to mouse across the screen to check both orders. In his mind, an FOB and stool test would be better organized together since the two are likely to be ordered in tandem. He went one step further to suggest brown font be used to distinguish the two test from a Urine Analysis (UA) which would be written in yellow.

The consideration of color was one raised by a number of participants. Many felt the use of red font was overused throughout and therefore desensitized users to potentially important alerts and/or reminders. Participants preferred having a gradated system where colors changed across a spectrum as the severity of a condition changed. In addition, many felt red font should be reserved only for panic values thereby indicating the highest severity and demanding immediate action. As one participant put it, there are *"of range values (normal), out of range values (abnormal), and 'make a call now' value (panic)."* This would be unlike many user interfaces where there were two possibilities: normal (in black font) and abnormal (in red font).

Mappings also help people conceptualize the probabilities of something happening if a certain course is taken, and even more, what that potential course entails. Decision aides are informatics tools that carry out this idea.

Interviews and observations documented two areas where mappings could help patients and physicians make more informed decisions. First, financial considerations were presented to patients *as well as* physicians when trying to decide appropriate drugs given one's insurance or lack thereof. Mammograms, B12 shots, cholesterol checks, all were wondered aloud by patients and physicians alike as to the costs and benefits to carrying out procedures.

Second, clinical decisions and care plans were discussed between patients and physicians. Already mentioned were the cases of the long-term implications of a Fosamax prescription and the costs-benefits of a heart valve replacement. Yet successful mappings in electronic form included comparing toddlers to normal growth and weight charts, to graphically demonstrate that a Prempro prescription had little effect on before-after blood pressure values. An example of a paper-based mapping was when a doctor used a decision tree for heart disease to show a patient the risk factors for a heart attack

3.4.3 DEFAULTS

Defaults refer to the human bias that naturally likes to stay a course rather than deviate onto something new. Choice architects can use this bias to influence choices and decisions.

In this study there were examples where defaults would fit and in fact were requested. Many had to do around usability such as automatically saving sessions rather than asking for confirmation when a user navigated from screen to screen. Defaults could be useful tools to address a variety of observed and discussed issues. First, diabetics that require pneumonia shots every five years could be automatically triggered when their individual appropriate date arrives. Second, an eye examination template could automatically load when it is time for a patient's eye exam; and should the patient refuse, the doctor could not sign, defer the exam to another time, or delete the template altogether. When considering how to institute competing best practices across a health system, a choice architect may derive a list with the preferred standard(s) at the top of the list in lieu of forcing one standard on all practices (people tend to choose the first option).

Another way of driving defaults is through the use of checkboxes. Checkboxes can standardize medical care but they can also be situated in ways that guide physician documentation without necessarily using reminders or alerts. One system, unlike the other two, used templates and included useful mechanisms by which one could click one box to fill out multiple boxes. This enabled capturing data and saving time.

Templates and order guides often utilized checkboxes to guide clinical cognitive work. Pediatricians selected templates from a menu of periods from months to years (3 months, 6 months, 1 year, etc.). Clicking on the desired menu option brought about a guide that doctors followed for documenting purposes. Some physicians resented this approach to documentation and termed it *"checkbox medicine."* They believed the guide restricted the practice of medicine and instead advocated using free text to gather rich patient data.

In addition, participants described concerns over what I will term, *checkbox fatigue*. It was explained by more than two participants that the personality traits of primary care physicians, who are high-achieving people, may spur them to fill out as many boxes as possible. Concerns described two possible results: 1. Physicians begin to take care of the charts more than the patients, and 2. The time required to fill in additional boxes (along with the load time required in between) could roll up significant time loss by the end of the day. The choice architect could employ perhaps two solutions that address these concerns: 1) Limit the number of boxes per screen to a standard set, or 2) Enable individual users to enter additional boxes above and beyond a standard set.

Physicians also expressed desire to have communications routed to default contacts. Default contacts might be commonly referred to specialists or labs. In one case, which was reported as a frequent occurrence, a physician was often unable to know if a below-knee venous Doppler order should be routed to Lab A or Lab B. Default addresses could be quite helpful.

3.4.4 GIVE FEEDBACK

Feedback tools provide information that inform altered or improved human performance. Giving feedback is different from understanding mapping in that the feedback is meant to support beneficial actions and prevent mistakes from occurring (or about to occur).

CDS feedback, when available, was provided mostly by pop-up windows and highlights. The pop-up windows required acknowledgment but observations noted few times when behavior was changed. Passive alerts in which passive health maintenance (HM) alerts were written in red font and often ignored. Ignoring was sometimes due to the presentation of the alerts themselves: small font, cut off by the screen; or failed to convey urgency when compared to other factors around patient visits. The CDS covered in this study did not provide any one electronic feedback mechanism that participants felt was a consistently effective safety support or behavioral modifier. Dr. Bracey referred to her paper-based immunization schedule as *“my alert”* and was stapled to the front of each patient chart. It was simple, compact, easy to fill in, and always available (as long as the chart could be located).

Having said that, there were a number of observed electronic CDS tools that altered clinician behaviors. Some examples include, a dosing alert that warned of a drug–vitamin interaction, stopping a duplicate Vitamin D lab order, using keywords to order medications and labs, i.e. “hg” for Hemoglobin A1C lab order, and an aspirin–alcohol warning that altered a doctor’s care plan.

The previously proposed *panel management tool* was described as a technology that would bring about changes to the ways physicians manage and interact with patients. The device would in theory allow practitioners to be *“proactive”* and seek out patients that could most use follow-up. If such a tool were to exist, it seems reasonable to expect that it in itself would act as a feedback mechanism; for it would provide (likely for the first time) physicians with a population view of their patients. It would also be reasonable to expect, given the existence of a panel management tool, that routine reports would provide physicians with progress reports that track panels of patients over time. This would be a powerful feedback mechanism that would likely lead to more advanced functionalities.

In the meantime, functionalities that seemed to impact participant behavior was self-made post-it notes on laptops, information gleaned from reference materials, and immunization reminders not from the systems but rather the patients themselves. The kinds of interactions participants expressed was a mix of point-of-care and process utilities: wanting systems with easy to follow formularies, process measure comparisons with clinic colleagues, or system recognition of an order sentence, *"Septra, five mill, PO BID temps ten days."*

3.4.5 EXPECT ERRORS

Errors happen, and so choice architects should try to understand what errors are likely to occur and design solutions that prevent errors or, at minimum, mitigate any harm that an error may cause.

Data entry and capture were described as burdensome because of the time it took to capture data but also for the sometimes unreliable means for capturing. Physicians expressed some concern that they might miss patient information while typing and navigating the EHR. Observation notes contain multiple instances where the physician's typing became intermittently slow and awkward while trying to ask questions and/or respond to patient questions. Physicians who worked with work stations situated in a way that required the doctor to turn away from the patient also expressed frustration that they were not able to better interact with patients. Others only used the system on the patient room to order medications and instead took notes on paper. This strategy, however, left possibility to missing data and the added layer or data entry added time to participants' days. Subjects consistently wanted computerized tools that enabled them to sit *"knee to knee"* with patients and engage patients during visits. In one example, to workaround data entry, a physician was observed carrying forward notes and labs as templates and then revising data. This could be a potential source of error. Finally, subjects described the need to have multiple sessions open to review the chart of a single patient. This could lead to an error of data not saving correctly.

Auto-calculators were not documented as being active in any one of the three observed systems. The lack of auto-calculators was a particular risk to pediatricians who often used manual calculators and transcribed values into EHRs. It should be noted that a family practitioner also felt pediatric dosing calculators were needed.

Navigation was pointed to as a fundamental source of frustration and a likely source for error. Participants described records not following the *"flow"* of ambulatory care and instead being more in line with an inpatient mental model.

One area for consideration is the multiple modalities users rely on in the course of clinical care. First, they often rely on paper to take notes in the patient room and then carry those notes back to their offices to complete the record. This adds time and effort to their day when time is at a premium and effort, cognitive and physical, has limits. Second, participants used a number of information tools to gain access: EHRs, the web, PDAs, etc. Error occurrences could possibly derive from misalignments in information resources.

Observations noted when systems were down, computers crashed, or access was denied. As can be expected, failed system logins was a particular source of frustrations among users.

3.4.6 STRUCTURE COMPLEX CHOICES

Structuring complex choices addresses humans' innate cognitive need to simplify, chunk, a large amount of data into sets that can be better manipulated by humans' working memory. For this category we will look at where exist opportunities to structure complexity in order to facilitate better decision-making.

A common complaint among participants was data fragmentation across the EHR. Dr. noted that in her system she must *"look about four places to check if a diabetic patient is up-to-date on recommended measures."* Participants explained the fragmentation did not alter any of their clinical decisions it resulted in more time to get to that decision. As I laid out before there were some hints that such might not be the case, but nonetheless, grouping data across the record is a prime example of the need to structure complex choices.

Subjects of all roles used the term *"snapshot"* to describe an information need they had. The snapshot, which may come in different forms, essentially provides an overview of a patient's condition. The snapshot likely differs according to a physician's role, i.e. a pediatrician and a general internist will each likely want something different, but the goal is the same: to quickly get up to speed on who the patient is, learn what has occurred before, and understand why the patient is here now. Dr. Altamirano, an OB/Gyn, noted that doctors are trained in medical school to present patients a certain way: *"Mrs. Smith is a 62-year-old gravida 5 para 5 woman, went through menopause about ten years ago, and she's here for this REASON. She's had these past surgeries, she's on these medicines, and she's allergic to penicillin."*

That snapshot introduces the patient to the doctor in the doctor's language who can then *"delve"* further into the record if one chooses to do so. When the snapshot was in the paper chart it was usually a half sheet long but always no more than one sheet long. It may or may not include a story, as was earlier described, it includes the pertinent facts. Those facts differ by role: 1) Pediatricians will want to know current height and weight, 2) OB/Gyns will want to know gravidy (the number of pregnancies) and paridy (the number of full-term pregnancies), 3) family practitioners and general internists will want to know age, weight, and blood pressure.

3.5 PERSONAS

Personas are amalgamations of qualitative data used, in this case, to model CDS users. Capitalized and bolded text indicates themes that are specifically addressed within each persona. Simply bold text indicates verbatim data taken from observations and interviews. The purpose of highlighting themes and data is to demonstrate the personas are grounded in evidence obtained through on-the-ground research.

PERSONA 1: DR. JONES – FAMILY PRACTITIONER

About Dr. Jones and Her Patients

Dr. Jones is a 48 year-old family practitioner who has been working in a large community practice for 19 years. She enjoys being a family practitioner because the **mix of patients** she sees provides her opportunities to meet with a variety of people, manage a variety of cases, and stay close to the community. In all what Dr. Jones enjoys most about being a family practitioner is the **relationships she builds and maintains with her patients**. She’s seen many that have grown up, and grown older, right before her eyes. Her philosophy is to treat the whole person, not just any one condition, and so she not only takes into account patients’ **physical well-being but also their emotional, social, and spiritual well-being**.

How She Views Her Work

The ***ENVIRONMENT*** in which Dr. Jones works can be, and usually is, quite hectic. This means that she is **often behind** schedule and there is **little down *TIME*** even though she **works through lunches and comes to work early**. It’s not unusual for Dr. Jones to **get fatigued** and **work on an empty stomach**. Days can be doubly hectic when **residents work with her in clinic**. ***WORKFLOW*** during these times adjusts so that she can address **a medical student’s questions and quiz the student in the hallway** while patients wait.

How She Views the System

Now that the system is in place and has been used for one year, Dr. Jones has mixed feelings about the kind of support it provides. **She appreciates having access to patient files and relies on *TEMPLATES* to remind her to check immunizations**. However, she feels the system doesn’t provide the kind of support she had expected of it. Dr. Jones **would like to see more sophistication in its health maintenance functionalities** so that she could ask the system about which of her patients are in most need of support, such as her diabetes patients who don’t regularly come to the office for check-ups. Dr. Jones expected the system to help her manage not only her clinical information but also take steps to promote healthy behaviors among her patients. She feels that at this time the **clinical decision support does not meet her needs**.

PERSONA 2: DR. SIMON – PEDIATRICIAN

About Dr. Simon and Her Patients

Dr. Simon is a **47 year-old pediatrician {just a nit but the picture doesn't match the persona}who is 21 years past her residency** and works in a four-person pediatric clinic. She **enjoys the practice** and her goal is to provide **quality** health care to her kids. Dr. Simon's colleagues comment that she's a bit atypical of most pediatricians; she comes across a little more **business-like and formal in her demeanor**. No one, though, questions her commitment to her kids and parents. She explained she had decided to become a pediatrician because **it matched better** for her. This wasn't always the case, for a few years she thought medicine wasn't for her and as a result got an **undergraduate degree in engineering**. But she couldn't escape the medicine bug and gravitated back into medicine. Her experience working with kids gave her the feeling there was **"a chance to make a difference"** in their lives and from then on, **"it had to be pediatrics."**

How she views her work

However rewarding it may be to cure children and help parents succeed at being good parents, work of pediatrician is tough. The ***ENVIRONMENT*** in which Dr. Simon works is not only fast-paced it requires a lot of physical energy. She quickly walks around the office moving from her workstation to chart, to a patient room, back to her workstation, and then off to another patient room. Different cases in each room are waiting for her: one room may have a teenage girl wanting to discuss a long-standing headache; another room may have a screaming **child who is afraid** to be in the doctor's office. The doctor is constantly washing her hands and moving from her laptop to making notes on paper. In this office, **any decision-making occurs in a noisy, fast-paced, and mobile environment**. Dr. Simon noted that when she used to use the paper chart **she would quickly review the problem, shots, and allergies** before walking into the room but it's harder to do that with the system now.

TIME is in demand especially now that EHR requires what Dr. Simon estimates is **another 1-2 hours of paperwork per day**. The effort is draining and becomes even more so during winter when things get "**crazily busy**." Dr. Simon eyes any time she can save and one area could be ***COLLABORATION WITH*** staff because the doctor would rather write To-Do lists for her nurse as opposed to communicating through the computer. In her mind, Dr. Simon **would just like to write notes asking the nurse to do this and that**.

In the course of her work Dr. Simon ***COLLABORATES WITH PATIENTS AND FAMILIES***. Dr. Simon views herself as part of a team with kids and parents to better insure her kids **grow up to be healthy and productive members of society.** She also wants to give children a sense of their own individuality and for parents to **respect their child's individuality**. For checkups and sick visits Dr. Simon uses any opportunity to educate parents as to what is normal given certain age ranges and those children are not just "clones" of parents. The system helps her when she can easily flip back and forth to show parents she has a tool that shows the data. This makes the doctor "feel great" because the data can help Dr. Simon explain a medical point.

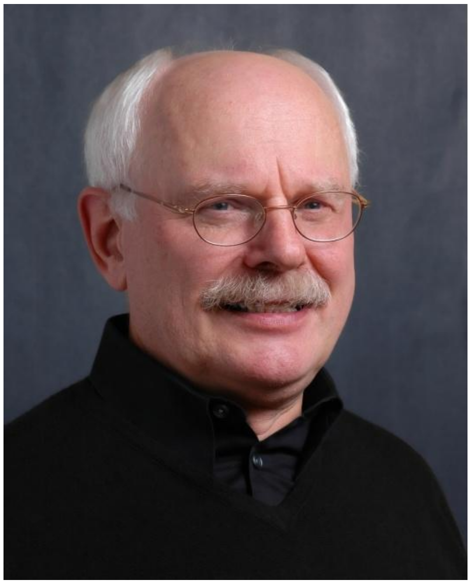
E-prescribing has quickly become a valuable EHR tool because it takes away much of the ***COGNITIVE WORK*** that was associated with follow-up calls and correcting illegible scripts. According to Dr. Simon, e-prescribing is one of only a few functions she likes about the system: "to have that task accurately done, and reflected ACCURATELY in the medical record…is GREAT."

How She Views the System

Dr. Simon finds aspects of the system very helpful: **the medication history, immunizations, accessing the labs (although they're not easy to review), and most importantly she likes the weight chart.** She always checks a kid's weight and how it compares to the previous visit. It's difficult for the doctor to use the system when a child has a complicated history because the doctor can't navigate as fast as the parent; usually it's the parent, talks. Whereas in a paper chart where she **used to look for a big dictation** she now has to ***NAVIGATE*** through multiple tabs to try and see when things happened but can't see the differences between **shot-only visits, telephone calls, patient visits, or maybe administrative information unrelated to a patient visit.** One thing that she thinks would be helpful for consolidating the information is to have a patient ***SNAPSHOT*** which shows previous diagnoses *not previous visits* and fits the assessments on one screen without having to scroll.

Dr. Simon would also like **the system to have a CDS auto-calculation function so that she and her colleagues no longer have to carry around calculators and manually calculate pediatric dosing**. Even better she'd like to enter an order like, "**Septra, five mil, PO BID temps ten days**." and the system gives the volume as well as the bottle size. "**That's what I think what a computer is built to do**," says Dr. Simon, "**Have those tables of data, and it ACCESSES them, and spits that data out.**"

PERSONA 3: DR. STEVENS – OBSTETRICIAN-GYNECOLOGIST



About Dr. Stevens and his Patients

Dr. Stevens is a 51 year-old physician "**who does obstetrics and gynecology**" and has been doing so for **over twenty years**. He considers himself a moderate user of his practice's EHR that has now been in place a little over **two and a half years**. He's quick to note that his experience with EHRs spans longer than that because the hospital where he covers has had a system for seven years. He likes EHRs in part because **he considers himself a bit of a techie**, but he has noticed how the EHR has changed health care. He feels clinicians can all too easily fall into the trap of **taking care of the record more than taking care of the patients**. "These systems," he says, "are built for **lawyers for sure**."

Dr. Stevens loves being an OB/Gyn for a number of reasons; number one being that he gets to **deliver babies**. He fulfills a range of responsibilities that include primary care, advanced surgery, and follow-up care. He finds the variety exciting, and because **he considers himself a primary care provider**, he likes that he can build relationships rather than **sending people off onto different specialists**. "It's nice to be able to process your way all the way through a problem," says Dr. Stevens. Still, though, the relationships may differ with family practitioners and general internists in that he may see some patients for windows of time: earlier in life when they carry a baby to term or later in life when hysterectomies become unfortunate considerations. He feels it's important to be able to re-establish relationships as quickly as possible which is why he likes to know something about their lives; something that helps "cement a person" in his memory so that he can relate to her.

How he views his work

The ***WORKFLOW*** of an OB/Gyn is demanding because it requires availability at different hours of the day and night. Some days he'll be on call, start mornings giving C-sections and inductions at the hospital, *then* go to his practice to see two or three patients, and then go back to the hospital to take care of those who were inducted in the morning.

Dr. Stevens receives "a LOT" of referrals from primary care practitioners and so values the contacts he's developed over the years. He knows well the people that refer to him and they know him well. He likes the system when it makes decisions easier and when the system doesn't it's just "one more bridge you have to cross." When describing decision making, the doctor discusses the ***COGNITIVE WORK*** that the system supports such as communications with staff and making information accessible for phone consults. However it is much harder to practice medicine when it comes to ***COLLABORATING***

WITH OUTSIDE INSTITUIONS; some labs arrive electronically and others arrive by fax. He feels his work is at the mercy of the Metropolitan Radiology Group who faxes their labs and Central City Radiology who prints their ultrasounds. Then there's the hospital which, when he tries to access their radiology PACS portal, crashes his laptop. These are just a few of the challenges he faces when integrating data into a patient's chart.

<u>How he views the system</u>

Dr. Stevens likes the system because he and others no longer have to hunt for missing charts like in the old days. He misses, though, the ability to get a sense of the patient that the paper chart provided; the ***SNAPSHOT***. Even the physical weight of the old paper chart gave him an understanding of a patient and a heavier chart would "jog" his memory of the relationship and cause him to take two or three extra minutes to cover the **OB history, age, gravidy, parity surgery history and basic summaries**. As it is now, the data is in too many places and takes too long to pull together into a whole picture.

He hasn't seen many ***CDS ALERTS*** himself but likes the idea of them. The few he has seen haven't been very helpful. One alert he thinks would be helpful would be for family practitioners, not OB/Gyns, because **he has recently seen patients with uteruses on estrogen therapy without progesterone**.

Dr. Stevens is aware of meaningful use and thinks that's a good thing. But the real issue is getting data "from the bottom up" and mandating data input and sharing. "The weakness of community based electronic medical record systems," opines Dr. Stevens, "is that they are not mandating meaningful data input."

PERSONA 4: DR. CRUZ – GENERAL INTERNIST

About Dr. Cruz and Her Patients

Dr. Cruz is a **45 year-old general internist** who is **16 years past her residency** and works in a five person clinic started by her and her partners. The practice has been quite successful, so much so that there is a waiting list to be accepted as a patient. Dr. Cruz chose to become an internist because she loves the **variety**, the endless **opportunities to learn**, and because she likes **"taking care of the sickest of the sick."** She loves working with her patients and **getting to know them over time and developing relationships with them**. Dr. Cruz believes being an internist **allows her to get to know her patients at a level not possible in other specialties**. The enjoyment she gains from working with her patients is tempered by how she perceives the overall healthcare system's focus on **profit over patients**. The information system reflects this to a degree in that she views the system as being somewhat **forced down her throat** (and her partners') by **people who know very little about** providing primary care. In her opinion, the system in its current form is built for more for **"the billers"** than for doctors.

How she views her work

Dr. Cruz loves the two-thirds of her job that involves taking care of patients but abhors the other one-third composed of documentation and administrative work; **one-third of the bad "overshadows" the two-thirds of the good**. Dr. Cruz **predominantly sees older patients** in the small clinic that at times **has trouble fitting wheelchairs in between the patient bed** and the monitor that rests on a swivel arm. She gets into the office around 9:30am after tending to hospital duties and already finds herself behind schedule, **"it's par for the course,"** she says. Walking into patient rooms, Dr. Cruz **lays out printed labs for both her and the patient to review together**; she prefers to have the monitor face her rather than the patient, and **accepts the PHQ-9 form** that the patient had filled out in the waiting room. She logs into the EHR system and pulls up a SOAP note without any visible allergy alerts displaying, and begins typing. Although the initial process looks straightforward, Dr. Cruz notes that when multiple meds and labs need to be reviewed the system is **"klunky"** and shows itself to be **more concerned with collecting data with which to monitor physicians rather than enhance physician workflow.** Much of the reviewing that she describes as ***COGNITIVE WORK*** had already **taken place the previous night** which Dr. Cruz quickly **points out is non-reimbursable**.

How she views the system

Dr. Cruz looks to **clinical decision support to provide her with algorithms** in **real-time** that guide her toward best practices. She **appreciates having the computer in the room which allows her to access Up-To-Date** at the point of care. She also very much **likes *DATA AVAILABILITY*** and **the ability to remotely access data** whether she's at the hospital or at home. However she also wants the system to support her in ways that **reduces paperwork so that she can have time to spend with her patients**. Many of the alerts she has come across are **not helpful because they fail to account for the context of primary care**. "**In the hospital things move faster** and conditions change faster," she says, "but in primary care the focus is on developing the right regiment over time….**any alerts should help physicians focus on preventive care**," she adds. Ideally a CDS system would **"pull out" diagnoses and feature patient risk** for disease.

The current level of ***USABILITY*** can make it difficult at times to navigate the record and see the data in the user interface. For example, **passive alerts live off-screen somewhere to the right** and any allergies **marked with a small red checkmark next to the word "Allergies".** Dr. Cruz and her colleagues have also been asking **"for three and-a-half years"** for a medication **snapshot organized by date and drug with explanations** as to why a medication might have been discontinued. ***COMPARTMENTALIZED DATA*** also makes **developing plans and assessments difficult because she cannot view lab results and enter data at the same time**. There are, however, some shortcuts like quick keys (**Hg for an A1c lab**) that enable Dr. Cruz to enter data quickly. Templates and flowsheets are also available but she is frustrated that there **is yet a template for a woman's well check**.

4. DISCUSSION

4.1 SIM AND BERLIN CDS TAXONOMY

The Sim and Berlin taxonomy is based on literature that was derived from MeSH heading-based literature searches. The authors therefore relied on an existing CDS definition for their analysis:

> "Decision Support Systems, Clinical." (Term entered, 1998) "Computer-based information systems used to integrate clinical and patient information and provide support for decision-making in patient care." (MeSH, accessed 8/17/10).

The MeSH heading is a system-oriented definition. From that, Sim and Berlin provide a system-centered view on CDS and directs focus on CDS components and how people interact with those components. This view dictates that systems act as repositories of knowledge that either “push” or “pull” CDS to defined users at particular times.

From the views of this study’s participants, the system was indeed a central entity within their work. Those that once had been using paper charts and then switched to the EHR could not conceive going back. The systems provided automatically updated medical lists, to varying degrees, which was highly valued. In addition, the systems created among users a sense of security that data was safe and accessible, both on-site and via remote locations, which were critical factors for acceptance.

Sim and Berlin go beyond merely presenting taxa (“axes”) and frame the taxonomy as a linear process that begins with a knowledge source, or sources, and ends with a specified “target decision maker.” (See Figure 16) The process contains two major limitations. First, the linear process moves from system to person with workflow and context tangential to the interactions between people and system. Note, for example, that context and workflow are isolated from the flow of knowledge from the system to the end user. Second, the process starts at one point and ends at another thereby insinuating that data leads to a decision, not vice versa.

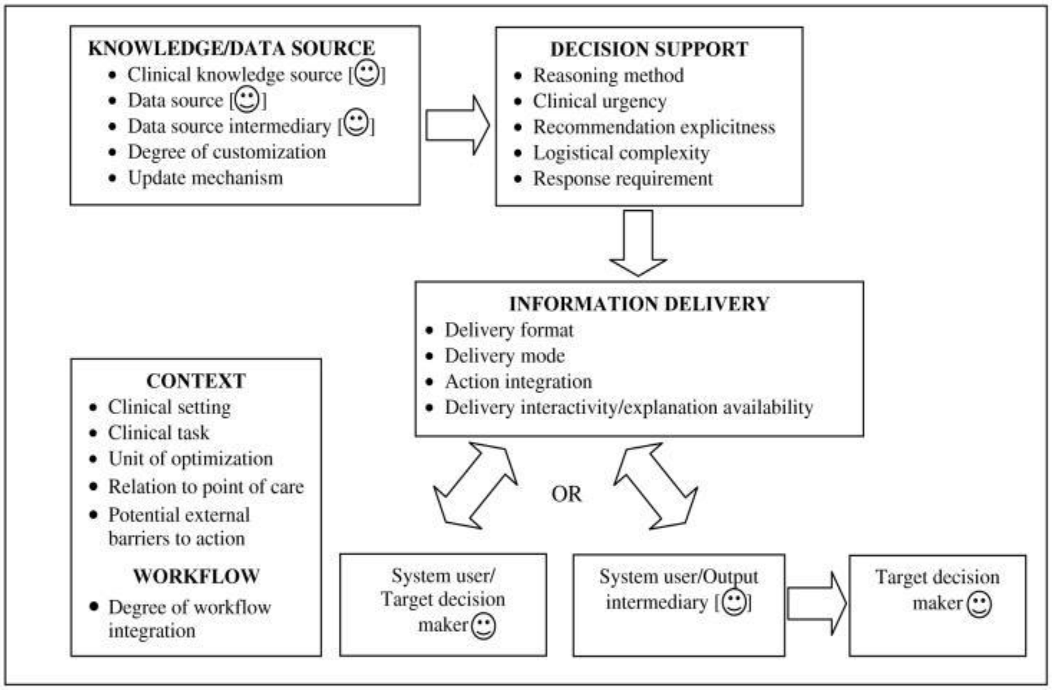


FIGURE 16: THE SIM AND BERLIN CDS TAXONOMY

In addition to process limitations there are particular limitations within the taxonomy itself. As the taxonomy was derived from controlled trial and randomized trial literature there may have been a bias toward articles that reported positive results. A randomized sample of Sim and Berlin’s articles (6 out of 30) was selected and of the six, five articles reported significantly beneficial results. (See Appendix M) The taxonomy, therefore, likely represents “best of breed” CDS systems that may diminish the occurrence of user behaviors such as experiencing alert fatigue.

Unlike developing systems meant to support synchronous decisions, participants expressed needs for tools that supported asynchronous decisions. One such example has already been discussed, panel management tools, and would assist with managing populations of patients. Other asynchronous opportunities for presenting CDS, however, may exist. For example, observed participants often prepared for patient visits minutes before walking into a patient room. Those minutes were used to read up on a condition or medication dosage. Participants also explained they prepared for patient visits to take place the following day. The needs for both synchronous and asynchronous tools are in line with Dixon’s argument that a “technology-enabled” EHR include both aspects as well as chronic care support for patients. (218)

The CDS axes are designated as if CDS is making a recommendation to users that want a recommendation. Those recommendations may or may not be acknowledged, with options in between, and recommends implicit or explicit user actions. “Clinical urgency”, for example, is also one axis that accounts for whether or not actions are required within "hours." The degrees of urgency are not defined. Finally, decision support is characterized by reasoning triggers and rules such as "algorithms...probabilistic reasoning...or fuzzy logic." It appears to me at this time that assumptions are being made that a guideline is available and presented to the user. It does not, at least in this category, seem to account for ignored recommendations or CDS actions.

4.2 GROUNDED THEORY

The grounded theory model for physician-centered understanding of CDS for community-based settings is using the system to link the user to higher-level goals and reflecting those higher level goals back to the user (see Figure 17).

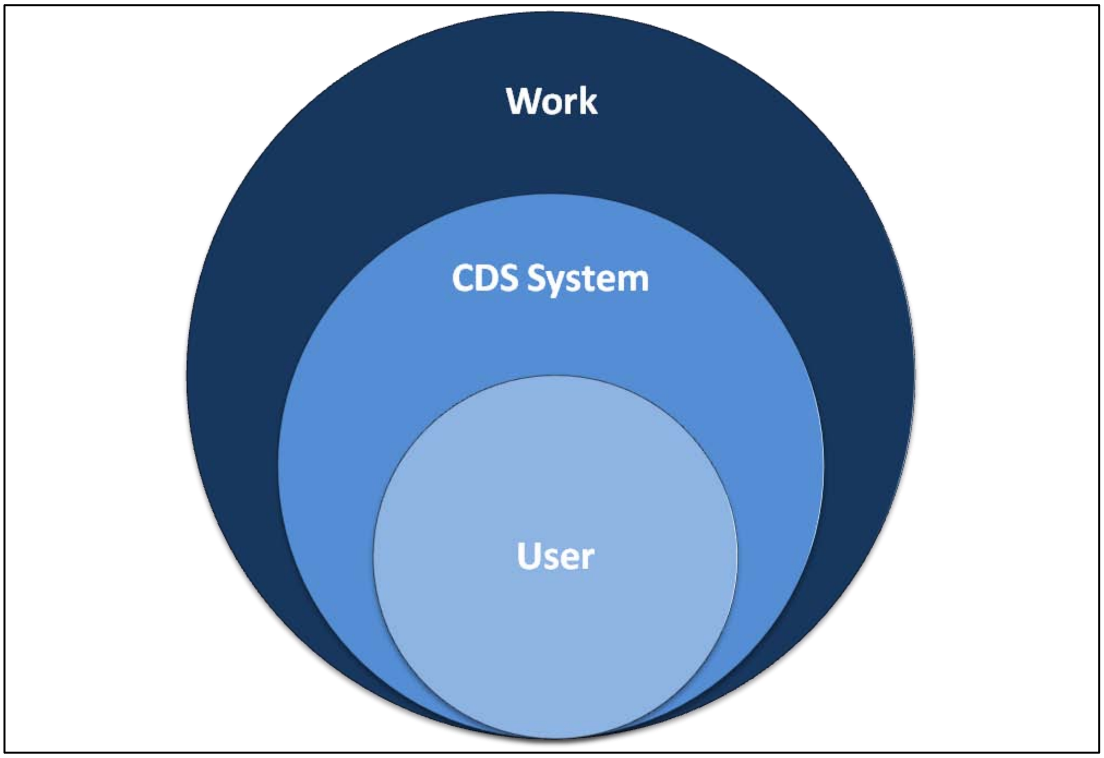


FIGURE 17: A USER-CENTERED MODEL OF THE CDS SYSTEM AND CLINICAL WORK

Unlike the Sim and Berlin taxonomy activities don’t occur around the system but rather occur through the system (See Figure 18). The effectiveness of the system may be measured by how well the system integrates the user and the work; the wider the chasm between the user and what the user wants to accomplish the poorer the system meets user needs.

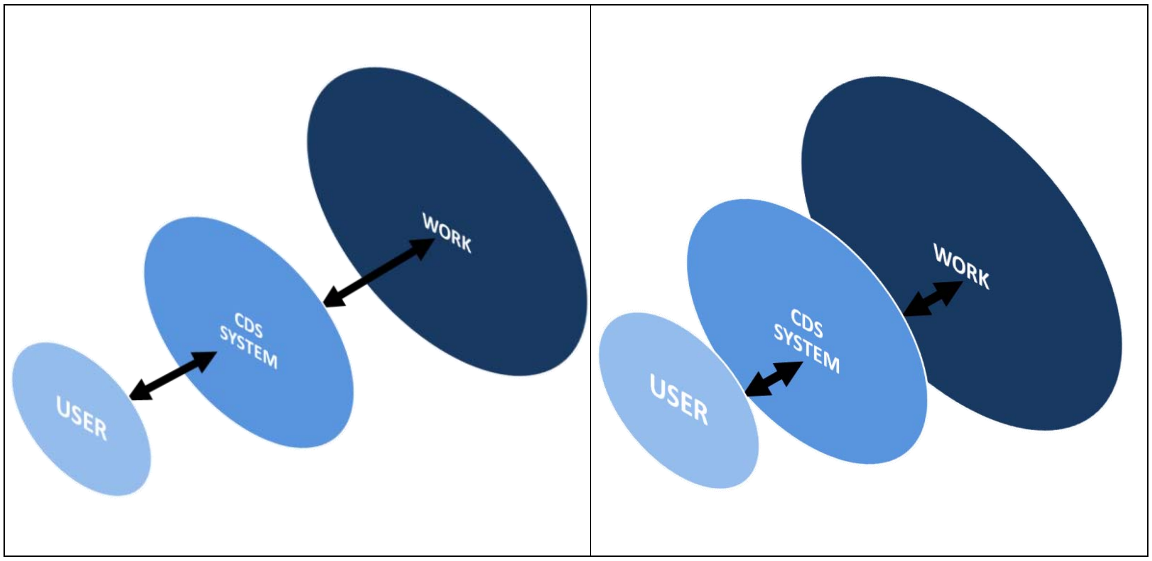


FIGURE 18: LINKING THE USER TO LARGER WORK GOALS

4.2.1 LEARNING ABOUT THE USERS

The grounded theory analysis provides a community-based-physician-centered view as to what encompasses CDS and how CDS can better meet physicians' felt needs. Three facets were used to arrive at an understanding of how participants saw themselves, interpreted their work, interacted with their systems' CDS functions, and what physicians need to better interact with their systems.

Interviews and observations revealed user characteristics that inform behaviors and goals. Users are self-demanding and self-critical perfectionists who demand CDS and systems that meet their expectations. Physicians see themselves as part of a larger community, even if at times they get frustrated that the larger community does not fully appreciate the sacrifices made to provide primary care.

It is important for CDS designers to be mindful of users' feelings such as frustration, pride, and satisfaction among others; and when those feelings surface in the context of clinical care. Background research demonstrated that emotions are powerful cognitive forces that have the ability to sway and influence "rational" decisions. Yet the EHR in general and CDS tools in particular engendered a wide array of emotions within and across all participants. It is perhaps therefore ironic that CDS invoked such strong emotions among the users to whom CDS technology was intended. For one purported reason for using CDS is to lessen clinician biases brought about by emotions that may impair optimal decision making.

Study participants were open, social, and engaged not only with their patients but also with the researcher. It is perhaps important to note that the physicians were very social people who enjoyed working with other patients and their staff. These factors may be understudied aspects of work in relation to how CDS fits within social, even communal, work environments this study noted.

CDS design can be informed by the understanding that physicians make decisions through a lens of relationships and want to develop and maintain strong relationships with their patients. This requires establishing and sharing high degrees of trust. This means that participants wanted to know that the systems and CDS with which they worked could be trusted as well.

As Lehrer referenced in his book, “How We Decide,” (83) decision-making with respect to others’ feelings and perspectives in mind is an important facet of decision-making. The ability to empathize and put oneself in another person’s shoes and account for their welfare is a fundamentally human cognitive trait. Physicians repeatedly expressed their desire to work on behalf of their patients’ and patients’ best interests. It could be beneficial for informaticians and software engineers to bear that in mind when developing next generation CDS tools. Clinical decision-making is not making safe and accurate decisions in the abstract nor is it driven by “rational” decision-making alone. Rather, clinical decision-making may be supported by a spectrum of cognitive processes that support building relationships with others such as patients, staff, as well as the larger community.

Unfortunately, CDS was not trusted often enough. The lack of trust in the systems had an impact on how participants felt they could perform at levels that establish and maintain those levels of trust of their patients.

CDS design could leverage the knowledge about participants’ personalities and perspectives as well as their desire to maintain bonds with patients. The aspects of participants’ approaches to medical care necessitate CDS that is personable, customizable to individual physicians’ needs, and totally professional. Results showed that physicians were very sensitive to not feeling in control when with patients and appreciated systems that helped them quickly communicate data, information, and knowledge to others. They felt that such ability engendered trust between patient and physician, as well as system, in that the physician had another “tool” in her or his armamentarium that can be used to improve patient care. Furthermore, the systems were implemented with high expectations at high costs. As many community-based practices are essentially small businesses it is critical that users feel that the systems and its CDS meet user expectations of quality, safety, and reliability.

4.2.2 LEARNING ABOUT THE WORK

Observing clinical workflow in the field provided a sense of what it is like, even if it was for just for one hour at a time, to be in the shoes of a primary care physician. The work is demanding and tiring with interruptions and distractions constantly occurring. The days are long and time is always in short supply. Within these environments, participants took up their work in a very manner-of-fact attitude and with a certain acceptance that the life of a primary care physician is varied but harried.

Decision support was not extremely apparent in the system but decision-making (cognitive work) is constant: trying to remember the proper name of a knee brace, let alone trying to order a knee brace, developing a patient plan with a noncompliant patient, managing scheduling, unsuccessfully trying to add a specific gout diagnosis ("gouty arthropathy") to the problem list and so sufficing with a general diagnosis ("gout unspecified"), negotiating insurance changes, observing medical students, and being observed by a researcher. With all of these things going on at once, it seems to me no wonder that doctor's want nothing less than a system that helps them get through their day rather than fight them along the way.

CDS in isolation, such as in development labs or controlled environments, is not the same as CDS in context. Context reveals the variety of decision-making opportunities that doctors, and all workers, face on a daily basis. Within that context, CDS plays a very small role yet it seems that in some circles (informatics circles) CDS is to drive change throughout healthcare. To drive change throughout healthcare would be to ease the cognitive load that physicians take on a day-to-day basis; and giving more alerts and reminders is *not* the way to make that happen. Making it easier for doctors to enter data, capture notes, offer easily recognizable shortcuts, even supplement records with images and drawings; these little things could do more to lighten the burden of clinical work thereby providing more room for complex decision making. This is not to say that alerts and reminders do not have their place, they do, but there have to be other design strategies (within the system and beyond) that take away much of the cognitive load that doctors carry around. After streamlining the system, then look for ways to integrate context-sensitive, patient-specific alerts and reminders.

Clinical decision support in its traditional sense is software designed to *support decisions*. In context, this is rarely the case thereby making "decision support" a misnomer. Decisions require time, reflection, weighing of values, options, and consequences. These windows of time do not occur in the environments that I have observed. There are no windows of time, there are only a few moments of time; and that is if the doctor and patient are lucky and are able to stop the air and contemplate. There should, or could, be supports built into systems but they aren't to support decisions but rather to support actions: prescribing, finding a document, comparing labs taken from different times, finding correct dosages for a new drug. The system we build are to support specific actions within the EHR tool, not "support" decisions that are made within a doctor's, patient's, or nurse's minds. People decide, tools help them, hinder them, or prevent them from taking action.

CDS could be designed with the knowledge that although navigation and finding information are not considered CDS, they do act as facilitators or barriers to CDS. In addition, CDS could be designed in ways that task shift "data work" to lower level staff members who (guided by flowsheets, reminders, and alerts) could collect data required for "routine" health maintenance. Shifting these tasks would allow physicians to do "doctor stuff" such as educating, counseling, and motivating patients to meet a variety of individual needs. Doctors often described these activities as the enjoyable aspects of their work, and those activities also happen to be in line with why these physicians chose to work in primary care settings.[8] Given this perspective, safe and reliable CDS isn't an end in itself; rather it is a means to accomplishing more for patients than what physicians are currently able to do.

"Cognitive work" was introduced as a concept that delineated "doctor work" from the myriad tasks that filled up all the seams throughout workdays. It was with cognitive work that physicians feel that "decision support" (*not clinical decision support)* may help. It was illuminating to learn about the demands of cognitive work and how it relates to physicians' work, compensation (or lack thereof), and even their self-perception.

Physicians expressed stress and frustration that the level of communications and coordination as well as the documentation heaped upon them would just be expected by the system. Still, physicians again matter-of-factly described how another all-too-busy day at the clinic would require them to work on their charting once they got home. Most interestingly, I found, was that participants often said they did not want to reduce the amount cognitive work in the abstract; rather, they wanted to reduce the amount of cognitive work so that they could spend more time with patients. In fact, anything about the system that slowed them down was perceived as time taken away from doctor-patient interactions.

Stead et al. too discussed cognitive work in the context of "patient-centered cognitive support" (PCCS) and singled it out as a biomedical informatics "grand challenge." (207) The authors viewed PCCS as providing models by which to users could synthesize and attribute context to disparate data within the EHR. Given what was found in this study it may be apt to assert that cognitive work is the activities that physicians carry out to bring data together, and cognitive support is the means by which the data is held together.

I {first person} propose a model that incorporates data from multiple sources to provide a patient model (See Figure 19). The patient model enables the user to gain a sense of a patient's status and story prior to ever seeing the patient.

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[8] A physician described "doctor stuff" as: "It's talking with people about…the big picture things. Like, for the diabetic it would be: Are you exercising, and why? And do you understand why we check your feet every time? Did you have Aqua Socks for when you go to the beach? And tell me about how nutrition's going. OK, well, we should, you know, be thinking about makin' these food substitutions. You know, is your husband supporting you better in your nutritional plans? Or do you still feel like he's undermining you? You know… that stuff. "

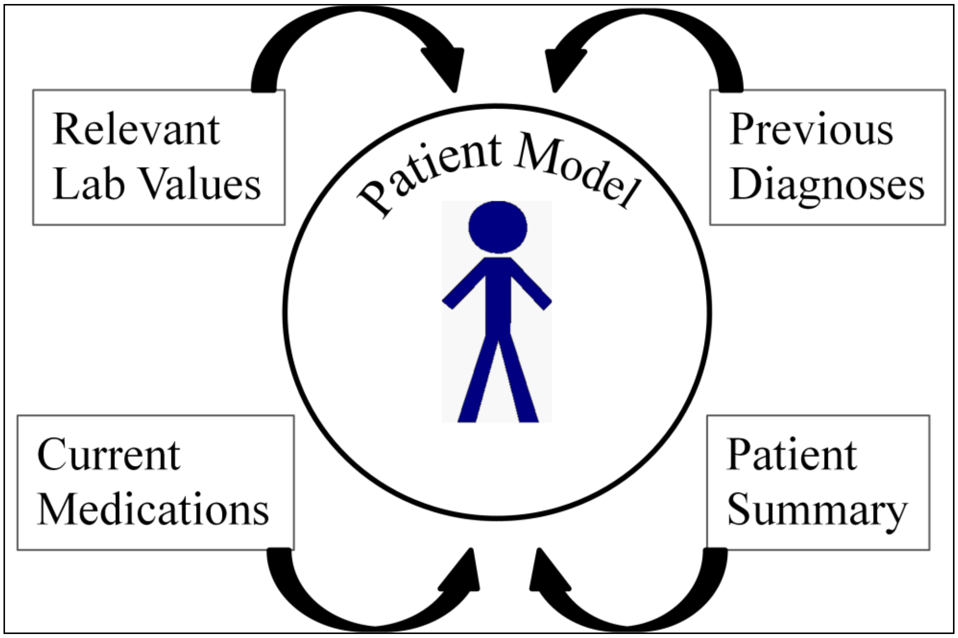

FIGURE 19: A COGNITIVE MODEL OF THE PATIENT

Study participants strongly asserted the need for such tools because they not only would save time navigating multiple data and information sources but also provide physicians with a better sense of patients' needs and their stories. This could prove to be a significant finding for it uncovers an unmet need that these community-based physicians yearned for: CDS tools that not only support task-oriented decision-making such as whether or not to order a lab or to screen for a mammogram, but model based decision-making based on "snapshots" or high-level view of a patient or a panel of patients.

Mental models, as described by Johnson-Laird in the background section, more accurately describe human cognition than formal or rules-based logic. Mental models are "parsimonious" in that they tend to contain as much information as necessary, no more and no less. This is very much in line with participants described needs for systems that provide patient stories and summaries that convey more information more quickly in two to three sentences than having compartmentalized data strewn across multiple EHR tabs. As Dr. McKean noted, sometimes the weight of a patient chart was all that was needed to convey a sense of a patient and her needs. Subjects often described the power patient pictures and their ability to guide care planning and contextualize orders, labs, and other tasks.

Although participants in this study may have felt that snapshots were more akin to an issue of usability, it may be proper to think of cognitive support as its own area of study. Usability is more commonly understood as heuristics that support navigability and findability within a system itself whereas cognitive support's purpose is to engender a mental picture of a patient in a clinician's mind. It is the difference between using CDS to develop an archetype of a patient and using CDS to know what to do to or with that archetype. Although not mutually exclusive, the two purposes are could be considered sequential in that cognitive support may encompass usability but not vice versa.

CDS could do well to help address some of the issues brought about by the cognitive work vs. procedural work conflict in terms of enabling ways to task shift work. Task shifting, in physicians' minds, provides opportunities to regain time for patient interviews that had been lost to documentation and navigating clunky EHR systems. Participants yearned to shift the proportion of "menial" work to others who they felt, with the support of robust CDS, could do a task just as well as a physician (See Figure 20). This, then, would free the physician to perform higher-level tasks that are more to their liking: patient education, patient counseling, care planning, and even staff training.

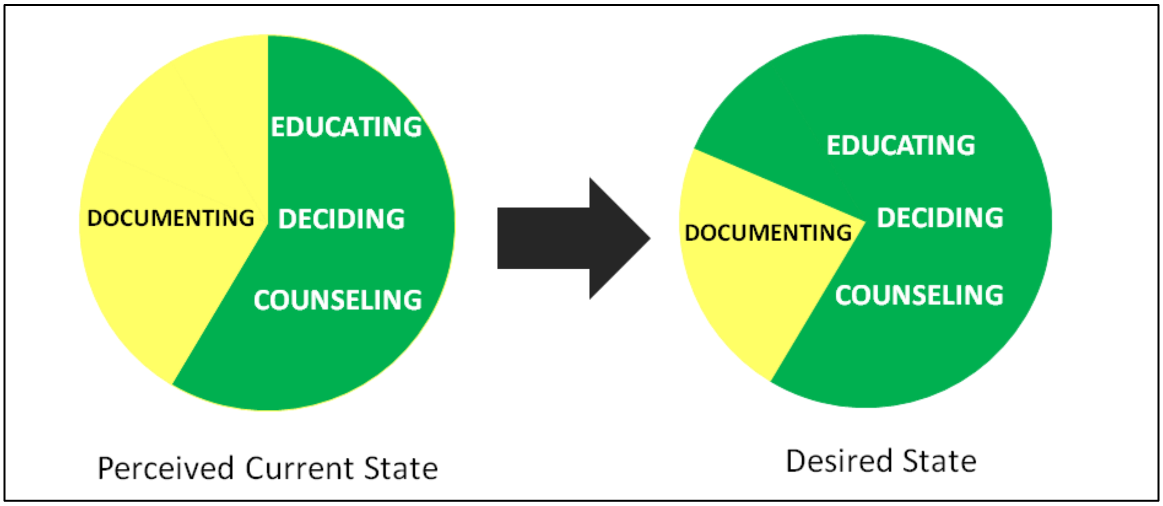

FIGURE 20: CDS TASK SHIFTING TO REDIRECT TIME AND EFFORT

Participants had ready examples of other clinics and colleagues that were undergoing such shifts. One clinic were in the process of developing patient care teams situated in "pods" that distributed work across doctors, MAs, and other support staff meant to manage panels of patients and the cognitive work required to support their care.

Dr. Timothy Hoff's book, Practice Under Pressure: Primary Care Physicians and their Medicine in the Twenty-First Century, is an invaluable resource that provides external validation of the results in this study. Comparing and contrasting results from this study with Hoff's lends greater trustworthiness to my (and his) results as well as contributing to a larger body of newly developing knowledge.

One finding in this study supports Dr. Hoff's discussion around "cognitive work" versus "procedural work." A participant in this study independently used the same distinction when explaining one of the many challenges primary care practitioners face. Participants explained kinds of procedural responsibilities that go beyond direct patient care. Community-based physicians are looked to provide sign offs on government forms such as court documents and certified driver licenses, they receive phone calls from patients seeking refills, they coordinate care with specialists and often times do not have all the necessary information with which to properly do it. In his interviews Hoff too learned that his subjects experience many similar challenges.

4.2.3 LEARNING ABOUT THE SYSTEM

Participants expressed clear distinctions between what was and what was *not* clinical decision support. Clinical decisions were quite distinct in their minds and held particular weight for them and their role as doctor. Participants conveyed the sense if not the words that decisions, and any mistakes from those decisions, could result in severe consequences for their patients, their practices, and themselves. It is perhaps very little surprise then that physicians delineated *clinical* decisions apart from *clinic* decisions.

Yet given what physicians had to say about clinical decision support, and what is not clinical decision support, it was fascinating to hear that distractions, interruptions, or general fatigue would not impact “ultimate” clinical decisions. Instead, subjects expressed their perspective that clinical barriers only slowed down inevitable clinical decisions. As results showed, however, there were examples of poor system designs altering clinical decisions of those very same physicians. With this it is perhaps worthy of further investigation to the nature of clinical decision-making as it relates to designing clinical decision support. There may not after all be a clear delineation from *clinical* decisions and some *clinic* decisions. It therefore leaves open questions about degree that users’ own definition of CDS because the concept may be more fluid than they, or informaticians, have traditionally thought.

Time in the field also revealed the difficulty participants had with capturing clinical data. This shortcoming is of critical note since it is the data that is to drive clinical decision support. CDS can only be as good as its data, and if the data is suspect then so too will be the CDS.

Participants were frustrated with the poor technology associated with data collection. I too, during my observations, quickly grew a sense of frustration around data collection tools. The experience with participants highlighted how much better systems need to be to enable the recording of discrete data and notes.

Whereas Sim and Berlin’s model is a one-way process from data entry to decision, a more fitting approach might be one based on explicit acknowledgment that effective decision support requires effective data gathering tools. In this respect, CPOE and CDS are intimately intertwined and perhaps ideally should be modeled as one (See Figure 21).

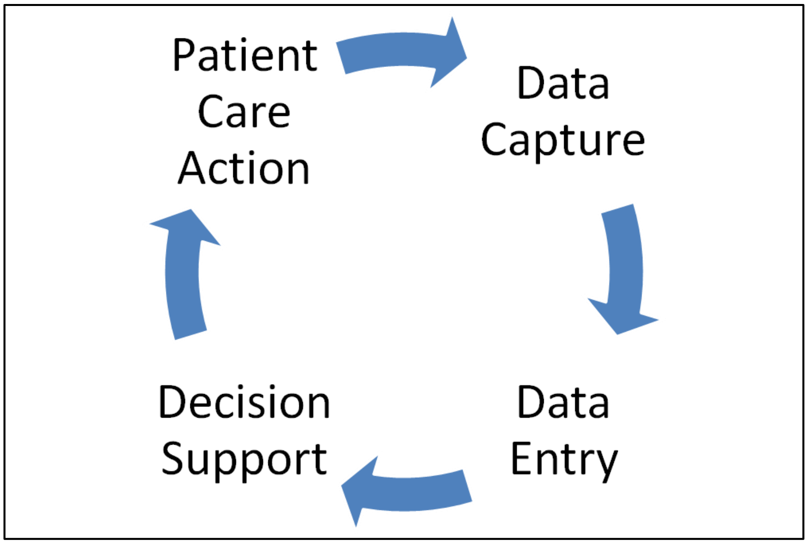

FIGURE 21: A PROPOSED MODEL FOR INTEGRATING DATA ENTRY WITH CDS

Interviews and observations also discovered multiple occurrences when and where the EHR is reviewed that could be potentially better opportunities for CDS presentation (See Figure 21). Physicians explained and were observed taking brief moments in between patient visits to brush up on the next patient before walking into the patient room. Furthermore, more structured planning occurred before the day started, at night, or even at home. Physicians described going through the extra work out of a need to feel prepared for patients. As one physician exclaimed, “I hate flailing around” in patient rooms.

CDS design may do well to take a higher level view of clinical workflow to direct resources where documentation and decision making is made. As the model in Figure 21 demonstrates, observations and interviews revealed opportunities to display CDS to users before the user interacts with patients. (define DC??? This is data collection, but above you call it data entry)

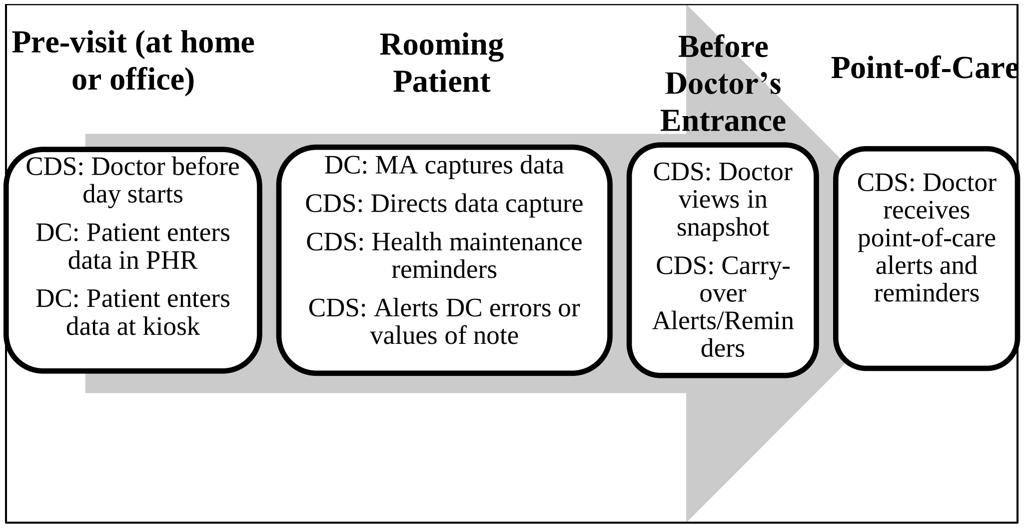

FIGURE 22: OPPORTUNITIES FOR CDS DISPLAY IN COMMUNITY-BASED SETTINGS

Decision support is not extremely apparent in the system but decision-making (cognitive work) is constant: trying to remember the proper name of the knee brace, trying to order the knee brace, developing a patient plan with a noncompliant patient, managing scheduling, unsuccessfully trying to add a specific gout diagnosis ("gouty arthropathy") to the problem list and so sufficing with a general diagnosis ("gout unspecified"), negotiating insurance changes, observing the medical student, being observed by me, etc. With all of these things going on at once, it seems to me no wonder that doctor's want nothing less than a system that helps them get through their day rather than fighting them along the way.

Physicians expressed the desire to both filter down data, but just as importantly, roll up data. Rolling up data would enable to attain high level views of patients quickly and reliably. Participants uniformly described these tools as "snapshots" and described a variety of them that had been in use with paper charts. Many expressed frustration, even sadness, that these tools were no longer available.

One family practitioner described Genograms as a type of snapshot that quickly and easily enables a physician to gain a high-level view of a patient's family history. Genograms describe a variety of family hierarchies, relationships, boundaries, and history. (239) Figure 23 provides a simple example that shows in text the names, medical history, ages, and occupations within the family unit. Square shapes represent males and circles represent females; extended relationships such as an engagement can be indicated by using a dotted line. Beyond the example given, standardized Genogram symbols reflect a wide variety of pairings such as domestic partnerships, medical conditions such as alcoholism, and relationships such as those that might be considered "close" or "strained". (239)

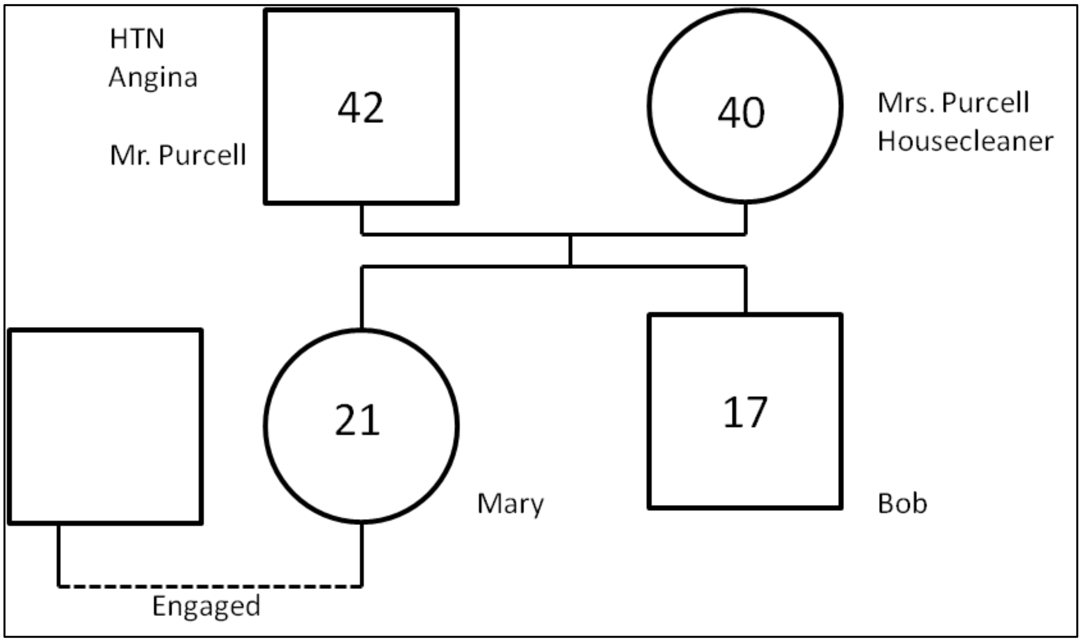

FIGURE 23: GENOGRAMS INDICATE GENDER, AGE, CONDITIONS, CHARACTERISTICS, AND RELATIONSHIP TYPES

The benefit of snapshots is that they not only provide a “big history” of their patients but that snapshots do so quickly. Using patients’ biographical information, flowsheets, and stories fits within clinic workflow and reacquaints clinicians with patients prior to entering patient rooms. Participants felt having a sense of the patient before entering the patient room was extremely valuable in that it helped the doctor socialize with patients thereby maintaining relationships and trust. Furthermore, doctors discussed how having a greater sense of the patient informed clinical decision making and care planning.

A proposed model (See Figure 24) demonstrates how the system can tie the user to different goals associated with community-based work. The user sets out to accomplish work that links their personal goals, driven by the desire to express personality and perspective as well as supporting relationships, to tasks and cognitive work. Whether done so poorly or effectively, the system acts as a tool that can link the user to higher level work goals.

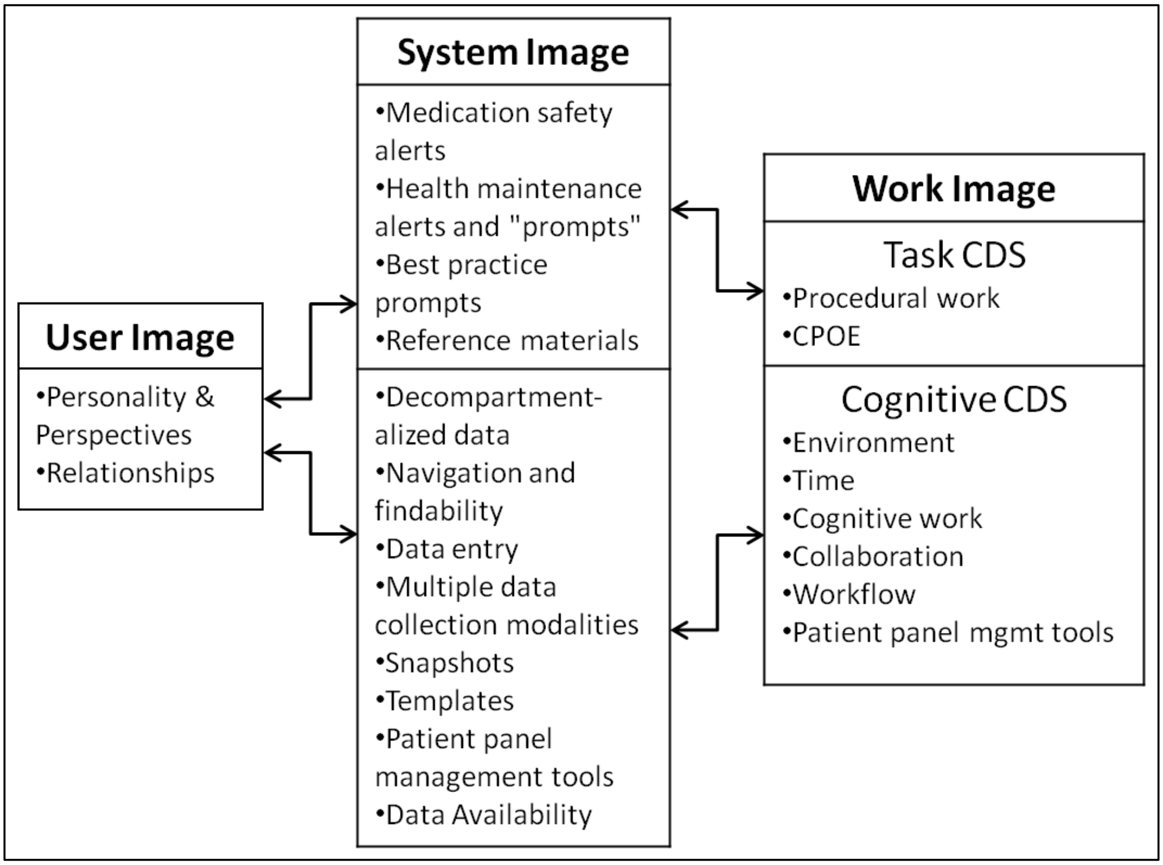

FIGURE 24: USERS RELY ON A SYSTEM TO CARRY OUT CLINICAL AND COGNITIVE WORK

Participants in this study expressed extreme frustration with data entry and the limited tools to support them. Hoff found this to be a complaint among physicians who noted having to take work home with them to complete charting. Such was the case with participants in this study. Participants in this study used and devised a number of strategies to enter data into the EHR, none of them particularly satisfactory. One form was to use voice recognition software which seems advantageous in theory, but becomes arduous when having to speak through a compartmentalized EHR. Others dictated notes into digital recorders or entered their own charts sometimes during visits and sometimes after work. Some doctors developed paper-based solutions so that they could better interact with their patients but this added more time and data entry, duplicating effort.

Hoff found physicians overall resented templates because they did not adequately reflect particular clinical role-based needs or they impinged on personal preferences. This study did not find uniformity around templates. Although some did lament the limitations templates placed on physicians, and when those templates were not in line with their particular roles, other physicians thought templates guided them through practice visits without interruptions. Templates reminded some to track health maintenance functions data such as immunizations, something they admitted was not previously on their agendas.

Hoff's general conclusion was that EHRs are "double edged swords" that are simple approaches to larger problems. EHRs indeed are not a panacea, but they do have advantages over paper charts. Participants enjoyed the ability to remotely access clinical data and relieved that foraging for paper charts was a thing of the past.

It is important to note, also, that Hoff did not conduct observations to go with his interviews and therefore did not note any physician-system interactions. It should be noted that in Hoff's and this research, participants continued to use the EHR systems despite complaints of poor usability and other system limitations. Going further, participants in this study expressed patience with the system and expressed opinions that over the time the systems and CDS would "get better."

Finally, unlike Dr. Hoff who devoted chapters in his book to the patient-centered medical home (PCMH), not one participant in this study mentioned the term. Despite semi-structured questioning with ample opportunities to expound, participants focused primarily on the system as it existed with their clinics' walls.

4.3 CHOICE ARCHITECTURE: NUDGES

Choice architecture is a framework developed by Thaler and Sunstein to operationalize research conducted in the fields of cognitive science and neuroeconomics. The framework is based on a recognition of, and appreciation for, innate cognitive biases that drive human behavior. Thaler, Sunstein, and others argue for leveraging those cognitive biases to promote behaviors and outcomes. This is a different approach than to try and promote certain behaviors by alerting, and therefore interrupting, people to change behavior. The analysis in this paper attempted to identify areas where choice architecture could promote certain clinical choices while minimally interrupting, if at all, a users' thought processes.

Cognitive science and neuroeconomics primarily rests on one foundation: people make decisions based on rewards and disappointments. For decades, research has demonstrated that the brain is hard wired to seek rewards and avoid disappointments. It is, however, not a binary choice between rewards and disappointments; rather, people are motivated by how much reward they receive *and* perceive relative to how much disappointment they receive *and* perceive. Different regions of the human brain use serotonin to generate the feelings of reward after we make a "good" choice and the disappointment we feel after making a "bad" choice.

As explained in the background section, the dual process model explains that the human brain can essentially be broken into two systems: System 1 which is fast, intuitive, and skilled; and System 2 which is slow, deliberate, and is guided by explicit rules. Subjects in this study provided a number of examples that described their cognitive processes as balancing these two cognitive systems while using EHR systems. One participant specifically explained how navigating the EHR and care planning were like two parts of his brain going at the same time. I believe this is a reflection of System 1 and System 2 systems thinking.

Participants gave examples how CDS, particularly alerts, in many cases interrupted the "flow" of the patient visit. They did not appreciate "switching" their brains to address an alert, particularly an unneeded or incorrect alert, while attempting to order medications, update medication lists, or perform a number of other CDS functions in the EHR.

"Choice architects" would frown on the use of alerts to inform physicians'' decisions *unless the use of those alerts are absolutely necessary*. One explanation from cognitive science has to do with the concept of loss aversion. Loss aversion refers to the innate human biological tendency to perceive a loss of something twice as much as a gain. If one is to take an alert as a "loss" (loss of time, loss of a sense of proficiency, loss of power) then it would take two "gains" to bring the physician back to cognitive equilibrium. Unfortunately, CDS in specific and EHRs in general do not provide enough gains to make up for the many losses that CDS forces on users. At the end of the day users feel frustrated. CDS by its very design often times breaks the cardinal rule of user-centered design: never make the user feel stupid.

An important consideration associated with loss aversion is the data gleaned about the users themselves. The community-based physicians included in this study are accomplished, highly skilled, highly trained, self-critical, and want to perform well. These are the "A" students who throughout much of their academic and professional lives succeeded in their endeavors to become doctors (and independent business owners). Loss aversion with this user group just might be more significant factor than typical users.

The benefits of applying a choice architecture framework for this study has been beneficial in that it provides a systematic framework for approaching and understanding ways in which CDS may better promote changes in behavior without interrupting clinical workflow and/or cognitive thoughtflow (my term). A systematic approach provides benefits in that it recognizes that behaviors are not wholly dependent on an information system. It looks at processes and interactions that may take place outside the system and meld the system to support those processes. In this respect, a choice architecture is very unlike the Sim and Berlin taxonomy which isolates context and workflow from the system. A choice architecture instead attempts to integrate all facets into a synthesized whole.

A side benefit of taking a cognitive approach to analyzing primary care practitioners is learning how their workflow may impact decision-making. Background research revealed that decision-making is hampered by stress and low blood sugar. Observations noted how little break time physicians experienced and what little time they had for snack breaks and lunches. It would be interesting to learn more how, and if, decision making was affected by these factors.

Another benefit is to test CDS in ways that cognitive scientists have done. One example would be to run the "endless bowl of soup" test with physicians. One famous cognitive study looked at how much soup people ate when a bowl automatically filled itself (from the bottom up). Results showed that people with bowls of soup that automatically fill at significantly more soup than those whose bowls did not fill. A similar strategy could be applied to templates and other clinical forms to see if the more options doctors have to fill data the more data they collect. If true, it would be an important finding so that CDS design could nudge doctors to provide less, or more, data.

Other CDS evaluations may rely on usability heuristics to inform design. Such an approach can benefit the user who works with an information system one-on-one. The singular human-computer interaction may be addressed but as observations and interviews revealed, CDS and the EHR work within a context that is distributed across many members, requires input and feedback from many inside and outside the clinic, and whose ultimate success often times rests on the person not using the system: the patient. It is for these reasons that a systematic framework such as the choice architecture can be valuable to informatics research.

Participant feedback on the choice architecture presented to them was muted which is perhaps to be expected. Participants were not expected to read pertinent research beforehand or become acquainted with choice architecture prior to being presented the results. It is then perhaps an encouraging sign that no participant returned feedback objecting to the findings and recommendations.

A limitation of the choice architecture approach to date is that nowhere has the framework has not been validated {unclear sentence}. For that matter, although each NUDGES category is rooted in years of research, the categories themselves have neither been validated (or at least that research was not found).

The choice architecture has been a valuable tool for systematically approaching clinical work and looking for ways to improve performance both within and outside of the system.

4.4 PERSONAS

An important product of this study is the personas that convey evidence-based understandings of study participants {more specifically a sample of primary care physicians}. The first benefit of the personas is that they provide a synthesized view of users who bring different viewpoints, opinions, and goals to their work. That information conveys personality and the stories of people who are the end users of CDS. Another benefit of the personas is that they frame users' needs within context of where the users work and with whom they work. Personalizing the data gathered from site visits acquaint those who may not work in clinical settings or meet clinicians, such as software developers, yet are expected to develop decision support and other clinically-related software.

Personas such as what was created in this study could be useful for a variety of purposes. First and foremost they can be used to inform the software development process. Tying together the themes that were elicited in story form can promote greater understanding among developers as to why users do what they do, or, want to do what they cannot currently do. Personas can also promote new avenues of questioning. Rather than focus being placed around a CDS system, any persona-related conversation will be necessarily user-related. Steering the conversations toward the users achieves the goal of considering the users, based on evidence, in software production.

Another benefit to personas is their potential use in policy-making. Just as software developers may not get opportunities to meet the people that ultimately use a product so too do policy makers get opportunities to meet the people affected by regulations and laws. And if policy makers do have such opportunities, then evidence-based personas can provide voice to users not typically sought out by policy makers. Personas could be immediately applied at any number of Regional Extension Centers (RECs) that are being organized to meet the coming needs of physicians and clinics transitioning from paper-based to EHR-based processes.

This leads to a third area where personas can be of value. Personas can be used in educational settings where students who might not have a chance to observe clinics or meet clinicians can learn who clinicians are, gain insight into clinicians' viewpoints, and discover what motivates clinicians. Providing this understanding in the educational setting is critical given the nation's investments in developing an informatics and HIT workforce. Personas are excellent tools for conveying user models to large constituencies of students.

A limitation of the personas from this study has been the little feedback gained from the users themselves, the informatics community, and the software development community. Future qualitative work would entail gathering user feedback to verify the truthfulness and trustworthiness of the personas. It would require learning from users if the personas sound real to them, if the personas remind users of someone they know or even remind them of themselves.[was member checking not applied to the personas? State this explicitly] Quantitative measurements via surveys would further personas' understanding and applicability. Questions to be asked would be to confirm personas' validity (how much benefit is derived) and reliability (how well do the personas convey user characteristics). A potential avenue of research is to conduct a study such as Long conducted (130) to better understand how personas may impact the design of informatics tools.

4.5 IMPLICATIONS FOR MEANINGFUL USE

This study is taking place in the shadow of the Health Information Technology for Economic and Clinical Health Act. Beginning in October 2010 (fiscal year 2011) eligible community-based physicians will be reimbursed for using certified EHRs in their practices. So it will not be enough for physicians to purchase and install EHRs, they must use the EHRs in "meaningful" ways such as capturing patient data and using CDS to influence practice. It is critical that EHR and CDS systems meet user needs for the multi-year, billions of dollars program to be successful. If not successful, improvements in patient care quality and safety are unlikely to result.

Meaningful use standards requires users to use EHR systems to capture data such as patient demographics and vital signs, manage lists such a medication and problem lists, enter orders, and use decision support tools such as drug-drug and drug-allergy "checks." (29) Voluntarily selected meaningful functions include formulary checks, providing care summaries for patients, and tools that find users with specific conditions and send them reminders for follow-up care.

Many of the above functions are in line with functions users from this study say they needed. For example, users wanted CDS drug-drug interaction alerts and checks, and they needed clinical summaries for patients. However, users already had drug-drug interaction checks - it is just that those checks were ineffective in their ability to aid physicians and/or change behavior. Clinical summaries would be beneficial for patients, but participants in this study reported needing clinical summary tools for themselves. The strength of meaningful use is that it provides an industry-wide first step by mandating *what* kinds of CDS need to be incorporated into certified EHRs. Meaningful use does not say, however, *how* to incorporate these tools effectively. What this study found is that *how* these tools are designed (or not designed) has not been sufficiently addressed.

Tools must be developed that address the challenges associated with efficient and effective data entry. It is effective and efficient data entry that improves the quality of data that drives decision support. Information design needs to address poor layouts and data displays that do not reflect clinical thinking. Examples of such design shortfalls include a drug formulary interface that did not list generic drugs in green font, or continually displaying non-panic level lab values thereby increasing the chances of them being ignored.

Furthermore, meaningful use does not address what this study found in terms of tools that support cognitive work as well as procedural or task-based work. When introducing the meaningful use guidelines, Blumenthal and Tavenner noted that CDS produces safer medical care in light of electronic prescriptions and order entry. (240) Typical of the traditional CDS paradigm, decision support is seen as something to be provided in the context of tasks. Cognitive support, however, describes what participants said they needed which was supporting the conceptions of patients and how to meet the needs of the patients. It speaks less to what information can be presented while tasks are being carried out, and more to how the doctor approaches the relationship and the decisions that go into supporting that relationship. Future iterations of meaningful use guidelines would do well to consider elements around the functions that are not only task-based but also cognitively-based.

5. FUTURE RESEARCH

Observations and interviews uncovered a number of areas that may lead to exciting areas of new research. Those areas extend from the cognitive capabilities of the users, to the redesign of work, to the functionalities within CDS in specific and EHRs in general. The suggestions listed below would not be mutually exclusive areas of research.

5.1 TASK CDS: ALERTS AND REMINDERS

This study revealed many limitations of CDS that have been reported in past informatics literature. Study participants felt that CDS tools required improvements in clinical reasoning, accuracy within clinic and patient context, and modes of presentation. Participants described their frustration with CDS technology led them to turn off alerts and reminders. It would be valuable to learn how quickly after initial use that participants had turned off alerts and reminders. Knowing the average amount of time it took before alerts and reminders were disabled could give developers a sense as to how much, or little, time is required to demonstrate value. Researchers would also do well to further understand how CDS alerts and reminders impact not only decision making but also behavior change in community-based settings. As was found in this study, CDS had minimal impact on behavior change.

One potential area of study is to learn about the cognitive impact alerts and reminders have on users. For example, background research in cognitive sciences revealed the concept of “loss aversion” and how humans avert losses because of disappointment. Furthermore, humans not only feel disappointment when something is lost but they feel the disappointment twice as much as when something is gained. Given subjects’ characteristics of being proud, diligent, and at times defensive about their status, it may be reasonable to think these users equated alerts or reminders as losses. If such is the case, then CDS provided few means for the participants to ever reap “gains” to achieve cognitive equilibrium. If one goes by the idea that an alert is a loss to a user’s self-esteem then the system must provide the user with two perceived gains. Participants described few gains from the system. Further investigation should shed light on what alerts and reminders mean to users and how they make users feel.

Another area of research is to better understand why users continue to use the systems if they feel any dissatisfaction with CDS alerts and reminders as well as the systems in general. This research demonstrated general unhappiness with the quality of alerts and reminders yet that did not stop users from using the system. Further investigation into motivations for continuing to use any CDS or the systems could provide informaticians and developers with even greater insight into what users value. Such knowledge could direct design and development toward functions and features that users appreciate and want expanded.

Alternatives to alerts and reminders were few, but those that were given provided considerations for research. One user described his desire to see alerts driven not only by clinical need but also by popular practice. For example, an alert would not only show that a medication like Tryptan may cause serotonin syndrome but also show how other physicians manage the patient and prescription. Having access to information from and about peers can be a powerful motivator and behavioral change agent.

Post-it notes, or rather the appreciation of post-it notes, provided another alternative to alerts or reminders. A physician described that colorful post-it notes in paper charts could spark her curiosity to read those notes, solely based on the motivation that the post-it note "didn't belong." User motivation to look at something that didn't "belong" in the record could be an interesting twist to passive (rather than active) reminders. Additional research could look into ways that the design of reminders most effectively piques the curiosity of users, thereby increasing the likelihood that users will view those reminders.

Few observed alerts and reminders showed ability to change user behavior. Gaining a more substantive view from a user perspective could assist in designs that better engage users and motivate them to utilize CDS to the fullest extent.

5.2 USER MENTAL MODELS

One area of research would be to further investigate user-centered mental models of physicians, staff, and patients. From studying physicians alone, this study revealed a gap between how users think about their work and how the systems support their ability to carry out that work. Two examples will help illustrate this point.

First, subjects expressed frustration that the systems displayed out of range lab values as either within range or without range; and when out of range, text was written in red font. Such data displays were not in line with how participants thought about lab data. Data presentation required greater context such as how a patient's current lab value compared to a previous lab value, and data presentation required design that equates red font with panic values. Participants stated that data were routinely ignored because data in red font were rarely, if ever, panic values. Thus the data display did not reflect participants' mental model of what was considered urgent.

Second, a physician lamented the review of systems (ROS) screen was listed in alphabetical order. She remarked that organizing the ROS alphabetically did not fit with her training and experience which was to go through an ROS in order from head to toe. Designing systems that did not match the user mental models may have placed additional cognitive burden on users thereby impeding chart review and data entry. Participants provided a variety of examples from ROS screens to lab order screens to patient summaries that did not represent the "flow" of clinical care.

The two examples lead to a larger challenge for informaticians; that is, to understand physicians' mental models of patients. Incomplete and/or highly compartmentalized data required participants to use valuable time and "brain power" to piece together a patient's history, current status, and requirements for optimal future treatment. Therefore it would be valuable to have a more complete understanding of how physicians use patient mental models to guide medical practice and how systems can best support the development of physician-specific mental models of patients.

Participants expressed two ways to represent patient models: snapshots and stories. Snapshots and stories were consistently referred to as tools that helped a physician get reacquainted with patients and support physician-patient relationships. Yet participants of different roles described the need for snapshots and stories to contain different information; information that supported the physician-specific work. Informaticians would do well to learn more about how physicians used snapshots and stories prior to using EHRs and to investigate if these tools not only improve physician satisfaction but also improve workflow and clinical decision-making.

5.3 USABILITY

Compartmentalized data display hindered physicians' ability to generate patient mental models and also hindered physicians' ability to navigate the system. Some participants described instances where poor navigation and usability changed decisions around what care processes to provide or not provide.

As previously noted, physicians used terms to describe the kind of system they would like to use:

- Clean
- Linear
- Familiar
- Skim
- Fast
- Flow
- Seamless

Participants uniformly complained that their current systems did not meet their desired qualities which slowed them down. One example is that of a system that relegates three lines (a small portion of screen space) to the text box in which clinic notes are written. Clinic notes are a predominant task in clinical work and so the text box should be much larger. EHR and CDS design should be guided by research that contributes to a body of knowledge around design best practices.

Users also complained that some systems prevented having two windows open simultaneously. Vendors institute this design constraint in the name of patient safety: limiting any ability for users to add data to wrong data fields. The design constraint, however, severely impacted the time physicians needed to piece together data and reports in order to complete charting. Such a design decision should be supported, and communicated, by evidence. The design constraint must be abandoned should evidence be lacking, and should evidence be convincing, then new evidence-based designs must be instituted.

5.4 DATA ENTRY

Observations and interviews revealed that clinical data were predominantly captured manually in EHR workstations located both in and out of patient rooms. Manual data entry slowed down workflow, interrupted physician-patient communication, and provided greater opportunities for error. As the quality of CDS hinges on the quality of its data, informaticians should direct their attention to more effective and efficient means of data entry. A goal that could be set out is to develop systems that support clinical work that is free from typing: a typingless office.

One reason for having a typingless office is to reduce the strain physicians described entering text while conducting patient interviews. Physicians described their concern that their divided attention could lead to missing important patient statements while entering data into the EHR. This resulted in either physicians being unsure about their ability to capture data or to develop workarounds that included writing notes on paper and later adding data to the system. This finding reveals duplication of work and possibility for error that should also be of concern to informaticians developing CDS tools.

Researchers should look to develop new tools and processes that automate data entry such as medical devices that populate EHR data fields and placing additional emphasis on data transfer among EHR systems within and across health systems.

5.5 TEMPLATES AND FLOWSHEETS

Templates and flowsheets may be important means for guiding data entry and patient care as well as standardizing elements of clinical practice. However, some subjects were suspicious of how templates and flowsheets caused them to practice a certain kind of medicine, one driven by those not in the clinic. Research should focus on personal, professional, and organizational changes brought about by templates and flowsheets. Investigations into this area could illuminate how practices change as their providers use and eventually internalize care pathways. There may be conflicts within clinics surrounding template care, such as the case of general internists lamenting templates that force them to adhere to, or work around, family practice and pediatric templates.

Participants as well voiced concern about the amounts of data they felt obligated to provide based on the numbers of data entry fields and checkboxes. I refer to this phenomenon as “checkbox fatigue.” Building on findings from cognitive science, researchers could look into ways that templates and flowsheets may generate such feelings and, if necessary, investigate designs that reduce any such feelings.

5.6 COGNITIVE WORK

Divided attention in community-based practices, as well as generally in clinical environments, may impact clinical decision making. Researchers would do well to look into how the environments in community-based clinics may help or hinder decision making. For example, cognitive science researchers are finding that decision making is helped or hindered depending on the amounts of glucose a brain finds available. (88) Observations noted how physicians take few breaks to eat throughout the day and many relied solely on coffee as their means of sustenance.

The researcher described being tired from observations of clinic work. Also, physicians described working long days and sometimes long nights after a day's work left additional charting. Physicians also worked at night and early in the morning to prepare for patient visits. Informaticians would do well to design CDS and EHR systems with a more complete understanding as to how the demands of community-based care impacts decision-making.

5.7 COLLABORATIONS

Observations and interviews uncovered decision-making that relied on collaborations among physicians and their staff as well as patients. Future research should continue to delve into areas of shared decision-making as it pertains to actors in community-based settings.

Collaborations with patients appeared to focus around "data dialogues" during which patients and physicians talked about or reviewed patient-specific data related to care or treatment. Sometimes data dialogues revolved around the EHR display and at other times they revolved around handwritten data on paper that patients brought with them to visits. Data dialogues provided participants and patients different ways to discuss care and to think frame strategies around future care. Using data as a basis for patient-physician communication could lead to interesting findings as to how best address patient *and physician* objectives within limited 15-20 minute patient visits.

Participants often used EHR displays as communication tools between themselves, patients, and patient families. Participants described a desire to include patients in their own care and that showing data in the EHR was one such way. However, participants were unsure if and how other physicians used the EHR display to involve patients and perhaps build consensus around care plans. Additional research could uncover ways in which data and information display support and supplement clinical care.

Collaboration among staff is an important consideration for future research in community-based CDS. Participants expressed a desire for CDS to drive change in work roles. This strategy provides an interesting approach in understanding ways CDS can be used to support team-based care as opposed to supporting the decisions of a sole physician user. Research should investigate how CDS can help providers practice at the "level of the license."

Observations also included some different ways community-based practices were staffed and so how the systems were being used. Most participants worked in partnership with a nurse or medical assistant and each person was responsible for particular clinical and data gathering activities. Greater understanding of these roles could inform appropriate CDS design that is directed at different users. One observed clinic was in the process of transforming staff into clinic teams that worked in “pods” and included one or two doctors, MA partners, a nurse, a “referral clerk” and a “panel manager” who tracked the care of multiple patients. Informaticians and CDS designers would do well to understand how CDS fits within redesigned roles and responsibilities.

6. LIMITATIONS

The author took a number of actions to address limitations to the study. First, all the data collection and coding were carried out by the researcher which can reduce the trustworthiness of the analysis. Two medical anthropologists were consulted about the grounded theory data and concepts. Each person coded one observation and one interview and then discussed the coding via e-mail or in-person. Coding schemes were compared, contrasted, and debated until all parties agreed that codes represented concepts that participants discussed or were observed doing. In addition to consulting with outside experts, the researcher leveraged the dissertation committee's knowledge and expertise of primary care and clinical decision support. Second, the committee was informed of progress and findings through periodic status reports. Additionally, the committee was consulted during in-person meetings at least once a quarter (every three months), online presentations, phone conversations, and individual meetings. The researcher made audio recordings of in-person and online meetings and generated notes based on committee discussions, critiques, and any concerns that might have arisen. Finally, member checking involved gathered follow-up information from the participants themselves. They were asked to comment on the findings and putative conclusions.{including the personas or not?} Their feedback helped identify the issues of primary concern and gain a sense that the conclusions represented their viewpoints.

The purposive sample strategically recruited participants from different roles, in different health systems, using different EHR/CDS systems. Participants were approached through references from health system liaisons, sometimes termed "shepherds," and through references from study participants themselves. This approach broadened the number of participants and produced a variety of physicians with EHR/CDS experience as well as clinical experience. However, the time commitments that study participants made could have limited the types of users willing to participate: either those that "loved" CDS and/or those that "hated" CDS. Recruiting strategies addressed this limitation by explicitly encouraging users with a variety of opinions about CDS to participate. Referrals were an effective means for becoming acquainted with a variety of users that had not been previously approached by their own health systems. Finding participants not normally approached to discuss CDS was an important indicator that the sample included a wider array of perspectives than may have traditionally been found.

Observations were limited by scope and seasonality. Obstetrician-gynecologists declined to be observed out of concern for their patients' privacy. That the researcher is male was an implicit barrier to observations, and when contacting prospective OB/Gyn participants, specific mention was often made that observations *were not* required. One OB/Gyn clinic allowed observations from two nurses' stations in place of patient room observations. One OB/Gyn clinic allowed the observation to occur from the physician office. This provided opportunities to witness OB/Gyns interacting with the system and CDS. The use of CDS and systems may have also been affected by seasonality. One pediatrician noted that workflow is different, and more demanding, during the winter cold season. Time and resource constraints prevented research to consider differences in CDS use by season; however, the large number of clinics and participants for this type of study lends greater confidence that CDS use and workflow were comparable and that seasonality was not a confounder of any great impact.

7. CONCLUSION

The first question this study set out to answer is, how did community-based physicians conceptualize decision support?

The participants in this study conceptualized clinical decision support as tools that are intended to inform clinical decisions by way of electronically delivered medication safety alerts, health maintenance alerts and prompts, best practice prompts, patient panel management tools, and access to accurate and timely reference materials.{also some type of patient overview or at a glance capability – where does this fit} There was general dissatisfaction with CDS particularly in relation to alerts and their inability to account for levels of severity, at times questionable accuracy of the content, and frustration with how alerts were presented. Participants reported turning off the CDS alerts soon after initial use. Yet subjects still held out hope that future iterations of CDS will help to identify contraindicated medications and promote use of the most efficacious medications on a patient-by-patient basis. {also lack of effective patient summarization views – okay I see this is 'what they need" but not how they currently think of CDS}

Participants desired tools that helped them and their patients achieve care in line with best practices. Yet exactly which best practices to follow remained a largely open question that will need to be addressed. A common preference was that for whatever solution the practices should fit with the way that each physician liked to practice. This desire for individual functionality yet reliance on agreed upon standards of care is not a new issue in informatics yet is still a major barrier in delivering CDS that alters how physicians practice medicine.

Despite the limitations of CDS that were observed and described it is notable that few participants wanted to do away with the system. Most participants exhibited reservation and acceptance of their EHRs, if not the accompanying CDS, mostly because they saw these systems as the inevitable future of health care. The sense gained from these physicians was that it will take some time for the systems to catch up to the way(s) that doctors think about and carry out the practice of medicine.

The second question this study set out to answer is, what do community-based physicians need from clinical decision support?

The participants in this study described needs that went beyond what they considered to be true "clinical decision support" tools. They described wanting tools that align time and resources in ways that allow physicians to focus wider range decision-making and clinical efforts. Such tools can be viewed as supporting ways in which the physician views the patient and patient needs within the context of an enhanced relationship.

Participants described needing tools that they did not consider clinical decision support such as improved usability like patient snapshots or coordinating patient care. Participants felt such tools supported, or would support, clinical practice rather than decision-making. Yet interviewees described the absence tools or ineffectiveness of such tools affected their ultimate clinical decision making. Therefore the boundary is blurred between participants' rote definition of CDS and tools that at the very least tangentially impact clinical decision making.

This study found that a critical factor to consider when developing CDS tools is the environment in which those tools are to be used. Therefore CDS tools must work for users that are under time constraints and rushing to keep up with schedules, move within a workflow that is highly interactive with patients and staff, and is physically demanding. Given this environment participants described needs for tools that support "cognitive" aspects of their work which require high level planning and detailed preparation for patient care. Unlike procedural work which is what dictates billing, cognitive aspects of work take up much time and goes unpaid. The dual nature of clinical work in community-based settings (cognitive and procedural) calls for a form of CDS that is more highly synthesized and accounts for not only what physicians want to do but also how they model patients and health care.

The strategies used for analysis were valuable in that they provided different lenses through which to view CDS. The taxonomy provided a traditional view of CDS which places the system apart from the environment and sets user actions along points through a CDS-based process. The grounded theory analysis provided a users' viewpoint that the system is not central to who they are and what they do but rather is a tool that helps or hinders their efforts to meet higher level goals. The choice architecture took cognitive abilities and limitations into consideration and provided a synthesized CDS view that shifted focus to how CDS fits within the larger environment and how processes can be reconfigured to enhance both decision-making and workflow.

There are contributions this study makes to the field of informatics. It provides biomedical informaticians insight into how and where CDS fit within these community-based practices. The study also lays out how the physicians perceived CDS and describes a gap between what they defined as CDS and how they wanted the system to support decision-making. Within the gap lies fertile ground for research into potentially new areas of clinical decision support such as cognitive support, physician-patient decision making, and using CDS to purposefully shift tasks among staff. The study identifies community-based physicians' attitudes and goals, and that decision-making may be influenced by the perceived quality and value of physician-patient relationships.

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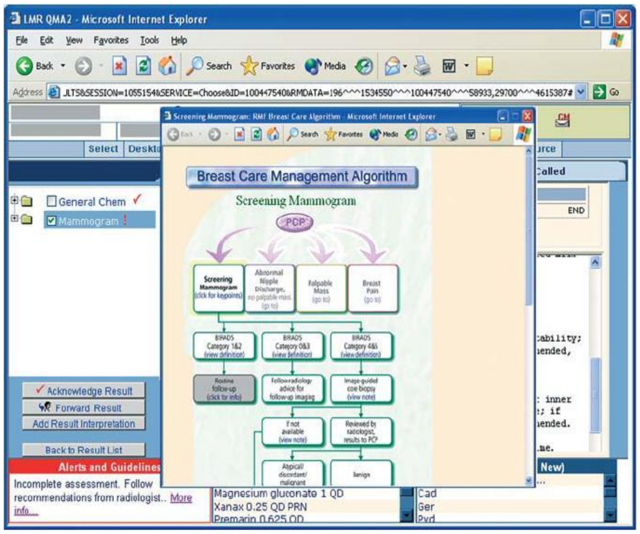
9. APPENDICES

APPENDIX A

An example of LMR care management algorithm. (241)

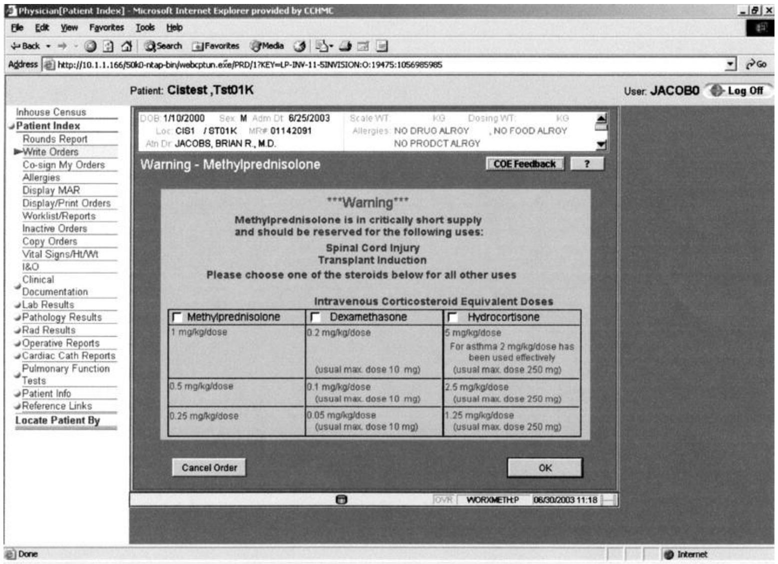


Incomplete assessment. Follow recommendations from radiologist.. More info...

Magnesium gluconate 1 QD
Xanax 0.25 QD PRN
Premarin 0.625 QD

FIGURE 25: LONGITUDINAL MEDICAL RECORD (LMR), PARTNERS HEALTHCARE, BOSTON, MA

An example of Cincinnati Children's Hospital Medical Center's Integrating Clinical Information System (ICIS). (242)



Address: http://10.1.1.166/50k0-ntap-bin/webcptun.exe/PRD/1?KEY=LP-INV-11-5INVISION:O:19475:1056985985

Patient: Cistest ,Tst01K   User: JACOB0

DOB: 1/10/2000 Sex: M Adm Dt: 6/25/2003 Scale WT: KG Dosing WT: KG
Loc: CIS1 / ST01K MR#: 01142091 Allergies: NO DRUG ALRGY , NO FOOD ALRGY
Atn Dr: JACOBS, BRIAN R., M.D. NO PRODCT ALRGY

Warning - Methylprednisolone

Warning

Methylprednisolone is in critically short supply and should be reserved for the following uses:

Spinal Cord Injury
Transplant Induction

Please choose one of the steroids below for all other uses

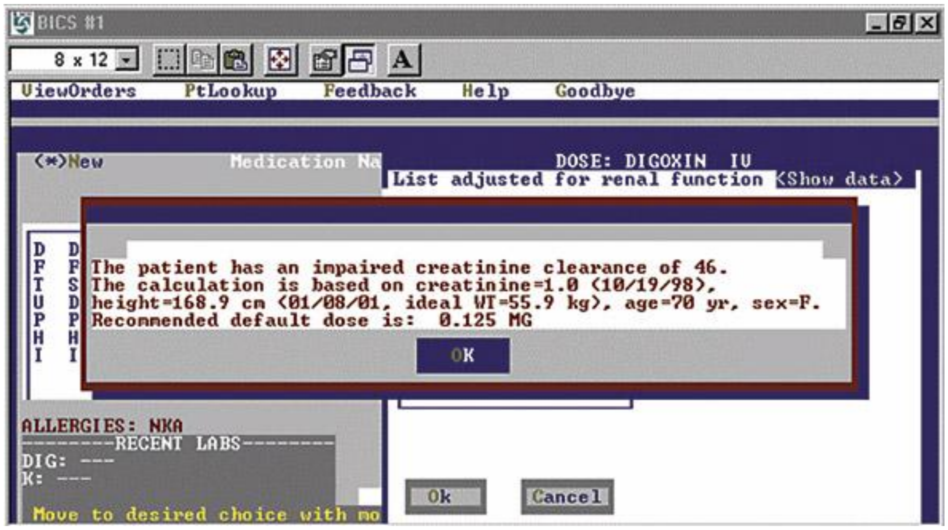
Intravenous Corticosteroid Equivalent Doses

☐ Methylprednisolone	☐ Dexamethasone	☐ Hydrocortisone
1 mg/kg/dose	0.2 mg/kg/dose (usual max. dose 10 mg)	5 mg/kg/dose For asthma 2 mg/kg/dose has been used effectively (usual max. dose 250 mg)
0.5 mg/kg/dose	0.1 mg/kg/dose (usual max. dose 10 mg)	2.5 mg/kg/dose (usual max. dose 250 mg)
0.25 mg/kg/dose	0.05 mg/kg/dose (usual max. dose 10 mg)	1.25 mg/kg/dose (usual max. dose 250 mg)

OVR WORXMETH:P 06/30/2003 11:18

FIGURE 26: ICIS

Example of the BICS system from the Brigham and Women's Hospital, Boston, MA (243)



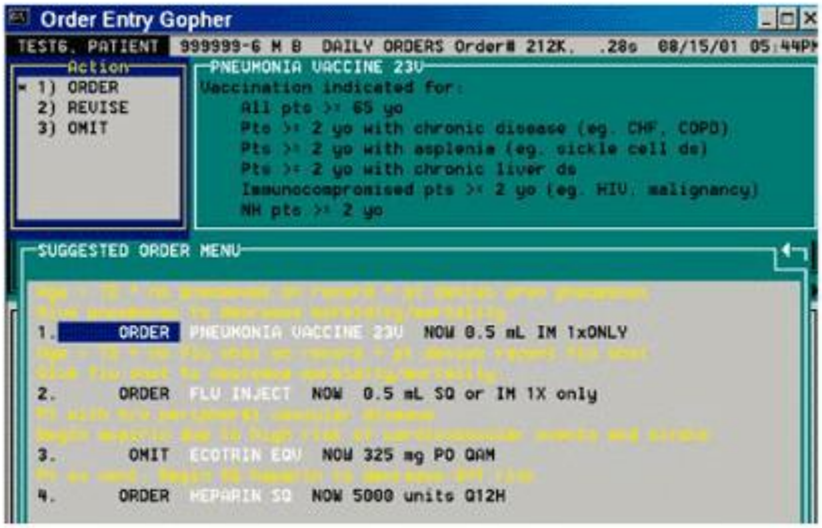
```
DOSE: DIGOXIN  IV
List adjusted for renal function <Show data>

The patient has an impaired creatinine clearance of 46.
The calculation is based on creatinine=1.0 (10/19/98),
height=168.9 cm (01/08/01, ideal WT=55.9 kg), age=70 yr, sex=F.
Recommended default dose is:  0.125 MG

ALLERGIES: NKA
---------RECENT LABS---------
DIG: ---
K: ---
Move to desired choice with mo
```

FIGURE 27: BICS

Example of the GOPHER system developed at the Regenstrief Institute, Indianapolis, IN (244)



```
TEST6, PATIENT  999999-6 M B  DAILY ORDERS Order# 212K.  .28s  08/15/01 05:44PM

PNEUMONIA VACCINE 23V
Vaccination indicated for:
    All pts >= 65 yo
    Pts >= 2 yo with chronic disease (eg. CHF, COPD)
    Pts >= 2 yo with asplenia (eg. sickle cell ds)
    Pts >= 2 yo with chronic liver ds
    Immunocompromised pts >= 2 yo (eg. HIV, malignancy)
    NH pts >= 2 yo

1.      ORDER  PNEUMONIA VACCINE 23V  NOW 0.5 mL IM 1xONLY
2.      ORDER  FLU INJECT  NOW  0.5 mL SQ or IM 1X only
3.       OMIT  ECOTRIN EQV  NOW 325 mg PO QAM
4.      ORDER  HEPARIN SQ  NOW 5000 units Q12H
```

FIGURE 28: GOPHER

APPENDIX B

April 21, 2009

Letter of Recommendation for

Josh came to our clinic 2 weeks ago as part of his research project. He was professional and well-prepared. He also seems to really have the best interest of medical care providers at heart and seeks to help develop computer systems that serve us better.

Josh provided our office with patient information forms to allow patients to understand what he was doing with us. In the exam rooms with patients he was professional and unobtrusive. He interviewed me for about half an hour over my lunch break.

I would strongly recommend that you make your clinic available as a research site for Josh. You can contribute to important work to make more useful computer systems for all of us. Please feel free to contact me or our practice administrator, Francie Karr, if you have further questions.

Sincerely,

[redacted]

Columbia Gorge Family Medicine

[redacted]

May 21, 2010

Letter of Recommendation for Joshua Richardson

Josh came to our clinic 2 weeks ago as part of his research project. He was professional and well-prepared. I introduced him to our team, which included the physician assistant, the medical assistant, the registered nurse, and the patient care coordinator. He was respectful to the team during his time at the clinic, and entertained questions from team members without hesitation.

Josh provided our office with patient information forms (in both English and Spanish) to allow patients to understand what he was doing with us. In the exam rooms with patients he was professional and unobtrusive. He interviewed me for about half an hour over my lunch break. His questions were innovative, and insightful to me. He encouraged me to convey my concerns about EMR. He provided me an opportunity to discuss my ideas on the impact of EMR in the workplace, as well as the potential EMR has to streamline healthcare delivery.

I would strongly recommend that you make your clinic available as a research site for Josh. You can contribute to important work to make more useful computer systems for all of us. Please feel free to contact me or our practice administrator, [redacted], if you have further questions.

Sincerely,

[redacted]

Virginia Garcia Memorial Health Center

Hillsboro, Oregon

[redacted]

[redacted]

Salem Pediatric Clinic
2478 13th Street SE   Salem, OR 97302
[redacted]

[redacted]

RE: JOSHUA RICHARDSON

To Whom It May Concern:

Joshua Richardson observed me in my office while conducting his research project regarding use of electronic medical records. Mr. Richardson conducted himself in a professional manner at all times. He imposed no impediment to my busy flow of patients during the observation time. I would unhesitatingly recommend him to be allowed to shadow you in order for him to collect data for his doctoral research.

Sincerely,

[redacted]

APPENDIX C

A Clinical Decision Support Needs Assessment among Community-based Physicians

OREGON
HEALTH & SCIENCE
UNIVERSITY
Department of Medical Informatics and
Clinical Epidemiology
3181 S.W. Sam Jackson Park Road
M/S BICC
Portland, Oregon 97239-3098
tel: 503 494-4502 | fax: 503 346-6815

Hello,

In Spring 2010 you participated in a study that used interviews and observations to gain insights into “clinical decision support.” All 31 participants from community-based practices around Oregon were offered the chance to review the preliminary results and all participants agreed to do so. For that, I am very grateful.

The study’s purpose is to inform software developers, policy makers, academics, and other community-based physicians how you and the other study participants understand clinical decision support; and what is needed from clinical decision support to better support your work. The attached summary report provides a high-level analysis of my findings.

I want to learn if you find my preliminary results to be truthful interpretations of how you conceptualize clinical decision support as well as how you feel clinical decision support could (or should) support you. Please feel free to share with me any feedback, comments, and/or criticisms you might have. My contact information (email, phone, and fax) is included throughout the summary report.

I would appreciate receiving any and all feedback before **5pm on Friday, August 13th**. Doing so will give me enough time to incorporate your feedback into a final report. I will be happy to share with you the final results, just let me know that you’d like to receive a copy.

Sincerely,

Josh

Joshua E. Richardson, MLIS, MS
National Library of Medicine Fellow
Department of Medical Informatics and Clinical Epidemiology
Oregon Health & Science University

APPENDIX D

Number (% of total)	
365 (69.5)	1 Errors related to the processes of healthcare
112 (21.3)	1.1 Errors in practice and healthcare systems
12 (2.3)	1.1.1 Errors relating to incorrect patient identification
15 (2.9)	1.1.2 Appointments and message handling errors
28 (5.3)	1.1.3 Patient record and filing system errors
25 (4.8)	1.1.4 Recall event and recall systems errors
6 (1.1)	1.1.5 Computer systems errors
6 (1.1)	1.1.6 Errors in the maintenance of a safe physical environment
7 (1.3)	1.1.7 Errors in provision of care after hours or inadequate staff coverage
3 (0.6)	1.1.8 Errors relating to patient confidentiality issues
10 (1.9)	1.1.9 Practice and healthcare systems errors not otherwise specified
65 (12.4)	1.2 Investigation errors
7 (1.3)	1.2.1 Errors relating to incorrect patient identification
12 (2.3)	1.2.2 Errors in the process of requesting investigations
9 (1.7)	1.2.3 Errors in the process of undertaking investigations
35 (6.7)	1.2.4 Errors in reporting processes or managing investigation reports
2 (0.4)	1.2.5 Investigation errors not otherwise specified

Number (% of total)	
107 (20.4)	1.3 Medication errors
31 (5.9)	1.3.1 Electronic prescription writing or medication charting errors
16 (3.1)	1.3.2 Other prescription or medication charting errors
38 (7.2)	1.3.3 Medication dispensing and delivery errors
11 (2.1)	1.3.4 Patient self-administration of medication errors
11 (2.1)	1.3.5 Medication errors not otherwise specified
13 (2.5)	1.4 Treatment errors (non-medication)
11 (2.1)	1.4.1 Errors in the process of providing immunizations
1 (0.2)	1.4.2 Errors in the process of undertaking procedures
1 (0.2)	1.4.3 Non-medication treatment errors not otherwise specified
68 (12.9)	1.5 Communication errors and process errors not otherwise specified
17 (3.2)	1.5.1 Errors in general communication with patients
31 (5.9)	1.5.2 Hospital discharge and other hospital-based communication errors
9 (1.7)	1.5.3 Errors in referral to other healthcare providers
8 (1.5)	1.5.4 Errors in general communication with other healthcare providers
3 (0.6)	1.5.5 Communication and process errors not otherwise specified
160 (30.5)	2 Errors related to the knowledge and skills of health professionals
62 (11.8)	2.1 Errors in diagnosis
2 (0.4)	2.1.1 Errors in patient history taking

Number (% of total)	
11 (2.1)	2.1.2 Errors in patient physical examination
27 (5.1)	2.1.3 Errors in investigations requested or their interpretation
22 (4.2)	2.1.4 Diagnosis-related errors not otherwise specified
98 (18.7)	2.2 Errors in managing patient care
57 (10.9)	2.2.1 Medication management errors
9 (1.7)	2.2.2 Knowledge or skills errors in undertaking immunizations
13 (2.5)	2.2.3 Knowledge or skills errors in undertaking procedures
19 (3.6)	2.2.4 Errors managing care not otherwise specified

TABLE 12: "TAPS TAXONOMY WITH RESULTS OF 525 PATIENT SAFETY EVENTS WITHIN 415 REPORTS" (21)

APPENDIX E

January 13, 2010

Re: Research Review Committee conceptual approval of research study

Dear Colleagues:

Consistent with procedures for Safety Net West (SNW), this letter is to inform you, members of OCHIN SNW clinics, of the Research Review Committee's conceptual support of a research project requesting participation by SNW clinics and physicians. At our December meeting, the SNW Research Review Committee reviewed a proposal submitted by Joshua Richardson, a PhD Candidate in the Medical Informatics program at OHSU and unanimously gave the proposal conceptual support. Members of SNW believe the study has the potential to inform the future development of clinical decision support in electronic medical records (EMR). The project proposes to observe physicians using clinical decision support tools built into the EMR and to interview physicians about their perspectives on these tools to assess their ideas, preferences and attitudes about such tools.

The Committee's support does not in any way obligate any clinic's or provider's participation; it simply indicates that the committee felt the research proposal is consistent with the mission and priorities of OCHIN SNW members. Joshua will be contacting the Medical Directors and clinic management of the organizations directly to determine if your organization might have interest in this study and to provide additional information. We encourage you to consider having the clinics and physician providers participate in the study as it has the potential to inform future decision support development in the OCHIN EMR.

If you have any concerns about SNW's conceptual approval of this study or about the general process of approving and communicating about research studies, please feel free to let us know. This is a new process for us and we are hoping for feedback about how to continuously improve.

Sincerely,

Mark Spofford, PhD	Susan Chauvie, RN, MPA-HA
Acting Director	Chief Clinical Officer
Safety Net West	OCHIN

APPENDIX F

Subject # Example (Clinic, doctor #, xx = 1001xx)

Role

Date

Time Begin Time End

Clinical Decision Support and Choice Architecture: A Needs Assessment of Community-based Physicians

Semi-Structured Interview Questionnaire

Interview Questions

1. Why did you decide to become a [state physician role]
2. In what ways does the current information system support clinical work?
3. Thinking broadly, (or in an "ideal world") how could the INFORMATION system support your work?
4. Thinking broadly, (or in an "ideal world") what problems could the INFORMATION system solve?
5. Thinking broadly, (or in an "ideal world") what things could the INFORMATION system ~~it~~ do to help you perform better?
6. Again thinking broadly, (or in an "ideal world") what OTHER types of decisions could the INFORMATION system help you make?
7. What tradeoffs would have to be made to get the INFORMATION system you want?

Follow-up Questions

1. What would [CDS function X] help you achieve?
2. How would you design [CDS function X]?

APPENDIX F

a. Context
    i. Clinical setting
    ii. Clinical Task
    iii. Unit of Optimization
    iv. Relation to Point of Care
    v. Potential External Barriers to Action
b. Knowledge and data source
    vi. Clinical Knowledge Source
    vii. Data Source
    viii. Data Source Intermediary
    ix. Data coding
    x. Degree of Customization
    xi. Update Mechanism
c. Decision support (reasoning method)
    xii. Reasoning Method
    xiii. Clinical Urgency
    xiv. Recommendation Explicitness
    xv. Logistical Complexity of Recommended Action
    xvi. Response Requirement
d. Information delivery
    xvii. Delivery Format
    xviii. Delivery Mode
    xix. Action Integration
    xx. Delivery Interactivity
    xxi. Explanation Availability
e. Workflow
    xxii. System User
    xxiii. Target Decision Maker
    xxiv. Output Intermediary
    xxv. Degree of Workflow Integration

APPENDIX G

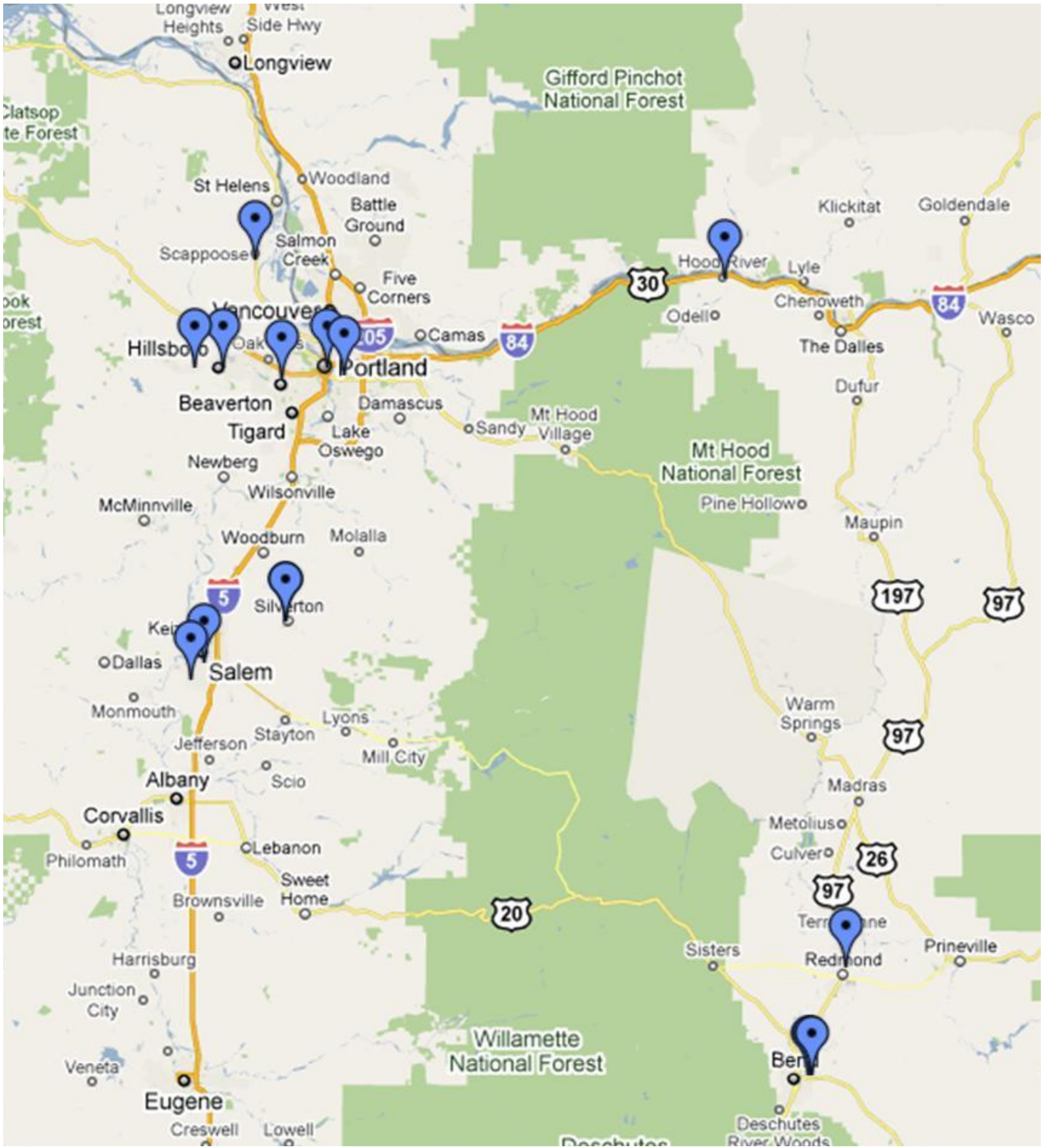


FIGURE 29: MAP OF OREGON CLINICS VISITED. NOTE: THERE ARE 3 CLINICS WITHIN BEND, OREGON AND 2 CLINICS IN SILVERTON, OREGON.

APPENDIX H

	Finding	**Recommendation**	**Example**
INCENTIVES	Doctors feel uninspired by data entry, thereby disincentivizing the most expensive professionals in clinical practice from collecting the data that mostly drives decision support.	Train medical assistants to collect clinical data and direct appropriate CDS to them.	Implement an electronic Coumadin protocol to guide a medical assistant with data collection, i.e. INR values, and notify a physician when a consult is required.
INCENTIVES*	Patients and doctors have conflicting incentives for a patient visit	Provide patients with a priority map prior to consult (online or in waiting room) that prioritizes what the patient wants to discuss and what the doctor wants to discuss	A patient is concerned about a sore elbow whereas CDS informs a physician sees that recent health indicators have trended poorly. The patient and doctor jointly fill out a form that prioritizes discussion topics so they can optimize the fifteen minute visit.
INCENTIVES	Patients and doctors value strong personal relationships	Provide a snapshot page that briefly tells the patient's story so that the physician can quickly reacquaint before entering the patient room	On a busy day the doctor pulls up a snapshot of a patient he hasn’t seen in two years. The patient photo reminds him that this patient was having marriage trouble at one time. He makes a mental note of checking in on the patient’s status and emotional health during the visit.
INCENTIVES	Doctors use the EHR system to communicate and educate patients.	Promote EHR-based best practices for communicating	A patient has struggled to keep her blood pressure in check. The doctor pulls up a run chart that shows trends

	Finding	Recommendation	Example
		and educating.	over time and together they piece together of what, if any, lifestyle changes occur during controlled and uncontrolled circumstances.
INCENTIVES	Payers want physicians to provide services that may be cheaper for someone else to do.	Doctors, payers, and informaticians design tools that support safe, reliable, and cost-effective task shifting.	A consortium of payers, CDS developers, and physicians agree on a plan that certain CDS-assisted practices can be carried out by someone without an MD.
INCENTIVES	Lab results from vendors arrive at different times causing physicians to write one or more patient letters.	Consolidate electronic lab data before sending to a physician unless specified that some data can arrive before other data.	Although a CMP is complete in piecemeal, the results are held until a batch send to the physician can be made.
INCENTIVES	Patients arrive at visits without having provided specimens and its resulting data.	Employ care coordination that involves home specimen collection whenever feasible.	A hypertensive patient will be visiting the doctor for a check-up. The doctor office mails an in-home cholesterol panel test beforehand with instructions to schedule an appointment *after* mailing back the blood sample.
UNDERSTAND MAPPINGS	Provide decision tools that graphically display a patient's current health status and potential health outcome.		A 60 year-old male with a history of CHF presents complaining of edema, yet he is non-compliant on his meds. The doctor displays a graph showing the patient's pitting edema scores of 3 (6mm) and 4 (8mm) and works with him

	Finding	Recommendation	Example
			to set a goal of score 1 (2mm).
UNDERSTAND MAPPINGS	Doctors want to document quickly and accurately	Provide an option to document Review of Systems anatomically (head-to-toe) in addition to alphabetical	A doctor was taught from medical school to do a review of systems from head to toe and document as such. The doctor selects ROS function that changes entries from alphabetical to "anatomical".
UNDERSTAND MAPPINGS	Doctors want to document quickly and accurately	Provide an option to document lab orders by anatomical system in addition to alphabetical	A doctor wants to order a fecal occult (F) and a stool test (S). He has his template organized by system so that he doesn't have to mouse from 'F' to the other end of the alphabet at 'S'.
UNDERSTAND MAPPINGS	When looking at columns of vital sign values the doctor found the O2 value missing. He scrolls far to the right and finds a lone O2 value by itself.	Condense vital sign values onto one screen for easier review.	Whenever possible, save screen real estate by consolidating data into graphical display format. Otherwise, consolidate values onto one screen and/or allow users to move columns.
UNDERSTAND MAPPINGS	Vague labels make it difficult to understand functionalities: not knowing what “Patient Service” means nor what information is associated and uncertainty between “lab letters” and “lab actions”	Provide roll-over messages as to what certain functions mean and/or do.	A physician rolls her mouse of the “lab letters” function and a rollover message states, “For sending lab follow-up patient letters.”
UNDERSTAND	Problem lists are organized in alphabetical order rather than by	Provide an option to organize problem lists by commonality as	The first item on the select list for hypertension is “Hypertension (Benign

	Finding	**Recommendation**	**Example**
MAPPINGS*	what’s most common.	well as alphabetically.	without HF).” The doctor says that a previous doctor would chart with that problem most likely because it was first on the list rather than because it was the most accurate.
UNDERSTAND MAPPINGS	Patients and doctors have conflicting incentives for a patient visit	Provide patients with a priority map prior to consult (online or waiting room) that prioritizes what the patient wants to discuss and what the doctor wants to discuss	A patient is concerned about a sore elbow whereas CDS informs a physician sees that recent health indicators have trended poorly. The patient and doctor jointly fill out a form that prioritizes discussion topics so they can optimize the fifteen minute visit.
DEFAULTS	Routine immunizations, lab orders, and health maintenance checks require doctor approval and selection which slows workflow.	Use default orders, with appropriate caveats, for routine immunizations, labs, and health maintenance checks.	An OB module for an Rh-negative woman automatically orders a RhoGAM at 28 weeks unless a user opts-out.
DEFAULTS	Clinics may soon have to come to terms with choosing among best practices	Post "preferred" guidelines at the top of a selection list	Should a 43 year-old woman get a mammogram? The clinic follows the USPSTF guideline but wants to allow flexibility. It lists different best practices but organizes the lists by clinic preference in descending order.

DEFAULTS	The more boxes on a sheet the more desire people have to fill them out leading to costs and benefits	Limit the number of boxes on any one page to an amount amenable to standards and evidence-based user preferences	A minimum set of boxes are included on a template.
DEFAULTS	The more boxes on a sheet the more desire people have to fill them out leading to costs and benefits	Let individual users or clinics choose the numbers of boxes beyond a standard set	A minimum set of boxes are included on a template with an option to enter more data if desired.
DEFAULTS	A doctor inserts a reminder into a lab order, rather than notes, so that if the lab is normal then it can be quickly forwarded to the MA for patient notification.	Combine messages with normal labs so that doctors can forward “what to do” actions to MAs or other supporting staff	A pap smear lab comes back normal and includes a default message that the patient can be expected for a rescreening in 3 years. The doctor reviews and agrees, forwards the lab/message to her MA who then informs the patient of results AND what action to take.
DEFAULTS	A doctor has to create notes from scratch for each time the same patient visits the office.	Have a patient-specific note that can be altered if required.	A familiar patient presents with chronic hyperlipidemia. The physician sees the condition is prepopulated in the note, decides it doesn’t need altering, and leaves the standard text in the record.

DEFAULTS*	Problem lists are organized in alphabetical order rather than by what's most common.	Provide an option to organize problem lists by commonality as well as alphabetically.	The first item on the select list for hypertension is "Hypertension (Benign without HF)." The doctor says that a previous doctor would chart with that problem most likely because it was first on the list rather than because it was the most accurate.
DEFAULTS	Additional clicks through EHR records asking if a form should be saved are annoying and provide one more opportunity for error.	Implement an auto-save function.	A doctor moves out of the "master document" to the visit notes and the system saves the data and moves to the next screen.
DEFAULTS	A doctor checks "normal" in multiple categories within one template.	Provide a "select all" option.	Review of systems is completely normal so doctor chooses the "select all" option and every box is completed.
GIVE FEEDBACK	Doctors are uncertain how much charting is too much charting.	Provide a feedback mechanism that compares the length of patient notes to an "average length" metric.	A doctor writes out notes and a progress bar fills up in real time. The end of the progress bar represents the average length of notes among a defined group of doctors. A doctor has the ability write more or fewer words than the average.
GIVE FEEDBACK	A doctor wants to gauge a future HbA1c screening by when one was last performed, not when one is theoretically due.	Provide feedback as to when the last screening was performed and the traditional screening date is due.	A diabetic patient comes for a patient visit to address a hurt foot. The doctor is curious when the last check was done, sees that it was 3 months ago, and so decides to order an A1c test.

GIVE FEEDBACK	It is difficult to differentiate newer labs from older labs.	As tests fade into the past the color of the font changes from black to light gray. When a certain time has passed the label disappears, the test is now considered "historical" not "active".	Labs are organized by date in descending order. Furthermore, labs conducted within the last month are written in black font whereas labs from six months ago are listed in gray font.
GIVE FEEDBACK	Interaction alerts and reminders are non-specific, questionable, cluttered, and lack the means for follow-up.	x	x
GIVE FEEDBACK	Health maintenance alerts demonstrate out of range values in red font thereby desensitizing doctors to potential panic values	Reserve red colored font for high priority notifications and panic values	A single A1c value is above normal. The value is shown in purple.
GIVE FEEDBACK	Health maintenance binary alerts (fire/not fire) do not reflect the standard of practice in primary care	Only fire an alert after data has trended a condition specific amount of time and/or readings	Three consecutive A1c values have been above normal. The most current value is shown in red and an alert displays.
GIVE FEEDBACK	Post-it notes in paper charts were low cost/high value reminders because they stood out, were up front, and could be easily discarded if needed	Provide post-it note like objects (with different colors) on a patient's snapshot page	A physician wrote herself a reminder to ask a child about adjusting from a recent family move across town.

GIVE FEEDBACK	"Low level" post-it note reminders get ignored over time	Have post-it notes increase in size on the snapshot page each time a record is opened until the issue is resolved	A physician wanted to remind himself to ask the patient about considering a new anti-depressant worth considering. Written on an e-post-it note months ago, when the chart is opened the note now takes up 1/8th of the screen. If it goes unaddressed, next time the note will take up 1/4th of the screen.
EXPECT ERRORS*	A doctor is asked to develop a patient's controlled substance refill schedule so that it ends on the 20th of every month. The doctor gets a calendar off the wall and attempts to calculate the dates. The process takes over 12 minutes of the visit.	Insert auto-calculating calendars that support a variety of scheduled refill requests.	A patient wants to get med refills on the 20th of every month. The doctor opens a calendar and drags the days included within a prescription. After the days are selected, the system automatically calculates the quantity needed.
EXPECT ERRORS	Pediatric EHR modules do not automate pediatric dose conversion calculators. Recommendation	Auto calculate pediatric dosing, but supply an answer using 'real world' numbers.	A pediatrician orders amoxicillin and the system automatically calculates the dosage to 6.397mg, but additionally rounds to a known dispensed dose of 6.5mg and inserts that value into the dosage field.

EXPECT ERRORS	A pediatrician manually calculates and enters a pediatric dose that is dangerously out of range.	Provide drug specific auto calculator that accounts for the child's age, weight, and dose.	A pediatrician skips the auto calculation feature in the system and attempts to enter her manually calculated Zithromax prescription into the system. However, the calculation is incorrect and is above a safe dosage and so the system disallows the order from going through.
EXPECT ERRORS	A pediatrician has to manually load a premature infant template for the current visit and she had forgotten to do so for the previous visit.	Have the system check that a child's age is in weeks, and if so, auto load a premie template.	A pediatrician is about to see a bat had been born prematurely. The system checks the child's age loads a "premie" template after calculating the infant's age.
EXPECT ERRORS	A pediatrician orders eye drops in 5ml bottles but later receives a call that the drops are only available in 10ml bottles.	Provide a dropdown order list with dosages in available amounts.	A pediatrician orders a prescription of tobramycin eye drops and is provided with a list of possible dosages.
EXPECT ERRORS	A billing form was closed even though known data was missing.	Do not allow a billing form to close if there is missing data.	A physician tries to carry out her E&M coding but prevented from doing so until appropriate data are entered.
EXPECT ERRORS*	A doctor is asked to develop a patient's controlled substance refill schedule so that it ends on the 20th of every month. The doctor gets a calendar off the wall and attempts to calculate the dates. The process takes over 12 minutes of the visit.	Insert auto-calculating calendars that support a variety of scheduled refill requests.	A patient requests a personalized refill schedule and so a doctor uses a calendaring tool that calculates and graphically shows when refills of certain amounts will be eligible.

STRUCTURE COMPLEX CHOICES	A labs order form has 50 labs to choose from making it difficult to find the one lab to order.	Provide different ways to organize lab order options.	A physician wants to order a stool and urine sample. She can organize the list alphabetically or by labs commonly ordered together.
STRUCTURE COMPLEX CHOICES	Clinical data are fragmented throughout the EHR, making it time consuming and frustrating to synthesize the data from which to make a decision.	Provide a synthesized, integrated, and customizable clinical summary that provides users with a patient "snapshot" from which decisions and patient care strategies can be more easily formulated or justified.	A physician is about to see an elderly patient with multiple conditions and polypharmacy. The doctor views one screen with a patient picture, written summary including family information, and a medication log that tracks the course of medications.
STRUCTURE COMPLEX CHOICES	Clinics may soon have to come to terms with choosing among best practices	Provide users, clinics, or entire systems with a suite of guidelines from which to choose	Bundle best practices to health systems who can then roll them out to their clinics.
STRUCTURE COMPLEX CHOICES	Doctors want to face patients during visits to support strong relationships and maximize visual observation of the patient.	Provide materials to doctors adopting EHRs the consequences (and potential costs) of poor workstation placement.	A clinic is going EHR and wonders if it should use workstations or laptops. Evidence-based research details the experiences of other doctors that is sure to include the impact felt when doctors could not face their patients while ordering meds or documenting.

APPENDIX I – FAMILY PRACTITIONER SNAPSHOT

Needed Snapshot Functionalities
Longitudinal
drag n drop Screenings of interest onto a longitudinal strip (shows current period on strip, past and future screenings)
bio, psycho, social, spiritual
Picture
patient and physician created
physician visit-centered view first, then visits to others
family hx, Genograms
Biosketch
Supporting Data
So immunizations, cancer screening, you know, Chlamydia screening in women between 18 and 25, or whatever the age range is, would be really HELPFUL, to either do today or be able to say to someone, ‘Oh, it looks like you need to come back soon, for these other kind of loose ends we need to tie up.’
The doctor had noted to herself to check the labs and so refers to the labs.
Pharmacies fax in refills and the doc is able to approve or disapprove with a checkmark, but he has to search through lots of screens to refamiliarize himself with the patient history before he can enter that simple checkmark.
I mean I would say that’s, that’s a big part in I’d say both the physical and spiritual emotional needs, try to whole person care, is kind of our vision.
if there was ways to quickly track whether or not certain things have been done for that patient. So say I have a diabetic patient and I’m doing their exam, you know. It would be nice if I could a get template which would pull up real quickly and just show me ok, this person is -- their last diabetic eye exam was here, their last whatever was here. They’re due for this, this, this, and this today.
the medication lists and histories to seemingly try to get a feel for what they’ve been seen for in the past. The doctor uses a filter to view only previous PCP visits.
I need to SEE to remind myself what’s going on, what I already KNOW about the person,

to help me sort of, you know, provide continuous care. So as I'm seeing someone back for an issue, to be able to FIND that easily, to have it linked together maybe in a thread that I can sort of FOLLOW
I'm interested in kind of both the biomedical and the mental health aspects of primary care
Before EMRs, Family Physicians routinely used Genograms [sounds like] which is a great tool for charting a family system, and where a patient is in a family system, and what a family medical history would look like. Whether the grandmother had an MI or the mother had breast cancer, it's a great, SIMPLE way to NOTE family, both medical history and sort of relationship history, and in a place to jot down that the grandparents immigrated from RUSSIA during the revolution. So stuff like that, and there's no way to do Genograms in electronic records, that I KNOW of any at this point. And so it's interesting that we LOST that tool
So that's sort of a BROADER idea of decision support, to KNOW that *Mr. Smith's* depression today perhaps is related to SPARKY having DIED, you know, a couple weeks ago. Or something like that. You know, so it's that sort of broader contextual care I think.
I think that is just HELPFUL to KNOW that stuff, and not only because it helps in DECISION-MAKING, around patient CARE, but it helps to create a relationship of TRUST with a patient, knowing things about them.
The doctor is trying to put together a picture of the patient's circumstances: family situation, substances, etc.
That some of the recordkeeping, there's a SUMMARY sheet that HAS a lot of good things, but it's MISSING some very IMPORTANT things. But again, this summary sheet comes up, and I can immediately see their chronic problems. I can see their MEDICATIONS. I can see whether they saw one of the physicians' assistants since they've seen my LAST. And so there's some very USEFUL things there.
I would like this system that I could EASILY look and say: 'Oh, it's time for their mammogram. They haven't had a Physical for this long.
R: I get to know the patients and get to hear what's going on with their lives. Yeah, so I guess more interested in their lives than the actual typical diseases.

APPENDIX J – OB/GYN SNAPSHOT

Needed Snapshot Functionalities
picture
pt presentation
pt primary care doc
contact list of most referred to
biosketch
para/grava
shortened timeline
Supporting Data
The EHR splash screens have patient basic information and a photo in the upper left hand corner. The RN makes a phone call letting a patient know that test results were AOK and plan to be seen next year.
the long term contact but also the -- being able to manage things yourself and not have to send things -- people on to different specialists.
four weeks to every WEEK, and so that the flow sheets that we use are really nice. It's nice if they could use the flow sheets for all use that we're using in there. They're easy to fill out, and they're easy. They're on one SCREEN, you can see 'em.
you start with the basics, history to present illness, and go down and kind of hit the KEY things
a quick admission note or something like that. So their age, gravidy, parity, kind of their surgery history, their OB history, ALLERGIES, medicines, just kind of real basic summaries. You know, that you could then add to that what's going on currently.
Her medicines, her allergies, the surgeries, what their last visit was, and just an easy ACCESS to their HISTORY. And in general, I guess, you know, again, I think if the future it's gonna save SPACE.

APPENDIX K – GENERAL INTERNIST SNAPSHOT

Needed Snapshot Functionalities
picture gallery
message(s) from MA
a medication flow sheet of any KIND that is USEFUL. In terms of SEEING, over time
what their body needs, what they tolerate, what our history has been.
seeing the BIG HISTORY of what you did WHEN, WHY, at what POINT, what the PROBLEMS were
one-check sign offs
it allows you to filter down but it doesn't allow you to build up.
Supporting Data
I WANT up on MY dashboard might be totally different than what my nurse practitioner wants up on HER dashboard
Also, just for what it's worth, you noted that Internists tend to see OLDER patients and so maybe it's a little bit different than from your clinic than a family practice clinic where your patients have a little more TIME to SPEND.
I chose this field because I'm deathly afraid of getting BORED. And it just can't really happen in Internal Medicine unless, I mean, there's so many different things to know. There's so many MORE things to learn every day of the week, every week of the year, there's more to learn.
THIS particular software, is I cannot look back in a medication flow sheet of any KIND that is USEFUL. In terms of SEEING, over time, 'Oh, I tried Lovastatin, and we ended it here because of a rash, and then we tried Simvastatin.' There's NO WAY in ECW for me to have a medication OVERVIEW without having to click open each individual drug and see dates. And that's a HUGE DOWNSIDE in terms of information management, side effects, drug interactions, etc.
we already had good SYSTEMS before the electronic record in our paper chart for keeping track of all the healthcare maintenance, on a simple, brightly colored single PAGE.
A very quick OVERVIEW of medication history that helps me SAFELY prescribe future medications. Not repeat past MISTAKES. Really fine-tune my prescribing pattern for

THIS patient to what their body needs, what they tolerate, what our history has been. Let’s say, depression. You now, people don’t remember all the drugs they’ve ever TRIED, but if I have that quick overview SHEET, I have a quick . . . or blood pressure medicine. Really, when we’re talking about CHRONIC disease management, seeing the BIG HISTORY of what you did WHEN, WHY, at what POINT, what the PROBLEMS were, is very USEFUL. And the TIME frame. ‘Cuz then, it’s much easier. That way I can correlate with, ‘What did the labs do? ‘ It used to be much easier to just look across my big SHEET and say, ‘Well, what were the lab results on that date, that changed my behavior here, with respect to this prescribing?’ So, for ME it’s EASE. It’s the eloquence of prescribing. It’s safety. And it is what I remember, too, about my EXPERIENCE with that PATIENT at that TIME. And that’s hard to capture in THIS, the same WAY, but you know, it’s one piece of paper in a CHART. That should be easy to replicate [laughs] in that system.
Yeah, it’s one sheet and you know, if a patient was with us, and had lots of meds for a while, but you can, you know, see where you CHANGED doses, very easily, what the DATE was. Cross reference back to the chart. Allergies noted down here. Was ready and itchy, you know. But I mean, it’s just quickly, at this point in time what were they taking? Were there drug interactions? THIS is not MINE. I just got one.
Quick comparison. And then you’ve signed paper forms and everything. OK. So let’s say we pull up somebody’s current medications. So say I wanna know HISTORICALLY what they were doing. This is the interface I get to instead of THIS. So right now it’s by DATE. So I can click that. Well, no meds were prescribed. Oh, refilled Clonasopam, but I don’t have any idea what the other meds were if I go by dates.
R: No. I can do drugs by NAME. And then I can click each one, so I can see there’s the history of THIS. And then if you click that, there’s the history of THAT and that. But I cannot SEE an overview.
I: So it allows you to filter down but it doesn’t allow you to build up.
There is not a good way to get a nice flow sheet for me. So that’s a hindrance.
A page like THAT. I want a page like that. The other thing that this doesn’t have, but I would really like it, is a way to TRACK how many . . . when refills were given for narcotics. So we don’t have a good way in our current system to keep track of narcotic refills. And that is an issue.
He dislikes the EHR templates for IM because it doesn’t fit his work. For example, the IM template contains data fields for head circumference and abdominal girth. Those are pediatric measures not used in IM.
I WANT up on MY dashboard might be totally different than what my nurse practitioner or our nurse practitioner wants up on HER dashboard.

APPENDIX L – PEDIATRICIAN SNAPSHOT

Needed Snapshot Functionalities
Parent names
I check on every patient, and I compare how today's weight compares to previous weight
Before seeing the next patient the doctor goes over the well check chart
Pets, favorite colors, religion, etc.
immunization graphic
physician-centered bold assessments
Supporting Data
a good part of my workday is just personal interaction with the families and the kids. Talking with the kids, remembering things ABOUT them, what they LIKE
Medications STOPPED? Perhaps three years ago? Not useful
I use the computer to refer back to what's happened previously for the patient. You know,
especially weight, I check on every patient, and I compare how today's weight compares to previous
weight in this line of health or illness. I use the growth chart constantly to see if a child is growing
appropriately. So it's great data store for me to reflect back on whether the patient might be in danger
today or not in danger or chronically or acutely ill.
Well, for the parts that are easy to ACCESS, like seeing what the medication history is, seeing what the lab history is, and seeing what the weight and dose history is, I feel GREAT.
ear, nose and throat doctor, I'd like it to come and dovetail in chronologically with my record, so that I can see, 'Oh, I saw her four times for an ear infection, and the next visit is the ear, nose, and throat doctor's visit.'
I have some data already about how she's growing, and then we're gonna show mom the

growth chart [pause] So that's a HELPFUL thing
I think it needs to be very . . . quick and easy to scan through. Like, you need to be able to . . . open up and see a large amount of HISTORY. You need to be able to see a medication history, a lab history, and a problem list history, quickly and easily. And it would be GREAT if it didn't require a lot of human effort to create that history because charts, like for example, on this chart summary page? Come on computer. Where I can see, scroll back and see why did they come in? You know, like if it says there's 15 visits for cough. That tells you something different than one visit for cough in their whole 15 years. Or see the fifth cough is somehow really important to the family versus the kid who comes in for cough every five days. Well, that's probably a case of his asthma's not well treated, or overanxious parents. So then this, where is this?
Before seeing the next patient the doctor goes over the well check chart, looks at the growth and weight charts and sees if the vaccines are current. She flips through various screens.
a good part of my workday is just personal interaction with the families and the kids. Talking with the kids, remembering things ABOUT them, what they LIKE, what activities they're doing.
What I find when I print out a NextGen master item document, is I may have three pages of what I think is really JUNK. ALL of the immunizations, ALL of the tasks, they're just so much data INCLUDED in a report that isn't HELPFUL to me at that moment. I get those reports from OTHER clinics. I can't make heads or tails of it. I don't have TIME to look through four pages. I'm gonna skip straight to the assessment and plan, and that better be CLEAR to me because I don't have time to look at the rest. So they could make the notes more CONCISE, and again, more like what I WOULD HAVE generated if I WERE dictating. I would feel like the notes would be more useful to me or to people looking at my notes, trying to get a story or a sense of the child.
I think the Information System could support me MORE if it were able to HIGHLIGHT my assessments, and you know, put those in BOLD so that they're always handy for me.
having all that excess DETAILING, yeah, they've got things like medications in the past that have been STOPPED. Medications added TODAY, medications CHANGED today, GREAT. Medications STOPPED? Perhaps three years ago? Not useful. Just clutters up my notes.

Title	Intervention	Result	Sig.<.05
A comparison of the effects of computer and manual reminders on compliance with a mental health clinical practice guideline	The CaseWalker generated reminders to screen patients for mood disorder, presented and scored the DSM-IV criteria for MDD, and created a progress notes based on answers given to questions derived from the guideline	The CaseWalker, compared with the paper checklist, resulted in a higher screening rate for mood disorder (86.5 vs. 61 percent, P = 0.008) and a higher rate of complete documentation of DSM-IV criteria (100 vs. 5.6 percent, P < 0.001).	Y
Controlled multicenter study on the effect of computer assistance in intensive insulin therapy of type 1 diabetics	presented a computer system which algorithm, as described by the authors, used the Skyler algorithms. However, it used additionally a linear dose calculation and variable maximal value	The HbA(1) values fell in the MSI group by 3.7+/-3.7% and in the CAMIT group significantly by 15.6+/-2.2% (P<0.05). Consequently, the computer-assisted intensive insulin therapy resulted in an improved metabolic control.	Y
A controlled trial of three referral methods for patients with third molars	Thirty two primary care dental practitioners (GDPs) were randomly allocated one of three referral strategies: current practice (control strategy); a neural network embedded within a computer program and a paper-based clinical algorithm.	The referral decisions made by the GDPs in the control group displayed greater accuracy and sensitivity but poorer specificity (0.83; 0.97; 0.22) compared with the neural network (0.67; 0.56; 0.79) and clinical algorithm (0.73; 0.56; 0.93).	N
Assessment of decision support for blood test ordering in primary care. a randomized trial	Decision support based on guidelines is more effective in changing blood test–ordering behavior than is decision support based on initially displaying a limited number of tests	General practitioners who used BloodLink-Guideline requested 20% fewer tests on average than did practitioners who used BloodLink-Restricted (mean [+/-SD], 5.5 +/- 0.9 tests vs. 6.9 +/- 1.6 tests, respectively; P = 0.003, Mann-Whitney test).	Y
Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized	all reminders pertaining to that patient were automatically presented in bold letters. Each reminder consisted of a notification that the SOC applied to the patient	Measuring compliance as the proportion of patients in compliance with all applicable SOC by their last visit during the study period, the reminder group had statistically significantly higher rates of compliance than the control group for all standards combined (58.8% vs 53.5%; odds ratio [OR], 1.24; 95% confidence interval [CI], 1.08-1.42; P =.002) and	Y

Title	Intervention	Result	Sig.<.05
Reminders Improving residents' compliance with standards of ambulatory care: results from the VA Cooperative Study on Computerized Reminders (cont.)		for 5 of the 13 standards examined individually. Measuring compliance as the proportion of all visits for which care was indicated in which residents provided proper care, the reminder group also had statistically significantly higher rates of compliance than the control group for all standards combined (17.9% vs 12.2%; OR, 1.57; 95% CI, 1.45-1.71; P<.001) and for 9 of the 13 standards examined individually.	
A computerized decision support system for ovarian stimulation by gonadotropins	We created software to help clinicians in monitoring ovarian stimulation and to provide a tool for evaluation of efficiency and complications.	In the retrospective study, computer-generated decisions were compared with clinicians' decisions in 118 stimulated cycles in 53 patients. In 90% of cases, the choice of FSH regimens and adjustments to dosages were identical. In the prospective study, the computer-generated decisions achieved a pregnancy rate per cycle of 18% (15 of 82 cycles), compared with 16% (13 of 82 cycles) achieved by clinicians.	Y