

Impacts of Clinical Decision Support Technology on Nursing and Medical Practice in U.S. Critical Care

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by Scott Weber, EdD, PhD-c, FACHE, FHIMSS

Assistant Professor, Health and Community Systems

University of Pittsburgh School of Nursing

415 Victoria Building, 3500 Victoria Street

Pittsburgh, PA 15261

E-Mail: webersjm@pitt.edu

Abstract

Aims and Objectives: To identify and explore the perceived experiences of nurses and physicians with incorporating an automated clinical decision support system in their critical care practices.

Background: Technological advancement has created ethical practice dilemmas in critical care settings. Information technology and statistical analyses have the potential to both further complicate and to contribute to the resolution of changing practice patterns.

The decision support technology used by participants in this study was the Cerner Acute Physiological, Age and Chronic Health Evaluation (APACHE) III system. The key function of this type of system is to predict the outcomes of decisions made in real life situations. The Cerner APACHE III provides decision support for situations such as: patient transfer and triage, life sustaining treatments, ventilation, hemodialysis, or the discontinuation of certain treatments.

Design: Descriptive interview-based design using qualitative methods.

Methods: Thirty-three healthcare clinical professionals working in a large U.S. medical center participated in in-depth interviews to describe their experiences integrating a clinical decision support system into their nursing or medical practices.

Results: Participants had strongly positive and negative impressions related to decision support system use in clinical practice. Participants opposed use of the computer as a "final decision maker" for patient care decisions, and had concerns about the issues of resource allocation so that insurers might acquire access to system information and use



it to deny services or payments to patients. Some participants felt that it was unethical or unprofessional to withhold system statistical predictions from patients and family members.

Conclusions: The issues underlying critical care clinicians' support or rejection of decision support technology must be examined more carefully to better define how to use this tool to optimally benefit patients and families and to better understand how use of these systems are influencing nursing or medical decision-making.

Clinicians in this study discussed their desire for transparency regarding use of the CSSD information, and provision of all information available as a way of supporting the autonomy of the family as they participated in end-of-life decisions. The consistent theme through all of the interviews was patient-family advocacy. Reservations about the use of CSSD were based primarily on the principle of non-maleficence. This demonstrates that patient care remains the central priority of the healthcare team.

Relevance to Clinical Practice: Using clinical decision support systems impacts health care practitioners' professional sensitivities as nurses or physicians in highly variable and often idiosyncratic ways. Dialogue between the professions of medicine and nursing could facilitate mutual understanding. Whether and how clinical decision support system analytic data are communicated to family members engaged in shared decision making regarding the withdrawal of life sustaining technologies depends on individual family circumstances.

Keywords: Clinical decision-making, clinical guidelines, multiprofessional practice, end-of-life decision-making, information technology, critical care

Introduction

Intensive care units (ICUs) are settings in which ethical and other practice dilemmas often arise. This conflicted work environment has the potential to powerfully impact staff. In fact, 45% of ICU nurses reported having left or considered leaving a position because of distress over professional decision-making and ethical practice (Hamric & Blackhall, 2007). Healthcare professionals rate situations in which they are pressured to prolong aggressive care as one of the most distressing (Hamric & Blackhall, 2007). Similarly, nurses and physicians cite uncertainty over matters such as "do not resuscitate" orders as problematic (Brett, 2002). Some family members have unrealistic expectations for the survival or recoveries of their loved ones. One study demonstrated that unrealistic family expectations are related to increased resource utilization without significant survival benefit (Berge, et al., 2005). Finally, another issue is the fact that nurses and physicians rate the communication between providers, patients and families as poor (Brett, 2002).

At the point of care level, many U.S. hospitals have implemented one type of information technology called a clinical decision support system (CDSS). Some of these systems are designed to assist clinicians, patients and families in making difficult treatment decisions.

The goal of the implementation of such systems is to provide clinicians with an additional source of objective information for clinical decision-making. Although there is evidence on the accuracy and implementation of these systems, little exists in the literature about how nurses and physicians use or experience the system, especially in critical, life and death patient care decisions. Unit culture can also affect timing of end of life decision-making and use of technologies (Baggs, et al., 2007). Therefore understanding the pattern of CDSS use within the unit is also important in understanding individual clinician use of CDSS output in decision-making with families and patients.

Background

Clinical decision support systems (CDSS) use technology to support clinical decision making by interfacing evidence-based clinical knowledge at the point of care with real time clinical data at significant clinical decision points (Snyder-Halpern, 1999; Spooner, 1999; Sim et al., 2001). First generation CDSS were developed in the 1950's (Miller, 1994). Modern clinical decision support systems were introduced in healthcare settings in the early 1980s (Knaus, Wagner & Lynn, 2001). The term 'decision support system' is often used generically and can refer to a variety of types of systems. Typically, the uses of CDSS in clinical decision making fall into one of four categories 1) generate alerts in response to clinical data; 2) critique care decisions; 3) recommend interventions at the request of a care provider; or 4) conduct retrospective quality assurance reviews. CDSS that use an active interaction model, such as generating clinical alerts or reminders based on clinician data entry and interaction, have been shown to be the most effective in improving clinical practice (Kawamoto, Houlihan, Balas, & Lobach, 2005).

The decision support technology used by participants in this study was the Cerner Acute Physiological, Age and Chronic Health Evaluation (APACHE) III system (Knaus, et al., 1991). The key function of this type of system is to predict the outcomes of decisions made in real life situations. The system is not meant to replace human judgment, but to support it as the name implies. This enables clinicians to consider all options and choose the best actions with the support of system predictions. The Cerner APACHE III provides decision support for situations such as: patient transfer and triage, life sustaining treatments, ventilation, hemodialysis, or the discontinuation of certain treatments. It calculates predictions by using logistic regression analysis and discriminate function analysis. The system consists of two parts: a daily score of acuity and mortality and a series of predictive equations linked to a reference patient database.

Most of the data required for the Cerner APACHE III system is transferred automatically when the nurse completes routine documentation of care. The data are then transferred from interfaced computerized systems, including: the electronic patient record, laboratory information system and respiratory care documentation system. Once a day, a nurse is required to enter a small amount of additional data such as the Glasgow Coma Score, acute myocardial infarction or open-heart surgery history and operative diagnoses.

There is evidence supporting the accuracy of the predictions produced by the Cerner APACHE III system. There is a strong positive correlation $r .95$ ($p < 0.05$) between Cerner APACHE III system-prediction and actual observed patient outcomes (Knaus, et al., 1991). Notably, studies show that correlations with outcome predictions are strongest in patients with the highest acuities (McClish & Powell, 2004; Brannen, Godfrey & Goetter, 2006).

Methods

Design

The purpose of this study was to identify and explore the perceived experiences of nurses and physicians as they incorporate an automated clinical decision support system in their critical care practices. The purpose of the study was to explore how clinicians use CDSS systems in general. The Cerner APACHE III system is a prominent and widely-used CDSS and this was the system in use in the 3 critical care units in which the study was based.

The investigator chose a qualitative study design using the grounded theory method. Grounded theory is an inductive method of inquiry and is particularly useful when little is known about a topic (Glaser & Strauss, 1967; Glaser, 1978; Strauss & Corbin 1990).

The research question for this study was as follows: "What are the experiences of critical care nurses and physicians using a clinical decision support system?"

Corollary research questions include:

- (2) For what types of patient care decisions have nurses and physicians used the Cerner APACHE III system in critical care?
- (3) What factors do critical care nurses and physicians perceive as enhancing their use of the Cerner APACHE III system?
- (4) What factors do nurses and physicians perceive as barriers to their use of the Cerner APACHE III system in critical care?
- (5) What is the perceived value of the Cerner APACHE III system to critical care nurses and physicians in their decision making process?

Selection of Grounded Theory as the Method for Data Analysis

Grounded theory was selected as the method of analysis of data because it is a systematic generation of theory from data that contains both inductive and deductive thinking, an approach which was needed to address our research question. Our goal, and a core goal of grounded theory analysis, is to discover the participants' main concern and identify how they continually try to resolve it (Glaser, 2001). The questions we asked,

implicitly, included “What’s going on?” and “What are the main practice dilemmas of the participants? How are those quandaries impacting professional practice of the participants, whether nurses or physicians?”

We attempted to answer these questions by our core variable and its subcores and properties as the study progressed (see below). According to Glaser, the grounded theory method does not aim for the “truth” but to conceptualize what’s going on by using empirical data (Glaser, 2003). In this way the method is said to resemble what many researchers do when retrospectively formulating new hypotheses to fit data. We did not start out with hypotheses, and in grounded theory the researcher does not pretend to have formulated the hypotheses in advance since preformed hypotheses are prohibited (Glaser & Strauss, 1967).

In addition, grounded theory is not a descriptive method, and the goal of our study was not, strictly speaking, to achieve accurate description. Instead our goal was to generate concepts that explain people’s actions regardless of time and place. In most behavioral research endeavors persons or patients are units of analysis whereas in grounded theory the unit of analysis is the incident (Glaser & Strauss, 1967). Our objective was not to simply ‘report facts’ but to derive a set of probability statements about the relationship between concepts, “an integrated set of conceptual hypotheses developed from empirical data” (Glaser, 2001). In this way, validity in its traditional sense is not an issue; instead validity should be judged by fit, relevance, workability, and modifiability (Glaser & Strauss, 1967; Glaser, 2001; Glaser, 2003). We continually evaluated our assumptions for generation and analysis of our data according to these key principles of grounded theory.

Data Collection

Setting

The Institutional Review Board approved this study for the Protection of Human Subjects at the hospital research site and the academic partner organization. In addition, all participants gave written consent to participate in the study. Data for this research was collected over a four-month period during 2009. The setting was a large, 380-bed, acute care hospital in the U.S. The medical center housed three intensive care units with a combined total of 86 beds. All critical care units had been using the Cerner APACHE III clinical decision support system for approximately nine years at the time of this study.

Sample

Inclusion criteria for the study included the following: participants had to be a registered nurse or physician working in at least one of the three critical care units at the research setting, they had to have completed at least one method of training with the Cerner APACHE III system (classroom training, one-on-one, or self-study), they had to have access to the system and be English speaking. No requirements for how subjects used

the CDSS were set at the outset since all participants had basic access to the system and system use (beyond basic nursing documentation) was optional. Participants for this study were recruited using convenience and purposive sampling methods. A total of 33 participants were included in the study ($N=33$). Participant characteristics can be found in Table 1. Demographic data did not specifically emerge or influence the results in this study.

Table 1. Participant Characteristics

	Physicians ($N=10$)		Nurses ($N=23$)	
	<i>N</i>	%	<i>N</i>	%
Ethnicity				
White	21	90	8	80
Black	1	5	0	0
Hispanic	1	5	1	10
Asian	0	0	1	10
Length of System Access				
14 Months	10	43	5	50
10 Months	13	57	5	50
Type of System Education				
Formal Class	23	100	0	0
1:1	0	0	0	0
Self-Study	0	0	10	100
Type of Critical Care Unit				
Respiratory ICU	15	66	5	50
Coronary Care ICU	4	17	2	20
Surgical ICU	4	17	3	30

Data Collection Procedures

In-depth interviews were used to collect data for this study. All interviews were conducted using in-person, face-to-face format, with the investigator during non-work hours for the participants. The interviews ranged in length from 50 minutes to one hour and 40 minutes.

A semi-structured interview guide was used during the interview process and was revised once in accordance with findings during the initial phase of the study (see Table 2). Participants were encouraged to freely discuss their experiences and perceptions related to their use of the Cerner APACHE III decision support system. The semi-structured interview format changed several times during the study as theoretical sampling stimulated new questions and perspectives. All interviews were audio taped and transcribed. The researcher also manually recorded field notes.

Table 2: Initial and Revised Interview Guides

A. Initial Interview Guide

Participant Code: ____ Date: ____ ICU: ____ Profession: ____ Time Start: ____ Time End: ____

I am interested in learning about your experiences with the Cerner APACHE III computerized clinical decision support system in your critical care practice setting.

1. Tell me about your experiences with the Cerner APACHE III system.

Probes: events, making decision to use, use for what reasons, feelings related to use of clinical decision systems

2. How would you describe your experiences with the technical process of accessing the Cerner APACHE III software and its use?

3. How would you describe your overall use of the Cerner APACHE III CDSS in the ICU?

4. Please tell me about what kinds of patient care decisions you have used the Cerner APACHE III system.

5. What factors enhance your use of the Cerner APACHE III system in your critical care setting?

6. What factors have been, or do you see as potential barriers to the use of the Cerner APACHE III system in critical care settings?

7. What value do you think the Cerner APACHE III system has for you and your patients?

Probes: desirability, utility, worthiness, help to you, what ways?, help to make patient care decision making?

8. In your opinion, what are some of the reasons why the system should not be used?

Probes: thoughts, feelings, in-patient care process, what part of patient care process?

9. What are some of the reasons why the clinical decision system should be used?

10. Please describe how often you use the Cerner APACHE III system in your critical care setting?

Probes: daily, multiple times a day, depend on acuity of patient, weekly, not at all

11. What is your view of why a clinician would use the Cerner APACHE III system as an aid to planning?

Probes: thought, feelings, experiences

12. For what types of patient care decisions do you perceive the Cerner APACHE III system would not be useful?

13. How do you feel about using a computerized decision support tool to help you make decisions about patient care?

Probes: experiences, perception, sense of systems

14. Please describe your feelings related to using the Cerner APACHE III for patient care decision making process, or for anything else you may be using it?

15. I am interested in your views relating to why you would not likely use the Cerner APACHE III system to assist you in patient care decision making.

16. Is there anything else you would like to share with me in regard to your experiences with the Cerner APACHE III system in your practice setting?

B. Revised Interview Guide

Questions Added:

17. What is your view of how patient/family care preferences affect decision making that is supported by a clinical decision system?

18. Please tell me about how you have used the system prior to actually making patient care decision.

19. In your opinion, what are some of the reasons why you would use the Cerner APACHE III system prior to actually making patient care decisions?

Questions Deleted and Rationales:

Based on pilot testing, #8 was deleted because it was determined to be redundant to #10 and #15. Also, it was deemed too difficult for participants to answer. Participants were unsure of time-use aspect because of day-by-day variance.

Analysis

Data was analyzed using the process of constant comparative analysis. This process was started after the first interview and continued throughout the study. Immediately after each

interview, the investigator reviewed each audiotape for quality and data content. Next, the data was imported into the *QSR N5* software package for qualitative data analysis. This software assists with the organization of data, including filing, marking codes, searching and retrieving (*QSR User Guide*, 2008).

Findings

Study recruitment continued until theoretical saturation was reached as themes became repeated, no new data were revealed, and clear patterns emerged from the data. The unifying theme expressed implicitly in every interview was that of human caring, Ethical concepts of respect for persons and advocacy for patients and families were repeatedly described in the narratives describing impacts on professional practice. The clinicians valued their roles in sustaining human life and promoting ethical human interactions. They expressed concern that the use of CDSS as a tool to prematurely discontinue life sustaining medical treatment could cause harm and not be in keeping with their ethic of respect for human life.

The theoretical framework that was inductively derived from the data is presented in this section. This theory provides an understanding of participants' experiences with clinical decision support system (CDSS) technology use in critical care settings. Brief excerpts from participants' experiences with using the system are presented to substantiate the core variables that emerged: "Forecasting Decision Outcomes" and the five major categories that were revealed:

- (1) CDSS inferences,
- (2) understanding CDSS technology,
- (3) creating CDSS inferences,
- (4) comparing CDSS derived data, and
- (5) trusting CDSS data.

The participants' level of system satisfaction is described and related to the five major categories and to the participants' level of system use. The corresponding levels of use, including no system use, system data entry use, and integrating CDSS-derived data into patient care decision making in collaboration with clinical expertise are also presented. A graphic representation of the core variable forecasting decision outcomes, the major theoretical categories and corresponding clinical decision system level of use and their relationship to satisfaction and dissatisfaction are presented in Figure 1.

Figure 1: Forecasting Decision Outcomes Model

Core Variable: "Forecasting Decision Outcomes"; Six Theoretical Categories, Levels of CDSS Use, and CDSS Satisfaction Levels



LEVELS OF CLINICAL DECISION SUPPORT SYSTEM USE

The First Major Theme to Emerge:

Rejection of the CDSS as the Final Decision Maker

Many participants in the study articulated their position that the decision support system predictions should not substitute for patient, family or clinician decisions. They were firm in their convictions that clinical decision making should remain in the hands of families and professionals rather than computers. This was an unexpected finding since we were not necessarily seeking to understand the use of APACHE in the context of end-of-life decision making; instead, this is what emerged from non-specific questions about decision support systems. However, two participants voiced fear and concern about using the system in patient care. A registered nurse who had not used the system, even though it was a unit-based standard of care, stated:

“I really worry about the system information because I think it could be used to hasten the withdrawal of active care, kind of like a finalizing tool. Docs and nurses could go to the technology and say, ‘Oh, mortality is so high here; let’s just put an end to this patient’s care.’ Using information, I think, just threatens those relationships.”

A second nurse who also refused to use the system, felt that computers, as well as humans, should not play a role in patient care decision making.

“We need to do everything for patients until a higher being decides differently, not a machine and not humans”

These two participants held very strong views that prohibited them from using the system for patient care. In probing more deeply into their reluctance to use the CDSS it became clear that they both held an antipathy toward use of any kind of machine as even just an adjunct to clinical decision-making. Others were more moderate in their opinions while still agreeing that clinicians and families should have the final say in decision making.

One physician expressed his viewpoint that the Cerner APACHE III predictions could be used to bring to an end to situations he considered unethical. Below he describes the possibility of presenting CDSS predictions to an ethics committee to validate withdrawal of life support. He commented:

“One type of decision where I think the technology would be helpful is for bioethics. When the patient continues to suffer when there is a 98% predicted mortality, I think we need to take some serious measures and go to bioethics with the APACHE information and all other information to resolve an unethical situation. We could say the patient has a 2% chance of actually having a viable livelihood based on our judgment and the APACHE data. However, it should never be used alone as a finalizing tool, to finalize care.”

Physicians consistently indicated that CDSS was used as an adjunct to clinical decision making, not the dominant component. This contrasted with the two nurses' fears regarding use of CDSS as a finalizing tool. Participants did not discuss whether they ever discussed this with each other, or whether their education or training may have influenced these beliefs.

The Second Major Theme to Emerge:

Concerns Regarding Resource Allocation

Participants voiced the fear of loss of professional control and autonomy in regards to resource allocation. Clinicians brought up the apparent threat of third party entities obtaining system data. They feared that organizations, such as insurers, might obtain data and use it in a threatening manner. For example, payers might use system predictions to allocate patient care resources, deny care or make reimbursement decisions. They felt that their ability to advocate for their own patients could be jeopardized. Both nurses and physicians feared that those organizations might also challenge clinicians' decisions when they contradicted system predictions. This emerged as a major control issue. One physician participant expressed his fears:

“Eventually, third party insurers will gain access to system data, and they are going to start saying, ‘No, we’re not going to pay for this. The predicted mortality for this patient was 99%. Why did you provide such aggressive treatment?’ We have already turned too much control over to outside decision makers in health care. Doctors are complaining they need approval for this and that. We don’t need another loss of control in decision making.”

However, not all system users viewed third party access to information as negative. One physician felt that sharing system predictions with insurers would give him more power to allocate resources as he saw fit to benefit his patients. He commented:

“If, or I should say when insurance companies get their hands on technology data, I think it will be to the physician’s advantage. It’s all a matter of who’s in control. If I’m asked why I continued the patient’s ICU stay and treat the patient, I could use the APACHE information to substantiate my decisions. Do I feel I have to do this, prove my decisions? No. But if it will help the patient’s hospital bill, I will use the data.”

These statements by physicians are not implausible. A recent study of computerized decision support tools described an institution that routinely shared mortality predictions with insurance companies (Jennings, 2006). They viewed this as a positive opportunity to demonstrate that they were utilizing resources effectively (Jennings, 2006). Our participants indicated that clinicians should use caution when voluntarily sharing system predictions with third party entities due to the risk of unintended consequences.

The Third Major Theme to Emerge:

Responsibility to Share with Family

Although Cerner APACHE III predictions were not routinely shared with family members, when they were, participants viewed it positively. One nurse felt that when families asked for more information, clinicians had a responsibility to share APACHE predictions. She stated:

“After I learned about the APACHE system and system overall, I began to think about how this information may be of help to patients, and particularly family members who are trying to decide what to do for their significant other. I think we now have the data, so we need to share it with family members.”

Another participant, who was a physician, had similar feelings, as evidenced in his comment:

“From an ethical standpoint, if we have information, then we are ethically bound to share it with the patient and/or family. We need to tell consumers that we now have a mechanism to give us some predictions, some good predictions on how their loved one is going to do. This will build trust between practitioners and patients or their families.”

Some participants believed that the APACHE predictions were especially valuable when family members had unrealistic expectations for the patient’s survival. For example, when the patient’s estimated mortality is very high based on professional judgment. They felt that at times the predictions helped family members to make the difficult choice of discontinuing life support. A nurse clinician explained:

“The most common type of decision I think the APACHE should be used to help with, and I stress just used as one other piece of information, is life support withdrawal, especially when the family is unrealistic about how their significant other is doing. The physician has said, ‘Based on many other patients in the same situation, the probability of survival is 2%.’”

This particular nurse pointed out the importance of human interaction and the fact that a computer could not emulate this aspect of patient care. All of the responses from participants demonstrated that they viewed sharing with family members as positive and at times felt duty-bound to do so. This represents a departure from one study in which clinicians routinely concealed system use from families so that they did not seem preoccupied with profits, rather than patients (Jennings, 2006).

The Resulting Grounded Theory:

Forecasting Decision Outcomes

The core variable, “Forecasting Decision Outcomes”, was identified by the investigator following the analyses of interviews with nurses and physicians who had experiences with the Cerner APACHE III clinical decision system in critical care. The terms “forecasting” and “predicting” were used frequently and interchangeably by participants.

Participants’ key perception was that the unique contribution of CDSS technology to clinical decision making is its ability to predict or forecast patient outcomes prior to actual decision making. Examples of these outcomes include: patient mortality, length of stay, patient acuity, probability and usefulness of active treatment, and need for a critical care bed. As one physician participant who frequently used the CDSS stated,

“If we believe that mortality is high for the patient, and the data supports this, the outcomes of some of our decisions can be forecast before we even make them, like aggressively using vasopressive drugs when the patient’s mortality is very high. Chances are the patient will expire no matter how aggressive we get, so we can begin to predict the outcomes of some of our decisions before we make the actual decision.”

Participants who used CDSS technology to forecast decision outcomes were more educated about the technology, had a longer period of time with which they had access to this technology, tended to be older, and had more years of clinical practice experience. Conversely, participants who used this technology less and did not use the Cerner APACHE III system to forecast decision outcomes were less educated about system technology, had shorter time where they had access to CDSS technology, and had fewer years of clinical practice experience.

Prior to using a CDSS to forecast decision outcomes in critical care, nurses and physicians described a process involving a series of decision phases which either led to participants' decisions to use or not to use the CDSS. These phases, which represent the major theoretical categories, are:

- (1) learning CDSS technology;
- (2) understanding CDSS technology;
- (3) creating CDSS inferences;
- (4) comparing CDSS derived data; and
- (5) trusting CDSS data.

Nurses and physicians described their decision to use the system for forecasting decision outcomes as a linear process. However, the process became reiterative when participants experienced dissatisfaction during one of the phases within the process used to decide whether to use the CDSS. The experience of gaining satisfaction was defined as:

- (1) accepting the concept of using a computerized system to support clinical decision making;
- (2) gaining a basic understanding of how the system is used in the clinical setting;
- (3) finding strong positive correlation between the system-derived data and actual observed patient outcomes; and
- (4) trusting the CDSS data.

Dissatisfaction was defined as:

- (1) rejecting the concept of using a computerized system to support clinical decision making;
- (2) finding weak correlation between the system-derived data and actual observed patient outcomes; and
- (3) not trusting the system-derived data.

The reiterative process continued until nurses and physicians were satisfied with their experiences from each phase. Participants' levels of satisfaction or dissatisfaction directly determined their level of clinical decision system use. This was articulated by one participant who was a registered nurse with three years experience:

“I learned about the APACHE III system in the class that was offered. Immediately I had problems with the idea of using a computer to help make decisions about human lives. However, it is a unit standard that we enter data, so I do that, but I think it’s unethical to use this system to affect patient care decision making.”

Another nurse participant, who had attended the CDSS training class and had read a few articles about clinical decision support systems in the medical literature, clearly described the linear process she used to decide to use the system. Additionally, she described how her level of satisfaction influenced her decision to use the Cerner APACHE III system to forecast decision outcomes.

“I learned about using a decision system in patient care decision making from the class and from a little reading I had done. So I began to compare the APACHE data to what was actually happening with my patients. I found when the APACHE predicted mortality was high, the patient usually died. I then started doing this with more patients, not just mine, whenever I had time. What happened to the patient was similar to what I was seeing.”

The decision making process to use the system was terminated when participants experienced repeated dissatisfaction as an outcome of any of the phases. If participants experienced dissatisfaction following their initial experience in any of the five phases, they would repeat that phase two to three times. If dissatisfaction continued after two to three experiences, participants made the decision to use the system only at the data entry level.

For example, if dissimilar results were found when participants compared CDSS predictions to actual observed, the participant did one of three things:

- (1) stayed in the comparing CDSS-derived data phase and repeated the process;
- (2) returned to the creating CDSS inferences phase; or
- (3) demonstrated low level or no use of the CDSS.

A few participants (one nurse and one physician) chose no clinical decision system use after experiencing repeated dissatisfaction in the comparing CDSS-derived data phase. Conversely, if participants experienced satisfaction following a phase, they moved in a linear fashion to the next higher phase and eventually to the highest level of use, “forecasting decision outcomes.”

Use of the system for forecasting decision outcomes meant participants eventually progressed satisfactorily through all of the phases.

Major Theoretical Categories to Emerge from the Findings

Five major processes:

- (1) system learning;
- (2) understanding system technology;
- (3) creating system inferences;
- (4) comparing system-derived data; and
- (5) trusting system data,

led to the process of *forecasting decision outcomes*. They represent a linear progression through the process of using a clinical decision system with a potential of movement along the continuum of CDSS use based on satisfaction or dissatisfaction. Each category represents an integral element within the participants' descriptions of their experiences that led to using the clinical decision system in critical care practice at a forecasting decision outcomes level.

Summary of Findings

A clinical decision support system, such as the Cerner APACHE III, can evoke varying feelings and ethical viewpoints from members of the healthcare team. In this study, two of the eight nurses' feelings were so negative that they refused to use the CDSS. Both of these nurses used values-based arguments. One nurse commented that only God can make decisions regarding sustaining life and the other claimed that she feared that the technology could be used as a "finalizing tool" to make decisions to hasten the withdrawal of active medical interventions.

Physicians, overall, agreed that the CDSS should be only one part of clinical decision making, and that clinical judgment must dominate for end-of-life decision making. One physician felt that use of the system enhanced arguments presented to ethics committees when he/she was advocating for withdrawing medical interventions for a suffering patient

The participants expressed concern that third party entities, such as insurance companies, would gain access to the decision system predictions for individual patients, and that payment of benefits could be affected. They supported limitation of the sharing of information as a way of protecting both themselves and the patient.

Clinicians discussed their desire for transparency regarding use of the CSSD information, and provision of all information available as a way of supporting the autonomy of the family as they participated in end-of-life decisions. The consistent theme through all of the interviews was patient-family advocacy. Reservations about the use of CSSD were based primarily on the principle of non-maleficence. This demonstrates that patient care remains the central priority of the healthcare team.

Relevance to Clinical Practice

Although the findings cannot be generalized to all critical care clinicians, this study provides an accurate description of how CDSS impacted physicians' and nurses' perceptions of professional practice. The implications for practice are relevant to the education of practitioners about CDSS, utilization of predictions, communication to lay-person family members, and common assumptions regarding the interface of technology and ethical concerns.

Equity in education regarding CDSS was lacking. Nurses were provided no formal training for use of CDSS. Yet they were expected to regularly contribute to the database. Formal education of all practitioners using the system, including a discussion of its ethical limitations is necessary. If at least part of the training were shared by both the nursing and medical professions, dialogue could help establish that the system is used in the context of all other data, including nursing and medical judgment, and the dialogue might help dispel fears that CDSS will be used to justify premature discontinuation of life sustaining treatment.

Open and honest communication with families in critical care is the accepted strategy in the United States for helping families to cope with illness and the approaching death of a relative (Shannon, 2001). The role of the critical care nurse has expanded to include the responsibility of working with patients and families to provide (or assist them to access) information that will guide them in critical decisions (Browning, 2009). The American Association of Critical Care Nurses' public policy statement indicates that the critical care nurse's role includes respecting and supporting the right of the patient or the patient's designated surrogate to "autonomous informed decision making" (AACN, 2009).

Whether and how statistical information is provided to families, most of whom are lay persons with little medical or mathematical background, is less clear. Family members require time to integrate and realize the seriousness of their relative's illness (Swigart, 1996). Two thirds of family members in the ICU suffer anxiety and depression that may further cloud their ability to understand highly technical information (Pochard et.al, 2001). Adapting the complexity of the information provided to an individual family is sound practice, and waiting until family members ask about the statistical likelihood of recovery would seem wisely indicated.

Finally, this study focused on critical care clinicians' use of a very specialized type of information technology, one that shapes decision-making in the ICU. That the overarching or core theme was concern for human life, caring and respect, resonates as positive. This study portrays most clinicians actively in practice, using available technologies and attuned to an evidence-base, but yet clearly discerning the necessity to view this technology within the context of the individual patient's circumstances. Ethical concepts of respect for persons and advocacy for the individual patient and family were clearly demonstrated.

Conflict of Interest Statement

On behalf of the author of this manuscript, I have no conflicts of interest to report.

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Biographical Statement:

Dr. Scott Weber is assistant professor of Nursing and Public Health, University of Pittsburgh. He also serves as coordinator of the Nursing Education Area of Concentration. Dr. Weber is a fellow of the American College of Healthcare Executives and of the Healthcare Information and Management Systems Society.

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Wendy Seidlitz

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