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Computerized Decision Support Systems: Implications for Practice

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The informatics literature variously defines Computerized Decision Support (CDS) systems. These definitions are sometimes narrow and sometime broad, leading to occasional confusion in terminology. For purposes of this paper, a broad definition that enjoys some professional consensus has been adapted from Langston and colleagues: CDS systems encompass any computer software employing a knowledge base (facts and/or rules) designed for use by a clinician involved in patient care, as a direct aid to clinical decision-making [1]

Likewise, CDS systems vary in scope. Some systems may assist with a very narrow range of decisions (preventing pressure ulcers, troubleshooting pulmonary artery catheter wave forms[2]. Others are designed to assist with a broad range of decisions, such as COMMES (Creighton Online Multiple Modular Expert System) which was designed to provide consultation and suggested nursing care plans for patients with an extensive number of nursing and medical problems[3]. Finally, CDS systems vary in terms of complexity, ranging from simply providing access to reference materials to systems that transform data into information, combine the information with different kinds of information, detect associations between these different kinds of information to recognize patterns and present the new information to clinicians in such a way as to influence the immediate decision making situation[4]

CDS systems are most useful when they are part of an integrated information system. Pryor, in describing the development of an integrated hospital information system (HELP), reports that the process began with an analysis of all the CDS used within the hospital and culminated in the identification of six major uses of decision support[5]

1. Alerting: Alerting systems are those which notify the clinician of an immediate problem that calls for a prompt action or decision. These alerts are commonly clinician alerts that appear on the screen at the time of entry of orders, assessments or laboratory values. These systems may also provide management alerts based on problems with an individual patient (DRG cost overrun) or an individual clinician (use of expensive resources not generally warranted).

2. Interpretation: This type of CDS system is one that works to interpret particular data such as electrocardiogram or blood gases. A system such as this works by assimilating the data and transforming it into a conceptual understanding or interpretation. The interpretation is then presented to the clinician for use in decision-making.

3. Assisting: A CDS system that is used to speed or simplify the clincian interactions with the computer is classified as an "assisting" system. These systems usually assist in the ordering or charting process by offering the clinician such things as standing order lists, patient-specific drug dosing, or appropriate parameters for charting based on earlier identified patient problems.

4. Critiquing: The fourth use for CDS systems identified by Pryor is in "critiquing." Systems that do this are primarily in the research stage and not yet available for implementation. This type of system is usually designed to "critique" a set of orders for particular problems. For example, a clinician might enter orders for a change in respirator settings which the system would then critique in light of the most recently entered blood gases. The clinician would be presented with an alternate set of orders and the rationale for changes made. The clinician would have the option of accepting or rejecting the changes suggested by the computer.
5. Diagnosing: This type of decision support system uses general assessment data to generate suggested diagnoses. These systems may then ask for additional data so as to rule out, rule in or otherwise refine the list of diagnostic possibilities. Other programs that can be considered in this category are those that provide predictive scoring of mortality, estimation of treatment benefits based on effects of competing risks or prediction of specific risks (pressure ulcers, falls)[6]

6. Managing: The computer automatically generates the treatment or plan of care from assessment data and/ or diagnostic categories and the physician or nurse critique the computer and it's logic. While those with fixed protocols are easy to program and to implement, the lack of individualization to the clinician with the job of extensive critiquing. This type of system can be used in a developmental manner, however, so that clinicians give rationale for changing the plan or the protocol and this is used to determine further data needs and decision rules so that the protocols are further refined. The variation in intervention and the rationale offered can be combined with data of outcomes of care, to determine which interventions are most effective in producing the desired outcome, so the refined protocols result in a progressively higher quality of care. This process of validation and stabilization to achieve higher quality outcomes is referred to as "Clinical Practice Improvement"[7]

Some informaticists would argue that alerting and assisting systems are simply transaction rocessing systems because there is little or not data transformation or integration. This would depend to some extent on the complexity of the alerting and assisting system, however, and this distinction may not be as important to clinicians as to academicians.

The categories of CDS discussed above, while not exhaustive, are instructive and practical. Other types of CDS are also available or becoming available to the clinician. These include real-time access to reference materials, such as MEDLINE, CINAHL or some other knowledge based system[8,9] Also new combinations of CDS and simulations are being tried. While computerized training and simulations have traditionally been available only in classroom situations, there is work towards making them into useful clinical decision-support tools. For instance, this type of system may become part of certain ordering procedures. An example in the area of wound care would be a system that generates a list of available wound care products, a chain of decision rules related to wound dressing selection before the order is completed, and an imbedded video clip that demonstrates correct application procedures for the type of dressing. Model-based decision making systems are also available but are not in wide clinical use[9]. These systems assist the clinician (or the patient) to choose from among multiple, potentially effective alternative interventions that have varying degrees of benefits, burdens and risks by weighting the factors. These may be more commonly used in management where modeling can be used to make projections based on trends in data, such as changes in patient demographics and sub-populations.

The promise of decision-support systems is great. Eddy believes that the complexity of modern health care has now exceeded the limitations of the unaided human mind[10] An

amazing example of that problem is the report of East and Morris that 236 variables were used in making decisions about management of mechanical ventilation in a critically ill patient[11] Furthermore, considering that there are only seven commonly used ventilator settings, they estimated there are more than 37 billion permutations available from these 7 settings. If properly programmed through numerous iterations in consultation with expert clinicians, CDS systems such as this undoubtedly improve on human decision-making. When CDS systems are developed with "specific executable protocols" and refined through both expert-clinician critique and incorporation of effective practices discovered through examination of severity-adjusted outcomes as they relate to specific variations in practice, these systems have the potential to simultaneously decrease harmful variation in care, improve clinical decision-making, optimize outcomes of care and thus cut health care costs [11,12] Because this type of CDS system, used in the process of Clinical Practice Improvement described above, produces dramatic improvements in quality of care and cost savings, it is entirely possible that this technology may be instrumental in saving the health care systems of all countries plagued with costs that outstrip the rate of inflation and consume a higher and higher proportion of their gross national product.

Problems and Issues in Implementation

Research has shown that the most important factors associated with success or failure of a DSS are directly related to the user[13,14]. This provides challenges across a range of factors. For example, a CDS system must have access to all information that the user deems necessary for decision support in solving a specific class of problems. This requires the system to be fully integrated with existing hospital information systems. Without this level of integration and access to pertinent databases, the support for problem-solving will fall short and the system will not be successful. Another factor influencing success or failure is the usability of the system. While CDS's are very comprehensive and powerful systems, the challenge is to design an interface that is highly intuitive since the users are primarily non-technical professionals with high domain, low technical expertise and little time. Hence, a system with a great deal of functionality but requiring two weeks to learn is not likely to be successful. The acceptance and use of DSS's also depends on the ability of the system to provide decisional support that is seen by the users as accurate and appropriate. Since the persons using such systems are experts in the problem domain, they can commonly recognize the degree to which this objective is met. Hence, systems with poor performance are doomed to early failure. However, the reason for the poor performance may not directly reside with the DSS. For example, a DSS relies on the input of many other systems, such as databases. If the data coming into the DSS is inaccurate or unreliable, it will not provide the decision support expected. On the contrary, it is likely that it will simply allow users to more quickly make poor decisions. Poor DSS performance may also stem from improper modeling of the domain due to poor domain information.

Often this is the result of too little involvement of the domain expert users during development. This is problematic, not only because of the enormous time commitment required on the part of the users, but also because the inherent evolutionary nature of DSS's. Since they are consciously iterative, in a sense they are never finished. Although there are many other implementation problems associated with DSS's, in general there are solutions that maximize the probability of a successful DSS. Careful development which involves the user(s) in non-trivial ways at every step is one of the major keys to success. In the U.S., integration with existing hospital information systems is complicated by many factors. First, no single information systems vendor has a dominate share the health care market which creates customization challenges. Second, a high percentage of health organizations

information systems are in a state of transition. Third, with horizontal and vertical integration of health organizations, it is not unusual to find a single organization with multiple information systems. Fourth, other segments of the health care delivery system are growing at a much faster pace than hospitals and have different decision support needs than hospitals. Optimal CDS systems must be designed with an appreciation for the diversity of hardware, operating systems, data storage formats and data element definition idiosyncrasies. Fortunately, many informaticists and some health reformers are working on solutions. For example, the HL-7 project is dedicated to establishing structural data transfer standards which ideally will allow across-platform communication without extraordinary customization or the use of generic (and expensive) interface engines.

Professional Concerns

While the professional concerns that most often find voice in the nursing informatics literature are related to patient confidentiality, the medical informatics literature tends to emphasize concerns related to professional autonomy and replacement of specialists with generalists. It is probably worthwhile to consider whether CDS systems would enable lesser educated persons to replace nurses, but it seems unlikely for the following reason. Even the most sophisticated CDS system, employing many highly-evolved specific executable protocols, would 1) still have many protocols under development that would require the input of many domain experts, 2) require professional nursing judgement to accurately identify situations in which the protocol should be countermanded, and 3) require professional nursing expertise to assure the accuracy of the on-going assessment data. There is also speculation that, given these systems are capable of providing a log of the decisions made by individual professionals and the outcomes thus produced, the information could be used to evaluate a person's performance for purposes of relicensure or recertification[15] This is an interesting idea that has some merit but some frightening implications. This is one more reason that nursing experts must move forward in identifying the unique outcomes of nursing care.

Legal Issues

Whether CDS systems offer legal protection or legal liability is completely dependent on the quality of the data entered and the integrity of the underlying facts and rules. For the most part a well-developed integrated system with several types of CDS system will offer protection from liability. For example, it can minimize several sources of serious error if it has a good alerting system, it can encourage good and consistent recordkeeping if it has a good assisting system, it can encourage consensus among professionals concerning the appropriate course of care if it uses a good managing system, and it can provide evidence of good outcomes in similar cases. To offer real protection, the facts and rules must be congruent with standards of care and must also consider national guidelines and new research findings. On the other hand, if staff are presented with an alert or a research based protocol and deviate from the recommendation without adequate justification and documentation, this fact becomes a weapon in court.

Ethical Issues

There are three basic ethical issues that are heightened when patient records are automated. These are issues related to protecting privacy, managing access and assuring accuracy[16] When one integrates CDS systems into the information system, assuring accuracy takes on new and ominous dimensions. As previously explained, poor information can result in poor decision-making. This means the nurse's ethical obligations extend to active involvement in the implementation phase of an information system, communicating problems and information needs to the systems managers and critiquing CDS systems for domain accuracy. Following

implementation, the nurse has an enhanced obligation to assure that digitized and mechanical input is accurate, that the data are complete and that he/she is using available CDS appropriately to enhance quality of care.In talking about specific executable protocols that have been developed using the known state of the science and the clinical judgements of multiple experts and refined through a process of validation and stabilization, East and Morris discuss use of these new CDS systems in light of the same ethical principles one would consider in implementing a new therapy[11]. These principles are nonmaleficence, beneficence, autonomy and distributive justice. Given that the development process alone generally produces a protocol that is superior to the practice pattern of any single clinician and that the clinician can override the protocol based on individual patient needs, use of this type of CDS would appear to maximize the potential for benefit and minimizes the potential for harm. Patients remain, as always, able to exercise their autonomy is refusing or accepting treatment. In addition, because the validation and stabilization process results in better knowledge of outcomes of treatment, clinicians should be able to assist patients in making more truly informed decisions. Distributive justice may also be positively impacted, given that superior care resulting in better outcomes generally minimizes complications and excess resource utilization, making certain resources less scarce and more readily available to others.

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