Factor Analysis: An Applied Approach towards the Adoption of Cloud Computing to Enhance the Healthcare Services in Malaysia

P.D.D.Dominic*, Kalai Anand Ratnam**
* Department of Computer & Information Science, Universiti Teknologi PETRONAS, Malaysia
** Asia Pacific University of Technology &Innovation, Technology Park Malaysia, Malaysia

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ABSTRACT

The global healthcare industry is continuing to grow, and it is important to realize that the healthcare providers will have to continue to invest in IT based systems to improve overall operations and cross system communications. The study focuses on the relationships between healthcare providers, IT resources and health insurance providers in determining the adoption of cloud services to improve collaboration and efficiency. The results obtained in this study yields that IT resources had significant influence on healthcare providers and health insurance providers. The efficiency and collaboration can be improvised with the adoption of cloud services. The findings of this study are supported with results of reliability analysis, descriptive analysis, exploratory factor analysis and confirmatory factor analysis.

Corresponding Author:

Kalai Anand Ratnam,
School of Interactive Technologies, Faculty of Computing, Engineering & Technology,
Asia Pacific University of Technology & Innovation (A.P.U),
Technology Park Malaysia, 57000 Bukit Jalil, Kuala Lumpur, Malaysia.
Email: anand@apu.edu.my

1. INTRODUCTION

The healthcare sector is facing tough challenges to reduce the costs associated in providing healthcare services by adopting new platforms to supplement electronic medical records and sharing of information securely and instantly with among business associates, government agencies and health care providers [1]. Healthcare center's such as hospitals and dispensaries in rural areas are facing the most challenge when comes to health information management as it's a complex task, and to provide healthcare service of high quality, is determined by an information processing system which is efficient and extensive. The ongoing research and development in the area of cloud computing within the domain of healthcare sector will potentially have great impact as it's a computing platform which is continuously evolving providing shared resources for business processes, applications and infrastructure [2]. The core underlying technology which enables resource sharing on the cloud is virtualization. Given the high scalability with virtually unlimited computing power, cloud computing may be used in other areas such e-Governance Systems, Decision Support Systems, Scientific Medical Research and etc.

A variety of IT infrastructures and applications are used in most health care organizations which consistently require continuous upgrades as a result of high demand from the healthcare sector. Further to that the cost of computerized systems for the health care sector is far too expensive considering the fact that the primary activity is medical related and IT is only an enabler to assist vital decisions to be made at the point of care. Most of the health care organizations at present, especially in the rural areas do not have any sort of systems or have opted to develop systems on their own, some even purchase solutions off the shelf. To add to that, a number of small-medium sized health care organizations are still using paper-based forms in their day to day operations, This is due to the perception that investing in IT is a costly affair. The way on how the health care organizations run their operations, especially in regards to patient's medical information

resulted in difficulty of accessing patient data. As such Cloud computing introduces an effective method of delivering services and value to the healthcare providers.

Cloud Computing is none other than a rapidly growing technology which includes several types of services offered over the Internet either as fixed subscription model or pay-as-you use model. With cloud computing, applications deployed can be scaled at any time without having to physically add any sort of hardware, thus the strategy to adopt cloud computing will help organizations to focus on the core activity with much less hassle but greater effectiveness and efficiency. It remains a challenge to see how cloud computing will make a difference in the healthcare sector since the operations are unique, diverse and complex, and the compliance of privacy guidelines is important to protect the privacy of health records. Many healthcare providers are looking from different perspectives to reduce costs incurred by Health Information Technology related services, as such the sort of IT solutions put in place will be a major role in realizing improved quality in clinical services. To see the outcome of cloud computing addressing and contributing towards the issues faced by health care providers will definitely be something of great interest to look into.

Rapid decrease in hardware cost, virtually unlimited increase in computational power and storage capacity with the power of multi-core architecture are the three main factors that has created interest in cloud computing among healthcare providers [3]. As mentioned in [4] on average a hospital requires up to 175TB of storage space to store diagnostic images and clinical records. It is estimated that by the year 2020, medical data is projected to hit over 35 Zettabytes and this is relatively an extremely large size.

Cloud powered solutions within the healthcare industry offers a number of key benefits, such as the follows:

- Cloud computing enables endless connectivity among hospitals, doctors, patients and other associates thus reducing cost and saving time [5].
- Regardless of healthcare organizations size and location, access to resources that are previously difficult to reach is now possible with the cloud providing powerful IT resources and computing infrastructure of world class that are readily available without huge-investment [6].
- Flexible fee structure: For healthcare organizations where paid-up capital and cash flow pose a challenge, pay-as-you-go model will be an ideal solution [7]
- Unification of data administration: Cloud powered information management platform will be the backbone for healthcare providers, thus enabling seamless sharing and integration with other applications [8].

2. RESEARCH DESIGN AND METHOD

2.1 Research Context

The context of this research has been restricted to only hospitals and clinics in Malaysia which consist those from the public and private sector. The main reason for selecting the healthcare sector as the area for enhancing its services with the adoption of cloud based technology is due to its demand and need for an integrated system across the healthcare ecosystem, which is believed to be the catalyst in providing services of global standards with availability of information instantaneously.

2.2 Problem Statements

P1: A platform to integrate health sector related entities such as patients, national emergency call center, health insurance providers and both public and private healthcare providers in Malaysia are not available.
P2: Costs of medical related hardware(s), are increasing, limited sharing of critical information & scalability is an issue.
P3: Practically patients would not seek for medical treatment in fixed medical center and when cases are referred to the main hospitals typically the problem of not being able to recognize information and compatibility issues between information systems during referral process of the medical records tend to occur.
P4: It is important for healthcare providers to share health care information electronically, but the disadvantages posed by electronic health records that unable to communicate with one another, a poor information-exchange infrastructure platform, and the high cost of setting up electronic interfaces and information exchanges are some of the major contributing factors.
P5: Despite the health information system implemented by the government, there are number of different instruments and parallel systems being operated by various hospitals in throughout the country.

2.3 Research Objective

The primary objective of this study is to further identify the relationship between efficiency and collaboration in enhancing the healthcare services. The objectives of this study are as follows:

- To identify and evaluate major attributes involved in the formulation of Information Technology (IT) capability in healthcare services.
- To formulate a theoretical framework for Information Technology (IT) capability in healthcare services.
- To evaluate and construct prototype architecture of a private cloud driven hospital information management system (HIMS) integrating health insurance providers to further enhance health services by creating an integration service between hospitals to hospitals and insurance providers to hospitals.
- To propose a strategy for implementing the prototype architecture of a cloud driven hospital information management system (HIMS).

3. RESULTS AND ANALYSIS

The objective of carrying out this study is to attempt to identify factors that influences the adoption of cloud computing to enhance the services of the Malaysian healthcare sector, and further study the relationships between those factors. The concerns on system utilization, system integration, security, efficiency & management actions are considered to be the essential factors associating the adoption of cloud computing for the Malaysian healthcare sector in improving collaboration and efficiency. The following hypotheses are to be specifically tested in this study as illustrated in Figure 1.

H1: An effective healthcare provider has a direct positive influence on the efficiency.
H2: An effective healthcare provider has a direct positive influence on the extent of the collaboration.
H3: IT Resources has a direct positive influence on the extent of efficiency.
H4: IT Resources has a direct positive influence on the extent of collaboration.
H5: An effective health Insurance provider has a direct positive influence on the efficiency.
H6: An effective health Insurance provider has a direct positive influence on the extent of the collaboration.

3.1 Descriptive Analysis

For this study, both online and paper based questionnaire were used as the survey instruments. The target group of respondents were doctors, nurses, IT engineers, lab technicians and administrative staffs. A total of two hundred (200) questionnaires were distributed to various hospitals in the state of Penang, Selangor, Johor and Perak. In addition to the paper based questionnaires which were distributed, an online survey link was posted on http://www.questionpro.com. The links were distributed through the initial meetings which were held with hospitals officials. A window period of 1 ½ months was the time frame to complete the data gathering. During the phase of pilot study, a total of 50 respondents from the Johor state hospital participated. The objective of the pilot study was to determine the clarity, comprehensiveness, appropriateness of the questions which were designed. Besides presenting Cronbach's Alpha to assess reliability, Average Variance Extracted (AVE) were presented as an added indicator in supporting validity of the items and constructs.

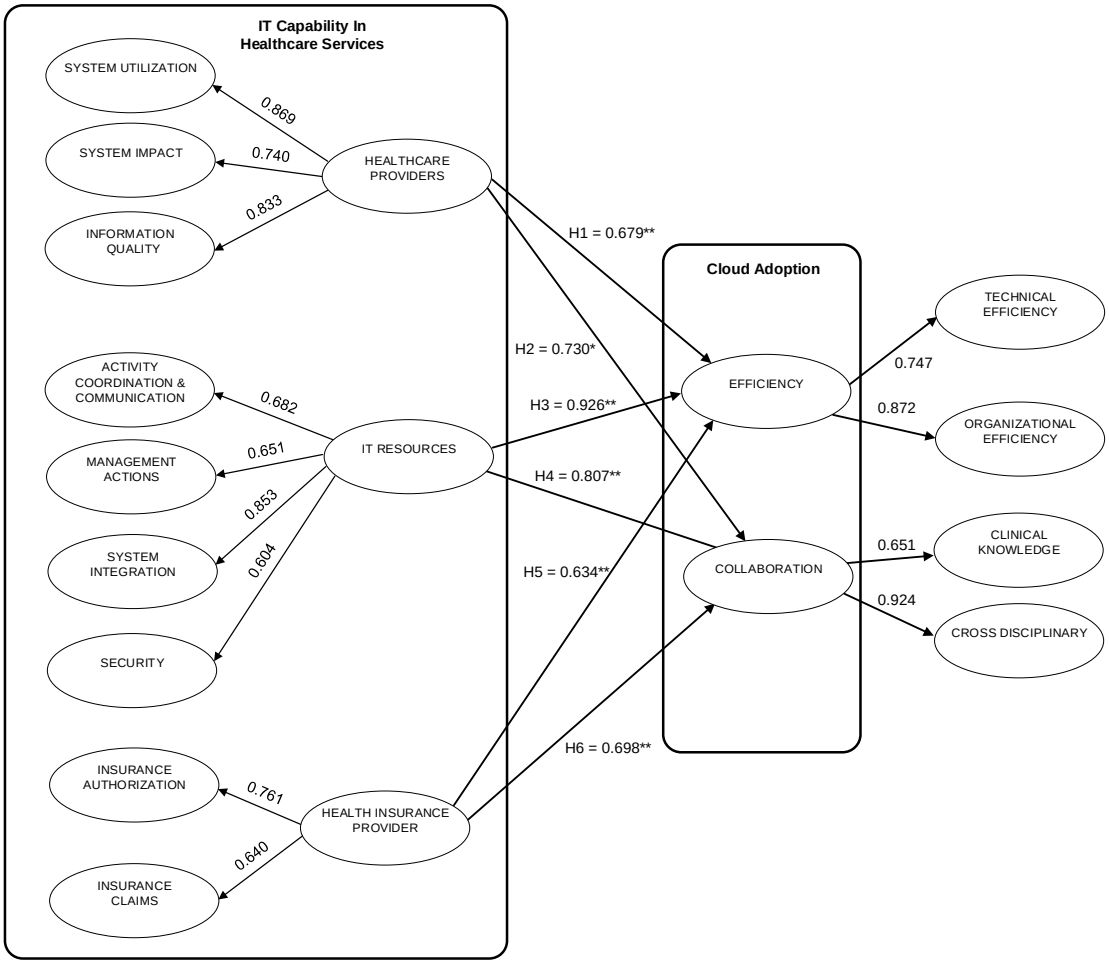
Three hundred and twenty respondents (47.5% doctors, 27.8% IT systems engineers, 9.1% lab technicians, 8.1% nurses, 6.9% administrative staffs and 6% accountants) were those who participated as part of the analysis procedure in this study. Most of the respondents were from the public hospital (about 78.8%), followed by (about 20.9%) from the private hospital and (about 0.3%) from private clinics. Out of the 320 respondents (about 68.4%) are from hospitals in the urban zone, (about 15%) from the semi urban zone and (about 16.6%) from the small healthcare centres located in the rural area. One of the important observation which made was that (about 99.7%) of medical centres have some sort of hospital information management systems in place but (about 93.1%) of them are not even linked up with their own branch offices as well and only (6.9%) are linked up. This clearly shows the level of system integration for information sharing and exchange is relatively low. In regards to the sampling technique, the Simple Random Sampling (SRS) was used by obtaining samples from identifiable groups to quantitatively evaluate the scaled items.

In regards to the utilization (about 72.2%) rely on the usage hospital information and management systems and (about 27.8) seldom uses them, as their job role does not require them to rely on it. As the utilization of hospital information management system is relatively high, it's clearly evident that it is an important tool for data capturing, data processing and decision making. From the perspective of system integration (about 86.6%) of the respondents agree that having a totally integrated system will increase both efficiency and effectiveness across the organization, but (about 98.4) of the respondents mentioned that due

to heterogeneous systems, the data exchange of among different systems tend to fail due to technical problems.

3.2 Reliability Analysis

A total of 55 items measuring 13 constructs were assessed for reliability, the alpha values ranged from 0.693 to 0.951 in this study. As emphasized by [9] and [10], the acceptable value for Cronbach's alpha would be from the range of 0.70 – 0.95. The Average Variance Extracted (AVE) which reflects the overall amount of variance in the indicators were in the range of 0.602 to 0.761 for the hypothesized constructs, and the range is acceptable as it exceeds the recommended value of 0.50 as mentioned by [11] and [12] .



Note: *** p <= 0.001; *p <= 0.05*

Figure 1. Research Model

3.3 Exploratory Factor Analysis (EFA)

In this study, the researcher adopted the PAF (Principal Axis Factoring) rotation method as the preferred Exploratory Factor Analysis method as it has the ability to recover from weak factors. The healthcare provider variables for every item were analysed to identify the factor structure. Three variables with 25 items loaded on the healthcare providers construct. The analysis yielded three factors for the construct healthcare providers explaining a total variance of 84.1% for factor 1, 83.7% for factor 2 and 84.3% for factor 3. Factor 1 were labelled system utilization, factor 2 was labelled system impact and factor 3 was labelled quality process. All the items of system utilization, system impact and quality process carried loading factor values that are acceptable with the exception of item QP6 of quality process. Item QP6 achieved a loading value of 0.426, which is a relatively a low loading, as such the item will be eliminated from being used in further analysis.

Similar to healthcare provider, variables belonging to IT Resources were further analysed to identify the factor structure. There are four variables with 30 items within IT resources construct and the analysis yielded four factors for the construct IT resources construct explaining a total variance of 84.1% for factor 1, 82.1% for factor 2, 73.9% for factor 3 and 55.8% for factor 4. All the items of Activity Coordination & Communication, Management Actions, System Integration and Security carried a loading factor value that are acceptable within the recommended threshold. The only exception is item ACC1 of Activity Coordination & Communication which has achieved a value of .398, this value is relatively low and will not be used in further analysis.

To assess the construct validity of health insurance providers, 2 Variables with 11 items, namely insurance authorization and insurance claims with 7 and 4 items respectively and the analysis yielded two factors with a total variance of 77.4% for factor 1 and 69.6% for factor 2. Factor 1 was labelled insurance authorization and factor 2 was labelled insurance claims. All the items appeared to have loading factor values which are acceptable within the specified threshold and thus will be utilized for further analysis.

To assess the construct validity of Efficiency, 2 variables with 8 items, technical efficiency and organization efficiency with 4 and 4 items respectively and the analysis yielded two factors with a total variance of 81.2% for factor 1 and 90.4% for factor 2. All the items appeared to have loading factor values which are acceptable within the specified threshold and thus will be utilized for further analysis.

To assess the construct validity of collaboration, 2 variables with 7 items, namely clinical knowledge and cross disciplinary with 4 and 3 items respectively. The analysis yielded two factors with a total variance of 55.1% for factor 1 and 55.2% for factor 2. All the items appeared to have loading factor values which are acceptable within the specified threshold.

As there are prerequisites prior to carrying out EFA, The Bartlett test of sphericity and The Kaiser–Meyer–Olkin (KMO) test of sampling adequacy were carried out as a basis to justify the appropriateness of the EFA. The Kaiser–Meyer–Olkin (KMO) overall measure of sampling adequacy was more than 0.70 for all constructs measured. Since the KMO value was well above 0.70, the variables were inter-related and they shared common factors. The communalities values ranged from 0.610 to 0.793 suggesting that the variance of the original values was fairly explained by the common factors. The results of the factor analysis produced a relatively clean factor structure with high loadings on the important and respective factors. Most of the variables measured, loaded heavily on one factor and this indicates that there were minimal overlap among factors and that all factors were structured independently. The higher loadings indicate the correlations of the variables with the factors on which they were loaded. The results obtained showed that the Alpha coefficient ranged from 0.604 to 0.924, well above the minimum value of 0.50 which is considered acceptable as an indication of reliability in this study.

3.4 Confirmatory Factor Analysis (CFA)

To confirm the factor structure on the all the 54 items finalized in the EFA, Confirmatory Factor Analysis (CFA) was carried out to determine the outcome of the overall measurement model as a whole. An in-depth analysis of the covariance structures between all the exogenous and endogenous constructs were analysed as a whole. The results of the estimation for the First Order-Factor CFA Measurement Model provided a satisfactory result. The significant $\chi 2/df$ value as well as other fit indices indicated a relatively good model fit between the model and the data. The researcher carried out another step in assessing the fit of the individual parameter values. The complete standardized factor loadings for each indicator were significant (t-value > 1.96), and the indicators loaded very well on the respective factors, and were explained substantially by the latent factors. As such it can be confirmed that the latent factors were confirmed by the data obtained through the survey. During the final run, all values in the Standardised Regression Weights (SRW) output were above 0.60. Since the model fit results were well acceptable within the criteria, the next step was to evaluate the model fit indexes to identify the measurement model fitness. The model fit output readings were acceptable with the following values; Chi-Square = 1136.254; df = 514; p = 0.002; $\chi 2/df$= 2.210 < 3, GFI = 0.950; CFI = 0.970; NFI = 0.920 & RMSEA = 0.048.

4. CONCLUSION

The current study has successfully managed to investigate the factors that determine the adoption of cloud computing to enhance the services of the Malaysia's healthcare sector through the approach of factor analysis. Based on the statistical findings and evaluation of relevant indicators, it is quite evident that the adoption of cloud for the healthcare sector will have a significant impact within the Malaysia healthcare sector. We have seen that based on the study above the efficiency and collaboration can be improved through the adoption of cloud services. It also clearly indicates that sharing of health information with a total integrated system driven by collaboration is one of the key factors for the successful implementation of healthcare systems. The overall costs of the IT infrastructure will be far more cost effective with the adoption

of cloud platform as access to applications are consumed as a service. The authors believe that with the adoption of cloud services, establishing a health exchange for the Malaysian healthcare sector will allow greater collaboration between researchers, physicians and other relevant entities.

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Dr. P. D. D. Dominic obtained his M.Sc degree in operations research in 1985, MBA from Regional Engineering College, Tiruchirappalli, India during 1991, Post Graduate Diploma in Operations Research in 2000 and completed his Ph.D during 2004 in the area of job shop scheduling at Alagappa University, Karaikudi, India. Presently he is working as an Associate Professor, in the Department of Computers and Information Science, Universiti Teknologi PETRONAS, Malaysia. His fields of interest are Operations Management, KM, and Decisions Support Systems. He has published more than 50 technical papers in International, National journals.

Kalai Anand Ratnam is currently a PhD student at the Department of Computer and Information Sciences, Universiti Teknologi PETRONAS, 31750, Tronoh, Perak, Malaysia. He received a Master of Network Computing from Monash University Australia in 2002. His research interests includes the area of Health Informatics, Knowledge Management & Cloud Computing. He has published technical papers in both conferences and journals, managed software projects for startup companies and mentored students for software design and development competitions in both local and international arena.