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Characteristics of Hospitals That Adopt Hospital Information Systems in Mongolia And Its Impact on Patient Safety and Quality of Care

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Objectives: Our objective was to determine the relationship between the adoption of hospital information system (HIS) in Mongolian tertiary and secondary care hospitals and the hospital's organizational & geographical characteristics, its impact on patient safety & quality of healthcare. **Methods:** This wasa cross sectional study involving the executive directors and 39 quality managersat 39 hospitals. Data werecollected using questionnaire to determine the adoption rate of HIS and their hospital's organizational & geographical characteristics. **Results:** The adoption of HIS significantly affected by hospital size, ownership type, health maintenance organization penetration, and hospital location (urban versus rural). The adoption of HIS was found to partially impactpatient safety and quality of healthcare outcomes. **Conclusion:** In terms of theoretical implications, this study confirms that hospital organizational & geographical characteristics (structure) impact the adoption of HIS (process) which in turn affects healthcare outcomes (outcome). These finding validate Avedis Donabedian's "Structure-Process-Outcome" model. The present findings also confirm that hospitals with these structural attributes adopted more technologies.

Keywords: Patient safety, healthcare quality, clinical information technology, administrative technique, hospital information system.

Introduction

Worldwide, the use of hospital information systems (HIS) to support national health-care services is expandingrapidly and is increasingly important. HIS areincreasingly recognized to play a critical role in addressing quality of care and patient safety concerns. Organizational and geographical characteristics related to the successful implementation of hospital information systems and improved medical outcomes is anarea where further research is needed [1-3]. Mongolian public hospitals are financed from the state budget, the health insurance fund, and user fees. Public hospitals mostly serve poor and low-middle-

income people, who make up about 60% of the total population (higher-income citizens tend to seek care from private hospitals or abroad), so improving public hospital management will primarily benefit the poorer and lower-middle-income groups. The public sector accounts for 78% of total hospital beds and 80% of total hospital admissions, and absorbs nearly 70% of the national health budget [4]. A significant number of healthcare providers still keep patient information on paper. HIS is fundamental factor for healthcare delivery [5]. The Institute of Medicine has published estimates that between 44,000 and 98,000 patients die per year in the U.S alone due to preventable treatment errors, with as many as a million patients suffering non-mortal, but serious harm [6]. HIS's are reported to enhance patient safety by reducing complications and mortality rates, as well as by minimizing medical errors [7]. In our study, we examined 52 information technologies which were grouped into three clusters: clinical, administrative and strategic technologies.

The aim of our research was to determine the relationships between the adoption of hospital information system and the hospital's organizational & geographical characteristics. We also sought to determine its impact on patient safety & quality of healthcare in Mongolian tertiary and secondary care hospitals. We hypothesized that the hospital's organizational & geographical characteristics were related to hospital's adoption of clinical, administrative, and strategic technology.

Materials and Methods

Survey design and setting

This was a cross sectional study involving the executive directors and 39 quality managers at secondary hospitals (District and province union hospitals, n=34) and tertiary care hospitals (n=5) located in Mongolia.

Participants and sample size

Participants of the study were hospital executive directors and quality managers from 39 secondary and tertiary care hospitals.

Data collection

Data were collected using a questionnaire regarding HIS usage and from the hospital's organizational & geographical characteristics as reported in the 2017 Mongolian health statisticsmeasuring quality of healthcare & patient safety indicatorsgathered by the Mongolian Health Development Center. Hospital characteristics gathered included organizational characteristics (size, ownership, and HMO penetration) and geographical location.

Organizational characteristics

1. Hospital size – the number of set-up and staffed beds. The data set divides the hospitals into three size categories based on the number of beds, teaching status, and urban/rural location: small, medium, and large.
2. Ownership – two types of ownership are analyzed in this study: for-profit and not-for-profit. Hospitals owned by the government, and other nongovernment hospitals (not-for-profit and church operated) are referred to as not-for-profit, while hospitals owned by investors (individuals, partnership, or corporation) are categorized as for-profit.
3. Health maintenance organization penetration – refers to the presence or absence of HMO contracts in the hospitals.

Geographical characteristic

1. Each hospital's location (Urban/rural).

The definition and measurement of the adoption hospital information system

Based our literature review, and the classification of hospital information systems we selected the cluster of technology approach of Austin & Boxerman (1998) and divided the HIS into three clusters: clinical, administrative, strategic decision-support [8, 9].

A technology adoption score that corresponds to the total number of technologies under each cluster was developed. Hospitals weregiven a score of 1 for each technology they had adopted under the three categories. Therefore, a hospital scored between 0 to 25 for the clinical technologies. A score of 0 indicates that the hospital hadnot adopted any of the technologies under this cluster while a score of 25 indicates that the hospital hadadopted all the 25 technologies. The scores ranged between 0 to 18 and 0 to 9 for administrative and strategic technologies clusters, respectively. Similarly, a score of 0 indicated no adoption of the technologies while higher scores indicated the adoption of more technologies.

Clinical technologies: The clinical technologies cluster refered to technologies that were directly associated with patient diagnosis, treatment, and evaluation of outcomes.

Administrative technologies: Administrative technologies

applications in werenot directly related to patient care activities. They rather were used in the billing and human resource departments and include financial information systems, purchasing and inventory control, payroll,outpatient clinic scheduling, office automation, and others.

Strategic technologies: They were used by the hospitals' management team to make strategic-planning and revenue-generating decisions as well as monitoring and performance evaluations. Similar to administrative and strategic technology's applications were not directly related to patient care.

Measurement of the patient safety and quality of health care indicators

Patient safety was measured in terms of four conditions. Patient Safety Indicators (PSIs):

1. Death in low mortality diagnosis related groups (DRG)- In-hospital deaths per 1,000 patients.
2. Decubitus (pressure) ulcer - Cases of decubitus ulcer per 1,000 discharges with a length of stay greater than 4 days.
3. Latrogenic pneumothorax – Cases of latrogenic pneumothorax per 1,000 discharges.
4. Selected infection due to medical care (PSI 7) - Cases of infections due to medical care, primarily those related to intravenous lines (IV) and catheters.

Measurement of quality of healthcare indicators

They weremeasured in this study in terms of inpatient quality indicators (IQIs). The indicators were:

1. Mortality due to acute myocardial infarction –defined as the "number of deaths per 100 discharges with thisprincipal diagnosis code from ICD-9.
2. Mortality due to congestive heart failure – refers to the number of deaths per 100 discharges with this principal diagnosis code from ICD-9.
3. Mortality due to pneumonia– refers to mortality in discharges with principal diagnosis code of pneumonia.

Statistical analysis

Statistical analysis were performed using SAS 9.1 software. Two different analyses were performed.First, negative binomial regression was used to identify the organizational and geographical characteristics that impact the adoption of clinical, administrative, and strategic technologies in Mongolian public hospitals. Quality of care and patient safety wereanalyzed as dependent variables while hospital organizational and geographical characteristics were analyzed as independent variables with respect to adoption of HIS. The statistical model was:

Adoption of three clusters of technology = f (size; ownership type; HMO and hospital location)

Second. Multiple regression was also used to determine the relationship between patient safety & quality of care and the three technology groups. The response variables were the patient safety and quality of care indicators and the predictor variable was adoption of HIS, as scored in each of three technologyclusters, while the organizational and geographical characteristics were used as control variables. The effects of clinical, administrative, and strategic technologies on patient safety and quality of care were analyzed separately. The statistical models were:

Patient Safety = f (size, ownership type, HMO, and hospital location, three technologyclusters)

Quality of Care = f (size, ownership type, HMO, hospital location, three technology clusters)

Result

Participant's characteristics of the study

Participant's age range from 35-56 years old and 71.7% were women. Fifty-nine percent of hospital executive directors and 80% of hospital quality managers had more than five years of working experience in health care administration sector and management respectively.

Descriptive statistical analysis for organizational & geographical characteristics of Mongolian secondary and tertiary care hospitals

Based on the number of beds, hospitals were divided into three groups: small, medium, and large. Seventeen of the hospitals were small (43.5%) and 17 were medium (43.5%), while only 5 hospitals (12.8%) were large. Nearly two-thirds of the hospitals were located in rural areas 64%, while theremaining proportion of the hospitals (36%) were located in urban areas. A large majority of the hospitals were not-for-profit (87.2% vs. 12.8%).

Descriptive statistical analysis for organizational & geographical characteristics impact on the adoption of HIS in the Mongolian secondary and tertiary care hospitals

The mean values for each of the technological categories were consistently for large hospitals than that of the medium and small hospitals. On average, large hospitals adopted 13.47 clinical, 7.17 administrative, and 5.35 strategic technologies compared to 9.25 clinical, 5.36 administrative and 4.17 strategic technologies for the medium and 8.89 clinical, 3.25 administrative and 1.25 strategic technologies for the small size hospitals. Large hospitals hadtwo to three times greater adoption rates than those of small hospitals.

For-profit hospitals on average adopted more technologies than not-for-profit hospitals: for-profit hospitals adoption rates were 11.6 clinical, 6.7 administrative and 4.14 strategic technologies compared to not-for-profit adoption rates of 8.45 clinical, 5.85 administrative and 2.10 strategic. For-profit hospitals hadhigher HIS adoption rate than not-for-profit hospitals.

Hospitals with an HMO contract exhibited higher mean values for all of the technological categories (10.54 for clinical, 5.28 for administrative and 4.78 for strategic technologies) compared to hospitals without an HMO contract (7.18 for clinical, 4.46 for administrative, and 1.81 for strategic technologies). This data indicate that hospitals which had HMO contracts had twice the technology adoption rate than hospitals without HMO contract.

Finally, the geographical location waspositively related to the HIS adoption rate. Urban hospitals had three times greater technologyadoption rate than rural hospitals.

The adoption rate of overall ranged between 29.02 and 38.05 with a mean of 33.29%. The above data indicatethat the adoption of 3 cluster's technologies among Mongolian public hospitals had not yet reached the half of all point at the time of the survey (see Table 1).

Regression analysis for organizational & geographical characteristics impact on HIS's adoption

Organizational & geographical characteristics impact on the adoption of clinical technologies: We are examined relationship between each of the elements of the healthcare IT cluster and the hospitals' organizational and geographical characteristics.

The adoption of clinical technologies in Mongolian secondary and tertiary care hospitals were positively associated with size ($p < .001$), urban location ($p < .001$), and HMO penetration ($p < .05$) (Table 2).

Organizational & geographical characteristics impact on the adoption of administrative technologies: Administrative technologies were positively affected by size ($p < .001$), urban location ($p < .01$), and HMO penetration ($p < .05$). Ownership type did not appear to affect the adoption of administrative technologies (Table 2).

Organizational & geographical characteristics impact on the adoption of strategic technologies: The adoption of strategic technologies was positively associated with size ($p < .001$), urban location ($p < .001$), ownership ($p < .01$), and HMO penetration ($p < .01$). Hospital location did not significantly impactthe adoption of strategic technologies (Table 2).

Regression analysis: Relationship between HIS's adoption and patient safety and quality of healthcare:

We are examined relationship between the three technology clusters and the hospital's healthcare delivery outcome.

First, patient safety was measured through four indicators selected because of their importance to Medicare. These included death in low mortality diagnosis related groups (DRGs), decubitus ulcer, iatrogenic pneumothorax and selected infection.

Second, quality of healthcare was measured through three indicators: In-hospital mortality due to acute myocardial infarction, congestive heart failure and pneumonia. Regression analysis was used to determine the relationship between each of these indicators and the three technology clusters (Table 3).

In-hospital mortality due to pneumothorax significantly negatively associated (i.e. the rate decreased) with the adoption of clinical technologies ($p <0.05$) but not with administrative and strategic technologies ($p=0.08$ and $p=0.25$ respectively). In low mortality DRGs, selected infections were also significantly negatively associated with the adoption of strategic technologies ($p <0.05$, $p <0.01$) but no significant association was found with the implementation of clinical and administrative technology. Decubitus ulcer rates were not associated with the adoption of the IT (Table 3).

In-hospital mortality due to acute myocardial infarction was not significantly associated with the adoption of any of the technology clusters. In hospital mortality due to congestive heart failure and pneumonia significantly negatively associated

Table 1. The adoption rate of hospital information system in Mongolian secondary and tertiary care hospitals

Dependent variables							
Independent variables	Clinical		Administrative		Strategic		Rate (%)
	Number	Rate (%)	Number	Rate (%)	Number	Rate(%)	
Size							
Small (43.5%)	8.89	35.56	3.25	18	1.5	16	23.18
Medium(43.5%)	9.25	37	5.36	29.7	4.17	46.3	37.66
Large(12.8%)	13.47	53	7.17	39.83	5.35	59.44	50.75
Ownership							
Non-profit (87.2%)	8.45	33.8	5.85	32.5	2.1	23.33	29.87
Profit (12.8%)	11.6	46.4	6.7	37.22	4.14	46	43.2
HMO[a]							
HMO (76.9%)	10.54	42.16	5.28	29.33	4.78	53.11	41.53
Absence HMO (23.1%)	7.18	28.72	4.46	24.77	1.81	20.11	24.53
Location							
Urban (36%)	10.99	43.6	7.02	39	0.78	8.66	30.42
Rural (64%)	4.25	17	1.25	6.94	1.47	16.33	13.42
Rate of overall	38.05%		29.02%		32.8%		
Mean overall rate	33.29%						

[a] Health maintenance organization

Table 2: Multiple regression results showing the associations between the organizational & geographical characteristics and the adoption of hospital information system

Dependent variables						
Independent variables	Clinical		Administrative		Strategic	
	β	95% CI	β	95% CI	β	95% CI
Size	0.256***	0.2325, 0.2803	0.3654***	0.3452, 0.3856	0.0006***	0.0007, 0.005
Ownership	0.0456	0.0396, 0.0516	0.0352	0.009, 0.061	0.1995 **	0.098, 0.301
HMO[a]	0.2560*	0.1215, 0.4505	0.1985*	0.179, 0.218	0.2236**	0.1512, 0.296
Location	0.2840***	0.1427, 0.4253	0.2256**	0.1227, 0.3285	0.2256***	0.1489, 1.488

* p value <0.05, **p value <0.01, ***p value <0.001, [a] Health maintenance organization, Positive β values indicate higher rates associated with hospitals that have the corresponding hospital information systems

with the adoption of clinical technologies (p<.05 and p<0.01) but were not found significantly association with strategic and administrative technologies (Table 3). The multicollinearity analysis is shown in table 4. Problematic multicollinearity was unlikely since the tolerance values are greater than 0.2 or 0.1 while simultaneously the value of the variance inflation factors (VIF) are below 10 for all of variables.

Discussion

Surveying hospitals regarding their hospital information systems is new in Mongolia. Our study shows that among Mongolian tertiary and secondary care hospitals, organizational and geographical characteristics such as hospital size, ownership, health maintenance organization and hospital location play a significant role in determining the adoption of various healthcare

Table 3. Regression results showing the associations between the adoption of hospital information systems and patient safety & quality of healthcare

Variables	Clinical		Administrative		Strategic	
	β	95% CI	β	95% CI	β	95% CI
Patient safety indicators						
Death in low mortality DRG [a]:	0.0179	-0.1144, 0.1501	0.0206	-0.0980, 0.1392	0.1414*	0.0200, 0.2627
Pressure ulcer	0.0987	-0.0277, 0.2252	0.0897	-0.0594, 0.2389	0.0501	-0.0312, 0.1314
Iatrogenic pneumothorax	0.1566*	0.0218, 0.2913	0.0578	-0.0622, 0.1779	0.0987	-0.0152, 0.2125
Blood Stream Infection	0.0425	-0.0238, 0.1089	0.0145	-0.1022, 0.1312	0.1812**	0.0562, 0.3062
Quality of healthcare indicators						
Acute myocardial infarction	-0.0043	-0.0530, 0.0443	-0.0008	-0.0014, 0.0030	0.0003	-0.0028, 0.0034
Congestive heart failure	-0.0040*	-0.0078, -0.0001	0.0006	-0.0021, 0.0034	-0.0026	-0.0058, 0.0006
Pneumonia	0.1812**	0.0562, 0.3062	0.0015	-0.0020, 0.0050	-0.0045	-0.0115, 0.0024

*p value <0.05, ** p value <0.01, *** p value <0.001, [a] Diagnose related group, Positive β values indicate higher rates associated with hospitals that have the corresponding hospital information systems

Table 4. Multicollinearity analysis of independent variables used in the analysis on adoption of hospital information systems on patient safety and quality of healthcare

Variables	Clinical		Administrative		Strategic	
	Tolerance	VIF‡	Tolerance	VIF	Tolerance	VIF
Patient safety indicators						
Death in low mortality DRG [a]:	0.67	1.49	0.69	1.44	0.51	1,97
Pressure ulcer	0.84	1.19	0.61	1.53	0.69	1.45
Iatrogenic pneumothorax	0.51	1.97	0.75	1.25	0.69	1.44
Blood Stream Infection	0.63	1.59	0.85	1.18	0.54	1.86
Quality of healthcare indicators						
AMI[b]	0.82	1.22	0.63	1.53	0.85	1.18
Congestive heart failure	0.56	1.80	0.53	1.78	0.59	1.80
Pneumonia	0.50	1.99	0.98	2.25	0.78	1.49

‡ Variance Inflation Factor (VIF), [a] Diagnose related group, [b] Acute myocardial infarction

IT applications. Most prior studies on HIS were restricted in scope as they primarily focused on a limited number of technologies, single healthcare outcomes, individual healthcare institutions, and limited geographic locations.

Our study differs from other similar studies by applying a more inclusive and complex approach: first, by using the most recent data, it explores organizational and geographical characteristics that may affect HIS adoption in hospitals using

the most recent data; second, by examining the effects of technology adoption by selecting 52 HIT applications under three technology clusters based on their potential impact on selected healthcare outcomes; third, previous studies conducted in this field only determine the rate and role of HIS adoption. Our study analyzes the present rate of adoption and the factors influencing adoption with the some health care delivery outcomes.

This study applies Avedis Donabedian's (1980) "Structure-process-outcome" conceptual model that is a widely used in the study of hospital quality of care [10]. This approach analyzes quality of healthcare outcome from three dimensions: Structure, process, and outcome.

Structure refers to the community, organizational, provider, and population characteristics within the healthcare IT industry. The application of structural dimensions in the assessment of quality of care is justified because this information can be relatively easy to acquire from administrative data [11]. Process measures refer to the actual healthcare provision activities measured by healthcare IT professionals. They also refer to the patient-provider interaction or more specifically the way patients are treated by health providers and evaluated by healthcare IT professionals. Outcomes canbe influenced by both structure and process, though a study by Hoenig et al. (2002) indicated that outcomes are influenced less by structure and more by process measures [12].

Some hospital characteristics may have stronger effects on HIS adoption than others, there may be other characteristics with no significant effect. The literature shows that the adoption of one or more of the HIS's applications may lead to improved quality of care by providing better surveillance, increasing adherence to guidelines, reducing inpatient days, increasing appropriateness of orders, enhancing integrated data review, and positively impacting medication and non-medication quality of health care measures. In terms of patient safety, the adoption of HIS's applications may lead to reduced error of omission, reduced numbers of adverse drug effects and serious medication errors, improved physician prescribing behavior, increased patient ID confirmation, and reduced number of fatal hospitalizations [13].

From an organizational characteristics, we found that size of hospital was the most important predictor of the adoption of HIS. Large hospitals consistently adopted the largest number of clinical, administrative and strategic IT applications compared to small and medium size hospitals. These results are similar to the findings of other authors. Burke et al. (2002) and Wang et al. (2005) also found positive associations between adoption of clinical, administrative, strategic technologies and hospital size [14,15]. Furukawa et al. (2008) as well as Parente and Van Horn (2006) also showed a significant relationship between hospital size and adoption of some clinical technologies applications. The logic behind this finding may be the fact that large hospitals generally have advantages due to economies of scale compared to medium and small hospitals [16,17].

Jinhyung Lee et al showed the rate of clinical IT adoption differs in degree by hospital characteristics. Teaching status, for-profit status, and bed-size of hospitals were closely related to clinical IT adoption. Teaching hospitals, not-for-profit hospitals, and hospitals with large bed-size had higher clinical IT adoption rate [18].

In Mongolia, the adoption rate of overall ranged between 29.02 and 38.05 with a mean of 33.29%. These data suggest that the adoption of 3 cluster's technologies among Mongolian public hospitals had not yet reached the half of all point at the time of the survey (Table 1). In Florida's hospitals, mean rate of HIS adoption was found to be higher (clinical technology 45%, administrative technology 74% strategic technology 50%, mean adoption rate HIS 57%) than Mongolian public hospitals adoption rate [19]. A study conducted in the United States of America reported a 50% failure for clinical technology implemented in healthcare organizations. These findings are generalizable to many industrialized countries [20].

Other study results shows that for-profit ownership type significantly affected on the adoption of clinical and strategic technologies but not administrative technologies. The positive effects of for-profit ownership on some clinical technology's applications were also found by Taylor et al [21]. Hikmet et al showed that ownership status had a significant effect on administrative, strategic, but not on the clinical status [19].

Our analysis of the geographical characteristics of Mongolian hospitals suggests that urban location was the most important indicator of the adoption of all categories of health care IT. This confirms the findings of other studies [21]. Compared to rural areas, urban areas are more developed in terms of economic activities. Therefore, hospitals in urban areas have better opportunities to partner with various industries, government

agencies, and institutions of higher learning and research, and they may be able to secure external financial resources and acquire information about these relatively new HIS technologies. But some researcher's results in highly developed countries, differ from ours. Hikmet et al examined whether specific organizational and geographical characteristics influenced adoption of HIS in 98 hospitals in Florida. They observed that hospital size, ownership status were significant predictors of HIS adoption, but not geographic location. The strongest effects were that of hospital size and for profit ownership status. In contrast, in our study the adoption of clinical HIS was predicted only by hospital size. In today's interconnected society in highly developed countries, financial and infrastructural resources are accessible in nearly all geographic locations, and today's highly mobile work force ensures that the needed technical skills and capability are usuallyavailable wherever they are needed irrespective of geographic location [21]. However, the situation is very different in developing countries as reflected in our results.

The relationships between the adoption of health care IT and selected patient safety and quality of health care measures were also analyzed. Patient safety indicators that in-hospital mortality due to pneumothorax significantly negatively associated (i.e. the rate decreased) with the adoption of clinical technologies ($p < .05$). Previous studies have found that clinical IT could significantly increase quality and productivity, and decrease costs, although some studies have found a weak impact [12, 21].

Amarasingham et al. (2009) demonstrated that HIS could increase patient safety by reducing complications and mortality rates, as well as by minimizing medical errors [7]. Walsh et al. (2005) indicated that HIS adoption may reduce the number of adverse drug effects and serious medication errors [22].

In our study, two of the quality of healthcare indicators, hospital mortality due to congestive heart failure and pneumonia significantly were negatively associated with the adoption of clinical technologies ($p<.05$). This finding is consistent with findings of Amarisingham et al (2009) who found a significant reduction in pneumonia-attributed mortality due to the adoption of healthcare IT in hospitals [7].

A number of authors have indicated that the adoption of HIS applications may lead to improved quality of care. Samore et al. (1997) found an association between HIT adoption and better surveillance, while Mullett et al. (2001) found a relationship between HIT use and reduced inpatient days [23, 24]. McCullough et al. (2010) as well as Kazley and Ozcan (2008) found a positive association between information technology use and better performance on some quality of care indicators [25, 26] .

Additionally, Ingebrigtsen et al. (2014) conducted a systematic review to examine evidence of associations between clinical leadership and successful information technology (IT) adoption in healthcare organizations. Their study result shows that clinical leaders who have technical informatics skills and prior experience with IT project management are likely to develop a vision that comprises a long-term commitment to the use of IT. This leads to proactive leadership behavior and partnerships with IT professionals that are associated with successful organizational and clinical outcomes [27].

Finally, the systematic review study Kruse et al. (2018) shows that at least one improved medical outcome as a result of health information technology adoption was identified in 81% (25/37) of research studies, while no statistical difference in outcomes was identified in 19% of included studies [28].

Limitation and future study

This study has some limitations. First, we used a raw count of deployed HIS technologies as a measure of HIS adoption. We recommend that future research examine not only if HIT application is deployed, but also which of these applications is deployed, in order to make a fair assessment of the dependent variable. Our study focused on only four patient safety and three quality of care indicators due to the limitations of the available data. Future healthcare researchers should further explore these and other characteristics in greater depth using a more generalizable sample of healthcare organizations. We suggest that future researchers consider a national-level study to fully explore the role of individual characteristics on hospitals.

Conclusion: In terms of theoretical considerations, this study confirms that organizational & geographical characteristics (structure) impact on the adoption of HIS (process) which in turn affects healthcare outcomes (outcome). This finding is a validation of Avedis Donabedian's "Structure-Process-Outcome" model. The present findings also confirm that hospitals with these structural attributes adopted more technologies.

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