AN INVESTIGATION OF THE USE OF KMS ON CLINICAL PERFORMANCE

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Abstract: Use of Information Technology (IT) to facilitate storage, search and access to codified knowledge can enhance organizational performance. Considering the knowledge intensive nature of medical decision making, use of knowledge management systems (KMS) can potentially enhance delivery of patient care. This paper reports on a field study that investigated the impact of use of a KMS by emergency physicians on their decision making behaviors (admission of patients for in-hospital care) and efficiency of care. The findings indicate that in the emergency room (ER) under study, the use of a KMS for placing diagnostic orders resulted in lower hospital admissions, cost savings, and a shorter ER stay.

1 INTRODUCTION

An extensive body of research based on knowledge-based view of organizations (for example, Alavi and Leidner, 2001; Spender, 1996; Nonaka and Takeuchi, 1995) suggests that Information Technology (IT) can enhance organizational performance through consistent and effective application of knowledge in organizational practices. Considering the knowledge-intensive nature of the healthcare domain, the high rate of change and innovation, and the wide scope of knowledge needed by the professionals in this field, patient care can greatly benefit from advanced information technologies that facilitate storage, search, and timely access to the best knowledge available.

In the U.S., IT is viewed as integral to achieving substantial quality and efficiency improvements in healthcare delivery and management. A key idea underlying this view is the use of IT to support knowledge management (KM) to enhance and facilitate clinical decision-making. The goal is to apply best available evidence gained from scientific method to delivery of patient care. It seeks the ideal in which all medical professionals should make explicit, conscious and judicious use of all available best knowledge in making clinical decisions. Proponents argue that application of evidence-based practice would reduce the inconsistencies and uncertainties in patient care. Many institutions try to implement evidence-based clinical decision-making in the form of policy, recommendations, guidelines and regulations. However, translating such institutional behaviors into actual behaviors practiced by healthcare professionals is a challenging task. IT is seen by many as an integral solution to close the gap in implementing evidence-based clinical decision-making practices. By codifying best available knowledge and integrating it into the electronic medical record (EMR) systems that healthcare professionals interact with to manage various clinical information, hospitals and medical practices might be able to implement the evidence-based practice more consistently and improve their performance.

The literature, however, is clear that mere stocking of knowledge through codification is not enough to improve organizational performance (Alavi and Tiwana, 2002). Knowledge needs to be applied in practice in order to produce intended outcomes (Cook and Brown, 1999; Orlikowski, 2002). Thus, the potential benefits KMS cannot be realized through the codification and accumulation of medical knowledge in IT systems alone. Rather, it is in the ability to take effective action by *applying* knowledge. Thus, it is not clear to what extent KMS will be effective for Physicians who make complex

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clinical decisions in constrained timeframes and under high degree of uncertainty.

In order to address this issue, we have conducted a field study to examine the impact of KMS in an emergency room (ER) at a major hospital in the United States. Specifically; we investigated the following research questions:

Research Question 1: How does the use knowledge management system change the clinical decision-making behaviors by medical professionals?

Research Question 2: What are the impacts of the use of knowledge management system on cost and efficiency in clinical decision-making?

2 A FIELD STUDY OF KMS USE IN AN EMERGENCY ROOM

Lately, the popularity and deployment of EMR (electronic medical records) have been on the rise in the U.S. EMR systems are integrated IT systems for healthcare information management and process support. We anticipate that the eventual ubiquitous availability of EMR systems in the U.S. will create the necessary “backbone” that serves as the infrastructure for knowledge codification, storage, search, and delivery for clinical decision-making. This in turn creates a need for conducting studies that provide the necessary insights and understanding for development and deployment of knowledge management systems (KMS) for effective and efficient delivery of patient care.

The effectiveness and outcomes of the decisions made in an emergency room depend on timely and accurate diagnosis and delivery of appropriate treatments to patients. These decisions are in turn impacted by the timely availability of the requisite knowledge such as the knowledge of diagnostic tests and their outcomes, treatment protocols, and accurate presentation of the patient’s condition and symptoms. As such, clinical decisions in emergency rooms can benefit from the codification, accumulation, and delivery of knowledge to augment physicians’ judgment and know-how.

We investigated the impact of the use of a KMS by emergency room physicians on the rate of admission of emergency room patients to the hospital, emergency room charges, and patient time spent in the ER. The emergency room under investigation serves the 573-bed university hospital and is staffed by 38 physicians, working between one to fifteen 8-hour shifts per month. The ER treated approximately 93 patients per day and in 2009, a total of about 34,000 patients were treated at this facility.

The emergency room in our field study routinely collects and maintains patient records in a data warehouse. The records of all adult patients (18 years and older) who visited the ER in a 321 day period between January 2009 and November 2009 were used in this study (the precise dates were masked to protect patient anonymity). For the purpose of this study, we analyzed the records of ER patients who complained of abdominal pain as their primary symptom. We chose to focus on abdominal pain complaints because they represent relatively ambiguous cases and can potentially benefit the most from the use of a KMS. Considering patient privacy issues, we used a de-identified data sample. This was accomplished by creating new data sets from the warehouse patient records by excluding all identifying fields, assigning appropriate aliases, and copying the remaining data fields. The data fields used in our analyses are described in Table 1.

The IT infrastructure in the ER consisted of an EMR system, FirstNet, by Cerner Corporation in Kansas City, Missouri. FirstNet functionalities include electronic records and notes, results management (e.g., lab and radiology reports), clinical provider order entry (e.g., test orders), and a KMS for decision support (e.g., standard diagnostic orders and clinical guidelines and protocols). The KMS module provides physicians with recommended diagnostic tests and medication order sets, based on the patient’s symptoms. As such, this module can enhance the accuracy of diagnosis and delivery of appropriate patient care. The standard order sets (the codified knowledge embedded in the system) are developed by expert physicians based on the best available evidence of their efficacy. Physicians and nurses, however, can choose not to use the KMS recommendation and place their own orders.

We focused our investigation on the impact of the use of diagnostic order sets placed through the KMS on patient care outcomes.

In order to control for the exogenous impact of the severity of the conditions that affect the outcome of the ER visit, we only focused on two most prevalent acuity levels (urgent and emergent), resulting in a sample of 2238 emergency department visits. A small number of immediate, stable, and non-urgent cases were dropped. Table 2 shows basic descriptive statistics and the correlations between variables. All correlations with an absolute value of 0.07 or greater are significant at the p <0.05 levels.

Table 1: Emergency Room (ER) Patient Record Fields Included in the Study.

Field	Description
Admitted to Hospital	Outcome of ER stay resulted in admission to hospital for in-patient care
Duration of ER Stay	Length of stay in ER
Total Charges	Total of doctor charges and hospital charges for this ER stay (available only for a subset of patients)
Acuity	Level of acuity of patient condition as assessed at time of arrival to ER
Age	Age of patient on date of admission
Gender	Gender of patient
First Diagnostic Order through KMS	During this ER stay the first diagnostic order was placed via the KMS (a standard care set)
Total Number of Diagnostic Orders	Total number of diagnostic orders placed during this ER stay
Number of KMS Diagnostic Orders	Of the total number of diagnostic orders placed during this ER stay, the number placed through KMS
Rate of orders placed through KMS	Number of diagnostic orders through KMS divided by ER stay duration
Average Diagnostic Order Placement as % of ER Duration	Considering all diagnostic orders placed during this ER stay, the average time of order placement as a percentage of stay duration

3 PRELIMINARY RESULTS

We ran separate analyses to answer the research questions. In the first analysis, we examined if the use of recommendations from KMS affect hospital admissions. In particular, we focused on the impact of the use of the system (represented by Ordering Rate through KMS) on specific clinical decision-making behaviors (represented by Total Number of Diagnostic Orders, Average Diagnostic Order, and First Diagnostic Order through KMS). Since hospital admission is a binary variable, we used the logistic regression. Table 3 presents the logistic regression results for the predictors of hospital admissions. Model 1 contains three significant control variables related to the inherent complexity of patient care: acuity, age, and gender. The parameter estimates for acuity and age have the expected signs and magnitude: higher acuity patients are far more likely (~ 3x as likely) to be admitted to the hospital than lower acuity patients; each additional year of patient age leads to a very slight (~ 1.02x) increase in hospital admission. Model 1 has an AIC value of 2739 and a log-likelihood of -1365 (df=4). Model 2 is a full test with our explanatory variables. It has an AIC value of 2294 and a log-likelihood of -1138 (df=9). This is a statistically significant improvement over model 1 in model fit (p<0.001). Our results show that the use of KMS in clinical decision making contributes to the reduction of hospital admission. Furthermore, if the first diagnostic order follows the recommendation from the system, the reduction of the admission rate is even larger.

In the second analysis, we explored if the use of recommendations from KMS affected patient care cost. Since the total charge does not follow the normal distribution, we used a log transformation. The results of an OLS regression model of predictors of total charges (log transformed) are presented in Table 4. This model includes only the 788 emergency room encounters for which both physician charges and emergency department hospital charges are available. For those patients who were eventually admitted to the hospital, hospital charges were not available as the charges were rolled into other hospital charges incurred during the in-patient care. Because a portion of total charges are directly associated with the duration of a patient's emergency room stay, duration is included as an additional control variable. As expected, our results show that the duration of stay and total number of orders are the main drivers of the total charges. Our results also show that if the physician starts with a diagnostic order recommended by the KMS, it leads to a significant reduction in total charges.

Given that duration is one of the key variables that affect the total cost, in the third analysis, we examined if the use of recommendations from the KMS can contribute to the reduction of the duration. The results of an OLS regression model of predictors of duration of stay in the emergency department are presented in Table 5.

Taken together, our analyses show several statistically significant relationships for emergency room encounters with patients. The variables of acuity, age, and total number of diagnostic orders all increase the likelihood of an encounter resulting in a hospital admission. Also, female patients are less likely to result in hospital admission. However, we found that when a physician places a higher rate of diagnostic orders through the KMS, it significantly reduces the chance that the patient gets admitted in the hospital. Furthermore, this relationship is strengthened when the first diagnostic order is placed through the KMS.

Table 2: Correlations (n-2238).

		mean	s.d.	1	2	3	4	5	6	7	8	9
1	Admitted to Hospital (1=Yes)	0.40	0.49									
2	Duration of ER Stay	0.38	0.23	0.43								
3	Acuity (1=Higher)	0.34	0.47	0.29	0.07							
4	Age	44.6	18.2	0.23	0.09	0.16						
5	Gender (1=Female)	0.67	0.47	-0.13	0.02	-0.17	-0.09					
6	First Diag. Order through KMS (1=Yes)	0.69	0.46	0.05	0.03	0.04	0.03	-0.01				
7	Total Number of Diagnostic Orders	11.0	4.6	0.45	0.29	0.20	0.20	-0.02	0.23			
8	Number of KMS Diagnostic Orders	4.00	4.56	0.08	0.07	0.02	0.09	-0.04	0.59	0.20		
9	KMS Diagnostic Ordering Rate	13.1	14.3	-0.12	-0.31	-0.02	0.01	-0.02	0.47	0.02	0.76	
10	Average Diagnostic Order Placement as % of ER Duration	0.22	0.14	0.08	-0.13	-0.04	-0.00	0.03	-0.15	0.19	-0.09	-0.06

Table 3: Logistic Regression for (In-Patient) Hospital Admission (n=2238).

	Model 1: Controls				Model 2: Full Model			
	Est.	Exp (Est.)	Std. Error	Sig.	Est.	Exp (Est.)	Std. Err.	Sig.
(Intercept)	-1.58	0.21	0.18	***	-3.72	0.02	0.25	***
Acuity	1.10	3.02	0.10	***	0.91	2.49	0.11	***
Age	0.02	1.02	0.00	***	0.02	1.02	0.00	***
Gender	-0.37	0.69	0.10	***	-0.55	0.58	0.11	***
First Diagnostic Order through KMS					-0.12	0.89	0.15	
Total Number of Diagnostic Orders					0.26	1.30	0.02	***
KMS Diagnostic Ordering Rate					-0.08	0.92	0.02	***
Average Diagnostic Order Placement as % of ER Duration					0.23	1.26	0.41	
Interaction: First Order through KMS X KMS Diagnostic Ordering Rate					0.05	1.06	0.02	**

** $p < 0.01$; *** $p < 0.001$

In the subset of patient encounters where hospital charge data are available, patient age, the duration of emergency department stay, and the total number of diagnostic orders are all associated with higher charges. Female patients and encounters where the diagnostic orders are placed earlier in the stay are all associated with lower charges. If the physician starts the diagnostic orders following the recommendations from the system, it leads to a significant reduction of total cost.

In the full data set the measures associated with a longer duration of emergency department stay were gender (female) and the total number of diagnostic orders. Encounters with higher acuity and encounters where the diagnostic orders were placed earlier in the stay had lower durations. Again, if the physician starts the diagnostic orders following the recommendations from the system, it leads to a significant reduction in the duration of patient stay in ER.

Table 4: OLS Regression for Total Charges (Log Transformed) (n=788).

	Estimate	Std. Error	Sig.
(Intercept)	6.18	0.10	***
Acuity	0.04	0.05	
Age	0.00	0.00	**
Gender	-0.09	0.05	*
Duration	2.02	0.19	***
First Diagnostic Order through KMS	-0.22	0.07	***
Total Number of Diagnostic Orders	0.12	0.01	***
KMS Diagnostic Ordering Rate	0.00	0.00	
Average Diagnostic Order Placement as % of ER Duration	-0.87	0.17	***
Interaction: First Order through KMS * KMS Diagnostic Ordering Rate	0.00	0.00	

*$p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; Adj. $R^2 = 0.47$

Table 5: OLS Regression for ER Duration (n=2238).

	Estimate	Std. Error	Sig.
(Intercept)	0.30	0.02	***
Acuity	-0.03	0.01	***
Age	0.00	0.00	
Gender	0.04	0.01	***
Admitted to Hospital	0.19	0.01	***
First Diagnostic Order through KMS	-0.03	0.01	**
Total Number of Diagnostic Orders	0.01	0.00	***
Average Diagnostic Order Placement as % of ER Duration	-0.36	0.03	***

** $p < 0.01$; *** $p < 0.001$; Adj. $R^2 = 0.24$

4 CONCLUSIONS

An open question—and one that Information Systems (IS) researchers are well-situated to help address—is if and when knowledge management systems may actually impact practice. It is merely not enough to identify best practices; it is a greater challenge to consistently enact them. Our study provides preliminary evidence in how the implementation of KMS for diagnostic testing in an ER is leading to positive patient outcomes.

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