Evaluating the Factors Affecting the Implementation of Hospital Information System (HIS) Using AHP Method

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Abstract: Hospital Information System (HIS) is a comprehensive, integrated information system designed to manage the administrative, financial and clinical aspects of a hospital. In this study those aspects of the implementation of HIS in two public hospitals in Malaysia is described. A quantitative study was conducted to obtain views on information system development and implementation in the Malaysian hospitals. A survey was conducted with personnel experts representing both the system providers and the end-users guided by a questionnaire. Therefore, in the current paper, a model of ranking factors of HIS implementation was developed. The findings indicated that physicians have a high perception means for the technology and showed that HIS would increase physician's performance regarding to decision making. The relevant factors prioritized and ranked by using the Analytical Hierarchy Process (AHP). The aim of ranking and using this approach is to investigate which factors are more important in HIS implementation from the experts' perspectives. The result of performing AHP is as a novelty which assists HIS implementation success and also healthcare organizations to motivate their users in accepting of a new technology. The factors were categorized into few themes namely the system development, human resource, scope of implementation, support system, user-friendly, and administrative including of training, hardware and security. Quality human resource, good support system, user-friendly and adequate training of the end-user will determine the success of implementation of HIS. At the end, it is hoped that HIS will be implemented in all other hospitals with effective integration and networking.

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1. Introduction

In developing countries, hospitals are the main healthcare providers (Muzafar & Haroon, 2009). Accordingly, hospitals have to be the main target institutions when aiming to improve health information systems (Muzafar & Haroon, 2009). Hospital Information System (HIS) is a comprehensive, integrated information system designed to manage the administrative, financial and clinical aspects of a hospital. The aim of HIS as an area of medical informatics is to achieve the best possible support of patient care and administration by electronic data processing. Healthcare sector has been grown up and positively impacted by Information Technology (IT). Unlikely, in developing countries if a hospital did decide to transform its Information System (IS) and implement an HIS, there would be surprisingly a rare literature on useful experiences to assist that hospital through the transformation (Ismail et al., 2010). "This is because literature on implementation of HIS is extremely limited" (Ovretveit et al., 2007; Saba et al., 2014; Haron et al., 2011), and whatever literature is available is predominantly from developed countries where the circumstances, systems, processes, and cultures are different from that of developing countries (Muzafar & Haroon, 2009). The main objective of the study is to describe the motivated factors of HIS implementation, its ranking and also its user perspective in two public Malaysian hospitals. It is aimed to assess the application and impact of HIS on hospital end users.

Small numbers of hospitals in Malaysia have implemented an HIS. There are some studies that conducted a qualitative research to determine factors that affect the implementation of HIS (Ismail et al., 2013; Meethongjan et al., 2013). This study hoped that by conducting the survey in some public hospitals which have already implemented HIS, can determine the effective and imperative factors influencing HIS implementation that will render fostering in all other hospitals with effective integration and networking.

The remainder of this paper is structured as follows. Section 1 describes the HIS and gives an overview of this research. The section 2 introduces the proposed research model and explained each of its model elements. In Section 3, we explain the research methodology step by step. Section 4 and 5 are allocated to the data collection, and to the

background mathematical of the Analytical Hierarchy Process (AHP), respectively. Finally, we present the results of AHP and conclusions in sections 6 and 7, respectively.

2. Proposed research model

The HIS implementation model as presented in Figure 1 provides a conceptual framework to identify the factors and sub factors that are critical and have more influence on HIS success. This is amongst the first study pertaining to the implementation of HIS that has been applied from the previous qualitative literature review study. According to Ismail et al., (2010), in their study it is identified that system development and maintenance, human resource, scope of implementation, support system, user friendliness and administrative positively have an effect on implementation of HIS. The framework in this study comprised of six factors and sub-factors. Basically, they are recognized as system development and maintenance, human resource, scope of implementation, support system, and user friendliness and administrative. The administrative theme is further divided into three sub-themes which are training, hardware and security.

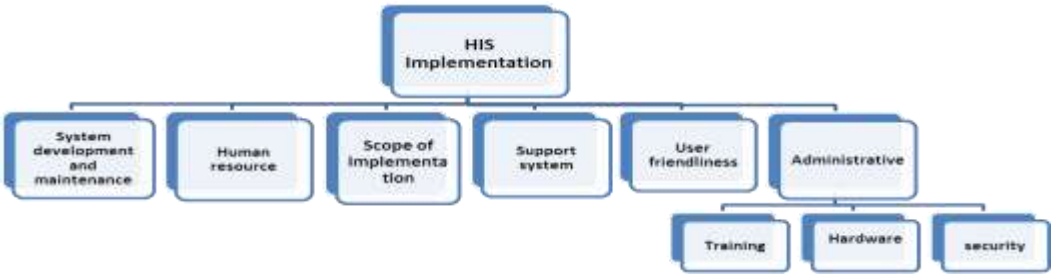

Figure 1. Research Framework

2.1 System development and maintenance

Related to the system development, few issues were sought by hospital information technology department. Hospitals mentioned that their IT systems were developed simultaneously with the hospital construction (Ismail et al., 2010). “The IT system in the hospital is the turnkey project; the software and the whole system have been pre-determined by the headquarters” (Lee et al., 2012).

2.2 Human resource

Human capital is one of the most imperative assets in an organization. In case of human resource, departments need to run the IT system in the hospital. In order to develop and run the IT system in hospitals, many IT experts are required, but it does not need much manpower to run the system (Costa & Machado, 2004). This human factor can be grouped in two distinctive groups which are user characteristic and user perception (Farquhar & Surry, 1994).

2.3 Scope of implementation

In term of scope of implementation, hospitals implemented Total Hospital Information System (THIS), Intermediate Hospital Information System (IHIS) and basic Hospital Information System (BHIS) (Ismail et al., 2013; Mohd & Syed Mohamad, 2005). THIS has the most complete system whereas BHIS has the least complete and limited system. Malaysia as a developing country has been invested a lot of resources in Information Communication Technology (ICT) in order to improve healthcare services. But unfortunately the level of ICT integration in healthcare in Malaysia is still not promising (Lee et al., 2012).

2.4 Support system

In the case of IT, support system is maintained by the vendors 24 hours a day, 7 days a week in all public hospitals. Basically, call centers is equipped to entertain any queries and complaints from the user (Otieno et al., 2008; Ismail et al., 2010). According to the most of the Malaysian public hospitals "We were provided with good support system to assist with any problems we encounter; there are no backup system and no hardcopy, therefore if something happens; there is no data on the patient" (Chang et al., 2007; Lung et al., 2014). One of the examples of support system is running on clinical section of the hospital. This introduced under the functionality of LHP projects which assists departments to start the process of digitalization. (Rehman et al., 2014).

2.5 User-friendliness

According to Kounalakis et al. (2003), user-friendly interface will foster the adoption of HIS where medical workers do not need to spend extra effort to familiarize with the system.

In case of user-friendly, it is troublesome to use different passwords to access pharmacy system and to do other things. There is lots of clicking to navigate and to get from one menu to another it takes sometimes up to ten clicks. Totally, some hospitals have the most user friendly system; those who have worked in various hospitals with IT system will agree that special hospitals in Malaysia are the most user-

friendly (Kounalakis et al., 2003; Lee et al., 2012; Younus et al., 2015; Ahmad et al., 2014).

2.6 Administrative

The administrative theme was subdivided into 3 sub themes namely training, the hardware installed and the system security.

Training provided will raise employees' knowledge in operating the IS and then creating positive attitude in trading with the system in their work. Besides that, informal training like knowledge sharing, peer helping and workers community boost the willingness to adopt an IS (Jean Lee & Yu, 2004). Therefore new staffs are trained by batches and when it is required. Hardware: Based on various levels of implementation, different hospitals need different types of upgrading (Hassan, 2004). Security: all the systems provide their own level of security and data protection is given utmost priority. Each staff will have different IDs and passwords for pharmacy and others. They are encouraged to use different passwords (MOH Malaysia, 2010; Nodehi et al., 2014; Harouni et al., 2014).

The data collected analyzed and summarized into the table below that found in previous research which has an effect on HIS implementation and were shown (See Table 1).

Table 1. Factors influencing HIS implementation

Elements of HIS implementation	HIS implementation sub-factors	References
System development and maintenance	–	[5,11]
Human resource		[5,21]
Scope of implementation		[6,11,13]
Support system	–	[1,5,16,22]
User friendliness	–	[10,11]
Administrative	Training	[7,11,23]
	Hardware	[4,11]
	Security	[11,21]

3. Research methodology

Researcher covered the topic of HIS implementation shown that HIS are being accepted slowly by public hospital of Malaysia. A quantitative, survey-based research study was performed and was analyzed to explaining the factors that have an imperative effect on HIS implementation. The two public Malaysian hospitals have been chosen to conduct this research. Survey distributed to 12 personnel experts who had experiences using the HIS. 12 experts fulfilled the questionnaire in this study. The survey contains number of questions that were design to capture information about the constructs in the research model. The questions that measured were relevant to system development and maintenance, human resource, scope of implementation, support system, and user friendliness and administrative besides its sub-factors. AHP was used to obtain the ranking of these factors. Figure 2 contains a description of each step in this study.

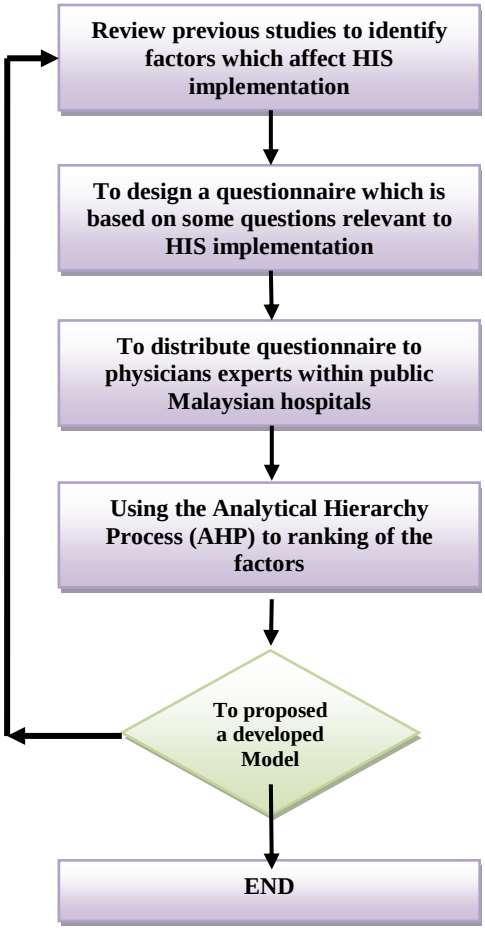

Figure 2. Research methodology

4. Data collection

In this study a pairwise questionnaires was used and distributed among 12 experts that had experience in HIS in healthcare organizations. Therefore, for this questionnaire the survey instrument was made available to the participants via e-mail. They were requested to fill the pairwise questionnaire a given pairwise questionnaire. The collected data was analyzed using the Expert choice software. The statistics for the respondents demographic is shown in Table 2. The most of respondents aged between

30-48 years old, while 75% of the respondents were male. The respondents were expert in online banking systems. Table 3 presents the information according to the years of experience.

Table 2. Demographic data for questionnaire

Demographics	Responses obtained	Percentage %
Gender		
Male	9	75%
Female	3	25%
Total	12	100%
Age		
30-38	3	25%
38-45	3	25%
45-48	6	50%
Total	12	100%

Table 3. Experience of experts in the survey

Experience	Less than 3 years	Between 3 and 6	Between 6 to 8	More than 8 years
Percentage	40%	20%	20%	20%

5. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a mathematical method that is used for multi-criteria decision-making (Masood et al., 2013; Hashmi et al., 2013; Nilashi et al., 2012). The AHP (Saaty 1972; 1980) was proposed as a method to solve decision problems using a hierarchical structure of criteria and alternatives. AHP has become one of the most popular decision-making methods due to the use of pairwise comparisons to input qualitative information. Pairwise comparisons are required in the scale of 1-9. 1 infers equal importance, 3 for moderate importance, 5 for strong importance, 7 for very strong importance and 9 for extreme importance. The values of 2, 4, 6 and 8 are compromises between the previous definitions. Pairwise comparisons given by the decision-maker are placed into reciprocal matrices.

Values from the decision-maker for each pairwise selection are placed into the matrix and inverses are automatically added in the transpose position. The priorities are the principle eigenvectors of the matrix. Separate reciprocal matrices with alternative pairwise selections are required for each qualitative criterion. A score (in a numerical format) for each alternative is also required in respect to each quantitative criterion (Haron et al., 2011). The quantitative scores are normalised for the analysis. The priority values from the qualitative input and the normalised values from the quantitative input are used to form a score for each alternative by applying the Weighted Sum Method (WSM). The criteria weights can either be collected as numerical values or from pairwise selections (in the same way as above).

Saaty (1980) acknowledged that intransitivity can occur when providing pairwise comparisons. For instance, a decision-maker can be intransient when expressing A is better than B, B is better than C and C is better than A. The decision-maker can also be numerically inconsistent by the decision-maker expressing A is better than B by 2, B is better than C by 2 and A is better than C by 6. Saaty (1980) consequently suggested the use of a Consistency Ratio (CR) to check that pairwise input is transitive. A CR works by quantifying how consistent the decision-maker's judgements are in relation to a large sample of random judgements. Saaty (1980) proposed that if the CR is larger than 0.1 then the decision-maker's input is intransient and therefore unreliable.

AHP uses redundant judgments for checking consistency, and this can exponentially increase the number of judgments to be drawn out from decision makers (Ibrahim et al., 2011b; Chin et al., 2002; Drake, 1998; Hafeez et al., 2002; Ossadnik & Lange, 1999; Rehman et al., 2011). Steps for AHP method is shown in Figure 3.

Consistency Index (CI) for AHP method can be computed by using equation as follows (Nilashi et al., 2011a):

$$CI = \frac{maks.\ eigenvalue - n}{n-1} \quad (1)$$

$$maks.eigenvalue = \sum_i wi.ci \quad (2)$$

After calculating the CI in the AHP method, the next step is computing Consistency Ratio (CR) by using equation (3):

$$CR = \frac{CI}{RI} \quad (3)$$

where *n* is amount of items compared, *ci* is sum of column, *CR* is consistency ratio, *wi* is indicated weight, *CI* denotes consistency index and *RI* is random consistency index. The values for RI can be presented in Table 4 as follows:

Table 4: The values for RI

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

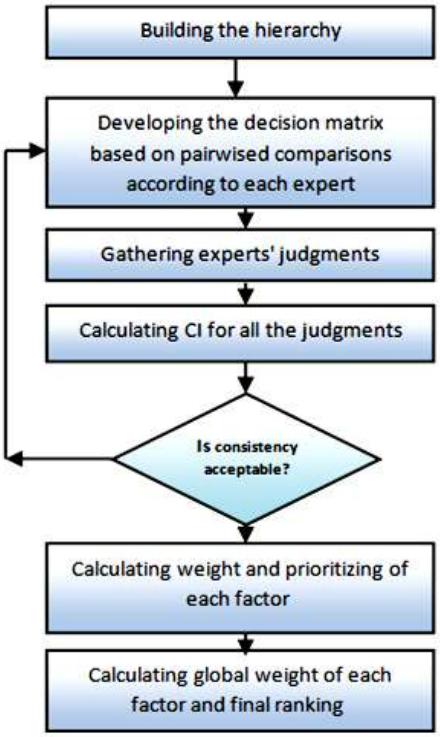

Figure 3.Steps for AHP method

6. Prioritization of factors and sub factors using AHP

For prioritization of sub-criteria expert choice was used for all pairwise comparison matrixes. Figure 4 shows Relative Weight of all sub-criteria of HIS implementation factors.

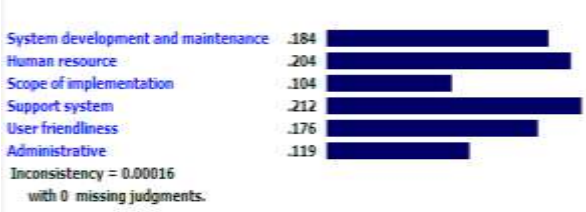

Figure 4. Prioritization micro-level factors that influenced EMR success

According to the results of AHP method generated by expert choice software, support system has the most importance in relation to the others, with weight 0.214 and therefore this criteria is in the top priority. Human resource, system development and user friendliness are in the second, third and fourth ranks with weights 0.204, 0.184 and 0.176. IR of pairwise comparison is equal to 0.00016 and it is acceptable as it is lower than 0.10. Figure 5 shows relative weight of all sub-criteria of administrative factor.

Figure 5. The ranking of sub-criteria of administrative

As shown in Figure 5, from the result of AHP method, training is the most important factor with weigh 0.353 and therefore this criteria is in the top priority. Security and hardware criteria are in the second priority (with weight 0.333) and third (with weight 0.314) priority. Inconsistency rate of pairwise comparison is 0.0 and because it is lower than 0.10, then these comparisons is acceptable.

7. Conclusion

In this paper, we developed a hierarchy model for prioritizing the factors that influenced HIS implementation success. From the developed model, 6 main factors for HIS implementation were considered for assessing using AHP. The data in this study were collected through pairwise questionnaire that distributed to experts that had experiences in using HIS. Based on AHP method, expert choice software was used to determine the priority of factors in the questionnaire. According to the results of expert choice software, support system was the most importance in the top priority. Human resource, system development and user friendliness were in the second, third and fourth ranks with weights 0.204, 0.184 and 0.176. Inconsistency rate of pairwise comparison is equal to 0.00016. Also, training was the most importance, weighted 0.353 in the top priority for sub-criteria of administrative. Security and hardware criteria were in the second priority (weighted 0.333) and third (weighted 0.314) priority with inconsistency rate of pairwise comparison 0.0. The result of this study is not limited to Malaysia hospital setting; it can be applied in other countries through more testing and validating.

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References

1. Ahmad, A.M.Sulong, G., Rehman, A., Alkawaz,M.H., Saba, T. (2014) Data Hiding Based on Improved Exploiting Modification Direction Method and Huffman Coding, Journal of Intelligent Systems, vol. 23 (4), pp. 451-459, doi. 10.1515/jisys-2014-0007
2. Chang, I., Hwang, H.-G., Hung, W.-F., & Li, Y.-C. (2007). Physicians' acceptance of pharmacokinetics-

based clinical decision support systems. Expert Systems with Applications, 33(2), 296-303.
3. Costa, A. L., de Oliveira, M. M. B., & de Oliveira Machado, R. (2004). An information system for drug prescription and distribution in a public hospital. International Journal of Medical Informatics, 73(4), 371-381.
4. Farquhar, J. D., & Surry, D. W. (1994). Adoption analysis: An additional tool for instructional developers. Programmed Learning and Educational Technology, 31(1), 19-25.
5. Harouni, M., Rahim, M.S.M., Al-Rodhaan,M., Saba, T., Rehman, A., Al-Dhelaan, A. (2014) Online Persian/Arabic script classification without contextual information, The Imaging Science Journal, vol. 62(8), pp. 437-448, doi. 10.1179/1743131X14Y.0000000083.
6. Hashmi, K. H., Khalil, S., Zakria, G., Jawad, K. M., Hameed, U., & Sharif, M. (2013). Evaluation and Prioritization of Key Parameters for Optimization of HSM of Ti Alloys. Life Science Journal, 10(9s).
7. Hassan, G. (2004). Managing a multiple hospital HIS implementation project. Paper presented at the E-Health Asia Conference.
8. Haron, H. Rehman, A., Wulandhari, L.A., Saba, T. (2011) Improved vertex chain code based mapping algorithm for curve length estimation, Journal of Computer Science vol. 7(5), pp. 736-743.
9. Ibrahim, O., M. Nilashi, K. Bagherifard, N. Hashemi, N. Janahmadi, M. Barisami, 2011b. Application of AHP and K-Means clustering for ranking and classifying customer trust in M-commerce. Australian Journal of Basic and Applied Sciences, 5(12): 1441-1457
10. Ismail, A., Jamil, A. T., Rahman, A. F. A., Bakar, J. M. A., Saad, N. M., & Saadi, H. (2010). The Implementation of Hospital Information System (HIS) in tertiary hospitals in malaysia: a qualitative study. Malaysian Journal of Public Health Medicine, 10(2), 16-24.
11. Ismail, N. I., Abdullah, N. H., Shamsudin, A., & Ariffin, N.A. N. (2013). Implementation Differences of Hospital Information System (HIS) in Malaysian Public Hospitals. Technology, 20(21), 22.
12. Jean Lee, S. K., and Yu, K., Corporate culture and organizational performance. J. Manag. Psychol. 19(4):340–359, 2004.
13. K.Hafeez,Y.Zhang, N.Malak," Determining key capabilities of a firm using analytic hierarchy", process, International Journal of Production Economics 76,2002.
14. K.S .Chin, Pun K S, Xu Y, Chan J S F. "An AHP based study of critical factors for TQM implementation in Shanghai manufacturing industries",Technovation 22, 2002.
15. Lung, J.W.J., Salam, M.S.H, Rehman, A., Rahim, M.S.M., Saba, T. (2014) Fuzzy phoneme classification using multi-speaker vocal tract length normalization, IETE Technical Review, vol. 31 (2), pp. 128-136, doi. 10.1080/02564602.2014.892669.
16. Lee, H. W., Ramayah, T., & Zakaria, N. (2012). External factors in hospital information system (HIS) adoption model: a case on malaysia. Journal of medical systems, 36(4), 2129-2140.
17. Masood, S. A., Jahanzaib, M., & Akhtar, K. (2013). Key Performance Indicators Prioritization in Whole Business Process: A Case of Manufacturing Industry. Life Science Journal, 10(4s).
18. Mohd, H., & Syed Mohamad, S. M. (2005). Acceptance model of electronic medical record. Journal of Advancing Information and Management Studies, 2(1), 75-92.
19. Meethongjan,K., Dzulkifli,M., Rehman,A., Altameem,A., Saba, T. (2013) An intelligent fused approach for face recognition, Journal of Intelligent Systems vol.22(2), pp. 197-212.
20. Muzaffar A. Malik., & Haroon R. Khan. (2009). Understanding the Implementation of an Electronic Hospital Information System in a Developing Country: A Case Study from Pakistan. Health Informatics Programme, Department of Information Science University of Otago, 6.
21. Nilashi, M., Bagherifard, K., Ibrahim, O., Janahmadi, N., & Barisami, M. (2011a). An Application Expert System for Evaluating Effective Factors on Trust in B2C Websites. Engineering, 3(11).
22. Nilashi, M., Bagherifard, K., Ibrahim, O., Janahmadi, N., & Ebrahimi, L. Ranking Parameters on Quality of Online Shopping Websites Using Multi-Criteria Method. Research Journal of Applied Sciences, Engineering and Technology 4(21): 4380-4396, 2012.
23. Nodehi, A. Sulong, G. Al-Rodhaan, M. Al-Dhelaan, A., Rehman, A. Saba, T. (2014) Intelligent fuzzy approach for fast fractal image compression, EURASIP Journal on Advances in Signal Processing, doi. 10.1186/1687-6180-2014-112.
24. Otieno, G. O., Hinako, T., Motohiro, A., Daisuke, K., & Keiko, N. (2008). Measuring effectiveness of Electronic medical records systems: towards building a composite index for benchmarking hospitals. International Journal of Medical Informatics, 77(10), 657-669.
25. Øvretveit, J., Scott, T., Rundall, T. G., Shortell, S. M., & Brommels, M. (2007). Implementation of electronic medical records in hospitals: two case studies. Health Policy, 84(2), 181-190.
26. P. R.Drake, "Using the Analytic Hierarchy Process in Engineering Education", Int. J. Engineering Education,Vol. 14, No. 3,1998.
27. Rehman, A., Alqahtani,S., Altameem, A., Saba, T. (2014) Virtual machine security challenges: case studies, International Journal of Machine Learning and Cybernetics, vol.5(5), pp.729-742.
28. Rehman, A. Mohammad, D. Sulong, G. Saba, T.(2009). Simple and effective techniques for core-region detection and slant correction in offline script recognition Proceedings of IEEE International Conference on Signal and Image Processing Applications (ICSIPA'09), pp. 15-20.
29. Saba,T., Rehman, A., Al-Dhelaan,A., Al-Rodhaan, M. (2014) Evaluation of current documents image denoising techniques: a comparative study, Applied Artificial Intelligence, vol.28(9),pp. 879-887.
30. W.Ossadnik, O.Lange, "AHP-based evaluation of AHP-Software", European Journal of Operational Research 118, 1999.
31. Whetstone, M., and Goldsmith, R., Factors influencing intention to use personal health records. Int. J. Pharm. Healthc. Mark. 3 (1):8–25, 2009.
32. Younus, Z.S. Mohamad, D. Saba, T. Alkawaz,M.H. Rehman, A. Al-Rodhaan,M. Al-Dhelaan, A. (2015) Content-based image retrieval using PSO and k-means clustering algorithm, Arabian Journal of Geosciences, vol. 8(8) , pp. 6211-6224, doi. 10.1007/s12517-014-1584-7.