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Physician Satisfaction and Usability of Clinical Decision Support Tools in an Academic Medical Center’s Electronic Patient Record

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PHYSICIAN SATISFACTION AND USABILITY OF CLINICAL DECISION SUPPORT TOOLS IN AN ACADEMIC MEDICAL CENTER'S ELECTRONIC PATIENT RECORD

BY

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Despite the available research on the benefits, capabilities, and implementation barriers and challenges of electronic Clinical Decision Support (CDS) tools physicians are still reluctant to utilize them. There are multiple studies that demonstrate limited buy-in and overall disinclination to use them however few studies evaluate physician satisfaction with CDS tools and the usability factors that may be associated with increasing satisfaction. The Questionnaire for User Interaction Satisfaction (QUIS) was disseminated to all P4 Residents and P4 Physician Hospitalists who routinely use the academic medical center's electronic medical record (EMR). Overall user satisfaction was most correlated with the Layout/Screen Design and System Learning usability factors. It was unexpectedly not associated with Capabilities. The development of these tools should consider and encourage practices that invite analysts and physicians to collaborate on the principles and standards to guide design. Studies that focus on human-computer interactions can assist with the development of meaningful design strategies that will increase physician satisfaction resulting in increased physician usage of available CDS tools. Since CDS tools are often implemented to assist physicians with effective decision making to improve patient outcomes, ongoing efforts are needed to foster any long term successes of CDS tools.

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Chapter 1: Introduction

Background and Need

Successful Clinical Decision Support (CDS) tool implementation and utilization in an Electronic Medical Record (EMR) requires that form meets function and physicians report a high level of satisfaction. Much research has been done related to CDS tools with a focus on critical challenges and barriers to their implementation (Bates, et al., 2003). Additionally, there are multiple studies that have explored in detail the capabilities of CDS tools as well as benefits and advantages of unlocking the potential of CDS tools (Garg, et al., 2005; Wells, Ashton & Jackson, 2005; Sim, et al., 2001; Handler, et al., 2004; Sittig, et al., 2008). Drug interaction checking, patient-specific reminders such as recording new diagnoses, evidence-based guideline links and early warning systems are just a few of the myriad decision support tools available to providers. Medication error prevention, increased guideline adherence, and earlier notification of changes in patient status are some of the proven patient safety measures, outcomes benefits and advantages that come with increasing the use of these tools.

Early evaluations of EMRs focus mainly on overall system satisfaction after a paper to electronic record conversion (Fairley, et al., 2013; Noblin, et al., 2013; Kochevar, et al., 2011; Al-Mujaini et al., 2011). Few satisfaction evaluations of the individual components within a mature EMR exist. In terms of physician satisfaction with CDS tools specifically, there is a paucity of research available. There is a systematic review by Bright, et al., (2012) which does indicate that less than 50% of clinicians use available CDS. Unfortunately this review did not get to the heart of the contributing factors related to the level of physician satisfaction with available CDS tools in an EMR nor does it offer methods to raise that level. Given our current understanding of the problem more research into physicians' satisfaction with these tools and how that level of satisfaction can be raised is needed. Further research is still needed to promote its widespread use.

Problem Statement

Integrated, assistive decision-making platforms are technological tools designed to help providers and end users access and synthesize information available in Electronic Patient Records. Chief among these integrated and assistive means are Clinical Decision Support (CDS) tools. Built-in programs, application overlays, vendor provided external links, drug dosing alerts, disease specific algorithms and service specific reminders are just a few of the numerous decision support tools that are available to provide end-users with the potential to connect regulatory initiatives with patient data, enhance compliance with evidence-based guidelines, increase organizational reimbursement and improve patient safety. However, if the physicians are not satisfied with how these tools function, collect data, or the timing of their activation then their level of satisfaction and utilization of available tools will likely remain low. Provider feedback in a qualitative study of electronic CDS (eCDS) tools by Kortteisto, et al., 2012 indicated that perceived usefulness resulted in professionals using the eCDS guidance while perceived non-helpfulness lead to non-use. Common physician concerns with the eCDS usability included; complexity of text and terminology, time requirements of reviewing patient reminders, low thresholds that trigger frequent alerts, and the volume of alerts which often leads physicians to go past them.

CDS tools vary in their levels of form and function in an EMR. They occur as simple reminders, rule-based alerts, calculations, information retrieval mechanisms and external knowledge resources typically found as internet based content. These tools play a key role in adding value to an organization by improving patient safety, increasing compliance with growing regulatory measures and securing full market basket reimbursements.

Study Site

The study site is a 603 bed academic medical center located in the northeastern United States. It is the only tertiary care center as well as the regional trauma center within that particular region. It is home to multiple Centers of Excellence and Programs of Distinction including Stroke and Heart Failure and is opening a new Medical and Research Translation building which will be devoted to imaging, neurosciences and cancer care. The medical center has also recently acquired two local hospitals as it expands its healthcare delivery system. Each of these hospitals will eventually transition to Cerner solutions which is the study site's main EPR vendor.

Currently, our academic center uses various disparate request processes however the most frequently used method involves the use of an online HelpDesk where providers and end users request EMR changes and enhancements. In reviewing the requests there is anecdotal evidence that existing order plans, care sets, and clinical workflows do not provide enough guidance to meet the growing organizational needs. Expanded CMS requirements, state disease registry participation, advanced certification designations, quality improvement initiatives, patient safety and improved outcomes, Department of

Health and Joint Commission corrections are many of the organizational needs that are exerting greater pressure on organizational performance and its financial bottom line. Providers can barely keep up with what is asked of them internally thus driving the desire for greater integration and utilization of CDS tools. Given our current understanding of the problem more research into physicians' satisfaction with these tools and how that level of satisfaction can be raised is needed. Further research is still needed to promote its widespread use.

Identifying the methods needed to raise the level of physician satisfaction with CDS tools and make them more usable in the institution will assist them in meeting the organizational needs.

Research Questions

The central question of this study is, "What is the physician's overall level of satisfaction regarding the CDS tools available to them?" Additional questions to be answered are "Which basic attributes or usability factors can predict satisfaction of the physicians?" and "Is there a correlation between usability factors and overall physician satisfaction?" The purpose of this study is to investigate physicians' overall level of satisfaction with the current CDS tools available to them in the institution's EMR, specifically the pop-up alerts and determine which specific attributes or usability factors can predict physician satisfaction. For this study, attributes and usability factors are interchangeable terms. The analysis will address the following hypothesis: Individual interface or usability factors are contributory to overall physician satisfaction levels of clinical decision support tools.

This study will use the Questionnaire for User Interaction Satisfaction (QUIS) 7.0 to answer the research questions. The QUIS is a well validated questionnaire developed by researchers in the Human/Computer Interaction Lab at the University of Maryland. Researchers used Cronbach's alpha as the measure of reliability across multiple interfaces for each item. Early versions of the questionnaire had overall Cronbach's in the range of .89 - .94 with inter-item alpha values varying between .002 - .006. Later, modified versions had a low variability of Cronbach's reliability values that indicated a high degree of stability (Chin, Diehl, & Norman, 1988). The tool was designed to assess overall subjective satisfaction along with specific aspects of the human/computer interface. Its design allows it to be constructed according to the needs of each interface/usability analysis by including only the measures of interest to the user. The questionnaire is arranged in a hierarchical format and contains the following: 1. Demographic Questionnaire 2. Six scales that measure overall reaction ratings of the system 3. Four measures of specific interface factors: screen factors, terminology and system feedback, learning factors, system capabilities and 4. Optional sections to evaluate specific components of the system: technical manuals and on-line help, on-line tutorials, multimedia, Internet access and software installation (Harper, Slaughter, & Norman, 1998). This study will utilize the demographics portion, the overall measure of satisfaction and measures of user satisfaction in four specific interface aspects (Tool Layout/Design, Terminology and System Information, Clinical Decision Support Tool Capabilities and Learning). Each area will provide a measurement of overall satisfaction for that facet of the interface as well each individual factor that makes up the facet. Scoring for each is based on a 9 point scale. To determine the physicians' overall satisfaction the average score of overall user reactions will be combined to offer a general measure of satisfaction.

Population

Data obtained through the Lights On Network®, a cloud-based analytical product of the Cerner Corporation's health solutions, revealed that the total number of resident physicians enter an average of 1.05 million electronic orders monthly into the EMR while the Attending physicians, with the exception of the institution's Hospitalists, as a whole average about half of that. As such, residents and Hospitalists are more likely to encounter the alerts within the EMR system during their ordering conversation. Additionally, of the total number of applicable discern alerts, the range of overrides reported was 90.4% - 92.6%. This range does not drill down into the override reasons.

Participants who will be asked to respond to the survey will be a convenience sample selected from all of the current EMR positions identified as P4 Resident which includes residents from all services who are in their first, second, third, fourth or fifth post graduate year (PGY). Additionally, those identified as P4 Hospitalists will be included as they are Attending physicians who enter their own orders. These groups of ordering providers generally enter more electronic orders than the residents and Attendings in service specialties. Further, they have more direct, hands on practice with patients which lends itself to having a more thorough understanding of workflow within the EMR system. They also tend to be more up to date with changing regulatory requirements, are assigned to participate in the development of service orders and are often involved with the development of Department of Health and Joint Commission corrections. These corrections are often the result of an error or near miss and residents are frequently tasked with developing these, which are often in the form of CDS tools. Although Attending physicians within service specialties such as Orthopedics, Vascular Surgery or Neurosurgery do enter electronic orders, they will be excluded from the study based on their lower rate of order entry which limits their exposure to the varied alerts. Additionally, they are not involved with the development of CDS tools as often.

Chapter 2: Literature Review

This review of the literature summarizes what is currently known about CDS systems and tools, EMR satisfaction and the methods used to determine satisfaction. This review focuses on the research on; the challenges and barriers to CDS implementation within the EMR, CDS tool design and capabilities in the EMR, physician satisfaction with an EMR and survey instruments. The review reveals the need for further research related to CDS tool usability and user satisfaction specific to CDS tools and the means to increase user satisfaction of these tools among physicians.

Research on Barriers and Challenges to Implementation of CDS

The benefits of CDS tools to high quality care and patient safety cannot be realized when health care providers do not accept or utilize the available tools. A recent report from the organization's Chief Information Officer stated that 97% of all alerts in the EMR system are overridden. This override percentage aligns with a systematic review by Moxey, et al., 2010 that revealed that up to 96% of the EMR alerts were being overridden or ignored by physicians. This particular systematic review reflects the trend in the CDS literature that focuses solely on single intervention studies as it specifically looked at medication interaction alerts. Most of these studies, however, leave room for further investigation by exploring the attitudes and perceptions of CDS tools overall.

Still, further studies indicated that wider adoption of CDS has been hindered by; a lack of widely available standards for representing data, poor integration of CDS into clinical workflow, a limited understanding of organizational issues relate to CDS and poor provider support for CDS workflow in EMR systems (Middleford, 2009). Given the available research, it appears that emphasis on quantifying dissatisfaction as a stand-alone barrier in the literature is lacking and therefore difficult to ascertain the immediate consequences of user dissatisfaction. In fact much of its reporting is often anecdotal or is defined as an overall measure of whether or not implementation of a CDS tool had a positive impact on areas such as quality of care or medical decision making and not specifically usability.

Health care professionals have cited the following as major barriers to implementing or utilizing CDS tools; frequent or false alarms, poor interface usability, time pressures and inadequate training (Kortteisto, Komulainen, Makela, Kunnamo, & Kaila, 2012). Additionally, provider workload, applicability of a CDS tool, use of hybrid charts, alert sensitivity and specificity, and quality of alerts were also cited as major barriers to implementation (Patterson, et al., 2005; Coleman, et al., 2013). However, Santucci, et al., 2016 does report that a lack of customization for ICU medication alerts led to dissatisfaction with CDS and infrequent use of some of the beneficial features. Again, these studies fail to distinguish dissatisfaction as a specific impediment to CDS tool use and tend to report it as a side-effect of implementation. Interestingly, Apkon, et al., 2005, describes the evaluation of a Congress mandated single CDS coupler introduced into the Department of Defense's new health information network. Although their study provided no strong evidence to support the utilization of the coupler they do purposely survey providers to assess their satisfaction with the couplers. Physicians, nurse practitioners and physician's assistants overall, when asked specifically about satisfaction, felt that the coupler took up too much time (83%), which is consistent with other literature, however they do not correlate the results to the usability of the intervention since the providers knew they would be the group designated to using the coupler.

Conversely, much of the literature emphasizes the following as essential to successful implementation and adoption of CDS tools; compatibility with applications, system maturity, upgrade availability, and integration of the right information to the right person, in the right intervention format and at the right time of the workflow while other studies assert that usability and satisfaction with the CDS tool are critical (Garg, et al., 2005; Coleman, et al., 2013, Press, et al., 2015). A study that focused on improving guideline adherence using CDS tools identified timely and complete data entry, data storage and workflow processes as additional prerequisites to successful implementation or use of CDS tools (Panzarasa, et al., 2007).

Research has also identified critical challenges to unlocking the full potential of CDS tools and systems. Sittig, et al., 2008 have placed these challenges into three large categories and are as follows; 1. Improving the effectiveness of CDS interventions through improved human-computer interfaces using appropriate summarization, prioritization and filtering to drive clinical decisions 2. Create new CDS interventions through content development and implementation and data mining and 3. Disseminate best practices in CDS designs, implementation, architecture and Internet based repositories.

Usability testing prior to implementation can be a means to address poor adoption rates of CDS tool and improve satisfaction. A lack of usability testing prior to intervention implementation can result in misidentifying barriers, a failure to recognize areas of improvement or poor integration, all of which affect end user satisfaction. Much of the literature review related to implementation success, barriers and challenges suggest approaches which require the end users to come together in a concentrated effort to; offer a wide range of perspectives, create an opportunity for all stakeholders to collaborate and explore the potential of CDS tools and resolve usability issues which can lead to dissatisfaction. They also recommend further work with human factors that influence responsiveness to system enhancements (Greenes, 2011; Moxey, et al., 2010).

Research on CDS Design and Capabilities

Studies have defined Clinical Decision Support as any information added by a system is logically filtered or generated through algorithms and presented at appropriate times. Its role is to assist the clinician's decision-making process to foster; better health processes and outcomes, increased compliance with guidelines, improved individual patient care and enhance population health (Handler, et al., 2004; Sittig, et al., 2008; Byrne, et al., 2011). CDS tools for use in or with an EMR system have been available for decades and their effects are well documented. Typically, CDS tools and systems include; classic alerts, reminders and calculations that can prompt and guide a provider toward specific actions, information retrieval tools designed to assist in the search of context-specific knowledge and external knowledge resources typically found in the form of internet based content (i.e. UpToDate). Coupling CDS with EMR data combines a powerful means to synthesize and translate information immediately into individualized, evidence-based recommendations that inform health care decisions at the patient's point of care (Bright, et al., 2012; Garg, et al, 2005; Handler, et al, 2004; Sittig, et al, 2008; Wells, Ashton & Jackson, 2005).

CDS tools are designed to provide clinicians with additional decision-making material. Studies have identified the following design components as necessary for effective CDS; speed, needs anticipation, real-time delivery, workflow “fit”, usability, simplicity, evaluation and feedback. Additionally, use of appropriate visual representation of clinical data, controlled terminology, CDS interventions matched to clinical goals and timing of advice have been cited as important design principles (Bright et al., 2012; Bates, et al, 2000; Horsky, et al., 2012). The capability for these tools to retrieve and compile data from the EMR is already in place in many health care institutions. Horsky, et al., (2012) suggest that institutional developers abide by common design approaches derived from human-computer interaction research in addition to proven usability principles used in other domains of the EMR.

Carefully built tools can; connect regulatory initiatives with patient data that affects organizational reimbursement, enhance compliance with evidence-based guidelines, improve patient safety and health outcomes and guide practice based research (Sim, et al., 2001). Bates, et al., (2003) believe that decision support via information systems, primarily the EMR, offers health care providers with the tools necessary to achieve large gains in performance and narrow the gap between research knowledge and actual practice. Researchers at the Mayo Clinic’s Employee and Community Health practice implemented a web-based CDS system designed to remind practitioners of the need for a recommended one-time dose of the herpes zoster vaccine among eligible patients. Of their two primary care practices, one saw a 58.3% increase in the rate of herpes zoster vaccination and the other practice saw a 42.5% increase (Chaudhry, et al., 2013). Additional studies have associated CDS tools with early improvement of antimicrobial prescribing practices for acute respiratory infections and pneumonia (Buising et al., 2008;

Litvin, et al., 2012) and higher rates of venous thromboembolism prophylaxis and reduced thrombotic events in hospitalized patients (Mitchell, Collen, Petteys & Holley, 2011). Further, Bright, et al., 2012, supports the use of CDS tools as a means to prevent adverse events. Detecting critical lab values and identifying potentially inappropriate or incompatible drug therapies were reported as highly valued capabilities of CDS tools in an EMR.

Research on EMR and Clinical Decision Support Tool Satisfaction

Early efforts to evaluate EMR systems often focused on gaining physician buy-in, increasing adoption and end-user acceptance (Sittig, Kuperman & Fiskio, 1999). Moreover, studies specifically centering on end-user satisfaction frequently concentrated on; provider perceptions during early implementation phases of EMRs, conversion to computerized provider order entry (CPOE) or paper to electronic conversions and often involved smaller, individual practices. Few of these studies looked at mature EMR systems (Al-Azmi, Al-Enezi & Chowdhury, 2009; Kochevar, et al., 2011; Noblin, et al., 2013; Makam, et al., 2014).

A great deal of research has been dedicated to analyzing the effects of implementing CDS systems, tools, and interventions on provider performance, guideline adherence and patient outcomes (Vogel, 2014) without much emphasis on satisfaction. But there are studies specific to CDS systems and tools which have regularly cited cost, increased time consumption, training and screen layout as indicators of satisfaction (Garg, et al., 2005). An early study of a CDS system designed to embed clinical guidelines related to adult lower back pain, fever in children and occupational exposure to blood/body fluids revealed that satisfaction also depends on the purpose of the alerts and the population it is designed to serve. Further, the authors reported that physicians were more satisfied with alerts and reminders related to more rare chief complaints that required additional technical knowledge (Mikulich, Ching, Liu, Steinfeldt & Schriger, 2001). This suggests that fewer, more targeted interventions increase satisfaction. A more recent satisfaction study of a CDS system in a family physician practice in Belgium reported that physicians were more likely to be dissatisfied with the system when they were very busy and had no time to read the alerts and reminders. More importantly, however, were the quantity of the reminders and their doubts regarding their correctness (Heselmans, et al., 2012).

Few studies on overall satisfaction of CDS tools in mature EMRs exist. Most available literature relates to satisfaction in primary care practices or in targeted services or is elicited as a side effect in response to single intervention CDS tool implementation (Bauer, et al., 2002; Gill, et al., 2011). Knowing how to utilize health information technology (HIT) and CDS depends on understanding clinicians' patterns of decision-making, as well as the components which affect overall satisfaction of the tools they use (Fiks, 2011; Fox, et al., 2010).

Design principles, implementation challenges, barriers and strategies as well as effects on patient safety, patient outcomes and medical error prevention are well documented (Horsky, et al., 2012; Bates, et al, 2003; Garg, et al., 2005; Handler, et al., 2004). In addition to the barriers and complexities of implementing CDS tools and despite the growing emphasis on these tools and systems to improve care and reduce cost, the evidence that supports widespread use is relatively limited. It is important to note that in Bright, et al, less than 50% of clinicians used the available CDS indicating further research is still needed in order to promote its widespread use (2012).

Research on Use of QUIS Satisfaction Tool

End-user computing satisfaction (EUCS) constructs have been studied for decades and have recognized that because the use of a decision support system is often involuntary, perceptual measures of satisfaction are the critical factors to use. And, as far back as 1986, researchers were calling for more experimental research on factors which influence the success of end-user computing as well as evaluating systems based on its degree of use in decision making (Doll & Torkzadeh, 1988; Horton & Thompson, 2005).

Studies that specifically used the QUIS for overall physician satisfaction and usability of CDS tools in a mature EMR were difficult to find. Much of the research on the use of survey instruments to evaluate satisfaction and usability reveals multiple studies related to the development and validity testing of self-administered satisfaction survey instruments, utilization of home grown surveys or the use of hybrids of existing reliable and valid questionnaires (Mertz, et al., 2015; Boyer, et al., 2011; Foraker, et al., 2015). In an early study, Sittig, et al., used the QUIS to measure user interaction satisfaction with an EMR but only during routine clinical use (1999).

Russ, et al., examined the human factors responsible for improving usability in CDS tools using the Computer System Usability Questionnaire (CSUQ). Similar to the QUIS, the CSUQ also captures satisfaction with usability factors, but their research focused only on medication alerts in a simulation study limited to three standardized, constructed patient scenarios in a mock EMR system (2014). Although the CSUQ also uses subscales it does not offer the same level of satisfaction specificity as the QUIS in that the QUIS measures a user's overall satisfaction with each usability facet as well as the factors that make up that facet.

Interface design and usability testing is a critical component to the human-computer interaction experience. Formal evaluation studies can provide important information that can assist with increasing usability as well as enhance the end-user's knowledge and understanding of interface design. Therefore measuring and understanding users' reactions to CDS tools is exceedingly valuable to those responsible for their design, build and implementation (Horton & Thompson, 2005).

It is well known that successful implementation and utilization of CDS often hinges on provider buy-in (Feblowitz, et al., 2014), and while some research equates high acceptance rates with high use rates and user satisfaction, subjective user satisfaction is a critical measure of the success or failure of a CDS system or tool. But there are still studies that raise questions about the true success of CDS relative to satisfaction. For example, systems or CDS tools have been evaluated favorably on performance measures only, however they may not be used if the user is dissatisfied. And, despite the myriad modalities currently employed in electronic records, physician satisfaction related to these tools is not well known.

This review of literature reveals that more research related to overall provider satisfaction with CDS tools is needed in order to determine what providers' perceived needs and expectations are. Further, to assist and facilitate the design of usable interactive systems according to usability engineering principles, usability evaluation plays a fundamental role in a human-centered design process (Granic, 2008). Consequently, more investigation into the application of human factor principles and the interactions between users and CDS is necessary to understanding how to increase overall end-user satisfaction of CDS tools.

Chapter 3: Methodology

CDS systems and tools are able to add value to an organization by improving patient safety, increasing compliance with guidelines and regulatory measures and assuring quality of care. Evaluation of end-user interaction and satisfaction with the current CDS tools can allow for the key stakeholders to have greater input into their design and implementation that should ensure the final product meets their expectations. This study intends to understand the factors affecting physicians' satisfaction and usability of the tools and identify which of the usability factors predict satisfaction.

It is also the intent of this study to benefit the organization's newly developing health system when developing and implementing any CDS tools by providing sound methods to raise satisfaction levels among physicians, and build more accessible and usable tools. It will also assist clinical analysts responsible for building tools, alerts and reminders to understand and meet the needs of the end-user better. It is expected that overall physician satisfaction levels will be higher when the interface or usability factors are rated higher.

CDS Tools and Alerts

Currently built into the institution's EMR is a combination of standard vendor alerts, known as Discern or Multum alerts and homegrown, institutional alerts. Standard vendor alerts are frequently specific to drug-drug interaction checking, drug under/over dosing, therapeutic duplication and duplicate order alerts. They may also be related to CMS requirements or bundles to assist providers in early diagnosis. Typically, vendor based alerts are built into the system with default layouts and varying functionality. All vendor alerts provide action buttons for the ordering providers to modify or cancel orders, disagree with a recommendation or provide a reason for override.

In-house clinical analysts frequently build institutional alerts often with service representatives who may or may not be the actual end-users. They are typically built in response to a sentinel event, to increase compliance with core measures and clinical guidelines or to prevent incomplete ordering. These alerts may or may not have an associated action button to direct providers to the next step and are often easy to override without any reason. Currently in the system are vendor based drug interaction checking mechanisms, duplicate order checking, and regulatory alerts related to CMS core measures to name a few. Some CDS tools that are institution specific include re-evaluation of urinary catheter necessity, methadone dosing, dosing for heparin protocols, Palliative care goals and treatments and C-difficile testing.

Nearly all of the alerts operate within a defined threshold. When these parameters, limits or filters are met the alert will pop up on the screen for the provider. When they appear is often defined by the rule that is firing it. Some appear immediately when a provider opens a chart while others fire when a specified event occurs often in varying parts of the clinical workflow.

Study Design

This research will use a cross-sectional design to study a subset of the resident physician and hospitalist population in an Academic Medical Center to answer the following research questions of interest; "What is the physician's overall level of satisfaction regarding the CDS tools available to them?", "Which basic attributes or usability factors can predict satisfaction of the physicians?" and "Is there a correlation between usability factors and overall physician satisfaction?" It will utilize a well-validated questionnaire, the QUIS, as the instrument to ask questions of and collect the data from the study participants.

Sample

Resident physicians, designated by a P4 Resident position in the EMR, from all services who are currently in post-graduate years 1-5, and who are currently practicing in the medical center were included as study participants. Attending physicians, designated by the P4 Provider Hospitalist position, were also included. The ordering volume subjects these particular Residents and Hospitalists to being exposed to at least twice the number of alerts during the ordering process where Resident physicians enter an average of over 1.05 million electronic orders per month into the EMR while Attending physicians only average around half of that number per month. There are currently 638 Residents and Hospitalists listed as active in the organization's EMR and are included in service specific email designated as School of Medicine (SOM) or University Hospital (UH) groups. SOM All Residents and Fellows and UH Hospitalists will be the groups included as recipients of the survey. Attending physicians who are not Hospitalists will be excluded due to their limited exposure to the electronic alerts in the EMR.

Data Collection

Prior to the survey being sent to the subjects permission will be sought from the Vice Dean of Graduate Medical Education as well as the Chief of Hospital Medicine. An email from the Chief Medical Information Officer (CMIO) was be sent out to the email groups and contained a brief description of the survey's purpose and why they were asked to take part in it. The email then invites the subject to participate in taking the survey which can be accessed by an anonymous link found within the body of the email. The link leads the participants to an electronic Qualtrics survey containing the QUIS questions. Qualtrics is a hosted survey and research tool that our University campus has subscribed to in order to collect and analyze data. The data collection span lasted from 02/19/2019 to 03/12/2019. The time frame was expanded to another week from the original 2 week timeline to allow for in-process surveys be complete. In order to maximize response rate an initial invitation email was sent followed by an additional email one week later where both contain an active and direct link to the survey. Anonymous results were returned to the investigator by logging into Qualtrics and accessing the final survey data. The results are stored in a password protected PC in a locked office.

Instrument. A standardized, general user evaluation instrument for interactive computer systems, the QUIS was created in the University of Maryland's Human Computer Interaction Laboratory to measure user reactions and subjective satisfaction with specific aspects of the human-computer interface. The questionnaire was first developed in 1988 using a psychological test construction. The reliability of the QUIS is high. Cronbach's alpha was used as the measure of reliability across multiple interfaces for each item. Early versions of the questionnaire had overall Cronbach's in the range of .89 - .94 with inter-item alpha values varying between .002 - .006. Later versions were modified with a low variability of Cronbach's reliability values that indicated a high degree of stability. Generalizability was established by having differing user populations evaluate different systems under different experimental conditions (Chin, Diehl, & Norman, 1988). Although the study does not specifically state that the user populations were resident physicians, it does indicate that they were regular PC users who were also professionals and hobbyists who were familiar with the products/software they were evaluating.

The questionnaire captures the overall subjective reaction of a user to a computer system and is diagnostic of its strengths and weaknesses. The QUIS is available as a short or long form. A student license to utilize the QUIS 7.0 long form for this study was obtained (Table 1). The questionnaire is arranged in a hierarchical format that contains the following:

1. Demographic questionnaire
2. Overall User Reaction: Utilizes six scales that measure overall reaction ratings of the system (only 4 are used for this study)
3. Four sections/measures of specific interface factors:
    1. Layout and screen design
    2. Terminology and System Information
    3. Decision Support Tool Capabilities
    4. Learning
4. Optional sections to evaluate technical manuals/on-line help, tutorials, multimedia, internet access and software installation

The questionnaire contains minor modifications to some of the wording of the questions in order to be more specific to Clinical Decision Support Tools in this study. Each item has a main component question followed by four to six related sub-component questions and uses a nine point Likert scale with positive descriptors that anchor the right end and negative descriptors anchoring the left. Users will rate each question on a Likert scale of 1 (the lowest rating) to 9 (the highest rating). The responses are as interval measurements. A "not applicable" option is also available as well as a space for raters to add comments. The optional sections are not utilized for this study. For satisfaction, the first four overall reaction items were aggregated to form the composite satisfaction score. For each usability factor, the sub-scale items were aggregated to form a total composite score for each category. Table 1 displays the section and text of each question. Prior to administration, the survey was piloted for functionality and clarity by three experts in the field.

Table 1. QUIS Survey Questions

Demographics	***Possible Response***
Age:	
Gender:	Male/Female
Role:	Resident PGY 1 Resident PGY 2 Resident PGY 3 Resident PGY 4 Resident PGY 5 Hospitalist
Have you participated in any aspect of the EMR development?	Yes/No. If yes, describe
Specialty:	Medicine Pediatrics Psychiatry
System Experience	
How long have you worked on this system?	Less than 6 months 6 months- less than 1 yr 1 year to less than 2 years 2 yrs to less than 3 years 3 years or more
On average, how much time do you spend per week on this system?	Less than 1 hr 1 to less than 4 hrs 4 to less than 10 hrs over 10 hrs
Of the following, check those that you have personally used and are familiar with:	personal computer laptop touch screen tablet/notebook database software voice recognition internet
Overall User Reactions:	***Scale 1-9***
Overall Reaction to Alerts and Pop-Ups	Terrible -Wonderful
Overall Reaction to ease of use	Difficult -Easy
Overall reaction to satisfaction	Frustrating - Satisfying

Overall reaction to flexibility	Rigid -Flexible
Alerts provided by the system have a warning effect	Never-Always
Automated alerts/popups slow down my care of the patient	Never-Always
Alerts/pop ups save me time by providing me with clear clinical decision making guidance	Never-Always
Decision support can be integrated into the system to enhance my clinical decision making	Strongly Disagree-Strongly Agree
Decision Support Tool Layout/Screen Design	***Scale 1-9***
Screen Layouts are helpful	Never-Always
Layout has adequate amount of information displayed on the screen	Inadequate-Adequate
Arrangement of the alert	Illogical-Logical
Sequence of alert screens	Confusing-Clear
The next screen in a sequence is predictable	Unpredictable-Predictable
Going back to previous screen	Impossible-easy
Terminology and System Information	***Scale 1-9***
Use of terminology found in alerts/pop-ups relates well to task	Never-Always
Computer terminology is used	Too frequently-Appropriately
Terminology on the screen	Ambiguous-Precise
Alerts/Pop-ups which appear on screen	Confusing-Clear
Instructions for actions/commands	Confusing-Clear
Clinical Decision Support Tool Capabilities	***Scale 1-9***
Correcting mistakes from an alert	Difficult-Easy
Ability to undo operations	Inadequate-Adequate
Ease of operation depends on your level of experience	Never-Always
You can navigate through alert knowing only a few commands	With Difficulty-Easily
You can use an alert's features	With Difficulty-Easily
Learning	***Scale 1-9***
Navigating through an alert/pop-up can be performed in a straightforward manner	Never-Always
Number of steps per alert	Too many-Just right
Steps to complete an alert/pop-up follow a logical sequence	Never-Always
Feedback on addressing an alert/pop-up	Unclear-Clear

Data Analysis

Response rates were calculated, analyzed and reported. Descriptive statistics will be used to examine data was obtained from the background characteristics; Age, Gender, Role, Specialty, length of time working on system, average amount of time spent per week on system and familiarization with systems/products. Data from the returned surveys in Qualtrics was exported using the formatting for upload into SPSS. Analysis was conducted in SPSS.

Cronbach’s alpha was examined and reported to confirm inter-item reliability to determine whether the predictor variables are associated with the outcome variable, the covariance was measured. The means and standard deviations from each predictor variable were calculated and compared to the results of the overall user reaction. The covariance was standardized into a correlation coefficient. Spearman’s correlation coefficient was used to identify whether the predictor variables are positively or negatively correlated to the outcome variable. This value assists in hypothesis testing by identifying whether or not the correlation is different from zero or no relationship through the application of the t-test in SPSS.

Next, a multiple regression analysis was performed in order to predict the relationship between satisfaction and the individual usability components of screen layout/design, terminology and system information, CDS tool capabilities and learning. The R square is evaluated to determine the measure of the correlation between the multiple predictor variables (Layout, Terminology, Capabilities and Learning) and the outcome variable. It indicates the proportion of the variance in the criterion variable which is accounted for by our model essentially measuring the how good a prediction of satisfaction can be made by knowing the predictor variables. The adjusted R square will also be reported as it accounts for the number of variables in the model and the number of participants to give a more useful measure of the success of the model.

Limitations:

Limitations to this study may be related to the use of a survey. Response rate and the timing of the study (new residents start in July) are critical to obtaining enough data and could provide misleading information. Further, survey question answers could lead to unclear data when options are interpreted differently by respondents. However, these limitations are mitigated by utilizing a well-validated survey instrument. Data errors can also occur due to non-responses as the number of respondents who choose to participate in the survey may be different from those who choose not to respond, consequently introducing bias. Another limitation is that the data collected from the survey is representative of how things are at a specific period of time. Residents change services frequently which may affect the number of alerts they are exposed to at any given time. Finally, this study utilizes a convenience sample from one institution. Results may not be generalizable.

Chapter 4: Results

Of the 638 Residents and Hospitalists, 103 (16%) responded to the survey. Table 1 outlines the demographics of the participants. The average age of the respondents was 31.5 years with males (59.2%) weighing in slightly more than females (40.8%). PGY-2 and PGY-3 represented more than half of the participants (Table 2). Most of the participants had 2 yrs or more experience with the Cerner system and were heavy users (Over 10 hours/week) (Table 3). Few respondents (8.8%) have participated in some EMR development.

Table 1: Demographic Characteristics

	N(%)
Age (mean)	31.5
Sex	
Female	42 (40.8%)
Male	61 (59.2%)

Table 2: Respondent Experience Level

	N(%)
Role	
PGY-1	15 (14.7%)
PGY-2	27(26.5%)
PGY-3	29(28.4%)
PGY-4	6(5.9%)
PGY-5	11(10.8%)
Hospitalist	14(13.7%)
Specialty	
Anesthesia	4 (3.9%)
Cardiology	1(.98%)
Dermatology	1(.98%)

Emergency Medicine	11(10.8%)
Endocrine	1(.98%)
Gastroenterology	1(.98%)
General Surgery	1(.98%)
Medicine	40(39.2%)
Neurology	2(1.9%)
OBGYN	6(5.9%)
Otolaryngology	1(.98%)
Pathology	2(1.9%)
Pediatric Infect Disease	1(.98%)
Pediatrics	15(14.7%)
Psychiatry	4(3.9%)
Pulmonary Critical Care	2(1.9%)
Surgery	4(3.9%)
Urology	5(4.9%)

Table 3 EMR Experience

	N(%)
Length of time working with the Cerner system	
<6 months	0
6 months – Less than 1 yr	12(11.9%)
1 yr - Less than 2 yrs	25(24.7%)
2 yrs – Less than 3 yrs	20(19.8%)
3 yrs or more	44(43.6%)
Average time spent per week on the Cerner system	
< 1 hour	0
1-Less than 4 hours	1 (1%)
4 -Less than 10 hours	4(4%)
Over 10 hours	96(95%)
Participated in EMR development	9 (8.8%)
No	93 (91.2%)
Yes	9 (8.8%)

Table 4 Technology Use

	N(%)
Personal computer	97 (94.2%)

Lap top	98 (95%)
Touch screen	80 (77.7%
Tablet/Notebook	77 (74.8%)
Database software	31 (30%)
Voice recognition	55 (53.4%)
Internet	95 (92.2%)

A Cronbach's alpha was obtained to confirm inter-item reliability. The analysis revealed the following; Satisfaction subscale consisted of 4 items (α = .87), Layout subscale consisted of 6 items (α= .91), Terminology subscale consisted of 5 items (α = .88), Capabilities subscale consisted of 5 items (α = .86), Learning subscale consisted of 4 items (α = .91). Given these values are higher than the .7 thresholds, reliability of the questionnaire is confirmed.

Table 5 illustrates the average response for overall EMR satisfaction and the four categories of usability. The average satisfaction rating was 4.1, indicating that overall, users tended toward either neutrality or dissatisfaction. The highest scoring usability category was Terminology (5.7), intimating that clarity, instructions or commands and how well the wording related to the task were valued overall by the end users. The lowest scoring usability category was Learning (4.5) suggesting that end users think that navigating through the steps of an alert is not as easy as it could be.

Table 5: Average rating of usability categories

	N	Minimum	Maximum	Mean	Std. Deviation
Satisfaction	99	1.00	8.25	4.0918	1.84948
Layout	88	1.00	8.00	4.7958	1.69555
Terminology	90	1.00	8.67	5.7152	1.56187
Capabilities	89	1.00	8.00	5.1365	1.75893
Learning	88	1.00	8.50	4.5341	1.89472

The results of Spearman's rho shows that there is a significant positive relationship between all four usability categories and overall satisfaction as follows: Layout $r(86) = .67$, $p < .01$, Terminology $r(88) = .47$, $p < .01$, Capabilities $r(87) = .54$, $p < .01$ and Learning $r(86) = .71$, $p < .01$.

Multiple regression analysis was used to test if the four usability factors significantly predicted participants' overall satisfaction with CDS tools (Table 6). The results of the model indicated the four predictors explained almost 55% of the variance. A significant relationship was found for both Layout and Learning. Where Layout are significantly and positively related satisfaction ($\beta = .39$ t (2.51), $p < .05$) as well as Learning ($\beta = .49$, t (3.72) $p < .01$).

Table 6: Regression Results- Usability Predictors of EMR Satisfaction

Variable	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
Layout	.439	.175	.390	2.202	.014
Terminology	-.001	.162	-.001	-.005	.996
Capabilities	-.126	.147	-.113	-.857	.394
Learning	.492	.132	.485	3.721	.000

Feedback obtained from the physicians at the end of the survey calls out some of the many reasons for low satisfaction by offering the following: "*Pop ups are frequent. They are irreversible. Often a cycle of alerts will need to be addressed multiple times when one small detail is altered. Less is more*", "*they need to be smarter",* and "*There are too many alerts in general, which definitely leads to alert fatigue. There are some which are really stupid, like the one that warns you that the patient you are ordering warfarin for has an elevated INR when it's in the target range. Also, the inability to cancel/reorder CBC w/ diff is aggravating. In general, when an automatic alert that makes you* *change/add a new order to a set, the sequence is frustrating because you then have to sign everything again, and when the computer has alerts about medication dosages, you have to click through every single one again, which gets tedious when doing an admission with a large volume of orders."*

Chapter 5: Discussion

Clinical Decision Support should offer the end users tools that make it possible to accomplish greater decision making power, improve performance, decrease the divide between knowledge and clinical practice and improve safety. Appropriate design strategies can improve satisfaction and assist with the development of more meaningful tools which assist in achieving those goals (Bates, et al., 2003, Horsky, et al., 2012).

The QUIS was used to evaluate Resident and Hospitalist satisfaction and associated usability factors with existing CDS tools, primarily pop-up alerts. The objective was to ascertain which usability factors (Layout, Terminology, Capabilities, Learning) correlate with and can predict user satisfaction. The outcomes of the study suggest that despite overall satisfaction being low, as a whole each of these factors contribute to the overall satisfaction levels of the end users. This is important as it supports Horsky's (2012) notion that greater advances can be gained by focusing on both human factors and user-centered design. It is also significant in that our organization has few common standards for the overall design and development of CDS tools.

Additionally, this study showed that we can predict satisfaction based on Layout and Learning however predictive strength may be limited by the low survey response rate. What the results further suggest are that efforts to address each usability factor during the design of pop-ups and alerts should be carefully considered. Bate's *Ten Commandments for Effective Clinical Decision Support* (2003) reiterates the need for CDS tools to be fast, fit into the provider’s workflow, have the capability to anticipate latent needs and use an easy screen design/flow. Simplicity and recoverability were also essential in that providers only want additional information when really necessary and prefer to change direction rather than be stopped. This is corroborated by the physician feedback on the QUIS. This type of feedback is highly valuable in that the utilization of any CDS tools doesn’t matter if the physician believes the alert actions either slow them down or have little effect on patient safety.

The findings of this study support the assertion that the usability factors of Layout, Terminology, Capabilities and Learning ultimately affect physician satisfaction with CDS tools and careful consideration of each of these factors during their design can play an important role in improving the overall effective utilization of them. Considering these can be seen as a promising solution to a standardized, systematic approach to their development and a means by which satisfaction with their use can be improved.

Limitations:

This quantitative study of physicians using CDS tools in a mature EMR in an Academic Medical Center should be interpreted with certain limitations. As with any study using end user reaction surveys, subjective responses rely on the respondent’s own understanding of CDS tools, what may be important only to them, and their most current feelings on those alerts they are exposed to most often. Not all respondents answered every question and despite missing values being accounted for dissatisfaction may be overestimated because only the most frustrated physicians opted to participate and survey question answers may have led to unclear data when the options are interpreted differently. For example some of our residents practice in two separate facilities that are technically part of the same system. Both of them use Cerner however one of them uses Soarian which currently doesn't support the CDS tools used in Millenium. There are also limitations to how the results can be generalized. This study utilizes a convenience sample from one institution. Given a response rate of 16%, it may be difficult to generalize to other Academic Medical Centers. However, the results are nonetheless important in knowing which human-computer interface design characteristics influence satisfaction. Sittig, et al., 2008 confirms that "a robust, reliable, evidence-based CDS value model is needed particularly for intrusive CDS interventions" (p.389).

Despite these limitations and the lack of studies on physician satisfaction with CDS tools in mature EMRs this study still has some important implications for improving physician satisfaction with these tools and applying usability factors in their design and development. The results suggest that concentrating on these factors as a basic building block may be responsible for improving satisfaction, which in turn results in better utilization and less overriding.

Future Research:

Further research that dives deeper into the survey sub-scale items may offer even more insight into which item specifically could increase overall satisfaction and how. It can also direct IT analysts and physicians on how to collaborate on the development of standards and policies surround the design and build of CDS tools so that form meets function. Physicians are not the only providers who can benefit from CDS tools. Registered nurses are also subject to the utilization of CDS where an alert can cross over between disciplines. Steps to include this discipline in a similar study may help to close the gap between critical information sharing and workflow. Turning the focus towards

CDS as a clinical decision aid and away from administrative enforcement may help improve satisfaction as well. Finally, identifying and leveraging alternative passive alerts as a means to direct providers towards patient information and processes that are not critical could lend itself to limiting the number of alerts that are intrusive and informational only. Implementing SmartZone may assist in this. SmartZone is a Cerner decision support tool designed to provide this type of information using a non-disruptive approach. It allows the providers to view patient specific items and take action on them if needed.

Conclusions:

CDS tools should be clear, actionable, facilitate desired behaviors and fit well into the clinical work flow in order to work optimally. This study confirms that if the providers aren't satisfied, they will continue to discount their value and override them whenever they can. The following feedback confirms this, "*pop up alerts are in general technology from the 1990s and we should be creating better tools to contextualize clinical decision making to the task at hand. Popups largely do the opposite of this."* However, given that all four usability factors had a positive correlation with satisfaction levels and Layout and Learning specifically were predictive of satisfaction, careful consideration should be given to the inclusion of these usability factors during the design and build of CDS tools. If we want to raise the satisfaction levels of the physicians attention to strategies for success is paramount. Increased numbers of alerts can cause physicians to override potentially critical alerts while clear, effective and actionable recommendations can decrease the effort and time needed by a physician to read, understand and even respond to system advice (Khalifa, 2014). Diving deeper into each subscale item of the four usability factors may provide more detailed insight into which of the individual aspects is most important.

Continuous efforts are needed to guarantee overall satisfaction with the CDS tools in the EMR. Given the low number of respondents who have participated in any EMR development, offering Residents and Hospitalists the opportunity to become more participative in the design and development of CDS tools may lead to a greater understanding of system limitations, new design strategies and increased satisfaction. Alerts should regularly be reviewed for efficiency, efficacy, underutilization and patient safety with careful consideration for removal or modification. Given the ever growing number of guidelines, protocols and regulatory requirements greater focus on the factors that make CDS tools more usable must be considered in order raise satisfaction levels. Human-computer interaction studies provide valuable information to assist in the understanding of how clinicians use systems (Sittig, 1999). Strategies to improve this must be developed collaboratively among providers, analysts and IT staff where the tools facilitate behaviors that the physicians believe to be useful, meaningful and easy.

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Appendix A: Output

Demographics

Age

	Frequency
26	3
27	6
28	11
29	13
30	14
31	11
32	11
33	8
34	3
35	1
36	4
37	2
38	2
39	1
41	3
43	1
55	1
Total	95

Gender

	Frequency
Male	61
Female	42
Total	103

Role

	Frequency
PGY-1	15
PGY-2	27
PGY-3	29
PGY-4	6

	Hospitalist	14
	PGY-5	11
	Total	102

Specialty (i.e. Medicine, Pediatrics, Surgery, etc)

	Frequency
Anesthesia	4
Cardiology	1
Dermatology	1
Emergency Medicine	11
Endocrine	1
Gastroenterology	1
General Surgery	1
Medicine	40
Neurology	2
OBGYN	6
Otolaryngology	1
Pathology	2
Pediatric Infectious Disease fellow	1
Pediatrics	15
Psychiatry	4
Pulmonary Critical Care	2
Surgery	4
Urology	5
Total	102

Have you participated in any EMR development?

	Frequency
No	93
Yes, Describe your participation**	9
Total	102

Have you participated in any EMR development? - Yes, Describe your participation - Text

***As QA/QI Chief we've tried to develop the order sets within the ED design and testing*
I am the associate CMIO
Ipass
QC for notes
rollouts, optimization
some participation in LGBTQ revision committee meetings
Worked on PowerPlan production for our division
Worked with Dr. Fochtmann to disseminate knowledge about NY Safe act integration into cerner to various attendings in psychiatry

How long have you worked with the Cerner system?

	Frequency
6 months - Less than 1 yr	12
1 yr - Less than 2 yrs	25
2 yrs - Less than 3 yrs	20
3 yrs or more	44
Total	101

On average, how much time do you spend per week on this system?

	Frequency
1 hour to less than 4 hours	1
4 hours to less than 10 hours	4
Over 10 hours	96
Total	101

Of the following, check those that you have personally used or are familiar with (check all that apply):

	Frequency
Personal computer	97
Laptop	98
Touch Screen	80
Tablet/Notebook	77
Database Software	31
Voice Recognition	55
Internet	95
Total	472

Cronbach's Alpha

Satisfaction

Cronbach's Alpha	N of Items
.873	4

Layout

Cronbach's Alpha	N of Items
.905	6

Terminology

Cronbach's Alpha	N of Items
.876	5

Capabilities

Cronbach's Alpha	N of Items
.858	5

Learning

Cronbach's Alpha	N of Items
.907	4

Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Satisfaction	99	1.00	8.25	4.0918	1.84948
Layout	88	1.00	8.00	4.7958	1.69555
Terminology	90	1.00	8.67	5.7152	1.56187
Capabilities	89	1.00	8.00	5.1365	1.75893
Learning	88	1.00	8.50	4.5341	1.89472
Valid N (listwise)	84				

Correlations

Correlations

			Satisfaction	Layout	Terminology	Capabilities	Learning
Spearman's rho	Satisfaction	Correlation Coefficient	1.000	.668**	.467**	.536**	.706**
		Sig. (2-tailed)	.	.000	.000	.000	.000
		N	99	88	90	89	88
	Layout	Correlation Coefficient	.668**	1.000	.770**	.755**	.766**
		Sig. (2-tailed)	.000	.	.000	.000	.000
		N	88	88	86	86	84
	Terminology	Correlation Coefficient	.467**	.770**	1.000	.719**	.549**
		Sig. (2-tailed)	.000	.000	.	.000	.000
		N	90	86	90	89	88
	Capabilities	Correlation Coefficient	.536**	.755**	.719**	1.000	.700**
		Sig. (2-tailed)	.000	.000	.000	.	.000
		N	89	86	89	89	87
	Learning	Correlation Coefficient	.706**	.766**	.549**	.700**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.
		N	88	84	88	87	88

Regression

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.740	.548	.525	1.29899

a. Predictors: (Constant), Learning, Terminology, Capabilities, Layout
b. Dependent Variable: Satisfaction

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	161.748	4	40.437	23.964	.000[b]
	Residual	133.302	79	1.687		
	Total	295.050	83			

a. Dependent Variable: Satisfaction
b. Predictors: (Constant), Learning, Terminology, Capabilities, Layout

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.418	.560		.746	.458
	Layout	.439	.175	.390	2.202	.014
	Terminology	-.001	.162	-.001	-.005	.996
	Capabilities	-.126	.147	-.113	-.857	.394
	Learning	.492	.132	.485	3.721	.000

b. Predictors: (Constant), Learning, Terminology, Capabilities, Layout