Running Head: EVALUATION OF A PHARMACY HIT SYSTEM

Summative Evaluation of a Pharmacy HIT System:

Factors Contributing to Success or Failure

Ken Bavier

Duke University School of Nursing

Hospital information technology systems (HIT) are playing an increasingly large role in facilitating the delivery of safe and efficient care while meeting data collection requirements for management and IT decision-making. Careful evaluation of these systems provides the investigator with information which can be used to improve the adoption, safety, efficiency, and effectiveness of such systems now and into the future. "A systematic assessment of health information technology is the precondition for better support of patient care" (Ammenwerth, Mannsmann, Iller, & Eichstadter, 2003). In addition, the Institute of Medicine has stated that "…a sizable portion of the recommended Health Care Quality Innovation Fund should be invested in projects that implement and evaluate IT applications and are likely to contribute to quality improvements" (Institute of Medicine (U.S.). Committee on Quality of Health Care in America, 2001). In light of the identified benefits of HIT systems, and considering the costs associated with their high rate of failure (Kaplan, 2001), evaluation should be viewed as an essential and ongoing part of any HIT project.

Kushniruk states that "Evaluation in health informatics spans a continuum from project planning to design and implementation" (Kushniruk, 2002). He describes this as an iterative process where methodologies specific to each phase of the system development lifecycle (SDLC) produce results that guide further improvements in the system. Formative evaluations and usability testing typify early stages of development and implementation, providing guidance in design and configuration as well as revealing strengths and weaknesses present in the system. Evaluation conducted during the implementation and maintenance phases of a SDLC allow for the management of those identified weaknesses as well as reconfiguration of the interfaces to reflect changing user

requirements. Summative evaluations occurring at the conclusion of each phase and at the end of the project lifecycle are useful to generalize within the organization at a minimum, and if done well can be generalized to other HIT environments as well.

This document focuses on the evaluation of a pharmacy medication management system geared toward an inpatient population. An extensive literature search was conducted, to include database searches of CINHAL and Medline, along with a web search using Google Scholar's search engine. Results were limited to English language documents occurring since 1990. It is noted that there are works earlier than 1990, however, no identified studies were specific to pharmacy HIT system evaluation.

DeLone and McLean's updated IS Success Model (Figure 1) (DeLone & McLean, 2003, p. 24) was used as a theoretical framework for the evaluation of the pharmacy HIT system. Evaluation criteria identified in the literature search were then collected (Appendix A) and reviewed for applicability to this project.

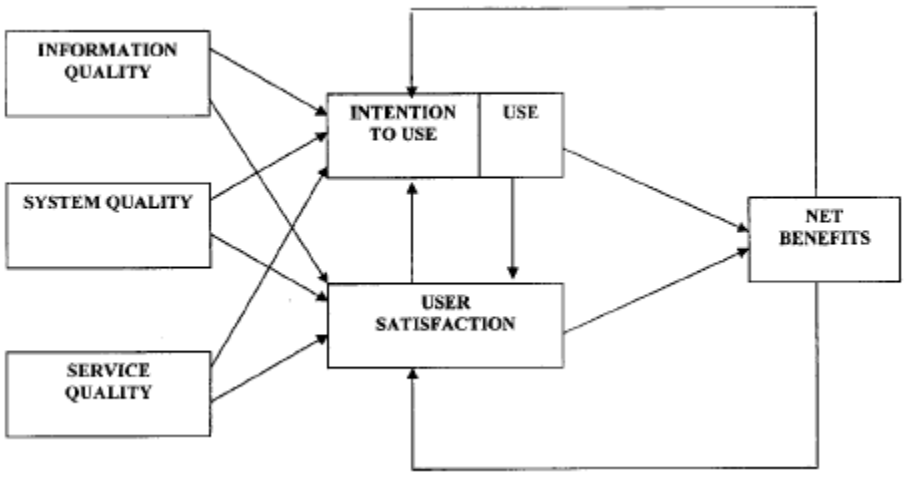

Figure 1. Updated DeLone and McLean IS Success Model. Depicts the system characteristics and feedback loops which can have a positive or negative influence on the success of the system.

Ten top criteria (Table 1) were selected based on the system being evaluated, in conjunction with information gathered during the interviewing of the pharmacy subject-matter expert at the hospital in question, and with the intent of reflecting on each of DeLone and McLean's' 6 domains of IS Success Model. It is important to note that many criteria overlap in their focus, and have been consolidated to facilitate the scope of this project. Evaluation questions were developed based on the top ten criteria to be administered using a PDA device to three end users. Additional questions were also developed to reflect the quality of the PDA evaluation tool itself.

Table 1

Top Ten Pharmacy Evaluation Criteria

Cost
Data Protection / Security
Accessibility of Data Produced / Stored
Usability
Reliability Of Hardware / Software
Exhaustiveness
Adaptability / Modifiability
Interoperability / Connectivity / Able to Interface
System Performance / Scalability
Does system meet needs of stakeholders

Results obtained using this evaluation tool are intended to provide information that will help further improve the existing pharmacy HIT system, give

insight into the process of evaluating such systems, provide guidance in how to improve the data collection instrument, and foster improved dialogue among stakeholders. It is the focus on the needs and opinions of all stakeholders that makes the results of an evaluation accurate in identifying strengths and weaknesses over the SDLC

Cost: A theme that is pervasive is most HIT literature, reflective of the challenges faced by organizations trying to grapple with large financial expenditures at a time when reimbursement is declining. Managed care and Insurance companies stand to gain from the computerization of hospital systems, yet bare no portion of the cost of implementing such systems. Much of the risk is carried by health care providers. If cost is included in the evaluation process, that information can guide future financial decision-making. When considering the cost of a system, we are really evaluating a number of factors. Saba states that a "cost-benefit analysis is necessary to determine if the system is worth its price" (Saba & McCormick, 2001). This analysis would take into consideration the cost of purchasing, maintenance, and training as well as the changes in productivity and administrative burden that result. These are examples of system qualities that influence the outcome of any HIT project. If the organization under evaluation cannot afford the HIT system that they are trying to implement, failure is likely. Clinicians may also view the expense of such a system as taking away from other more vital needs and resist its successful implementation. In the case of pharmacy HIT systems, savings from tighter control of medication stocks, prevention of accidental outdating of stocked medications, and compliance with state and Federal rules governing medication storage and retrieval can offset some of the costs associated with purchasing and maintaining such a system.

Data protection and security: These principles are increasingly important in preserving the sanctity of the provider – patient relationship. Patients who do not trust that their data will remain confidential will be hesitant in providing it in the manner necessary to deliver effective patient care. Regulations regarding data privacy and security in electronic systems exist at both Federal and state levels in the U.S. (HIPPA), but difficulties can be seen with data that is traveling across state borders where different privacy laws apply. In *Driving Toward Guiding Principles: A Goal for Privacy, Confidentiality, and Security of Health Information*, Buchovich, Rippen, and Rozen (1999) described privacy and security principles that technology is able to address. These include de-identifying patient records for research purposes, granting or restricting access to information based on policies and law, security in transmitting records using encryption and other means, and the vigilant maintenance of audit trails. Pharmacy HIT systems capture confidential data related to both the patient (frequency of use of narcotics and/or medications that they are taking) and the provider (was the med given on time, the correct dose, does the documentation reflect care provided?), and must conform to these criteria if they are to promote the type of outcomes that are desired. These considerations relate to the area of information quality according to the IS Success Model (DeLone & McLean, 2003).

Accessibility of data produced: The primary reason for embracing HIT is to allow for the collection and subsequent generation of knowledge from the volumes of data that are collected each day. Data that is not easily accessible cannot be used to generate knowledge, support daily operations, or facilitate effective patient care rendering the entire system a liability rather than an asset. Pharmacy systems that integrate with the

ordering and charting systems allow for data patterns to be examined that were previously difficult to coordinate. In addition to data retrieval, positioning of the computer terminals such that they augment the provider workflow is essential in encouraging staff adoption (Saba et al., 2001). Conversely, terminals that are located away from the patient care areas fosters old methods of documentation which result in a decrease in data entry and less frequent review of data contained on those terminals.

Usability of the interface: Usability studies are prolific throughout the evaluation literature reflecting the importance of designing and configuring computer interfaces to work naturally with the processes of providing care. Burkle stated that "Even if a system has been verified and validated, it may be so awkwardly designed that it cannot be used in real life, because using the system is either too cumbersome or consumes too much time" (Burkle, Ammenwerth, Prokosch, & Dudeck, 2001). This is further corroborated by Kushniruk who stated "In the field of medical informatics, issues of usability have come to the fore, with the ultimate acceptance or rejection of systems such as computerized patient records depending to a large extent on their degree of usability" (Kushniruk, Patel, & Cimino, 1997). Nurses and other providers are already working at high productivity levels, and the addition of HIT products must not add to their workload in any significant way. Pharmacy dispensing systems are used frequently by providers, thereby requiring that the interface be simple and intuitive. If the interface is bulky or cryptic it may magnify the risk of making errors or prolong the time it takes to provide treatment.

Reliability of System: Paramount in the realm of HIT is the requirement that systems are reliable over extended periods of time. Many health care operations operate

on a perpetual basis, making hardware or software failures not only annoying, but also highly disruptive to the business process. In addition to hardware and software reliability (which is a system quality) is the frequently overlooked evaluation of the vendor's reliability. This relates to the likelihood that the vendor "will survive and service our account through the life of our purchase" (Grams, 1998). Grams goes on to describe the difficulties that can occur if a vendor goes out of business or is acquired by a competitor. Their product upgrades can cease, access to proprietary code can become impossible, and the organization can loose the ability to access existing data repositories. Careful investigation into companies, their support policies, and their service track record can do much to allay fears of reliability issues after the sale. Vendor attentiveness could be categorized as a service quality in the context that pharmacy systems are mission-critical to inpatient care environments and require high levels of reliability and "up time".

Exhaustiveness: This concept relates to the extent that the HIT system addresses all aspects of scenarios that are likely to occur within an organization. Palvia, Sharma, & Conrath (Palvia, Sharma, & Conrath, 2001) listed exhaustiveness as one of 39 key concepts of a system (technology dimension). Early evaluative interventions allow for the opportunity to assess needs and ensure that those needs are addressed during the configuration of the system from the outset. Ongoing evaluation of the systems exhaustiveness will likely reveal areas of weakness that can be improved as the system evolves to meet the changing face of the organization within which it exists. If the system is not exhaustive, documentation will be inefficient, staff will be frustrated with the frequent need for improvisation, and the system will fail to meet organizational needs.

Adaptability/Modifiability: Within the context of an organization, an HIT system must conform to workflow processes and structural frameworks. These processes change over time, becoming inefficient and thereby affecting service quality. Systems that are operating in a manner that is no longer congruent with the organizational workflow lead to a decrease in user satisfaction and consequently decreased use (DeLone & McLean, 2003a). Changes in the physical size and structure of an organization or their data collection and maintenance requirements also occur over time. Systems that are adaptable in their design and configuration are easily reconfigured to account for these changes. Advances in equipment may require that a portion of the system be modified, and the rate of technology changing in Medicine is accelerating, making systems which are not very adaptable, quickly outdated.

Interoperability / Connectivity / Able to Interface: These three similar concepts have slightly different meanings but address similar concerns in the evaluation of any HIT system. Due to the significant number of concurrent systems that exist in most health care organizations, it is important that HIT move towards being more standards-based and able to productively co-exist. Data collected in one system may be useful in another system. Without the ability to interface or integrate with each other, the data cannot be easily assembled for the construct of knowledge. Palvia, et al. describes this characteristic as interactivity, and ranks it within their top ten evaluation criteria (Palvia et al., 2001). As HIT systems become more advanced and pervasive, these criteria will gain in importance. Pharmacy HIT systems can offer additional benefit to clinicians through connectivity with ordering systems (lab and medication documentation) and

provider documentation systems (allergy and lab result considerations) which are only starting to be realized.

System Performance / Scalability: Described by our pharmacist, Dave Haddon, as one of the key benefits of the selected Pharmacy HIT system, high performance scalable systems allow headroom for growth in the future, and operate smoothly in their current state. Pharmacy systems typically have large numbers of concurrent users entering critical data into remote systems. Rapid processing of such transactions prevents the system from decreasing provider productivity and negatively impacting user satisfaction. According to Dave, the network node style of system organization lends itself to expansion within the facility as well as to outlying satellites where restocking and medication outdates as well as the management of controlled substances is more difficult.

To what extent does the system meet the needs of Stakeholders: The last but arguably most important criteria to evaluate is the extent to which the system meets the need of all stakeholders (Chan, 2002; Kaplan, 2001; Palvia et al., 2001). This is usually accomplished by identifying and involving them in the system selection or configuration (the formative process). Due in part to the highly political nature of such system selection processes, this is often overlooked to the detriment of the entire project. Seeking information via qualitative surveys and question/answer sessions allows for needs, concerns, and misconceptions to be heard and addressed at the outset, before it is not feasible or prohibitively expensive to address.

In the evaluation of the pharmacy HIT system I reviewed, the primary stakeholders were identified to be administration (management), pharmacists, pharmacy technicians, and nurses. In order to evaluate these criteria with respect to the pharmacy

system, a PDA tool was developed with questions addressing each of the top ten criteria. Additional questions were added to evaluate the PDA tool itself.

Using a database creation program, a form tool is being developed which allows data to be entered, by end-users, on a PDA. Then the data will be analyzed to search for clues as to the strengths and weaknesses of the subject system. Preliminary use of the tool leads me to believe that evaluators who are not accustomed to that platform will find the tool somewhat difficult, though the questions have been designed in a way that makes the answer format consistent.

It is apparent after searching the literature that there are a myriad of criteria and techniques to use when conducting an HIT evaluation. These criteria have to be selected based on the system being evaluated and the context within which the evaluation occurs. Using DeLone and McLean's IS Success Model as a framework can help evaluators understand the factors that are influencing the success or failure of the system. Assuring user satisfaction is only achieved by addressing the factors influencing system, information, and service quality on a longitudinal basis from the formative evaluation to the summative and maintenance phases.

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Appendix A

Evaluation Criteria Identified in Referenced Literature:

I. Accuracy, Timeliness, reliability, training, ease of use, legibility, completeness, flexibility, conciseness, overall performance, accessibility, reduces costs, prevents errors or saves lives, does it capture nursing care, enhances work situation or contribute to employee satisfaction, efficiency, does it reduce administrative burden (Saba et al., 2001).

II. Difficulty, scarcity, utility, confidence, realism, criticality, novelty, simplification, interactivity, codability, operativeness, speed, exhaustiveness, inference, explainability, augmentation, specificity, precision, presentation, compatibility, documentation, user-friendliness, modifiability, stimulation, relief, non-threatening, managerial approval, enthusiasm, personnel assistance, inclusion, expert helpfulness, bureaucratization, education, adaptiveness, agreement, agreement, innovation, performance, feasibility, competitiveness (Palvia et al., 2001).

III. Accuracy of Information, timeliness and currency of information, user satisfaction and attitudes toward system, internal controls, project schedule compliance, adequacy of information, system security and disaster protection, Hardware performance, System performance versus specifications, system usage, user friendliness of system – user interface, quality and completeness of system documentation, system's impacts on users and their jobs, net operating costs – savings of system, quality of programs, system's fit with and impact upon organization (Kumar, 1990).

Appendix B

PDA question and answer format (5 pt Likert Scale):

Example:

[Strongly Disagree Disagree Neutral Agree Strongly Agree]

1. The Omnicell Pharmacy system was worth the expense.
2. The Omnicell Pharmacy system was a good value for the money.
3. The Omnicell Pharmacy system requires little ongoing support.
4. Access to the Omnicell system is secure.
5. Data collected by the Omnicell is private.
6. Omnicell security measures are easily defeated.
7. Data collected by the Omnicell is easy to review at a later time.
8. Data collected by the Omnicell is back up regularly.
9. If the Omnicell freezes up, I can unplug it to restart it.
10. The Omnicell screen is easy to understand.
11. I never have to look at the manual to solve problems.
12. There are too many steps to accomplish a task.
13. The Omnicell never shuts down.
14. Sometimes you have to reset the Omnicell.
15. Transactions occasionally end without warning.
16. I have problems with the drawers.
17. We have access to all the medications we need.
18. Partial doses are hard to document.
19. Medication bins are frequently empty.
20. It is easy to add new medications to stock.
21. Managing refrigerated medications is difficult.
22. Newly ordered medications are available in a reasonable timeframe.
23. The Omnicell talks to other hospital computer systems.
24. Pharmacy enters medications into the Omnicell database.
25. We can add additional medication storage lockers as needed.
26. Obtaining medications is a fast process.
27. The Omnicell system speeds up the management of controlled substances.
28. Management of the Omnicell requires little training.
29. We have much less trouble preventing medications from outdating.
30. Shift change is faster without the narcotic counts.
31. Narcotic counts are more accurate with the Omnicell.
32. Personal Digital Assistants (PDA) are a good platform for this type of evaluation.
33. The interface is clear and concise.
34. I have difficulty entering data in this form.
35. I am a regular PDA user