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An AHP Based Method to Prioritize the Barriers and Critical Success Factors of RFID Adoption in Healthcare

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Abstract: This study presents an approach for determining the key barriers and Critical Success Factors (CSF's) in adopting Radio Frequency Identification (RFID) Technology in healthcare. This approach replaces the traditional rule of thumb or experiences based judgement currently being used which may lead to many poor and costly decisions. The Analytic Hierarchy Process (AHP) was used to prioritize the barriers and CSF's and Delphi Method was employed to collect data from RFID consultants and IT managers. The study centred around Indonesian and Malaysian hospitals. The results of the study suggest that business barriers are considered to have a more impact than technology barriers. A sub-component of the business barrier which is a lack of information is the most important items within the sub-category of business barrier. On the other hand, strategic factor is considered to be more critical than management and operational factors. Top management support and the commitment of leadership is not only the most important sub-component within the strategic factor and also overall it is the most important CSF related with RFID adoption in healthcare.

Key words: RFID adoption, analytic hierarchy process, barriers, critical success factors, healthcare, IT managers

INTRODUCTION

The healthcare industry is a booming industry as people become more educated, wealthier and willing to pay for good health and well being. Technology is increasingly becoming an important tool to assist doctors and health workers in disease prognosis, treatment, care, etc. Technology saves lives, reduces manpower, improves efficiency and productivity and as well as reduce risks. Adoption of the latest technology is a must. Among the most promising technology is the use of radio frequency identification tags that is rapidly becoming the standard for hospitals (Ericson, 2004; Fisher and Monahan, 2008). However, adoption of Radio Frequency Identification (RFID) Technology brings worth it associated problems. Several factors such as organization and social factors that contribute to the success or failure of RFID adoption in hospitals must be further analyzed (Fisher and Monahan, 2008). Healthcare managers should understand the barriers factors of RFID adoptions to anti-cipate and ward off the critical barriers of RFID adoption in order to success RFID adoption in their healthcare organizations. Misunderstanding Critical Success Factors (CSF's), organizations will become a failure in the achievement of IT projects, cost of IT projects can be very high and obstacle in the organizations progress (Hochstrasser and Griffiths, 1991; Swamidass and Waller, 1991). On the other hand the understanding of CSF's can help managers to elicit the complexity of business process in main activities that are necessity for business success (Butler and Fitzgerald, 1999). Gunasekaran *et al*. (2001) believe that practitioners should establish CSF's of IT projects as far as tactical and operational level to achieve IT/IS projects successful.

Prioritization for the barriers and CSF's of RFID adoption are important using multiple criteria decision making because their factors have several levels, items and different impact of their factors. On the other hand, preferences of their factor importance are subjective of decision makers and use qualitative data. An AHP Method is multi criteria decision making method that has been used in almost all the application related with decision making (Vaidya and Kumar, 2006). This method can prioritize factors and items of factors and also can pervade the subjective preference from a decision maker. The purpose of this study is to prioritize the barriers and CSF's related to RFID adoption in healthcare industry using an AHP Method. The contribution of this study is the prioritization of barriers and CSF's of RFID adoption and items of their factors particularly in healthcare context using AHP as an appropriate formal method.

Literature review

RFID adoption in healthcare: An adoption of RFID in healthcare is relative newer than other sectors such as a military, retail, education, logistics, manufacturing and

supply chain. However, today many academician and practitioners articles reported that many healthcare organizations in several countries had been successful implemented RFID Technology such as hospitals in United States, Netherlands, Taiwan, Singapore and others countries (Swedberg, 2009; Wessel, 2007; Tzeng *et al*., 2008). In the future, Business Wire Market Research (BWM, 2008) predicted that market of RFID tags, readers and systems in healthcare industry will rapidly grow from 85.24 million dollar in 2007 to 2.05 billion dollar in 2017. Healthcare organizations were adopting RFID Technology for several reasons and perceived benefits. Some of these benefits include better patient safety, medical service, inventory management, productivity, lower cost and better effective business process (Tzeng *et al*., 2008; Evans and Piechowski, 2005). The beneficial for RFID adoptions related to the type of application areas such as tracking medical equipment, patients and medical staff. Medical staffs as nurses need a few time to seek and find medical equipment and deliver equipment founded to direct patient care (McCarthy, 2004). Medical staff can electronically identify patients during medical treatments and easier to identify where location and movement of patients (USMIHS, 2004; Fisher and Monahan, 2008). Manager can be simpler to find and manage inefficiencies of medical staff activities in current hospital operations (Fisher and Monahan, 2008).

The main impetus in healthcare industry is a relative difference than retail and manufacturer industry to adopt RFID Technology. It has three impetuses that triggered healthcare industry to adopt RFID Technology rapidly as a government organizations, healthcare industry need and external social need. US Food and Drugs (FDA) mandated healthcare industries that supply drugs to be affixed on each of drugs by RFID tags (FDA, 2006) and Mexico's Federal Seguro Popular has also mandated requirements for manufacturer and distributor to append RFID tags on pallet, cases and individual containers (Bacheldor, 2006). Evans and Piechowski (2005) summarized that nearly half (43%) of US healthcare industry needed RFID adoption to increase their strategic or competitive advantage and only 28% of respondents are spurred by government mandate. Finally, external social need can be main impetus healthcare industry adopted RFID Technology such as two Singapore's and several Taiwan's hospitals to mitigate panic public for SARS pandemics (Anonymous, 2003; Tzeng *et al*., 2008).

Indonesian and Malaysian hospitals indicated the barriers exits against RFID adoption and their hospitals managers are also relative less understood CSF's of RFID adoption. Two Singapore's hospitals have implemented RFID Technology to track patients, staff and visitor on May, 2003 (Anonymous, 2003). But hospitals of both countries have not implemented RFID Technology until now. Although, the price of RFID tags had decreased >70% and RFID readers dropped to nearly 40% from 2004-2006 (Bratten, 2006). Both governments had also allocated budget for improving patient safety/quality care, medical service and effective containment of contagious diseases (Badawi, 2007; Ministry of Health Republic of Indonesia, 2008).

Barriers factors of RFID adoption: Based on intensive literature reviews, researchers founded 4 researches that identified barriers factors of RFID adoption in several sectors areas and methodology used such as Tajima (2007) in the supply chain management, Kovavisaruch and Suntharasaj (2007) and Reyes and Jaska (2007) in general area by conceptual method and Evans and Piechowski (2005) in healthcare industry by survey methodology. Table 1 represents the barriers factors of RFID adoption identified from literature.

Critical success factors of RFID adoption: Bullen and Rockart (1981) define CSF's are the few key areas of activity in which favorable results are absolutely necessary for a particular manager to reach his goals. Based on this definition this study defines CSF's of RFID adoption are a few key factors of RFID adoption in which favorable results are absolutely necessary for a particular manager to reach his goals. IT managers need to identify and analysis CSF's of RFID adoption in order to extract business process in core activities and realize the full benefits of RFID adoption. The management organization must be interested for the CSF's and their business process and make their performance measures integral in

Table 1: Barriers factors of RFID adoption identified from literature (Evans and Piechowski, 2005; Kovavisaruch and Suntharasaj, 2007; Reyes and Jaska, 2007; Tajima, 2007)

Business barriers factors	Technology barriers factor
Lack of coordination between	Adverse effects for health organization and government and safety
Limited number of organizations that adopt RFID Technology	Complexity of RFID Technology and systems
Lack of information (incomplete and invalid)	Immature RFID standards
Actual ROI business<projected ROI	Immature Technology in RFID
No or insufficient in budget available	Dramatically changes to affect existing IT Systems
Lack of internal resource	Lack of reliability
Low expertise of vendor/consultant of RFID Technology	Lack of security
Risk of leakage of sensitive and confidential data	
Rejecting because of privacy and security issues	

Table 2: CSF's to RFID adoption identified from literature (Attaran, 2007; Fish and Forrest, 2006; Sullivan, 2005; Ngai *et al*., 2007)

Levels	Dimenstions of organization
Strategic	Creating strong internal and external motivation for improvement, developing a clear RFID strategy, partnership with competent RFID providers, strengthening understanding in organization, top management support and commitmentfrom leadership.
Management	Determining which practice should be incorporated into their RFID Systems, facilitating equipment vendor's investment, integrating RFID into a existing IT architecture, proper staff training, starting with small RFID project, utilizing a cross-sectional team
Operational	Avoiding major process changes/limit process changes, coordinating among department, continually improving procedures, integrating the data collected, lack of comprehensive facts and data, using cost-effectiveness reusable tags

order to prevent poor organization performance (Khandelwal, 2001). IT managers or RFID team project should understand the CSF's of RFID adoption to be better prepared and realize organization objectives/strategies for RFID implementation.

Several researchers had conducted research to explore CSF's of RFID adoption. A variety of research methodologies, number of industries and areas have been employed in RFID research. For research methodologies including descriptive (Attaran, 2007; Fish and Forrest, 2006; Sullivan, 2005), single case study (Ngai *et al*., 2007) and survey.

The type of industry engaged includes general industry sectors (Attaran, 2007; Fish and Forrest, 2006; Sullivan, 2005), aircraft engineering (Ngai *et al*., 2007) and maintenance firms. In addition for area research, including Supply Chain Management (SCM) (Attaran, 2007; Fish and Forrest, 2006; Sullivan, 2005) and Airline repairs (Ngai *et al*., 2007) and supply and maintenance. There is a lack of RFID studies to explore CSF's in healthcare, especially in developing countries such as Indonesian and Malaysian hospitals. This study categorizes CSF's are based on the level of hierarchy of organizations three dimensions, namely strategic, management and operational level. Table 2 shows the CSF's to RFID adoption identified from literature.

MATERIALS AND METHODS

Analytical hierarchy process method: Analytical hierarchy process was developed by Saaty (1980). AHP is a powerful decision making method to set prioritize among different attributes of a complex decision problem (Salmeron and Herrero, 2005). It is the method that uses the hierarchical levels to decompose the complexity of problems in decision making into structuring problems. AHP has been also used to rank and prioritize the factors that reflect the important for factors (Zahedi, 1986; Salmeron and Herrero, 2005).

Based on two reasons, we selected AHP Method for this study. Firstly, AHP is the appropriate method and related field reason. Zahedi (1986) reported that AHP is the suitable method that is used to reflect the importance factors that are associated by weights in order to prioritize the factors and items of factors. AHP Methods have been widely applied in an information technology and information systems research field (Lee, 1993; Min, 1992; Mitta, 1993; Yang and Huang, 2000) and have been selected to prioritize CSF's (Salmeron and Herrero, 2005). Secondly, based on summaries of barriers and CSF's of RFID adoption identified from literature, we found that several factors have more than three attributes (especially nine attributes for business factor) for each factor. AHP provides the pair-wise comparisons to be easy judgments for many factors and a consistency ratio to evaluate reliability and validity of judgments of the decision maker answers.

Salmeron and Herrero (2005) divided phase of the AHP into three basic phases. Firstly, the complex decision problem has to be decomposed and structured by hierarchy structure into several sub-problems. Secondly, primary data has to be collected and measured through pair-wise comparisons of the attributes. Finally, the priority weights of each factor and items of factors in each level and the consistency ratio each level has to be calculated.

Structuring the Hierarchy Model: Researchers have developed the research model that described the relationships between barriers and CSF's of RFID adoption and the constructs their hierarchy is shown in Fig. 1.

The barriers of RFID adoption are fist should be investigated and is continued to explore CSF's of RFID adoption. Researchers have established two factors for barriers of RFID adoption such as business and technology (Fig. 2) and have established three factors for CSF's of RFID adoption such as strategic, management and operational level (Fig. 3).

Collecting data and pair-wise comparisons: The Delphi Method is used to consolidate the judgments of each expert into a judgment on the factors and items of barriers

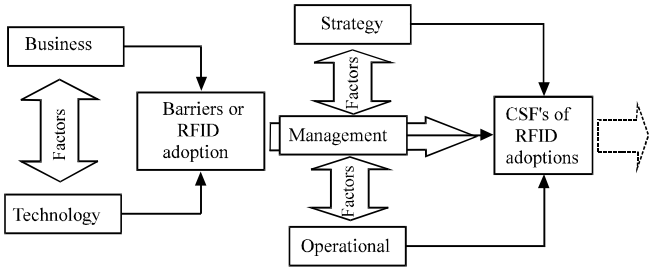

Fig. 1: Research Model

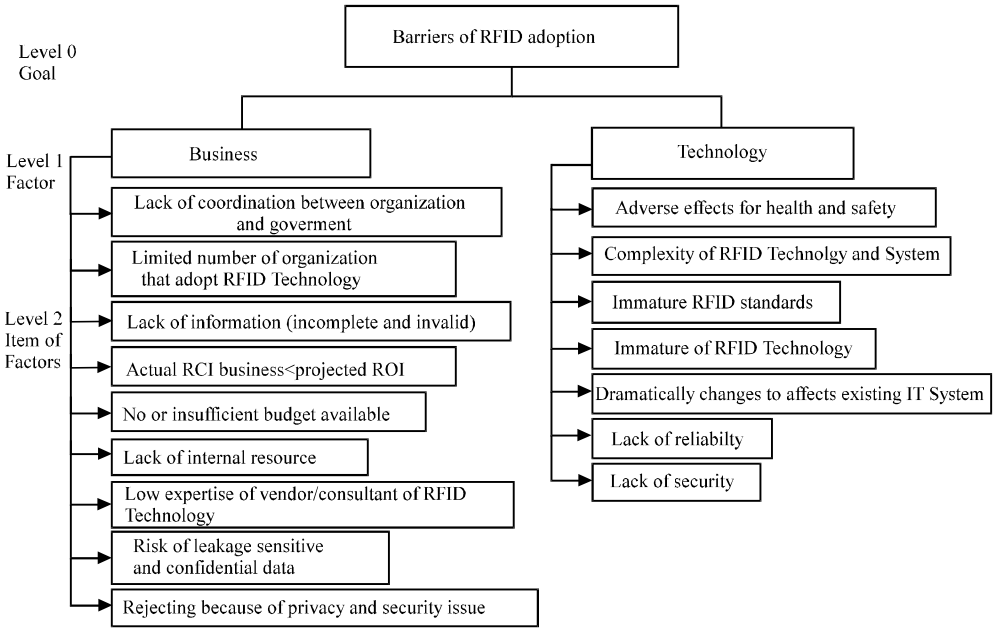

Fig. 2: Barriers factors of RFID adoption hierarchy structure

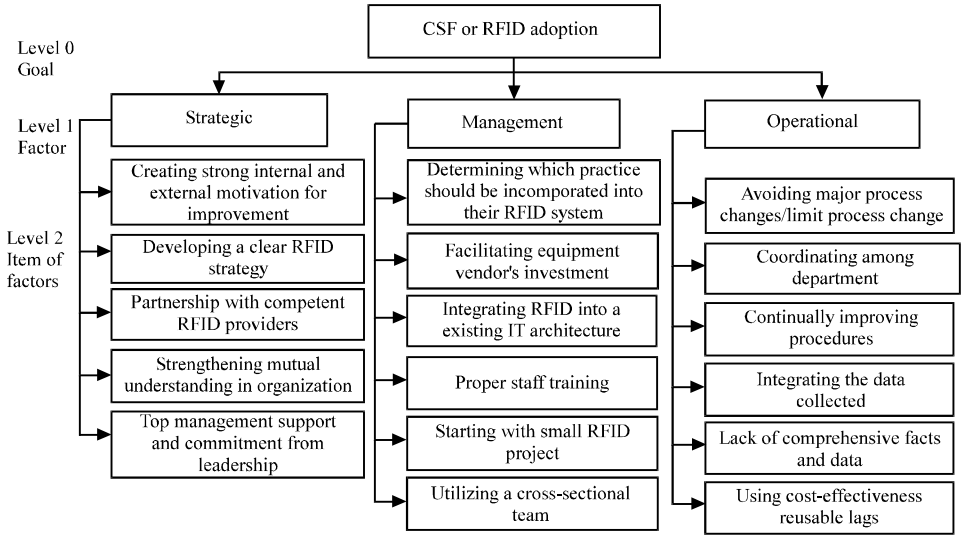

Fig. 3: CSF's of RFID adoption hierarchy structure

and CSF's of RFID adoption. The judgment of the experts for each factor and item of factors are analyzed and feedback to each expert. Each round of Delphi Method gives participants to revise their judgment. The round is done repeatedly until the final judgment and the limitation of the consistency ratio of pair-wise comparisons are reached. Neill (2005) suggests that participants do not directly interact with each other to ensure validity of the results of judgments. The study used group judgments of panelists using the geometric mean that is recommended by Saaty (1980).

The Delphi study used processed three rounds during 4 months. The experts are selected from the RFID consultants and hospitals managers who have knowledge and experience in the Information Technology (IT) including RFID application in healthcare. The panelists are four experts that described as follows:

Panelist 1: IT managers in the Malaysian university hospital
Panelist 2: IT managers in the Indonesian government hospital
Panelist 3: CEO in RFID Malaysian consultant company
Panelist 4: Project manager in RFID Indonesian consultant company

Calculating the priority weights and the consistency ratio: Priority weights of factors represent the importance of these factors. Priority weights have two types that are local priority weights and global priority weights. The local priority weights present the percentage of the parent node's priority that is inherited by the child (Forman and Selly, 2001). Local priority weights are derived from each set of pair-wise comparisons in each level. Global priority weights of each item of factors are the products of the factor's local priority weights with it is parent's global priority weights. In this study, the factors of barriers and CSF's of RFID adoption is level one of the hierarchy structures that have only the local priority weights. However, the level two that represents items of each factor has local and global priority weights.

The consistency ratio is a degree of inconsistency of decision maker judgment. The higher degree of the consistency ratio; it is mean inconsistency of judgment also higher. AHP allows inconsistency of decision makers but the degree of inconsistency must have less than the limitation of the consistency ratio. Zahedi (1986) and Forman and Selly (2001) recommended the consistency ratio is <10% that is usually considered acceptable. In this study, the degree of the consistency ratio used to represent the inconsistency of experts for the overall of factors in barriers and CSF's of RFID adoption and each factor. This study used expert choice software to calculate the priority weights each factor and item of factors and compute the consistency ratio. This software is used to Structure Hierarchy Model set the assessment of judgment individual or group decision using pair-wise comparisons matrix, calculate the priority weights and consistency ratio and synthesize and validate their results.

RESULTS

Consistency ratio: The consistency of the pair-wise judgments provided by panelists is importance considered to evaluate the consistency of decision makers as well as the consistency of all levels in the hierarchy structures (Yang and Huang, 2000). AHP Method provides the consistency ratio is measured of consistency for the pair-wise comparisons. A consistency ratio accepted is <0.1 (Zahedi, 1986). The consistency ratio of all the factors and overall in barriers and CSF's of RFID adoption are accepted (lowest 0.00 and highest 0.06) and are shown in Table 3.

Priority weights

Barriers of RFID adoption: The barriers of RFID adoption had been structuredbytwo levels (factors and items of factors). Based on the normalized priority weights at level one, benefits factor (Priority weights = 0.602) is found to be more important than the technology factor (0.398). It indicates that benefits factor higher impact than technology factors for RFID adoption. The normalized and global priority weights at level two indicate the relative importance of an item of factors under each of factors of barriers of RFID adoption in level one (Table 4). Prioritizing the items of each factor for barriers of RFID adoption are based on the global priority weights of each item. The normalized and global priority weights for factors and items of barriers of RFID adoption including the rank are shown in Table 4. It can be seen that the top three items of factors relative to the RFID adoption are as follows: lack of information (incomplete and invalid) and no or insufficient budget available in benefits factor and complexity of RFID Technology and Systems in technology factor.

Table 3: The consistency ratio for various factors and overall

Factors	Consistency ratio
Barriers of RFID adoption (overall)	0.00
Business	0.06
Technology	0.05
CSF's of RFID adoption (overall)	0.00
Strategic	0.02
Management	0.03
Operational	0.03

Table 4: Barriers of RFID adoption ranking with the global weights

Barriers of RFID adoption	Local priority weights	Global priority weights	Rank
Business	0.602	0.602	-
Lack of information (incomplete and invalid) (*)	0.152	0.092	1
No or insufficient budget available (*)	0.135	0.081	2
Actual ROI business<projected ROI	0.116	0.070	4
Lack of internal resource	0.110	0.066	6
Low expertise of vendor/consultant of RFID Technology	0.107	0.064	7
Rejecting because of privacy and security issues	0.107	0.064	8
Limited number of organizations that adopt RFID Technology	0.103	0.062	10
Lack of coordination between organization and government	0.094	0.057	11
Risk of leakage of sensitive and confidential	0.076	0.046	15
Technology	0.398	0.398	-
Complexity of RFID Technology and Systems (*)	0.194	0.077	3
Immature of RFID Technology	0.170	0.068	5
Immature of RFID standards	0.160	0.064	9
Dramatically changes to affect existing IT Systems	0.130	0.052	12
Lack of security	0.126	0.050	13
Lack of reliability	0.122	0.048	14
Adverse effects for health and safety	0.098	0.039	16

Legend* = Items of factors selected

Table 5: CSF's of RFID adoption ranking with the global weights

CSF's of RFID adoption	Local priority weights	Global priority weights	Rank
Strategic	0.410	0.410	-
Top management support and commitment of leadership (*)	0.280	0.114	1
Developing a clear RFID strategy (*)	0.238	0.098	2
Creating strong internal and external motivation for improvement (*)	0.190	0.078	3
Partnership with competent RFID providers	0.148	0.061	7
Strengthening mutual understanding in organization	0.144	0.058	9
Management	0.320	0.320	
Starting with small RFID project	0.234	0.075	4
Integrating RFID into an existing IT architecture	0.220	0.070	5
Proper staff training	0.170	0.055	10
Determining which practice should be incorporated into their RFID Systems	0.166	0.053	11
Utilizing a cross-sectional team	0.110	0.035	14
Facilitating equipment vendor's investment	0.100	0.032	16
Operational	0.270	0.270	-
Integrating the data collected	0.229	0.062	6
Coordinating among department	0.224	0.061	8
Continually improving procedures	0.177	0.048	12
Avoiding major process changes/limit process changes	0.152	0.041	13
Lack of comprehensive facts and data	0.127	0.034	15
Using cost-effectiveness reusable tags	0.091	0.024	17

Legend* = Items of factors selected

CSF's of RFID adoption: Based on the normalized priority weights at level one, strategic factor (Priority weights = 0.410) is found to be the most importance of the CSF's and the least important is the operational factors (0.270). The priority weights indicate that the importance of CSF's of RFID adoption is as follows; strategic (0.410), management (0.320) and operational (0.270). The normalized priority weights at level two indicate the relative important to items of factors under each of CSF's at level one.

The top three items of the strategic factors are as follows: top management support and commitment of leadership (Global priority weight = 0.114), developing a clear RFID strategy (0.098) and creating strong internal and external motivation for improvement (0.078). The top three items of the management factors are following; starting with small RFID project (0.075), integrating RFID into an existing IT architecture (0.070) and proper staff training (0.055). Under operational factor, the top three items are following: integrating data collected (0.062), coordinating among departments (0.061) and continually improving procedures (0.048). Most of the items of the strategic factors higher global priority weights than other factors. In fact, the top three of overall items of CSF's of RFID adoption are from items of strategic factors. Table 5 shown the rank that is based on the global priority weights of items for CSF's of RFID adoption.

DISCUSSION

Barriers of RFID adoption: From global priority weights of factors and items of factors, it is not surprising that practitioners more consider important a business factors than technology factors. The main reason of this result is impeding business barriers has a high impact and difficult to solve than technology factors. In these items of factors, the bigness of weights of the business factors than the technology factor has consequences several items of the business factors have higher weights than the technology factors except complexity of RFID Technology and systems and immature of RFID Technology. The fist most important item of barriers factors are a lack of information (incomplete and invalid). Most of the respondents have still regard and found out incomplete and invalid information about RFID application in healthcare. Fact, less of national academic journals, magazines, news study, workshops and others that describe RFID application in healthcare are reported and conducted in Indonesia and Malaysia. Hence many respondents had often a hunch that application of RFID technology is difficult and need high cost.

Second most important is no or insufficient budget available. Generally, the costs of new information technology are more expensive than older information technologies. Costs of RFID Technology such as the components, installation and software developer have higher costs. Hence most of the respondents regarded

that organizations should be more spent money to implement RFID Technology. Along with the increasing many organizations were implementing RFID Technology, many practitioners and organizations believe that costs of RFID Technology will decrease in the future (Bratten, 2006; Wintergreen, 2008). Third most important is complexity of RFID Technology and systems as one of the items of barriers technology. The number of RFID components such as RFID tags, reader, middleware, communication infrastructures and software as RFID Systems many respondents believe that RFID Technology and systems are more complex than another information technology that has been employed such as internet and hospitals information systems.

CSF's of RFID adoption: All respondents have given preference for CSF's adoption that strategic level more importance than a level in their bellow such as management and operational. It gives consequences the items of the factors in strategic level have high value than items of the factors in management and operational level. The findings of this study indicate that the driver of CSF's of RFID adoption is come from the top management and management and operational level in organizations should realize this effort. Three tops of CSF's items are items of factors in strategic level that is top management support and commitment of leadership, developing a clear RFID strategy and creating internal and external motivation for improvement.

First most of the important is top management support and commitment of leadership. Top management must support and commit to adopting RFID Technology to achieve their objectives or solve their problems. Second most of the important is developing a clear RFID strategy. The top managements must develop a clear RFID strategy that can provide the guidelines for management and operational level to realize RFID adoption. Communication of RFID strategy should be obtained to reduce misunderstand and given feedback to top managements the real problem and readiness of management and operational level.

Third most of the important is creating strong internal and external motivation for improvement. Strong internal motivation for improvement from top management to create development competitive advantages and solve their problems affects successfully of RFID adoption. The mandates of government and social needs may trigger strong motivation to improve effective operations and reduce medical errors using RFID Technology.

CONCLUSION

AHP has been proposed to prioritize the factors and items of factors that are critical barriers to against RFID adoption and critical success to affect successful RFID adoption in healthcare organizations. Prioritizing results of factors and items of barriers and success factors do not mean others factors and items are not important. The results are main issues that are possible to be considered by manager's healthcare organizations to reduce barriers of RFID adoption and increase stimulus of CSF's of RFID adoption.

By AHP analysis, the most importance items of barriers against RFID adoption are lack of information (incomplete and invalid) and no or insufficient budget available in barriers of RFID adoption as the side of internal and complexity of RFID Technology and Systems as the side of external organizations. It indicates that barriers of internal more impact than external organizations to impede RFID adoption in healthcare organizations. Internal organizations shall are more active in find complete and valid information and initiate negotiations to government and or shareholder and top executive that had budget and budget policy. Fewer previous types of information technology as RFID Technology has tags, readers and middleware including computers, software database and communication infrastructure. Hence, several of respondents believe that RFID Technology has complexity in technology and systems.

Organizations that need successfully adopt RFID adoption should combine CSF's in strategic, management and operational level. Top management support and commitment of leadership, developing a clear RFID strategy and creating internal and external motivation for improvement are items of strategic level that present the most important of CSF's using AHP analysis. These items of strategic factors suggest that strategic activities likely to succeed in RFID adoption concentrate on top management support and commitment of leadership, developing a clear RFID strategy and creating internal and external motivation for improvement.

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