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Implementation Success of Clinician Information Systems in Healthcare Contexts

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ABSTRACT

The success of information systems in healthcare contexts is becoming increasingly important as the healthcare profession continues to adopt information systems for its internal operations. Using the DeLone and McLean model of information systems success that has found traction in a variety of research contexts, we develop a model for examining the success of clinician information systems. Our research model, while grounded in prior literature on information systems success, also benefits from insights gained from preliminary interviews and surveys of healthcare professionals and clinicians. The pilot round of data collection is planned for next month and actual data collection for summer; we will present preliminary findings at the conference.

Keywords

Clinician information systems, success, use, service quality, net benefits.

INTRODUCTION

The success of information systems (IS) has generally been examined using the DeLone and McLean IS success model (1992; 2002; 2003) across a variety of research contexts. Our research aims to corroborate the determinants of success of information systems used by clinicians during the course of their work. Such an endeavor, we believe, is beneficial as many healthcare information systems are still at a very emergent stage of their development and can benefit from drawing on what we have learned from the IS success model over a decade of its use. This research is also timely as the medical profession, although embroiled in paper-based systems in many areas, is increasingly accepting the benefits of computerized systems. In addition, the governments at the federal, state, and local levels are also recognizing the increased use of information technologies in healthcare as an approach to reduce costs of healthcare in general.

Before venturing on a full-fledged undertaking to apply the IS success model to the healthcare context, we first set out to understand the particular issues of healthcare contexts by conducting two (lasting approximately two hours each) interviews with hospital administrators. We also collected freeform responses from twenty three clinicians (nurses) who have used information systems for patient care as part their work. This data collection was directed at finding the type of systems that clinicians normally use and the "net benefits" as identified by them.

Based on these preliminary findings, we modify the DeLone and McLean IS success model (1992; 2002; 2003) by adapting it to the healthcare context. Many of the revisions to the original IS success model centered on the specification of the dependent variable – individual impact, organizational impact, or net benefits. The benefits typically accrue to the individuals using the information system, customers benefiting from the information system, sponsors and organizations who provide the resources to develop and use the information system, and finally to the society at large. The specification of netbenefits from the perspective of multiple stakeholders was advocated by DeLone and McLean (2003). There is also some agreement within the clinicians' community that evaluations of healthcare information systems need to be multidimensional, covering many aspects beyond technical functionality (Littlejohns, Wyatt, and Garvican 2003).

This paper presents a revised IS success model for the healthcare context and also a revised survey instrument that may be used to examine IS success. We plan to conduct a pilot round of data collection and incorporate changes to the survey

instrument that may be necessary. Actual data collection is planned for the summer and preliminary findings will be presented at the conference.

CLINICIAN INFORMATION SYSTEMS

Information systems used in the general healthcare environments range widely in their scope and technology ranging from purely transactional Electronic Health Record Systems (EHR) to complex Clinical Decision Support Systems (CDSS). The terminology used to refer to such systems is many and varied: Electronic Medical Records (EMR), Health Information Systems, and Health Information Technology (HIT), Evidence-based medical systems (EMS), to name a few. This research is concerned with those information systems actually used by clinicians and excludes systems that may be used by administrators and other non-clinician decision makers. We verified the robustness of this particular classification by obtaining feedback about such information systems from practicing clinicians. A group of twenty three clinicians provided freeform responses of how they viewed clinician information systems. A sample of their responses is shown in Table 1.

Clinical systems are a collection of patient information including financial information, interface of testing results, and bedside documentation of assessments, computer order entry, medication administration, and discharge planning. I have used Lastword, Watchchild, and epic.
I have been an application analyst for approximately 5 years, but for the first 4 years I supported about 75 different clinical systems not including the EMR system. Clinical systems can be defined in my experience as an application used to document clinical data or interface data to another clinical system. Surgical Information Systems (SIS), Epic, Midas, Cbord, PACS, Horizon Lab just to name a few.
My personal definition of a clinical system is any system that allows me to perform my job quicker, more efficiently, and improve the outcomes of my patients, in terms of safety as well as quality, while being more user-friendly for the healthcare professional. I have worked with Meditech, which wasn't a favorite of mine, or user friendly. I currently work with VistA at the VA. This system also encompasses CPRS (Computerized Patient Record System) and BCMA, or Barcode Medication Administration.
A clinician support system is a knowledge system that supports a clinician's decision making. It may be utilized in diagnostics, prescription, prognosis and billing. In my case, I currently use a system called Milliman Care Guidelines. It is an evidence based tool utilized for inpatient admission justification and inpatient stay justification. Based on clinical received from a facility and the evidence based materials in Milliman, we are able to predict a patient's course of stay and treatment while inpatient. We are also able to justify if an admission should be for observation status only.
Clinician systems are any technology that aids the practitioner in caring for a patient. I utilized a system called Witt hemodynamic monitoring system in the cardiac catheterization lab. It is a system that obtains vital signs and invasive pressures when a patient is hooked up. These pieces of data are store in the system. The clinician can also document the procedure, outcomes and charges used during the procedure with this system. It is a scaled down version of an emergency medical response specifically for Cardiology.
Clinician systems could be an Enterprise Electronic Health Record such Epic or Cerner or McKesson. They have components that include Evidenced Based Medicine and Clinical Decision Support systems which aid clinicians in prescribing recommended medical treatments based upon documented research findings on care protocols for specific disease entities. Other types of clinical systems include: Point of Care systems that allow clinicians to document the care rendered, computerized physician order entry that allows clinicians to order certain tests required for diagnosing and treating diseases. Another example of a Clinical system may be a system specific to one department such as the Emergency Room, Operating Room or Radiology Diagnostic Imaging. These include Cerner Millenium, Knowledge Data Systems Order Entry, Medtake's Nursing Charting System and ORSOS Operating Room Scheduling Office System.

Table 1. Sample of Freeform Responses about Clinician Information Systems from 23 respondents

Drawing from these general notions, we define a clinician information system *as any computerized system used in healthcare settings to perform clinical tasks*. These systems may perform one or more of the following functions: documenting patient care, prescription or tests order entry systems, patient charting systems, treatment recommendation systems, barcode medication administration systems, patient monitoring systems, bedside documentation of assessment, discharge planning systems, and admission/stay justification systems. These are also information systems that directly impact patient care. A

patient registration system or billing system is NOT the focus of our study as they are simply administrative support systems that do not directly impact patient care.

CLINICIAN INFORMATION SYSTEMS SUCCESS MODEL

To examine the success of clinician information systems, we develop a model of clinician information systems success based on the DeLone and McLean (1992; 2002; 2003) IS success model, as shown in Figure 1. The links that are NOT hypothesized are shown as dotted lines.

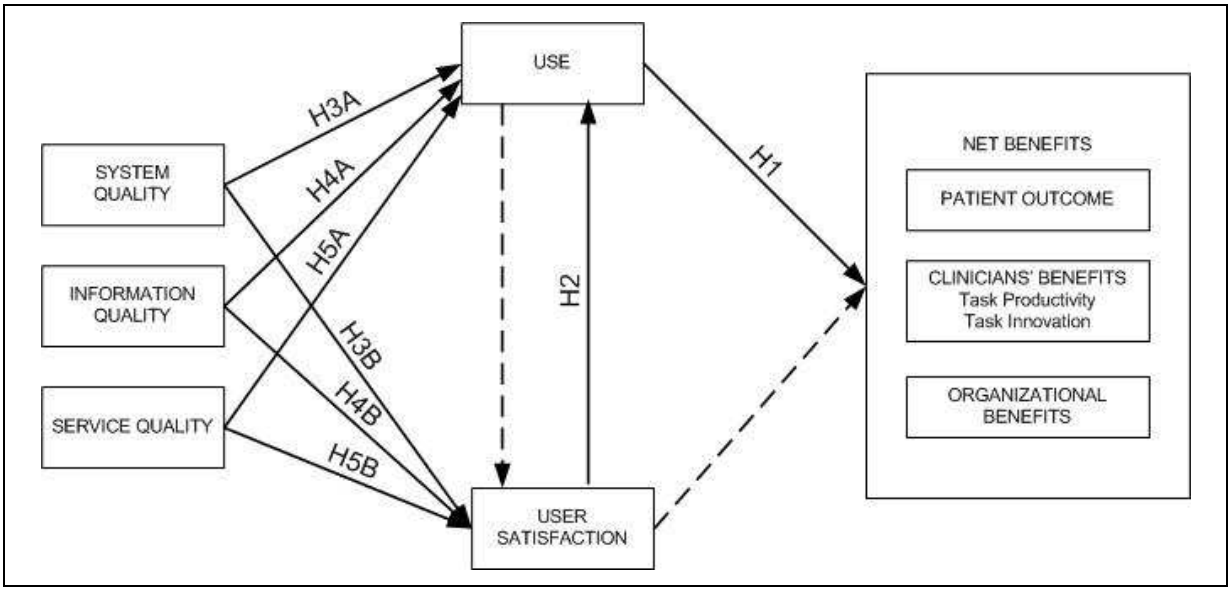

Figure 1. Clinician Information Systems Success Model

Net Benefits

The original IS success model (DeLone and McLean 1992) dealt with both individual impact and organizational impact as the dependent variables. In other words, the use of information systems by individuals was expected to have impacts for both the individuals and their organizations. In their later reformulations, DeLone and McLean (2002; 2003) conceptualized *Net Benefits* as the success variable that incorporated many other measures at the consumer, workgroup, industry, and societal levels. This new variable, *Net Benefits*, raises some interesting questions on its operationalization. Although the original IS success model used the term *impact*, Seddon (1997) used *consequences* and *net benefits* instead, in a later study. *Net Benefits* is probably the most accurate descriptor of the final success variable since the impact may be positive or negative.

In using net benefits as the dependent variable, the "recipient" of these benefits needs to be specified. In the case of clinician information systems, these benefits might accrue to the system designer, the actual user, or some other stakeholder group for which the system is explicitly designed. DeLone and McLean (1992) and Seddon (1997) recognized that different players may have different opinions as to what constitutes a benefit to them. This addresses the granularity of measurement of net benefits – individuals, groups, managements, and society – and requires some consideration to be assimilated into the healthcare context. First, we have two types of individuals as consumers of healthcare IT – the clinician who is actually using the information system and the patient for whom the information system is intended. But the patient is the "community" at large beneficiaries of the healthcare information systems. While the societal impact of many information systems is hard to study, in healthcare applications we can measure the "perceived" benefits to the patients through responses from clinicians themselves. While this may not be the ideal, there is no convincing reason for clinicians to misrepresent how the systems are benefiting this group. Short of cost-benefit analysis to the society as a whole, measuring the patient outcomes seems a prudent approach to measure the societal impact. While the granularity of this measurement is individual, the meaning and scope is actually societal.

To better understand net benefits in the healthcare context, we asked clinicians (the same group of twenty three referred to earlier) to describe what they viewed as net benefits from their experience of using such information systems. A sample of their responses is provided below:

Cost Savings, Length of stays, Inpatient Admissions converted to Observation stays, outcomes
As a caregiver an important operational measure would involve satisfaction and ease of use of the system improving productivity and efficiency through the ability to have concise definition and documentation of patient care. For patients, the operational definitions involve an evaluation of decreasing medication errors and improved patient outcomes with the application of standardized orders and evidence based practice. As a researcher, the operational definition would involve the interoperability of the systems to allow collection of data at the bedside that is accessible by a larger database for analysis of disease processes and guidelines for improved care.
End User Satisfaction, Cost Containment or How much the system has helped in reducing costs of duplicate tests, Patient Safety Improvements, Medication Error Reduction, Timely Access to service. I'd probably want to measure things that have an impact on IOM's aims.
Is productivity improved with the use of the clinician system? Have the number of errors decreased with the use of the system? Are fewer employees needed to do the job once the clinician system is implemented?

Table 2. Sample of Freeform Responses on Net Benefits by 23 respondents

The conceptualization of net benefits by Torkzadeh and Doll (1999), with a few modifications, seems most appropriate for our study. Doll and Torkzadeh (1999) developed a 12-item measure of IS impact involving the four dimensions: task productivity, task innovation, customer satisfaction and management control. Task productivity was defined as the extent to which an IS application improves the users' output per unit of time. Task innovation refers to the extent to which the application allows users to create and try out new ideas. This applies to certain types of system such as clinical decision support systems that are intended to improve decision making. The third dimension, customer satisfaction, refers to the extent to which the users help create a value for the firm's internal or external customers. We measure this dimension as patient outcome. Finally, management control refers to the extent to which the application helps to regulate work processes and performance. In health care context, this can be translated to organizational performance. Appendix A shows the items for net benefits.

System Use

System use is the extent to which an individual works with the information system (DeLone and McLean 1992). Different measures such as frequency of use, time of use, extensiveness of use, dependency, number of applications, and number of features have been used to measure system usage (e.g. Barki and Huff 1985; Igbaria and Zviran 1996; Szajna 1996; Schiffman, Meile and Igbaria 1992; Sanders and Courtney 1985). System usage may be mandatory or voluntary for individuals and measured using perceptual or actual measures (e.g. Szajna 1996). Individuals using the system are expected to gain benefits that may not have been possible otherwise (DeLone and McLean 1992; 2003); however, it is not necessary that individuals using the system are satisfied with it. Prior literature has found system use to both impact and not impact user satisfaction (e.g., Guimaraes, Yoon and Clevenson 1996; Mawhinney and Lederer 1990); and hence we do not hypothesize a relationship between system use and user satisfaction.

H1: System use is positively related to net benefits.

User Satisfaction

User satisfaction is the extent to which an individual believes that an information system meets the information requirements (Ives, Olson and Baroudi 1983; DeLone and McLean 1992; Sabherwal, Jeyaraj and Chowa, 2006). User satisfaction has been conceptualized variously – user information satisfaction (Bailey and Pearson 1983), end-user computing satisfaction (Doll and Torkzadeh 1988), and overall satisfaction (Sanders and Courtney 1985) have been used in prior literature to represent an individual's satisfaction. These approaches to user satisfaction have distinctive features and components. For instance, a confirmatory factor analysis of the end-user computing satisfaction measure (Doll and Torkzadeh 1988) instrument resulted in five factors: content, accuracy, format, ease of use, and timeliness (Doll, Xia and Torkzadeh 1994). Similarly, a psychometric evaluation of the short-form measure of user information satisfaction (Ives et.al. 1983) resulted in three factors: information product; EDP staff and services; and knowledge and involvement (Baroudi and Orlikowski 1988). Regardless, they have all essentially been used to capture an individual's satisfaction with an information system. User satisfaction is expected to influence system use since individuals who are more satisfied with the information system are more likely to use the system for similar needs on other occasions (DeLone and McLean 1992; Seddon 1997).

H2: User satisfaction is positively related to system use.

System Quality

System quality is the extent to which an individual perceives an information system to be superior (DeLone and McLean 1992). It is generally based on the characteristics of an information system such as reliability, accuracy, response time, friendliness, and interactivity that make it worthwhile for users (e.g. Igbaria and Guimaraes 1994; Guimaraes, Yoon and Clevenson 1996; Santhanam, Guimaraes and George 2000; Yoon and Guimaraes 1995). System quality may be viewed as the degree to which an individual believes it to be easy to use, timely, and responsive (Sabherwal et al. 2006). Information systems that possess such characteristics are likely to influence individuals to use the system for similar needs on other occasions as well as increase the individual's satisfaction with the system (DeLone and McLean 1992; Rai et al. 2002; Sabherwal et al. 2006).

H3A: System quality is positively related to system use.

H3B: System quality is positively related to user satisfaction.

Information Quality

Information quality generally deals with the desirable characteristics that an individual may expect of the information generated by an information system (Petter et al. 2008). It is viewed as the extent to which an individual perceives the information generated by an information system to be relevant, timely, and accurate (DeLone and McLean 1992; Seddon 1997; Rai et al. 2002). Information quality may be applicable to information systems that generate or provide information for decision-making (e.g., business intelligence tools) but may not be relevant for other systems (e.g., word-processing systems) (Seddon 1997). Individuals who believe that information provided by the systems enable them to make decisions quickly and effectively are more likely to use the system for similar needs on other occasions as well as be more satisfied with the system in general (DeLone and McLean 1992).

H4A: Information quality is positively related to system use.

H4B: Information quality is positively related to user satisfaction.

Service Quality

Service quality is the extent to which the service level delivered meets customer expectations. Delivering quality service means conforming to customer expectations on a consistent basis (Lewis and Booms 1983). Service quality has been predominantly examined using the SERVQUAL instrument containing five dimensions (tangibles, reliability, responsiveness, assurance and empathy) with 22-items for measuring service quality in marketing. The original SERVQUAL was developed by Parasuraman, Zeithaml, and Berry (1988) is based on the assumption that a gap exists between customers' expectations and their experiences. Customer expectations are subjective and comprise desired wants, or the extent to which customers believe a service provider should exhibit certain characteristics (Parasuraman et al. 1991). Service quality has been examined in such areas as: cultural perspective (Donthu and Yoo 1998), information service (Pitt et al. 1997), and banking (Rose et al. 2009). Van Dyke et al (1997) suggest the use of an IS-context-modified version of the SERVQUAL instrument to evaluate the quality of the services supplied by an information services provider. However, there are different perspectives on the appropriateness of using SERVQUAL in an IS context. In addition to these concerns, there exists some debate regarding the appropriateness of the SERVQUAL instrument. Prior studies reported different numbers of SERVQUAL dimensions. Some (Kettinger and Lee 1994; Nitecki 1996) concluded a three dimensional SERVQUAL model rather than the five proposed by Zeithaml, Parasuraman, and Berry (1990). Using a sample of IT professionals, Jiang et al. (2002) confirmed four dimensions of the instrument instead of five dimensions. Furthermore, Wright and O'Neill (2002) found that contact, tangibles and response are significant components for online library services evaluation. The mixed findings on SERVQUAL dimensions suggest a need to modified SERVQUAL instrument. Some argue for SERVPER – a performance-only approach addressing customers' perceptions of the performance of a service provider (Brady and Robertson 2001; Cronin and Taylor 1992). Other researchers debate on the predictive power of SERVQUAL (Bayraktaroglu and Atrek 2010). Many studies provide evidence that performance scores alone exhibit better reliability and validity than difference scores (Brady and Robertson 2001; Cronin and Taylor 1992, Landrum and Prybutok 2004). Based upon these findings, we used the SERVPERF (SERVQUAL based on performance) instrument for our study. To further make the instrument parsimonious, we used one item to measure each dimension of SERPERF. Service quality can facilitate individuals to use the information systems in general, and enable individuals to overcome potential issues with the information system eventually leading to greater satisfaction with the system.

H5A: Service quality is positively related to system use.

H5B: Service quality is positively related to user satisfaction.

CONCLUSION

In this study, we have recast the traditional information success model to the healthcare context. Our contribution lies in the specification of net benefits where we have adapted the Torkzadeh and Doll (1999) measures to the healthcare context. We have added additional items to all the four constructs in their questionnaire based on two field interviews and twenty three responses from clinicians. Our next step is to explore whether the addition of these items (validated by the interview and freeform responses) has affected the reliability estimates of the original questionnaire. After this verification, we will administer the questionnaire to clinicians who are using computerized systems for patient care to test the overall IS success model in the healthcare context.

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APPENDIX A

The instrument, based on Doll and Torkzadeh (1992) and incorporating insights from our preliminary data collection efforts, for measuring net benefits of clinician information systems is shown below:

Task productivity (alpha=0.90)

P1 this application saves me time 0.83
P2 this application increases my productivity 0.80
P3 this application allows me to accomplish more work than would otherwise be possible 0.76
P4 this application does not interfere with my workflow (Added)

Task innovation (alpha=0.95)

I1 this application helps me create new ideas 0.93
I2 this application helps me come up with new ideas related to my job 0.91
I3 this application helps me try out innovative ideas for patient care 0.82
I4 this application facilitates new approaches to patient care (Added)

Patient outcomes - Customer satisfaction (alpha=0.94)

C1 this application improves the hospital's ability to improve service to patients 0.92
C2 this application improves the patients' overall satisfaction 0.89
C3 this application helps me meet patient needs 0.84
C4 this application improves the overall care of the patient (Added)
C5 this application reduces the overall medical errors (Added)

Organizational Impact - Management control (alpha=0.97)

M1 this application helps the hospital control the work process 0.94
M2 this application improves management control 0.93
M3 this application helps the hospital monitor performance 0.91
M4 this application allows the hospital to improve reimbursement from insurers (Added)