Revisiting CDS Implementation Failure: The Physician's Perspective.

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I. INTRODUCTION.

Medical record keeping in the U.S is in a transition stage. The transformation from the 'old' paper medical charts to an Electronic Health Records (EHRs) is a $19 Billion (1) endeavor that aims to optimize our healthcare system by enhancing physician performance, standardizing delivery of care and eventually improving patient outcomes. This conversion seeks to reduce communication barriers between clinicians, provide instant accessibility of medical information to patients and reduce the increasing national healthcare costs. Achieving these objectives requires EHRs to include functionality that helps clinicians manage clinical states, remember drug dosages or drug interactions and select the most effective treatment or test for a specific clinical scenarios. This level of functionality is achieved by incorporating clinical decision support systems (CDSS) within EHRs and can only serve these functions if they present the right information, to right clinician, for the right patient and at the right time. (2) A variety of principles can be used to incorporate the 'right' information within the EHRs during CDSS implementation. These principles are commonly grouped into guidelines or clinical practice guidelines (CPGs) which are defined as " systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances." (3).

Clinical Practice Guidelines have been increasing in number for the past few decades and clinicians' viewpoints toward them have been a continuous field of study especially after the development of evidence-based medicine (EBM). EBM is not a new medical field but only lately has changed the practice of medicine by standardizing the clinical management of diseases. Physicians have mixed

feelings about EBM. They initially felt that these set of rules were too specific, restricted physician individuality and discouraged clinical thinking (4). The application of EBM has expanded at variable rates in academic institutions and community hospitals depending on physicians' personal choices and local administrative pressures. However, the pace of this transformation has increased with the transition from paper medical records to EHRs. In the past decade, EHRs implementations have grown rapidly accompanied by e-prescribing, drug interaction checks and clinical decision support systems (5). Physicians still adjusting to changing their clinical practices to include EBM had to now adapt to EHRs and CDSS. Younger physicians had no difficulties during this transforming period but clinicians with longer tenures may view this technological change as a difficult challenge (6,7). In addition to learning new skills, making significant changes in office workflow and introducing new technology, CDSS integrated EHRs required physicians to change their clinical thinking and partially surrender their own personal algorithms. These attitudes seemed to overshadow the anticipated benefits of CPG and EHR integrated CDSS which would provide physicians with updated objective and detailed information on clinical practice (8).

In the last two decades hundreds of reports have evaluated physician adoption of CPG and CDSS.. Researchers have tested CDSS in various medical arenas including assistance with medication management and presentation of evidence-based guidelines at different times during the patient encounter. Garg et al (9) in a systematic review evaluating the effects of CDSS on practitioner performance and patient outcomes has shown that CDSS improved physician performance in 66% of the trials reviewed. Moreover, 13% of the trials in the study showed an improvement in patient outcomes. More recently, Kawamoto et al (10) also performing a systematic review concluded that CDSS improved clinical practice in 68% of the trials. Thus, CDSS implementations have been successful in deploying and integrating specific guidelines but evidence for clinical, economic,

workload and efficiency outcomes remains sparse (11).

These systematic reviews showed that most CDSS implementation have significantly improved clinical care, but their effect is not homogeneous. Thus, this review attempts to understand the issue from a physician perspective and seeks to answer why CDSS integrations have not been consistently successful. Specifically, this capstone papers' main objective is to identify physician related factors that might not have been addressed prior or during CDSS implementation failures. In this paper I will propose that a possible reason for the continued failure of some CDSS implementations could be the lack of understanding of physician views and attitudes by the implementers. Moreover, this paper will identify and review these attitudes in order to differentiate if low physicians acceptance is inherent to CDSS (the messenger), directed toward the CPGs (the message) or a combination of both. Finally, this paper reviews the literature and shows that some of these clinician's attitudes have been present before the EHR era and may not be related to technology.

II. BACKGROUND.

Definition of Clinical Decision Support (CDS).

There are several definitions in the literature but perhaps the most clear defines a CDS ".. as any software designed to directly aid in clinical decision making in which characteristics of individual patients are matched to a computerized knowledge base for the purpose of generating patient-specific assessments or recommendations that are presented to clinicians for consideration ". (12)

Early attitudes with CDS.

Decision support systems, also known as expert systems, have been studied for many decades. MYCIN was a standalone infectious disease CDS used in the 1970's at Stanford University (13). MYCIN faced technological barriers but clinical difficulties were also prevalent from the start. Acceptability ratings by experts only reached 65% even when the authors showed that the system's accuracy was higher than 90% and never failed to cover a treatable pathogen (14) . Difficulties with updates, technology and time demands to use the system made MYCIN difficult to use (13). Eventually, technological barriers were overcome but the physician's low acceptance prevented MYCIN from ever be used to treat real patients.

Recent CDS reviews.

Since the early experience with MYCIN, CDS systems have been studied and implemented in other fields of medicine. Most CDS studies have concentrated in 4 areas: diagnosis, reminder, disease management and drug dosing / drug prescribing (9). Several authors have reviewed CDS implementations and the effects of CDS recommendations on physician performance for many years. Shea et al (15) summarized randomized controlled trials evaluating computer-based clinical reminders

for preventive care. The authors identified 16 trials which extended from the mid 1970's to the mid 1990's. Even though they concluded that computerized reminders improve preventive services, the results did not convincingly improved CDS reception since they also show that manual reminders had a comparable effect on the recommended services. In a similar time span Hunt and colleagues (12) studied physician performance. Their study covering 68 non-randomized controlled trials showed that CDS improved physician's performance specifically regarding preventive services. This positive findings did not extended to the drug-dosing studies where only two out of seven included trials found a significant effect on clinicians. These initial studies supported the assumption that physician's acceptance of CDS recommendations was on the rise. However, recently, Kawamoto et al (10) reviewed studies that used CDS in clinical practice to identify success features and quantify the actual changes in clinical care. The authors included 70 studies which showed that CDS improved clinical practice significantly in 68% of the cases. Success features included periodic performance feedback, patient involvement and requesting physician's reasoning for not following recommendations. The same report identified lack of local user involvement and CDS implementations without conventional education as two of most frequent causes for decreased success rates. Additional successful factors have been reported in a systemic review by Garg et al. The authors concluded that inclusion of automatic CDS prompts and local leadership were essential for the projects positive outcomes. Although, involvement of the paper's authors during the study may created a publication bias of selected successful trials, they concluded that local champions involvement is essential to facilitate the entire implementation process

More recently, a systemic review of CDS RCT by Bright et al shows that healthcare provider acceptance and use remained low. Although physician satisfaction is moderate in academic, community and VA ambulatory settings where EHRs are locally and commercially developed, evidence for

increased efficiency was not evident. Finally, a research study by Roshanov (16) that evaluated 162 randomized trials corroborated earlier successful factors including reasons for overriding alerts and shared decision-making with patients. Surprisingly the authors reported that CDS inclusion on EHRs or CPOE were associated with failure more frequently when compared with other methods of delivering advice. Thus, the most recent literature review helps implementers with the successful format for CDS integration but interestingly does not discuss how to approach and increase physician adoption of these CDS.

Roadmap for CDS.

In view of the difficulties faced with CDS, in 2005 AMIA as a work product for the Office of the National Coordinator (ONC) for Health Information Technology implementations created the "Roadmap for National Action on CDS (17)." Published in 2006 the report , described three goals considered essential to enhance healthcare through CDS:

-the use of best knowledge available when needed,
-high adoption and effective use,
-continuous improvement of CDS methods.

These three principles helped to guide CDS implementations in the years that followed. However, not all three goals were addressed equally. The availability of best knowledge for physicians increased tremendously since the Roadmap was first published with hundreds of new RCT reporting CDS implementations. The third goal was partly addressed by The National Quality Forum's CDS consensus report published in 2010: Driving quality and performance measurement -a foundation for CDS- aimed to spread a common CDS taxonomy to facilitate quality improvement adoption and

reporting (18). However, the second goal, regarding high adoption and effective use of CDS remains largely unfulfilled. Thus, redirection of these initial efforts are needed to change the sluggish rates of CDS adoption by physicians and to fulfill the promise to improve clinical outcomes through the use of evidence-based care.

III. METHODS.

This study used MEDLINE's PubMed, Cochrane Database and CINAHL to search for relevant studies. Search criteria were based on the following terms: clinical decision support, decision support, reminder, alert and randomized trial. The search criteria was arbitrarily set for papers published from January 2000 to March 2013. In addition, the references from these reports were studied to extract relevant papers. Papers were considered relevant to this study if they fulfilled selection criteria and the results showed minimal to no adherence by the physicians to the recommendations offered by the CDS. In addition, CDS integration in the workflow, availability at the point of care and actual usage by the physician were deemed necessary for inclusion.. Only studies published in English were considered.

In most papers that were reviewed, the physician's perspective before or after CDS implementation is discussed somewhat vaguely. Some trials described the time and type of training offered to the physicians but most did not elaborate in any of these features. A few studies reported post-implementation physician's attitudes but in most cases this information was lacking. Physicians pre-implementation views regarding the CDS system were not noted in any of the studies.

Success and failure were defined based on the statistical results reported in the original study. A study

was considered successful when there was an improvement noted in physician behavior regarding the CDS being implemented. Minimal or no changes in physician's acceptance of CDS recommendations were typically considered as noted as a failure.

For the purposes of this review, if the physician perspective was not specifically described in the paper then it was considered absent. For instance, if guidelines generated by the author's were used without specific mention of physicians agreement prior to the CDS implementation then these guidelines were regarded as not being acknowledged by all involved physicians.

Using thematic analysis, selected studies that showed no improvement in physician behavior were studied closely in an attempt to identify specific reasons that may have been the basis for the adverse results. The analysis was focused on the user's (physician's) perspectives. Initially, the causes for failure were extracted from the discussion sections of the papers. In many cases the authors reported these reasons as possible contributing factors to the negative results. Relevant features related to the physician's perspective were listed and eventually grouped in related themes. Once the themes were identified, the selected papers were revised again to search for any reference to these themes that may have been overlooked.

IV. FINDINGS.

Studies were reviewed to identify themes that could explain causes for lack of physician adherence to CDS guidelines. Three recurring themes from the physician's perspective were identified as possible contributing factors for failure: (a) the lack of physician agreement or acceptance of recommendations, (b) amount and quality of CDS training and (c) disruption of workflow (See Table 1). Even though there was variability in the clinical setting, it was surprising to see that the selected themes mentioned above were consistent across different studies which indicates that this variability may not be relevant.

There were varying degrees of acceptance depending on the study and the alert modality, which can be attributed to a number of limitations associated with the implementation of CDS. With respect to CDS regarding clinical guidelines, evidence-based guidelines were used with modification by the research authors in almost all cases. In general, the authors adapted guidelines to fit their local current practices. Educational lectures were given in some cases but more commonly the physicians received a printed copy or an email link to the guidelines website. In one case the guidelines were only available on request. In other cases the physicians that agreed to participate in the study were not able to see the recommendations until the trial started.. In one report the various hospitals participating in the trial had conflicting guidelines. None of the studies described a collective agreement by all participants on the recommendations to be implemented. No study described a pre-implementation questionnaire to assess the status of physician's attitudes toward evidence-based guidelines. In a few studies authors attempted to quantified reasons for rejection of recommendations with post-implementation surveys. Studies did not have a method to address discrepancies and disagreement with the CDS proposed guidelines.

Training of physicians was not clearly described in some studies. However, some authors speculated

that limited training should be considered as a reason for CDS failure. In most cases, the physicians were not trained specifically or in a timely fashion to use the new functionality. One study describes training that took place 6 months prior to the CDS implementation. In other report, physicians were given a packet with instructions to access a web-based educational module. Finally, in one study physicians only received a generic e-mail message that explained the planned intervention.

Disruption of workflow has been reported previously as a barrier for EHR implementations. In some implementations reviewed the CDS was not integrated into the EHR and was set-up as a standalone application either in a workstation or in a PDA. Sometimes, the CDS required the clinician to enter additional data. In one case the recommendations were visible on the computer screen but the physician needed to access a different screen to accept them. Another study described an application that required physicians switch between three pages which required further input. Some studies presented the recommendations hours before the patient encounter or when the patient's chart was opened for any reason.

V. DISCUSSION.

The CDS literature has several examples that report physician acceptability of CDS recommendations, particularly in the area of alerts, drug-dosing and reminders.

The area of alerts has the most extensive literature reviewing drug-drug interactions in various clinical settings. Early studies in a combined inpatient and outpatient setting showed that physicians decline 88% of critical drug interaction and allergy-drug interaction alerts (19). A follow up study in the same institution 6 years later continued to show high rates of overrides with critical alerts overridden over 85% of the time (20). The authors reiterated the recommendation to refine the logic in the VistA CPRS but also noted that in their institutions the drug-drug lists are maintained by a centralized support group located off campus.

More recent studies show improved physician acceptance of CDS recommendations. For instance, Isaac et al (21) studying medication overrides in ambulatory care reports that clinicians accepted 9.2% of the drug-drug interaction alerts and 23% of the allergy alerts. Similar to the first studies, this study noted that the drug-drug interaction list was maintained by Cerner pharmacists using a consensus process based on information from pharmaceutical companies without local physician input.

Further, Slight and colleagues (22) studied the override rates of drug alerts over a three year period in a primary care setting. They reported that physicians overrode drug-allergy alerts more than 70% of the time and drug-drug interaction (DDI) alerts 60% of the time. In addition, the study showed that the rates of override varied depending on the type of alert.

A recent study by Smithburger et al (23) may explain the etiology for the high rates of drug-drug interaction discrepancy between CDSS and physicians observed by the different researchers. The authors showed that the grading of the degree of severity of drug-drug interactions varied significantly between clinicians and proprietary databases. In this study, the authors described an agreement only 10% of the time.

The second type of CDSS commonly used to study acceptability of recommendations is drug-dosing systems. These CDSS are used to adjust anti-coagulation medications, antibiotics or to adjust medication doses for elderly or pediatric patients. Griffey et al (24) studied guided medication dosing in elderly emergency patients and showed that 92% of the alternate medications recommended by the CDSS based on the patient's age were declined by ER physicians. The authors reported that a possible reason for the high rates of declines was that the knowledge base used by the CDS was created by an expert panel of physicians which included various medical specialties but without any Emergency Medicine physician representation.

Similarly, a study by Kirkendall et al (25) has shown that dosing rules provided by EHR vendor databases are accurate only 55% of the time when compared with actual prescribing practices of pediatric care providers.

Finally, in the area of CDS reminders, Frances and colleagues (26) showed no significant difference in patient outcomes when using a physician reminder system in patients with coronary artery disease. The authors indicated that lack of physician participation in the design of the reminder as a possible explanation for the low adoption rates.

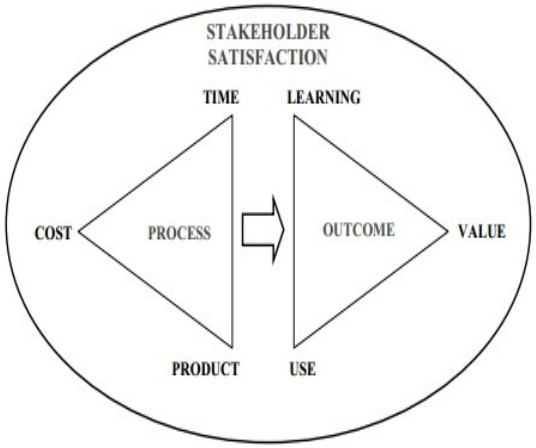
The studies mentioned above indicate that the acceptability rates of CDS recommendations by physicians vary widely. This capstone attempts to understand this problem and studies it from different angles. First, it considers the classic IT success model, which supports that identifying and addressing the end user is a critical step in all successful information technology projects. Second, it reviews the theory of planned behavior (TBP), a psychological theory which explains physician's attitudes and behavior in relation to the information contained in the CDSS. Finally, it extrapolates these attitudes to the evolving conflict between physician's and EBM in an attempt to understand the reason for the low adoption rates of CDSS.

The findings in this project show that the first reason for the continued failure of some CDS implementations is not addressing the end users' (i.e physicians') acceptance of recommendations in the pre-implementation phase. In some of these studies the physicians did not know or review the CPG to be implemented. There was diffusion of information but not acceptance of ideas. The implementers failed to engage the end user directly. Thus, the implemented CDS contained CPG that did not reflect the views of the intended users. The investigators assumed their adaptation of the CPGs would lead to immediate acceptance by all clinicians. Physicians are the primary end users of these CPGs and as such should be included in the all decision processes. This lack of communication about the specific changes expected from clinicians in their practices may have affected adherence rates.

The information technology (IT) project success criteria proposes that prioritizing end-user satisfaction is essential for effective use of any product and for the successful completion of the project.

5.1 IT project success criteria.

This basic criteria was proposed to evaluate the success of IT projects and helps understand the reasons for failed IT implementations. The IT success criteria as described by Nelson and colleagues (27) takes into account three process factors: time, cost and product and three outcome factors: learning, value and use. In this model stakeholders are divided into 3 groups: the IT team, the end users and top management. In all groups success is directly related to stakeholder satisfaction but each group prioritizes each of these six factors differently to define success.



Project Success Criteria.

(From Nelson, 2005)

In the IT success model, looking at the values placed on these criteria by the various groups helps understand why each stakeholder has a different view of success. For example, the IT team considered a project successful if the product was completed regardless of cost or time. Top management regarded a project successful if it improved user efficiency and effectiveness (value). Lastly, the end users definition of success involved the actual use of the product for its intended purpose. Even though working in harmony, different stakeholders are always looking to influence the success of the project from their own perspective. Satisfaction of all stakeholders is not needed for all projects to be successful but satisfaction of the end-user is critical.

A majority of CDS implementations were successful from a technological standpoint but the lack of

appropriate physicians adherence to CDS recommendations was a key factor that led to failure. . However, in most of the studies that were reviewed the physician's views regarding the specific CDS knowledge base was not addressed. Many authors were part of the group within their institution that tailored CDS recommendations to local practices standards-of-care but there were no attempts to reach a general consensus by all participating clinicians or even create a state of even general awareness.

In one study, even though, physician consensus was listed as a priority in a review of factors that affected implementation of guidelines, (28) the same authors ranked physician benefit focus as the second most-important factor to facilitate implementation of guidelines. While further studies are needed to clarify the importance of physician agreement with CDS recommendations and identify other factors having a contributing effect, including more physicians in the actual development and approval of guidelines could be an effective way of increasing guideline adherence.

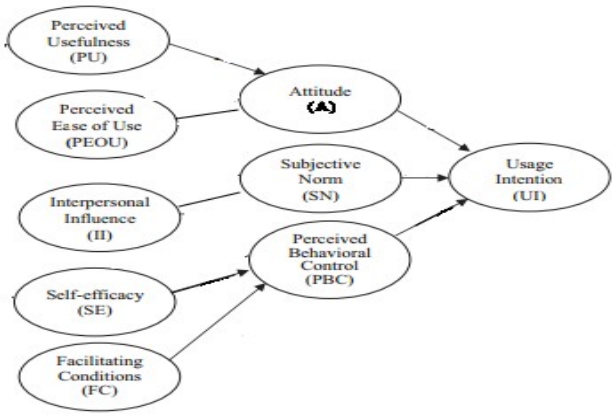
Finally, according to this model it may be helpful if physicians establish the success criteria for project. At different stages of the implementation, other stakeholders based on their own perspectives may indicate that the project has been completed successfully however physicians should demand the tailoring of the final product until it achieves its 'intended use'. For instance, a successful project may require 90% adoption by physicians and 90% acceptance of recommendations.

In order to prioritize the end user, clinicians attitudes should be identified, and evaluated before the project's start. The physician attitudes should then be addressed and the project goals adjusted. The theory of planned behavior (TPB) can help understand the basis for specific physician's attitudes.

5.2 Theory of planned behavior.

The TPB offers a theoretical construct that helps explain the low levels of acceptance of CDS recommendations. It proposes that low adherence by physicians could be related to their perceived disengagement with the CDS system or with the CDS knowledge base. The TPB model supports that the intention to perform a specific behavior is a direct result of three combining features: attitude (A), subjective norm (SN) and perceived behavioral control (PBC) (29). Attitude in turn is dependent on perceived usefulness (PU) and perceived ease of use (PEOU) which have been described as main predictors of technology adoption. All three factors when combined affect the user's usage intention. In turn, intention is required before actual behavior can take place (29.)

In the context of information adoption, “attitude” conveys the positive or negative evaluation of a user with regard to using a particular technology. In this case, a negative perceived usefulness of the CDS (or its knowledge base), leads to a negative attitude toward the CDS and a low usage intention. The SN is determined by the user's perception of the opinions of other relevant people in terms of whether or not he/she should use the technology. Lastly, PBC is determined by the users perception of his/her ability (e.g. skills) to use the technology (29).



Theory of Planned Behavior Framework.

(Adapted from Shin-Yuan, 2010).

Based on the TPB and in the context of CDS usage we can hypothesize that the physician's attitudes toward the use of guidelines correlates directly with the intention to use them.. This assumption is supported by a study that predicted the intention of physician's to use the Medline system for practicing evidence-based medicine (30).

Further, a recent study by Grimshaw and colleagues (31) explored the usefulness of various psychological models in predicting primary care physicians behavior. They explored factors associated with lumbar spine x-rays referrals for low back pain. Even though less than 30% of the contacted physicians agreed to participate in the study, their results showed that they were able to create psychological questionnaires that helped predict behavioral intention and that to some extend physician behavior in this specific setting (31). Godin et al (32) has studied factors that influence healthcare professionals ' intentions and behaviors. In their study, the authors systematically reviewed 76 studies that discussed determinants of behavior intention and behavior. They concluded that the theory of

reasoned action (TRA) and its derivation the theory of planned behavior (TPB) could adequately predicted healthcare professionals' behavior intention in the context studied.

A more recent study used a variation of the TPB model to predict the intention of physicians to use the Medline system. Their findings addressed each of the TPB model categories individually. They noted that higher perceived levels of ease of use and usefulness translate directly into a more positive attitude toward the system. In turn, they propose that changes in attitude will produce greater usage intention. Further, when addressing the SN feature, their alternate TPB model showed that physicians take into account the opinions of other clinicians. Lastly, the usage intention is significantly influenced by the physicians' perceived ability to use the system (30) .

None of the studies reviewed in this capstone utilized the TPB model to evaluate physician attitudes. However, close review of the papers allows to make some generalizations regarding the three TPB features that lead to usage intention of the CDS by physicians. First, the physician's attitude regarding the CDS knowledge base or the CDS itself was not considered in the majority of studies.
Second, in most studies Subjective Norm (SN) was not addressed directly. However, it is possible that even though in most cases randomization was based on physician and not location, physicians using the CDS were aware that other clinicians were participating in the study. Thus, at least in some cases, some clinicians could have been influenced by others to use the CDS. Finally, in the studies were learning sessions took place, the physician's Perceived Behavioral Control (PBC) increased as a direct result of increased self-efficacy. In addition to lectures, availability of guidelines either on paper or on-line would have also caused the clinician’s PBC to increase by creating facilitating conditions (i.e. easily accessible guidelines).

5.3 Physicians and EHR barriers.

Interestingly, the lack of acceptance of CDS recommendation by physicians may also be explained by lingering barriers that were the direct effect of the transformation of medical documentation from a paper to an electronic format. A recent review that categorizes barriers to EHR acceptance indicates that technical , time-related and psychological barriers perceived by physicians may play a critical role in the success (or failure) of EHR-CDS implementations (33) .

Category	Barriers
Technical	1 Lack of computer skills of the physicians and/or the staff
	2 Lack of technical training and support
	3 Complexity of the system
	4 Limitation of the system
	5 Lack of Customizability
	6 Lack of Reliability
Time	1 Time to select, purchase and implement the system
	2 Time to learn the system
	3 Time to enter data
	4 More time per patient
	5 Time to convert the records
Psychological	1 Lack of belief in EMRs
	2 Need for control

Taxonomy of Barriers affecting physician use of EHRs and CDS..

(Adapted from Boonstra, 2010)

The effects of these barriers may be more obvious when CDS implementations are shortly introduced just after EHR implementations. Elimination and mitigation of EHR barriers is critical to improve CDS

success particularly in the three categories mentioned above where barriers in both systems may overlap. For instance, the lack of computer skills and (technical) training are significant barriers for physicians adopting EHRs. Moreover, in 2007 Hing et al (34) reported that EHR adoption and use was inversely proportional to physicians age. These difficulties need to be addressed especially when a recent physician census in the U.S. shows that 45% of physicians are older than 50 years (35). Inadequate training correlates with the findings in this review and may partially explained failed CDS implementations. Time needed to learn the system can also be included in this category and thus could be addressed in a combined intervention.

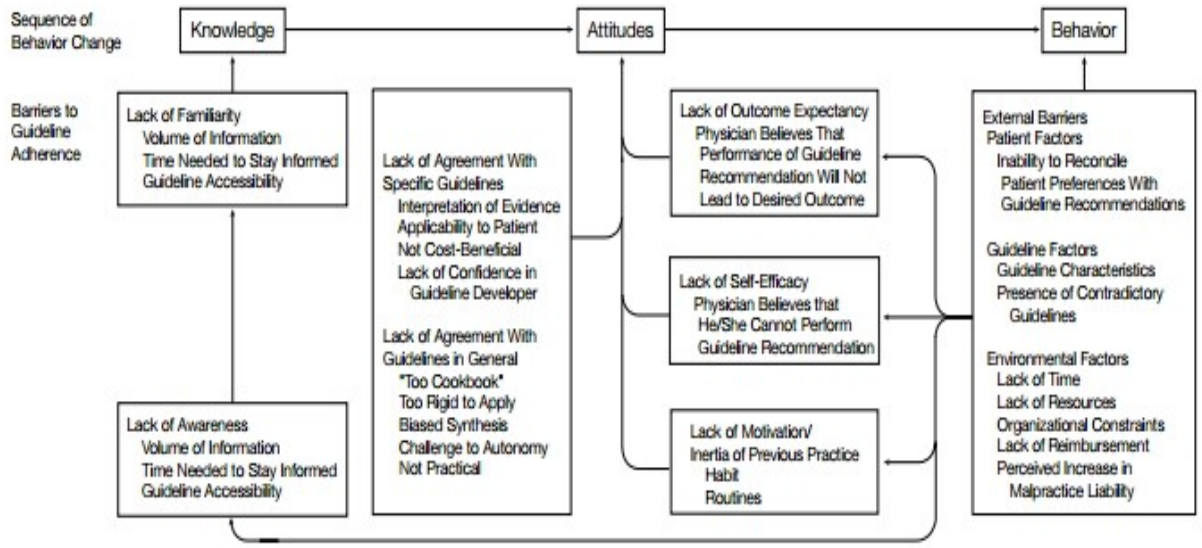
5.4 Physicians and EBM barriers.

The classical definition of EBM states that EBM "is the conscientious, explicit and *judicious* use of current best evidence in making decisions about the care of individual patients" (36). Other EBM experts teach that evidence alone is never sufficient to make a clinical decision (37) . Physicians must always trade off the benefits and risks, inconvenience and cost associated with alternative management strategies and in doing so, *consider* the patients values and preferences (37). In other words, EBM or more specifically the use of CPGs, is a process not an automatic response.

The process of CPG adoption can be divided in five stages that can be implicit or explicit: awareness (knowledge that the guideline exists), evaluation (assessment of the guideline), obtaining and reviewing data (retrieving relevant patient data that applies to the guideline), interpreting data (combining both pieces of data) and adherence (following the guidelines). (38). Some studies that have evaluated CPG adherence have difficulty addressing the clinical process that takes place after the evidence is presented. In other words, the studies showing that clinicians did not follow CPG recommendations may not indicate disagreement with the CPG itself but the lack of adherence maybe a result of the physicians' choice after considering other relevant factors (38). Studies that do not measure some of these implicit steps may falsely conclude that a CPG was not adopted (38) when in reality the CPG may not have been applicable. This finding should be considered specially in the studies that quantify CPG adherence as a measure patient outcomes.

Other CPG barriers are easier to quantify. For instance, Heselmans et al (39) reported that two primary reasons for low adoption of CPGs are the lack of EBM skills and the lack of time. Implementation of CPG embedded CDS systems has addressed these barriers by increasing accessibility and availability.

However, higher clinician awareness has not help to increase adherence which suggest that adherence may be influenced by other factors. Studies before the introduction of CDS show that awareness of a specific guideline does not necessarily translate into widespread adherence (40).



Barriers to Physician Adherence to Practice Guidelines in Relation to Behavioral Change.

(From Cabana, 1999)

Cabana and colleagues reviewed 76 studies describing barriers to CPG adherence by physicians. They created a model that correlated barriers into the three different stages of physician behavior change. The model includes seven barriers, the first two: lack of familiarity and lack of awareness are noted in the knowledge stage. The other five: the lack of agreement with specific guidelines, lack of agreement with guidelines in general, lack of outcome expectancy, lack of self-efficacy and lack of motivation are listed in the attitudes stage. Additional external barriers and environmental factors are grouped in the behavior stage.

Eliminating barriers in the attitudes stage could be more difficult than addressing barriers in the knowledge stage. For instance, a study of 511 German physicians interviewed to assess their perspectives on CPG showed that 38% thought that patients are best treated 'without guidelines and with the knowledge of individual needs and patient's possibilities (41). In the same study 38% of physicians viewed EBM as medicine 'which ignores alternative therapies and 33% felt that EBM 'impairs my professional autonomy in medical decision making' (41). These strong attitudes toward CPG overlap with the attitudes noted in the TPB and could be addressed in a similar fashion.

Thus, in order to alter physicians behavior, there must be a change in the perceived CPG usefulness and the ease of CDS use. Brouwers et al (42) have developed the Appraisal of Guidelines for Research and Evaluation (AGREE) II instrument to help increase the latter. AGREE II standardizes the assessment of CPG by assessing the quality of the CPG, providing a methodology for its development and informing what and how to report information in the guideline. Adoption of this process is important to reduce variability in the quality of CPGs and for the successful implementation of the resulting recommendations (42). Thus, improving the quality of CPGs can facilitate a change in physician's knowledge in the first step of CPG adoption, can decrease the time used in the decision process and in turn can have a positive effect in the physician's attitude and adherence. Integrating the TPB in the sequence of stages noted above creates a path to understand the importance of attitudes in the development of usage intention and behavioral change.

The implementer's failure to address the physician's knowledge and attitudes could explain unsuccessful CDS implementations. In some cases physicians were aware of the CPGs but did not agree with the recommendations thus could not apply them clinically. In one case multiple CPGs were available to the clinicians causing a conflict in recommendations and leading to minimal adoption.. In

several studies, one factor of note was the lack of provision of sufficient education or training thus causing a lack of familiarity with the CPG and stalling the adoption process.

5.5 Adoption model during CDS implementation.

Overlapping the three concepts discussed above: (a) the CPG barriers discussed by Cabana, (b) the TPB model and (c) the IT success model creates a model that proposes that successful CDS adoption by physicians is a sequence of attitudes and events.

Knowledge → Attitudes → Behavior (Usage)	from Cabana.
Usage → Satisfaction → Success	from IT Theory.
Attitudes → Intention → Behavior	from TPB.

= Knowledge → Attitudes → Intention → Usage → Satisfaction → Success

Adoption model during CDS implementation.

In this model, a successful CDS implementation is the result of a flow of physician's attitudes and behaviors. Thus, CDSS acceptance of recommendations (usage) is directly dependent on the physician's intention to use the CDSS. Developing this desired intention in turn requires the physician to have the right attitude toward the CDSS knowledge base used to generate the CDS recommendations. Further, the clinician's attitudes are a direct result of his/her familiarity with the content of the CDSS knowledge base. Thus, based on this model, CDSS implementations not evaluating baseline physician's attitudes toward the CDS knowledge base content and not measuring satisfaction throughout the deployment could limit the project's chances of success.

VI. LIMITATIONS.

This paper has several limitations. First, this review looks at success from a user's perspective. Additionally, in many of the papers reviewed CDS implementations are considered to have failed when the CDS recommendations were not significantly followed by the clinicians. In other words, failure occurred if the software was used by physicians but did not produce the expected change in physician behavior. Stakeholders in the CDS implementation team may probably disagree with this definition since in most studies the technological portions of the CDS were successfully implemented. Thus, this review is predominantly focused on the specific interaction between the physician, the information presented by the CDS and the application of this information by the clinician.

While early studies focused on improvement of physician performance, they typically looked at the physician's actual usage of the CDS but not at the influence that the use of CDS caused in altering clinical care. The measure of this effect is still difficult to evaluate and often indirectly measured in most studies, particularly since this effect cannot be quantified other than by recording patient outcomes. In contrast, more recent studies shift from measuring physician performance and focus on clinical outcomes.

Second, the quantity of CDS randomized control studies that examine CDS failure directly is extremely limited in the informatics literature. Most studies conclude that the CDS had a minimal impact when compared to usual care. In addition to the low numbers, studies show no homogeneity in the clinical settings or practice size.

Third, this review focuses on factors that were absent during CDS implementations and concludes that

this absence led to at least partial failure of the implementations. This assumption may not be accurate since avoiding past errors is far from a certain guarantee of success. Fourth, the authors of the reviewed studies were not contacted to confirm the assumption that the data not present in the studies was indeed not collected. This particularly applies to the case of clinically approved guidelines where it appears unlikely that physicians were contacted by the authors specifically to assess their personals views.

Fifth, the collection of articles spreads over the course of thirteen years. Considering older and more recent papers together may not accurately represent the current state of CDS implementations since there are significant technological differences among these studies, particularly as the technology has evolved rapidly.

This paper did not examine the unintended consequences of EHR implementations . Physician disapproval of CDS recommendations may be related to other EHR implementation issues. Poor user interface design and system delays are well known reasons for physicians to be dissatisfied with the EHR and consequently with the CDS. This is especially relevant if both implementations took place contemporaneously.

Finally, this paper did not evaluate the statistical studies used by the original authors. Thus, the calculations that caused the success or failure of the study are as they were presented in the original articles. This variability may not affect the study findings since most of the themes were not in most cases quantified.

VII. ADRESSING PHYSICIAN'S ATTITUDES.

According to the model proposed in this capstone, improving CDS implementation outcomes requires a change in physicians behavior. However, to achieve the latter changes need to be made to all preceding stages. Addressing physician knowledge is perhaps the most direct way to change clinician attitudes and usage intention..

Pre-implementation

Monitoring physician knowledge and identifying gaps is critical prior to CDS implementation. Altering physician attitudes toward the CDS should not be initial goal at this time. Instead, in this preparatory state the focus should be on identifying specific barriers that would prevent physician adoption of CDS recommendations. Quantifying physician perspectives regarding familiarity and satisfaction with the current EHR should be a first step. Questionnaires are perhaps the best way to obtain this information but one aspect of using questionnaires is that responses rates are only usually around 60% (43). The most effective way of administering a questionnaire is still not clear and most studies show equivalent response rates for pencil-and-paper versus a web-based version (44). Administration of the survey in both media could encourage a larger clinicians participation. Questions in the survey should include statements regarding well-known EHR barriers mentioned previously including technical, temporal and psychological factors. Most of these factors overlap only with the attitude and perceived behavioral control (PBC) sections of the TPB so additional questions regarding subjective norm (SN) should help identify any issues in interpersonal dependence.

Evaluation of physicians attitudes regarding specific guidelines should follow this initial assessment.

The objective here is to identify specific negative viewpoints and degree of agreement with the proposed recommendations. Recommendations from super-users and champions are valuable but inclusion of all clinicians should provide the implementers with a more complete picture. Some studies reviewed in this project presented the information to clinicians in different formats including printed handouts, e-mail links and short lectures but there was no physician's attitude assessment. Failing to identify the level of clinician's perceived usefulness and perceived ease of use may lead the implementers to misjudge the level of clinician's agreement. For instance, in the studies without educational lectures, the investigators expected all clinicians to read the handouts or read the e-mails sent but the actual number of clinicians that read this information could not be quantified. The failure to address the level of physician awareness and agreement with the information presented could have been avoided by maintaining a user log. Monitoring access to the provided information could help gauge the level of physician interest. Higher activity could reflect high levels of agreement, higher perceived usefulness, a more positive attitude and may reflect a higher usage intention. An alternative and perhaps more direct way to quantify agreement level could be the administration of a simple physician survey. The survey results could give the investigators a good idea on the expected success of the planned implementation as well.

The last phase prior to implementation addresses the physician's level of knowledge and usage of that knowledge in a clinical situation. This step will attempt to change and measure physician behavior. Knowing the levels of agreement obtained in the previous step would help implementers gauge the level of resistance, especially since studies show that guidelines that recommend changing established practice are more difficult to change than guidelines that recommend new behavior (40). Testing clinician's knowledge and its application could be difficult to implement but it could be presented as a Continuous Medical Education (CME) activity to encourage participation. O'brien et al (45) has shown

that educational detailing can change clinician behavior in small but measurable ways.

This step also addresses clinicians misconceptions regarding their actual level of knowledge. For instance, in a survey of 103 physicians most disagreed with the statement that rated their knowledge about diabetes management as low but when they were administered a pre-course test they only achieved a mean of 44% right answers (46). Finally, in this phase an additional step to measure the actual application of the acquired information could follow the educational detail. This step is important for simple exposure to the relevant 'correct' facts may have no effect on deeply imprinted decision pathways (47) A study by Ballard et al (48) has successfully used clinical vignettes to test and change physicians knowledge and attitudes after the implementation of CDS guidelines.

Post-implementation

Decreased ease of use leads to decreased physician performance and affects the physician's attitude toward the CDS. Measurement of post-implementation attitudes and acceptance can be addressed in two ways in this phase: indirect and direct feedback. The process should take place continuously and ideally recurrent issues should be prioritized. Both methods should be used since there are no current studies that compare the accuracy or efficiency of either type of feedback.

At least three indirect measures of indirect feedback can be evaluated in this stage: the time needed to use the CDS, the generation of reasons for override of alerts or reminders and the actual use of the CDS (i.e. order sets with embedded CPG).

-Time. Measuring time spent by physicians while performing specific CDS tasks is an essential way to

measure their performance. It does not require specific input and provides valuable information. Perceived usefulness and perceived ease of use are critical for acceptance of technology (49) but repeated delays in task performance by clinicians will cause physician frustration and decreased adoption. Individualized measurement of time needed to complete tasks pre and post implementation should help implementers note the effects of the CDS in the physician's workflow. Changes in physicians performance in this model indicate that a change in the CDS's content may be necessary. There are several examples where time usage can be calculated:

-measuring the time it takes by physicians to admit similar patients using order sets before and after the introduction of guidelines,
-calculating the time needed for a clinician to accept or reject an alert or reminder,
-measuring the time used to select recommended studies.

-The generation of a list of reasons for alert and reminder overrides is another way to monitor acceptance of recommendations. Alert rejection should be individualized and quantified. All responses including free text should be noted. High rates of alert overrides should be addressed and reevaluated. Optimizing reminders to increase usage has positively impacted healthcare providers performance with drug ordering and preventive care (50).Also important is this stage is the implementation of an automatic feedback to report to clinician their actual override of alert and reminders and their standing as compared with other peers.

-CDS usage. Physician and patients characteristics can be identified by monitoring individual physician usage of reminders and alerts. Knowing these features in advance may help predict their acceptance of future CPG. Tiering drug-drug alerts have shown to increase compliance by tailoring to

different users acceptance (51). Ballard et al reported that emergency physicians with tenures longer than 5 years were less likely to be aware of recent CPG embedded in CDS. Further, physician's ordering behavior could be noted to identify specific patient demographic characteristics that favor CPG acceptance. Sittig et al (52) reported that clinicians were more willing to accept CDS recommendations when the patient was elderly and had chronic conditions. Similarly, Carrol et al (53) studying four pediatric clinics found that CDS generated prompts were more likely to be addressed when the patient being seen was younger.

Matching CPGs features with patient demographics may help develop similar CPG for specific patient populations. In addition to demographics, patient location where CDS is used can be studied to measure physician usage. Sittig et al showed in the same report that clinicians indicated that they were less likely to be accept CPG suggestions when the patient was presenting for an acute condition (52). Finally, monitoring the use of physician order sets should help identify those poorly accepted. Order sets not used should have embedded guidelines reevaluated. Further, order sets used more frequently should be studied to isolate positive features that encourage adoption. Indirect feedback on CDS utilization should generate large amounts of user behavior information and should help improve users efficiency and performance in the future.

The second type of feedback, direct user feedback, can also help identify poorly use CDS elements. Surveys can narrow down specific issues and should be offered selectively to those most affected. Hoonaker et al (53) reviewed several CPOE questionnaires present in the literature that evaluated end-user satisfaction and selected the POESUS as the most appropriate to assess clinicians. Its value also resides in that the questionnaire uses a set of criteria that may extrapolated to evaluate other CDS systems. The evaluation of end-user satisfaction should be a continuous process and ideally should

occur anytime changes are made to the clinical workflow or when new CPGs are implemented. Finally, CDS content issues may require to retrace some pre-implementation steps to measure acceptance rates or other issues than precede the clinicians attitude. Finally, audit and feedback is a known strategy used to increase compliance with guidelines. Some authors have shown that specific direct feedback to providers is associated with improve completion of clinical reminders (54) but is not advocated by others (55).

VIII. Summary.

In the last ten years, hundreds of peer-reviewed articles have been published presenting CDS implementations attempts. Unfortunately, they are not all success stories, a significant number of them show that CDS adoption by physicians is low. This problem has been approached from different perspectives including the study of the CDS's user-interface, the evaluation of the CDS software and the adjustment of characteristics in the information used by the CDS. A different approach is to look at the physician's views and satisfaction.

This paper reviews the reviews the existing literature and attempts to show that many of the failed CDS implementation reviewed did not addressed the fundamental goal of IT projects: end-user satisfaction. The investigators in these CDS implementations started with a clear understanding of what was needed but overestimated their influence over the end-users. They assumed that the information presented in the EHRs if shown with convincing evidence, would lead to instant physician agreement. Perhaps, they expected some degree of resistance but did not anticipate that the CDS recommendations would be, in some cases, opposed consistently. The investigators did not realize that the *acceptance* of the CDS's

knowledge base was critical for entire project's success. In most of the reviewed studies dissemination of the CDS recommendations was limited while in others it did not occurred at all. Moreover, physician's satisfaction and the actual acceptance of CDS recommendations were almost universally not measured in these papers.

Despite its limitations, this study shows that most of the reviewed CDS implementation projects limited the clinical input to the CDS knowledge base to only a few physicians. Even though a complete agreement by all physicians with all recommendations should be the ideal, in the real world this is not achievable. In that situation, the goal should be an informational one within an educational forum where the presentation of evidence can be followed by discussion. This forum should lead to some type of consensus prior to any attempts of CDS implementations.

This paper attempts to show that a CDS implementation is a flow of attitudes and behaviors and CDS implementation success is the result of several stages which start by addressing the user's knowledge and understanding of the topic that needs optimization. . According to this model, it is possible that the reviewed studies approached CDS implementations the wrong way by prioritizing patient outcomes. In doing this, they evaluated patient outcomes before improving physician performance and tried to measure physician performance before optimizing the CDSS.

In the future, maybe CDSS will direct physician's decisions and physician's rejection of CDSS recommendations will not be accepted. Until then, additional focus on physician's views prior to CDSS implementations should lead to the reduction of implementation failures by increasing physician acceptance of CDS recommendations, improving physician performance and eventually producing superior patient outcomes.

IX. TABLE 1 Randomized controlled trials with borderline or failed CDS interventions.

Authors	Year	# of Mds/Setting	Lack of Acceptance (Physicians agreement with recommendations)	Poor Physician Training	Disruption of Workflow	Type of CDSS
Frances (26)	2001	66/IP	DBI	ND	Written reminders	Computerized reminder
Eccles (56)	2002	NR/OP	DBI, guidelines not current practice	1 day training	Guidelines were a separate path and not accessible directly	Guideline recommendations
Weir (57)	2002	Not reported/ IP	1/3 of physician's disagree with CDSS Guidelines available 'on request'. Informed that study being done. 40% CDS did not influence their practice	ND. Conflicting guidelines in different centers.	ND.	Automatic presentation of estimated stroke rates
Ansari (58)	2003	NR/OP	No description of physician agreement with guidelines.	Guidelines distributed in grand rounds, noon conferences and office.	ND.	Alert for use of guideline recommendations.
Tierney (59)	2003	246/ IP	Guidelines viewed as cookbook medicine	ND	Esc key	Auto display of guidelines
Tierney (60)	2004	NR/IP	Guidelines viewed as cookbook medicine	Guidelines given to PCPs	Esc Key	Automatic display of guidelines
Apkon (61)	2005	NR/OP	70% did not agree with recommendations.	ND	83% of physicians reported too time consuming.	Guideline recommendations
Roumie (62)	2006	182 / IP	DBI, ND.	No training. One email sent.	Alert sent when chart opened but not at specific time of encounter for BP adj.	One time patient specific alert based on Guidelines
Paul (63)	2006	NR/IP	Not acceptance of recommendations	ND	Separate system.	Manual entry needed.
Davis (64)	2007	36/OP	Not generally approved.	insufficient training,	Prescription writer in PDA to interface with EHR	Reminder based on guidelines.
Smith (65)	2008	97 /OP	DBI, Endocrinologist. 40% considered messages not useful. 50% did not use messages to manage patient.	ND.	Message sent 48 h before actual visit.	Specialty advice email

Tamblyn (66)	2008	28/ OP	Alerts not relevant.	ND	ND	Alerts to medications.
Field (67)	2009	NR / LT	DBI.	ND.	Unable to order drugs based on alerts. Systems not linked	Alert during medication orders
Sequist (68)	2009	110/OP	Lack of acceptance: Algorithms not accurate	1 h of training	ND	Reminders for screenings
Bertoni (69)	2009	68 /OP	DBI	Lectures and printed copies of guidelines	PDA based	Guideline recommendations
Kirwin (70)	2010	142/IP	Not approved by physicians	ND	Letter copy in EHR	Pharmacist generated letters.
Player (71)	2010	53/OP	DBI.	Packet with instructions provided but not monitored.	3 pages of alert forms.	Reminders
Gill (72)	2010	119/ OP	Lack of acceptance	ND	44% too disruptive	Guideline recommendations
O'Connor (73)	2010	41/OP	Not approved by all physicians.	ND	ND	Printed copy of specific guidelines.
Bell (74)	2010	NR/ OP	DBI	2 2h blocks, 6 months before intervention	Embedded	Alert and Reminder of guidelines
Tamblyn (75)	2010	2293/O P	N/A	ND	Required additional time to investigate not compliance	Summary of medication list
Strom (76)	2010	1963/ IP	DBI	ND	ND	Alert

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