Spring 5-14-2015

Understanding System Integration in Healthcare - The View of Hospital Nurses

Jun He
University of Michigan-Dearborn, junhe@umich.edu

Follow this and additional works at: http://aisel.aisnet.org/mwais2015

Understanding System Integration in Healthcare – The View of Hospital Nurses

Jun He
University of Michigan-Dearborn
junhe@umich.edu

ABSTRACT (REQUIRED)

The healthcare industry is undergoing an IT-enabled transformation via the adoption of integrated HIT systems. The transformation is partially a result of government mandate rather than a nature evolution of technology. Thus, the effectiveness of system integration in the healthcare industry may deviate from what we have observed in other industries. The current research attempts to enrich our understanding of how HIT users, hospital nurses in particular, perceive system integration in their workplace. A field study is conducted. The results reveal a lack of association among different aspects of system integration, suggesting that HIT users may not view system integration as a holistic feature of modern HIT systems.

Keywords (Required)

Health information technology, system integration, electronic health records.

INTRODUCTION

The healthcare industry is struggling with the rising cost of health maintenance and restricted reimbursements for Medicare and Medicaid services (Chandra et al., 2013). Adopting information technologies (IT) is widely recognized as a key strategy for restructuring healthcare for operation efficiency (Kvedar et al., 2014). With increasing investment in health information technology (HIT), the healthcare industry has evolved into an IT-intensive industry (Burke et al., 2002), and computers "are conveniently located at every corner" on the hospital operation floor (Chandra et al., 2013; p. 71). However, the deployment of HIT systems has not led to cost-saving for patients, healthcare providers, and the society (Fontenot, 2014).

Researchers attribute the poor performance of current HIT systems to the lack of interoperability among the systems (Mouttham et al., 2012). HIT systems must be integrated, and data be readily shared among different stakeholders, so that "connected health technologies can make health care more effective and efficient by electronically connecting clinicians to clinicians, patients to clinicians, and even patients to other patients" (Kvedar et al., 2014; p. 195). Disappointingly, many healthcare organizations fail to share data internally and externally (Ghosh, 2014), not to mention "meaningful use" of integrated HIT systems (Hsiao et al., 2012; Jones and Furukawa, 2014).

To constrain healthcare costs, the government mandates the adoption of integrated HIT systems, electronic health records (EHRs) in particular, through regulations and financial incentives (Murphy, 2010). The investment on HIT has accelerated. A recent report shows that $5 billion has been invested in digital health technology during the first three quarters of 2014, which exceeds the total investment for all of 2013 (Ghosh, 2014).

It is worrisome to note that the healthcare industry is not enthusiastic to embrace integrated HIT systems. Industry survey shows that hospitals emphasize on clinical functions when planning for new HIT systems (HIMSS, 2013), and about half adoptions of integrated HIT systems are caused by external or environmental pressures rather than rational decisions (Pobanzaou et al., 2014). Thus, it is important for researchers and HIT developers to understand the actual perceptions of integrated HIT systems among healthcare service providers.

The current research attempts to enrich our understanding of how HIT users, hospital nurses in particular, view the effectiveness of integrated HIT systems. In the following sections, the paper first reviews the literature on the importance of system integration, discusses current HIT environment in hospitals, and explains government efforts of promoting integrated HIT systems. Then, a research model is developed to assess the effectiveness of system integration as perceived by HIT users. A field study is conducted at a mid-sized hospital. The paper ends with a discussion of the results and the implications for HIT developers and researchers.

LITERATRUE REVIEW AND CONCEPTUAL MODEL

The Importance of System Integration

Business researchers have long recognized the importance of integrating information systems to business (Venkatraman 1991; 1994). Baets (1992) discussed the necessity and the procedure of aligning information systems with business strategy.

Integrated systems help organizations not merely automate business activities, but also restructure and transform business (Venkatraman, 1991). System integration is a logic extension of implementing localized information systems towards systematically "leverag(ing) IT capabilities throughout the entire business process" (Venkatraman, 1994; p. 76) for competitive advantages. Organizations leverage integrated systems to achieve improved operations and better control of cost and other resources, ultimately leading to organizational performance improvements (Chapman and Kihn, 2009).

In the IS literature, there is a tradition of studying system integration and its derivative of data integration to the success of modern organizations. For example, Goodhue and colleagues (1992) have discussed the benefits of data integration in improving communication and operational coordination across subunits within an organization. Having different systems coexist leads to "informational fragmentation" (Muscatello et al., 2003) or "functional silos" (Beretta, 2002), and results in the loss of operation efficiency as "dysfunction, redundancy, and waste" (Raymond and Uwizeyemungu, 2007; p. 502). Hasselbring (2000) concludes the necessity for system integration, arguing that "to support the intraorganizational business processes within organizations effectively, the existing information systems must be integrated" (p. 33-34).

HIT in Hospitals – Fragmented Systems

Healthcare is featured with fragmented services (Chaudhry et al., 2006). Healthcare professionals, hospital nurses in particular, often work on multiple tasks during their daily undertaking of healthcare service. Many of these tasks require the use of HIT systems. These systems are often developed in isolation to fulfil specific tasks, and are "characterized as a series of standalone systems with little integration." (Burke and Menachemin, 2004; p. 208). As such, hospital nurses have to switch between systems when an operation is interrupted with emergent tasks, and involved systems are unconnected or require different operation procedures. As a result, operation efficiency is inevitably impeded (Chandra et al., 2013).

The lack of system integration in hospitals is rarely observed in other industries (Austin et al., 1995; Chandra et al., 2013). Indeed, the popular assessment that hospitals lag other industries in IT adoption by 10 to 15 years (Raghupathi and Tan, 1999) is based on the long standing observation that "few hospitals have truly integrated systems with up-to-date financial, clinical, competitor, and environmental information" (Austin et al., 1995; p. 30), which remains true today. National survey of hospital IT market shows that specific clinic-function systems are still the main HIT systems newly deployed at hospitals (HIMSS, 2013).

Toward System Integration – The Promotion of EHR

To control the skyrocketing healthcare costs, the US government imposes legal requirements and provides financial supports to promote system integration in the healthcare industry (Murphy, 2010). The American Recovery and Reinvestment Act and its important Health Information Technology Act provision became law on February 17, 2009, requiring hospitals and physicians to meaningfully adopt and use advanced HIT with an emphasis on EHR. An EHR is a systematic collection of electronic health information about an individual patient or population. With EHR, HIT systems can be integrated by communicating with each other, sharing data, and leveraging healthcare resources. Under the law, the Medicare and Medicaid Electronic Health Records Incentive Programs began issuing incentive payments in 2011 to facilitate the adoption of EHRs. As of November 2014, 4708 hospitals and 409,974 healthcare professionals had adopted certified EHR technology, and received incentive payments over $26 billion (CMS, 2014).

The federal government's efforts on promoting EHR-centered HIT systems are extraordinary. The government even developed an official site of HIT technologies with a Certified Health IT Product List (CHPL), providing an "authoritative and comprehensive listing of certified Complete Electronic Health Records (EHRs) and EHR Module(s)." (http://www.healthit.gov/policy-researchers-implementers/certified-health-it-product-list-chpl).

Giving the government's ambitious support on the adoption of integrated HIT systems, many healthcare researchers are optimistic about the wellness of the healthcare industry, arguing that "… a predominant paradigm shift is occurring… a focus on interaction, collaboration and increased sharing of information and knowledge… is in turn be leading healthcare organizations to embrace the techniques … to create and sustain optimal healthcare outcomes." (Gabriel et al., 2014; p. 120). Some researchers remain skeptical. For example, Ghosh (2014) found that most healthcare organizations were stuck in sharing data, which "is probably the biggest disappointment for the industry during the last few years." (p 19). Fontenot (2014) challenged the effectiveness of HIT systems, arguing that because of the complex nature of healthcare and the misalignment between service and reimbursement, "the savings that were supposed to pile up during the transition to a paperless system have not met the dream's high expectations" (p. 68).

System integration in other industries is driven by operation efficiency and collaboration (Pinsonneault and Kraemer, 1997). The government's attempt of mandating the use of integrated HIT systems, EHR in particular, is unprecedented. From an information system development perspective, such mandatory approach lacks user participation and user inputs, which are

critical to the success of system implementation. Thus, we should examine the actual perceptions of the effectiveness of system integration among HIT users. If HIT users do not view EHR-centered HIT systems as useful in terms of enhancing their job performance, the chance of achieving system success, judged by the actual and meaningful use of EHR (Murphy, 2010), could be slim.

Conceptual Model – Users' Perceptions of System Integration

In the IS literature, system integration refers to that functional computer-based systems communicate with each other and that functional activities are interrelated and handled together (Kim, 1994; Morabito et al., 2010). System integration is often viewed as a reflective trait or dimension of system quality (DeLong and McLean, 1992; 2003; Wixom and Watson, 2001), and high levels of system integration is a natural result of leveraging IT resources for superior performance (Françoise et al., 2009). System integration in healthcare, however, is partially the result of government mandate. Thus, the effectiveness of system integration in the healthcare industry may deviate from what we have observed in other industries. To understand how HIT users view system integration in terms of improving job performance, the following conceptual model is developed.
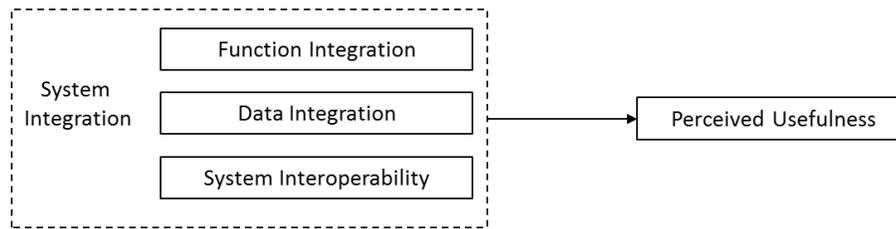

Figure 1. Conceptual Model

In the model, system integration has three inter-related aspects that are suggested in the literature: function integration, data integration, and system interoperability. Function integration refers to the integration across different applications and functions (Morabito et al., 2010); data integration refers to the standardization of data definitions and structures across different systems (Goodhue et al., 1992; Morabito et al., 2010); and system interoperability refers to accessing other systems without leaving a home system (Moutthamet al., 2012). HIT users' perceptions of system integration, as depicted by the three aspects, should be positively associated with the users' perceived usefulness of the system. That is, high levels of system integration will be associated with high levels of perceived usefulness, if healthcare workers view the effectiveness of system integration in a fashion similar to that of other industries.

RESEARCH METHODS AND RESULTS

Research Design

The researcher approached a midsized hospital with about 2000 employees for the study, and a field survey was designed as the major data collection method. With the support from the hospital management, the researcher sent to the IT departments a survey invitation with a link to an online survey; the invitation was then forwarded to all hospital employees via email. Participation in the survey was voluntary. The survey was deactivated after one month.

Construct Operationalization

The focal concept in the research is system integration. An expert panel that included two system developers, two nurses, and one physician was formed to discuss the meanings of system integration in the hospital operation environment. The panel discussed instrument measures that could be used to depict a holistic picture of system integration. Besides the three aspects of system integration as proposed in the conceptual model, the panel suggested another aspect of data sharing, which is about the practice of getting data from and exchanging files with different departments. As a result, seventeen items mapped under four aspects of system integration were suggested. Another small group of nurses reviewed the seventeen items and confirmed their semantic meanings. The seventeen items were then included in the survey questionnaire. They are:

Function Integration: 3 items, asking respondents to evaluate current systems in terms of handling multiple applications, presenting multiple features, and focusing on specific operation (reversed).

Data Integration: 3 items, asking respondents whether the format, meaning, and value of data were consistent across different systems.

System Interoperability: 7 items, asking respondents to evaluate current systems in terms of communicating with other systems, single login of multiple systems, operating multiple systems without switching from a home system, and consistent interface across different systems.

Data Sharing: 3 items, asking respondents whether current systems have access to other departments' systems in terms of sharing data and exchanging files.

The construct of perceived usefulness (four items) was adopted from Venkatesh et al. (2003).

In addition, four demographic factors are included as control variables in the test: gender, age, education, and tenure. The four items were measured with single-item questions.

Participants

273 people responded to the survey invitation by clicking on the embedded survey link. Most respondents (about 81%) are registered nurses or practicing nurses. After dropping incomplete and not-from-nurse responses, 188 effective records remained for data analysis.

Data Analysis

Exploratory factor analysis was performed to assess the internal relationships among the seventeen items. The results are presented in table 1.

	Component		
	1	2	3
Item01	.031	**.858**	.073
Item02	.124	**.825**	.043
Item03	-.106	**-.835**	.108
Item04	**.694**	.099	-.022
Item09	**.801**	.062	.064
Item10	**.818**	-.010	.041
Item11	**.780**	.005	-.002
Item12	**.764**	.073	.098
Item13	**.687**	-.024	.199
Item14	**.628**	.119	.142
Item15	.016	.178	**.754**
Item16	-.077	.178	**.793**
Item05*	.578	.045	.070
Item06*	-.180	.192	-.437
Item07*	-.094	.167	-.486
Item08*	-.347	.307	-.007
Item17*	.231	.326	.365

Note:
1. * item dropped due to low factor loadings
2. Extraction Method: Principal Component Analysis.
3. Rotation Method: Varimax with Kaiser Normalization.

Table 1. Factor Analysis

The test reveals some interesting results. Item05-08 and item17 have low loading coefficients and should be dropped. Item05-08 were designed to assess data integration, or data standardization across different systems. Factor analysis results indicate that the perception of data integration is not consistent among the sampled hospital nurses. These items were dropped from further analysis. The resulting factors, based on their items, were labeled as function integration (item 1-3), system interoperability (item 4, 9-14), and data sharing (item 15, 16).

The test of the conceptual model was conducted with Partial Least Squares (PLS). Construct internal reliability (Cronbach's Alpha) and correlation matrix are presented in Table 2. Testing results are summarized in Figure 2.

Variables	Items	Composite Reliability	1	2	3	4	5	6	7	8
1. Function Integration	3	0.903	**0.87**							
2. System Interoperability	7	0.896	0.14	**0.74**						
3. Data Sharing	2	0.882	0.15	0.07	**0.89**					
4. Perceived Usefulness	3	0.906	0.30	0.26	0.20	**0.87**				
5. Gender	1	-	0.03	-0.04	0.05	-0.06	-			
6. Age	1	-	-0.17	-0.18	-0.11	-0.13	-0.12	-		
7. Education	1	-	-0.01	-0.17	0.09	-0.17	0.12	-0.17	-	
8. Tenure	1	-	-0.09	-0.18	-0.10	-0.17	-0.14	0.76	-0.17	-

Note: Numbers in bold on the diagonal are the square root of average variance extracted (AVE).

Table 2. Construct Correlation Matrix
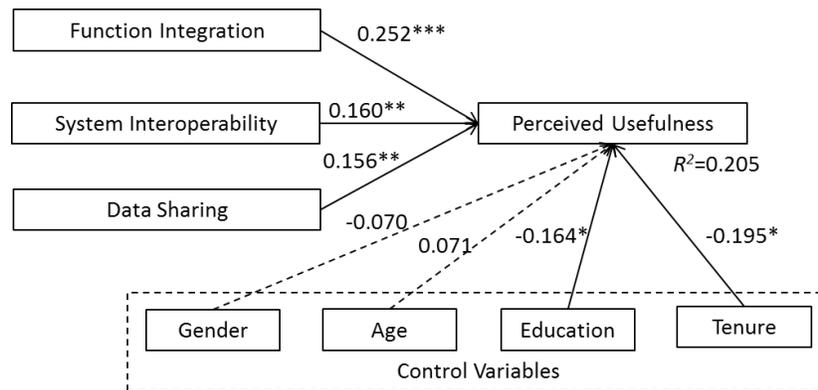
Note:
1) * p<0.05, ** p<0.01, *** p<0.001.
2) Dashed line indicates insignificant path (p>0.10)

Figure 2. Testing Results

The test results provide a peek of how hospital nurses view the effectiveness of system integration. The three aspects of system integration each presents a significant and positive effect on the perceived usefulness of the target system. Further examination of the results reveals some interesting findings:

1. Inter-correlations between the three aspects of system integration are low. Function integration, system interoperability and data sharing were proposed as three inter-related aspects of system integration. They were supposed to correlate with each other, as the evolution of technology towards integration requires coexistence of various features to support the ability of handling different applications, communicating with other systems, and sharing data (Françoise et al., 2009). A decrease on one aspect would negatively affect the levels of other aspects and the overall perceived usefulness of the system. The low correlations among the three aspects suggest that the sampled nurses do not see the connections between these aspects. The result, although surprising, is consistent with industry survey findings that hospitals focus much on clinical functions of HIT systems (HIMSS 2013), and integrated HIT systems, if they are implemented, are not fully exploited or "meaningfully" used (Hsiao et al., 2012; Jones and Furukawa, 2014).

2. Data integration items do not load well in the factor analysis. Data integration has long been recognized as an important aspect of system integration (Goodhue et al., 1992). But the poor item loadings suggest that views among the sampled nurses are not consistent regarding the use of standardized data. This may reflect that the sampled nurses work mostly with the systems in their own departments; the needs of sharing data and exchanging files with

other departments are not strong. The result is consistent with Ghosh's (2014) finding that most healthcare organizations are not effective on sharing data internally and externally.

3. The positive effects of three aspects of system integration on the perceived usefulness of investigated systems are positive and significant, but are small to moderate in magnitudes (the path coefficients are < 0.3). Examination of the correlation matrix also suggests that none of the three aspects of system integration exerts large direct effects on perceived usefulness. This finding suggests that the sampled nurses cautiously view system integration as a useful feature of the system being used. This may explain the observation that HIT users are not as enthusiastic as other stakeholders (e.g., the government, the society) in adopting integrated HIT systems.

4. Although control variables are not the focus of the research, their effects are interesting. Of the four control variables of gender, age, education, and tenure, the latter two exerts significant but negative effects on perceived usefulness. In other words, well-educated and senior nurses tend to view HIT systems less useful in comparison to their colleagues, indicating a dissatisfaction among knowledgeable and experienced users. HIT developers should strive to understand the actual needs of HIT users.

CONCLUSION

The healthcare industry is undergoing an IT-enabled transformation via the adoption of integrated HIT systems. The transformation is partially a result of government mandate rather than a nature evolution of technology. The perceived effectiveness of integrated HIT systems among HIT users, as examined in the study, are different from what we have observed in other industries. HIT users seem to emphasize on application, function, and communication, and are uncertain about using standardized data. HIT developers and researchers need to understand the actual needs and perceptions among HIT users.

REFERENCES

1. Austin, C.J., Trimm, J.M., and Sobczak, P.M. (1995) Information systems and strategic management, *Health Care Management Review*, 20, 3, 16-33.

2. Baets, W. (1992) Aligning information systems with business strategy, *Journal of Strategic Information Systems*, 1, 4, 205-213.

3. Beretta, S. (2002) Unleashing the integration potential of ERP systems: The role of process-based performance measurement systems, *Business Process Management Journal*, 8, 3, 254-277.

4. Burke, D.E., Wang, B.B.L., Wan, T.T.H., and Diana, M.L. (2002) Exploring hospitals' adoption of information technology, *Journal of Medical Systems*, 26, 4, 349-355.

5. Chandra, C., He, J., Liu, Z. and Ruohonen, T. (2013) Some promising areas for is research in the hospital industry: Implications from a case study of operating room scheduling, *Health and Technology*, 3, 1, 65-72.

6. Chapman, C.S., and Kihn, L.A. (2009) Information system integration, enabling control and performance, Account. Organizations, and Society, 34, 2, pp. 151–169.

7. Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E., Morton, S.C., Shekelle, P.G. (2006) Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care, *Annals of Internal Medicine*, 144, 10, 742-752.

8. CMS (Centers for Medicare & Medicaid Services) (2014) November 2014 EHR Incentive Program Summary Report, available at http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Downloads/November2014_SummaryReport.pdf

9. DeLone, W., and McLean, E.R. (2003) The DeLone and McLean model of information systems success: A ten-year update, *Journal of Management Information Systems*, 19, 4, 9-30.

10. DeLone,W.H., and McLean, E.R. (1992) Information systems success: The quest for the dependent variable, *Information Systems Research*, 3, 1, 60-95.

11. Fontenot, S.F. (2014). The affordable care act and electronic health care records: Can technology help reduce the cost of health care? *Physician Executive*, 40, 1, 68-72.

12. Françoise, O., Bourgault, M., and Pellerin, R. (2009) ERP implementation through critical success factors management, *Business Process Management Journal*, 15, 3, 371-394.

13. Gabriel, M.H., Jones, E.B., Samy, L., and King, J. (2014). Progress and challenges: Implementation and use of health information technology among critical-access hospitals, *Health Affairs*, 33, 7, 1262-1270.

14. Ghosh, R. (2014) Healthcare analytics: a year of many challenges, *OR-MS Today*, 41, 6, 18-20.

15. Goodhue, D.L., Wybo, M.D., and Kirsch, L.J. (1992) The impact of data integration on the costs and benefits of information systems, *MIS Quarterly*, 16, 3, 293-311.

16. Hasselbring W. (2000) Information system integration, *Communications of the ACM*, 43, 6, 32-38.

17. HIMSS (Healthcare Information and Management Systems Society) (2013) 2013 Annual Report of the U.S. Hospital IT Market, available at http://apps.himss.org/foundation/docs/2013HIMSSAnnualReportDorenfest.pdf.

18. Hsiao, C., Decker, S.L., Hing, E., Sisk, J.E. (2012) Most physicians were eligible for federal incentives in 2011, but few had ehr systems that met meaningful-use criteria, *Health Affairs*, 31, 5, 1100-1107.

19. Jones, E.B., and Furukawa, M.F. (2014). Adoption and use of electronic health records among federally qualified health centers grew substantially during 2010-12, *Health Affairs*, 33, 7, 1254-1261.

20. Kim, B.O. (1994) Business process reengineering: Building a cross-functional information architecture, *Journal of Systems Management*, 45, 12, 30-35.

21. Kvedar, J., Coye, M.J., and Everett, W. (2014). Connected health: A review of technologies and strategies to improve patient care with telemedicine and telehealth, *Health Affairs*, 33, 2, 194-199.

22. Morabito, V., Themistocleous, M., and Serrano, A. (2010) A Survey on integrated IS and competitive advantage, *Journal of Enterprise Information Management*, 23, 2, 201-214.

23. Mouttham, A., Kuziemsky, C., Langayan, D., Peyton, L., and Pereira, J. (2012) Interoperable support for collaborative, mobile, and accessible health care, *Information Systems Frontiers*, 14, 1, 73-85.

24. Murphy, J. (2010) The journey to meaningful use of electronic health records, *Nursing Economic*, 28, 4, 283-286.

25. Muscatello JR, Small MH, Chen IJ. (2003) Implementing enterprise resource planning (ERP) systems in small and midsize manufacturing firms, *International Journal of Operations & Production Management*, 23, 8, 850-871.

26. Pinsonneault A, and Kraemer KL. (1997) Middle management downsizing: An empirical investigation of the impact of information technology, *Management Science*, 43, 5, 659-679.

27. Poba-nzaou, P., Uwizeyemungu, S., Raymond, L., Pare, G. (2014). Motviations underlying the adoption of ERP systems in healthcare organizations: Insights from online stories, *Information Systems Frontiers*, 16, 4, 591-605.

28. Raghupathi, W., and Tan, J. (1999) Strategic uses of information technology in health care: A state-of-the-art survey, *Topics in Health Information Management*, 20, 1, 1-15.

29. Raymond L, and Uwizeyemungu S. (2007) A profile of ERP adoption in manufacturing SMEs, *Journal of Enterprise Information Management*, 20, 4, 487-502.

30. Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D. (2003) User acceptance of information technology: Toward a unified view, *MIS Quarterly*, 27, 3, 425-478.

31. Venkatraman, N. (1994) IT-enabled business transformation: From automation to business scope redefinition, *Sloan Management Review*, 35, 2, 73-87.

32. Wixom, B.H., and Watson, H.J. (2001) An empirical investigation of the factors affecting data warehousing success, *MIS Quarterly*, 25, 1, 17-41.