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Fuzzy Multi-Criteria Approaches for Evaluating the Critical Factors of Electronic Medical Record Adoption

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Abstract

Using Electronic Medical Records (EMRs) are computerized medical information systems that collect, store and display patient information that rising physician's performance in their daily work to enhance quality, safety and efficiency in different health environment settings. Nevertheless, their state of being adopted throughout the world is slow. Hence, the adoption of EMRs has become an important trend into the healthcare system that needs to be studied by Management Information System (MIS) researchers. Furthermore, in physician practices the rate of EMRs adoption has been reluctant in spite of the cost savings through lower administrative costs and medical errors related to EMR systems. The aim of this research is to identify, categorize, and analyze Meso-level dimension which introduced by Lau et al. (2012), for the adoption of EMRs in the healthcare context. Hence, we develop a Multi Criteria Decision Making (MCDM) framework for healthcare industry improvement and adoption of EMR. The purpose of ranking and weighting using the F-TOPSIS and F-AHP is to inspect which factors are most imperative in EMRs adoption among primary care physicians. Performing F-TOPSIS and F-AHP is as novelty methods in this study for identifying the critical factors of EMRs adoption to assist healthcare organizations specifically hospitals setting in pursuing their key users' behavior towards accepting of this new technology. Seven factors, namely time investment, screen/room, hybrid system, planning, resource training, workflow, and weight, was found as the most influential criteria and strongest drivers in the adoption of EMR in Malaysia's primary care setting.

Keywords: EMRs, Adoption, Fuzzy TOPSIS, Fuzzy AHP, Meso-Level Adoption Factors, HIS

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1. Introduction

Currently, there is a vast investment inInformation Technology (IT) by healthcare providersthat looked atthe development and adoption of Hospital Information System (HIS) for instance Electronic Medical Records(EMRs) (Kazley and Ozcan, 2007; Ahmadi et al., 2014, Ahmadi et al., 2013); Burt and Hing, 2005). ITis utilized by physicians' offices for billing purposes, but unfortunately the number incorporating IT into their practices for clinical purposes such as EMRs are low (Burt and Hing, 2005)."It is estimated that the healthcare industry is at least ten years behind other industries in terms of IT investment"(Skinner, 2003). Despite ITs' increasing ubiquity, decreasing costs, and the potential for benefits in the clinicaldecision-making process, the low rate of adoption occurs specifically in developing countries (Hsiao et al., 2009; Hung et al., 2009; Kalogriopoulos et al., 2009; Yang et al., 2013). Healthcare organizations are dissimilar from organizations operating within other businesscontexts, especially about individual autonomyand operational independence (Hu et al.,1999).

EMRs adoption has been attracted by little interest in the Management Information Systems (MIS)literature (Amy and Brian, 2007; Marques and Oliveira et al., 2011).In this research, an EMR explainedas computerizedHISwhere provider's record detailedencounter information such as patient demographics,encounter summaries, medical history, allergies, intolerances,and lab test histories. Some may support order entry,results management and decision support and some may also contain features or be integrated with software that can schedule appointments, perform billing tasks, and generate reports. The level ofprimary care in medical area is becoming a coreand essential part of healthcare community. "The term "general practice" was considered to refer to the same care setting as the term "primary care".

Primary care is defined as the first point of contact a person has with the health system and usually refers to family practice. This is the point where people receive care for most of their everyday health needs(Ludwick and Doucette, 2009).

In this research, themeso-level factors has been investigated which previous studies indicating its significant effect on adoption of EMRs. The framework of three dimensions consisting of micro, meso, and macro-level for EMR successdeveloped by Lau et al.(2012) insystematic review study.

Their study described the impact of EMR on physician practice in physician office setting (Lau et al., 2012). Basically, thisstudy applied the proposed framework in

Malaysia as a developing country to identify the crucial factors influencing EMR adoption among primary care's physicians. In addition, this research seeks to validate the developed framework to foster IT innovation in context of health care in increasing the advantages of serving a better and faster service by facilitating and extending such innovation among medical professionals. Therefore,the crucial factors in meso-level framework is determined to increase the knowledge of hospitalsin adopting ofEMRs among medical professionals specially physicansas important users of such a technology.In addition, this study providescontextual analyses of the factors by conducting two effective methods to contribute in further understanding ofthe EMRs adoption. The remainder of this paper is structured as follows. The section 2 introduces the proposed research model of this study. In section 3, the research methodology has been described step by step. Section 4, 5 and 6 allocated to the data collection and background mathematical of F- TOPSIS and F-AHP, respectively. Finally, we present the results of F-TOPSIS,F-AHP and conclusion in sections 7 and 8, and 9 respectively.

2. Proposed Research Model

The EMR adoption model of physician in primary care provides a conceptual model to identify the most influential factors that have a more significant effect on adoption of EMRs. This studywill evaluate and extend Clinical Adoption(CA) frameworkwhich developed through a systematic review study conducted by Lau et al.(2012) which was based on aforementioned dimensions.

Their study was based onDeLone and McLean (1992) with regard to the IS success modelthat was followed.Lau's CA framework comprised of micro, meso and macro-level dimensions. Each dimension has its own category and sub-categorywhich would influence physicians in EMRs adoption. In the current research it has been concentrated on the meso-level of a particular framework. At meso-level, the adoption framework of primary care physician explains ClinicalInformation System Success (CISS) in particular the EMRs system.In this study, EMR adoptionhas been examined in practice of physician in primary care setting through the lens of CA framework. Hence, this study concentrated onmeso-level dimensioncombining of the relevant criteria that influence an EMR adoption.

At the end, the proposed model of F-TOPSIS and F-AHP physician adoption model in meso-level dimension developed and showed in Figure 1.At the meso-level dimension, there arethree main factors, including people, organization and implementation. The following proposed model described each of the main factors in detail and its sub factors respectively.

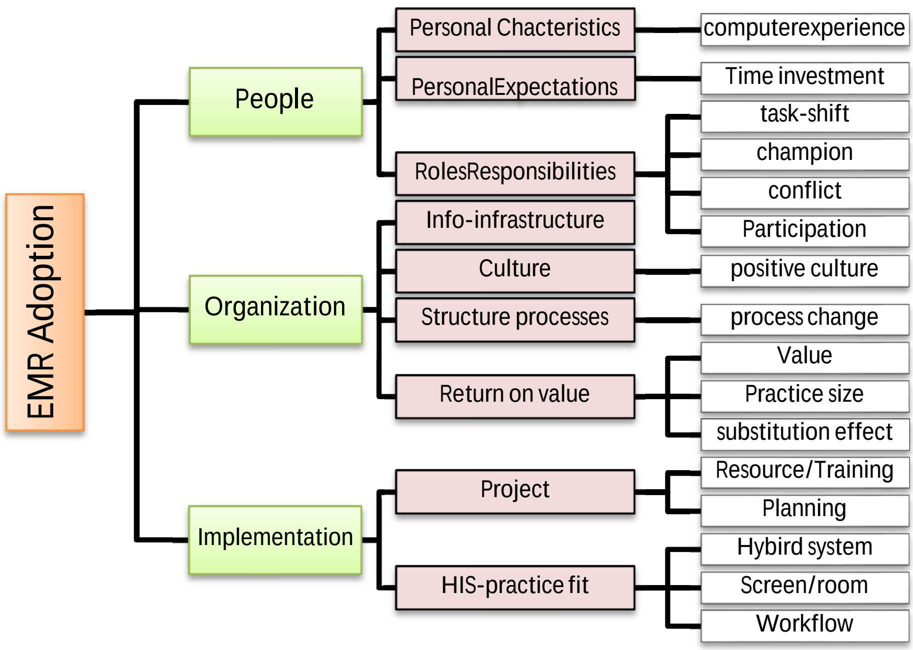

Figure 1: Fuzzy TOPSIS Physician EMRAdoption Model in Meso-Level

People are the integral part of the system success thatmay adopt or refuse the new technology based on their characteristics, expectations and responsibilities. People factors covers personalcharacteristics and expectations likethe prior EMRs experience of the users (Van et al., 2001), and their personal timeinvestment in exchange for the benefits expected fromthe system (Ludwick and Doucette, 2009).

Roles/responsibilities included theneed for champions and staff participation (Bassa et al., 2005), anda shift in tasks (documentation by staff vs physicians)(Ludwick and Doucette, 2009). That could lead to role ambiguity and conflict(Crosson et al., 2005).Organization factors covered structure/processesand culture that emphasized EMRs adoption/use(Crosson et al., 2005), EMRs-practice fit (hybrid EMRs/papersystems), and EMRs-supported office and work flow design (Crosson et al., 2005) such as the placement of computer screens in consulting rooms.

Return-onvalueconcentrated on verified value at the practicelevel, such as the replacement effectfromguidelinedriventest orders and prescribing, and tangible cost-efficiencygain with larger practice size and patient volume (Mitchellet al., 2003). Implementation factors covered the area thatthe introduction of EMRs into the practice wasdesigned and conducted as a priority project with devotedtime and resources (Samoutis et al., 2008).The service supportprovided during implementation was essential(Randeree, 2007), since they influenced the disruptions thatphysicians and office staff had to defeat while learningto use the EMRs and redesign their work routines.

Table 1: Meso-Level DimensioniNfluenced EMRs aDoption

People	**People sub-factors**	**References**
Individuals-Groups	Personal characteristics Computer experience	Van Wijk et al.(2001)
	Personal expectations Time investment	Keshavjee et al. (2001), Ludwick and Doucette (2009), Robinson (2003)
	Roles-responsibilities Task shift Champion Conflict Participation	Keshavjee et al. (2001), Tamblyn et al. (2003), Miller et al. (2005), Crosson et al. (2005), Bassa et al. (2005).
Organization	**Organization Sub-factors**	**References**
Strategy	Culture Structure-processes	Crosson et al. (2005), Baron (2007)
	Info-infrastructure	Ludwick and Doucette (2009)
	Return on value Value Practice Substitution effect	Mitchell et al. (2003)
Implementation	**Implementation Sub-factors**	**References**
Stage	Project Resource/Training Planning HIS-Practice Fit Hybrid system Screen/room Workflow	Samoutis et al. (2008), Randeree (2007), Wager et al. (2000), Cauldwell et al. (2007), Crosson et al. (2007)

3. Research Methodology

EMR in this study has been focusedas a new technology in primary care whichhas been trying to describe the factors which have the more priority in its adoption.

A set of pairwaise questionnaire and Likert questionnaire, survey-based research study was carried out and analyzed to exploring and explaining the most influential criteria that have an impact on EMR adoption. EightMalaysia primarycare clinicsin variousspecialtieshave been chosen to conduct this research. 12 experts with experiencing use of EMR system was chosen to fulfill the set of pairwise questionnaire to more validating the findings of this study and the Likert questionnaire survey was emailedin electronic website to 350physicians who work in office settings in the Malaysia primary care. In overall, 12 experts and 300 physicians fulfilled the questionnaire in this study and the rest did not complete due to their time constrain. The survey contains numbers of questions that were designed to capture information about the constructs in the research model. The itemsthat were measuredwas based on people, organization and implementationfactors with their relevant sub-factors. F-TOPSIS and F-AHPwere used to obtain the ranks and weights of parameters in meso-level dimension of EMRs adoption. Figure 2 contains a description of eachstep taken by thepresent study.

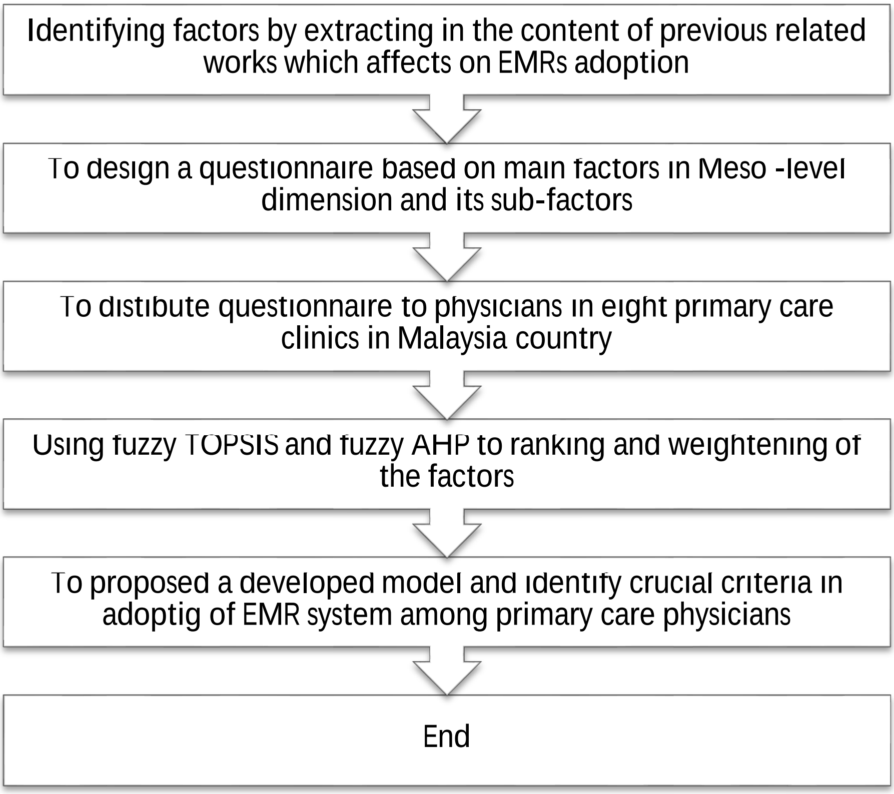

Figure 2. Research Methodology

4. Data Collection

In this study, the primary data was collected through 2 sets of pairwise and Likert questionnaires whichdelivered to the physicians and experts in using the EMR system. One of the ways in which questionnaire can be administered is the emailed questionnaire; one of the most general approach to collecting information is to send the questionnaire to prospective respondents by email. Obviously this approach presupposes thatshould have access to their addresses. In this research, the questionnaires by email have been used by researchers as an efficient and effective instrument to collect data from the respondents. For this study, numbers of respondents for first pairwise questionnaire, were 12 (n=12) experts. Numbers of respondents for a secondset of likertquestionnaire, were approximately 350 (n=350) physicians.All experts give the feedback in the pairwise questionnaire.

But in the second stage of the questionnaire (Likert) almost (85%) of the respondents provided answers to all the questions in the instrument. The first section comprises of information on respondent demographic profile, twelve sections on the independent variable, namely, personal characteristics, personal expectations, roles, responsibilities, strategy, culture, structure-process, info infrastructure, returns on value, stage, project, HIS practice fit. Five options (index) ranked from 1-5 for the raised questions as:1= very low important 2=low important 3=moderately important 4= high important 5= very high important. Table 2 provides the respondents' demographic profile. About sixty four percent of physicians were male and almost thirty seven percent were female who were as a medical professionals in primary care office settings. For the expert respondents, 12 experts in the field of Hospital Information System (HIS) with expertise in one to over ten years of experience in particular with regard to EMRs technology.

Table 2. The Respondents' Demographic Profile

Likert Questionnaire			
Aspects	Category	Respondents (n)	Respondents (%)
Gender	Male	190	63.33%
	Female	110	36.66%
Age	26-33	45	15%
	34-50	90	30%
	51-65	165	55%
Medical specialization	Generalist	178	59.33%
	Specialist	122	40.66%
Pairwise Questionnaire			
Gender	Male	3	25%
	Female	9	75%
Age	30-40	4	33.33
	40-45	5	41.66
	45-50	3	25
Years of electronic medical recoı	1-5	4	33.33%
	6-10	5	41.66%
	Over 10	3	25%

5. Background of Fuzzy TOPSIS

TOPSIS, one of the known classical MCDM methods (Nilashi et al., 2012a), was first developed by Hwang and Yoon (1981) that can be used with both normal numbers and fuzzy numbers.In addition, TOPSIS is attractive in that limited subjective input is needed for decision makers.

The only subjective input needed is weights.Since the preferred ratings usually refer to the subjective uncertainty, it is natural to extend TOPSIS to consider the situation of fuzzy numbers (Bagherifard et al., 2014). F-TOPSIS can be intuitively extended by using the fuzzy arithmetic operations as follows (Nilashi et al., 2012b; Nilashi and Ibrahim, 2013).

Given a set of alternatives, $A = \{A_i \mid i = 1, \cdots, n\}$, and a set of criteria, $C = \{C_j \mid j = 1, \cdots, m\}$, where $\tilde{X} = \{\tilde{x}_{ij} \mid i = 1, \cdots, n;\ j = 1, \cdots m\}$ denotes the set of fuzzy ratings and $\tilde{W} = \{\tilde{w}_j \mid j = 1, \cdots, m\}$ is the set of fuzzy weights.

The first step of TOPSIS is to calculate normalized ratings by

$$\tilde{r}_{ij}(\boldsymbol{x}) = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{n} \tilde{x}_{ij}^{2}}}, \quad i = 1, \cdots, n; \quad j = 1, \cdots, m \tag{1}$$

and then to calculate the weighted normalized ratings by

$$\tilde{v}_{ij}(\boldsymbol{x}) = \tilde{w}_j \tilde{r}_{ij}(\boldsymbol{x}), \quad i = 1, \cdots, n; \quad j = 1, \cdots, m \tag{2}$$

Next the Positive Ideal Point (PIS) and the Negative Ideal Point (NIS) are derived as

$$PIS = \tilde{\boldsymbol{A}}^{+} = \{\tilde{v}_1^{+}(\boldsymbol{x}), \tilde{v}_2^{+}(\boldsymbol{x}), \cdots, \tilde{v}_j^{+}(\boldsymbol{x}), \cdots, \tilde{v}_m^{+}(\boldsymbol{x})\} \text{;}$$

$$PIS = \tilde{\boldsymbol{A}}^{-} = \{\tilde{v}_1^{-}(\boldsymbol{x}), \tilde{v}_2^{-}(\boldsymbol{x}), \cdots, \tilde{v}_j^{-}(\boldsymbol{x}), \cdots, \tilde{v}_m^{-}(\boldsymbol{x})\} \text{;}$$

Similar to the crisp situation, the following step is to calculate the separation from the PIS and the NIS between the alternatives. The separation values can also be measured using the Euclidean distance given as:

$$\tilde{S}_i^{+} = \sqrt{\sum_{j=1}^{m} [\tilde{v}_{ij}(\boldsymbol{x}) - \tilde{v}_j^{+}(\boldsymbol{x})]^2}, i = 1, \cdots, n \tag{5}$$

And

$$\tilde{S}_i^{-} = \sqrt{\sum_{j=1}^{m} [\tilde{v}_{ij}(\boldsymbol{x}) - \tilde{v}_j^{-}(\boldsymbol{x})]^2}, i = 1, \cdots, n. \tag{6}$$

Where

$$\max\{\tilde{v}_{ij}(\boldsymbol{x})\} - \tilde{v}_j^{+}(\boldsymbol{x}) = \min\{\tilde{v}_{ij}(\boldsymbol{x})\} - \tilde{v}_j^{-}(\boldsymbol{x}) = 0. \quad . \tag{7}$$

Then, the defuzzified separation values should be derived using one of defuzzified methods, such as CoA to calculate the similarities to the PIS.

Next, the similarities to the PIS is given as

$$C_i^* = D(S_i^-) \Big/ [D(S_i^+) + D(S_i^-)] \quad ,i = 1,\cdots,n \tag{8}$$

where $C_i^* \in [0,1] \quad \forall i = 1,\cdots,n$.

Finally, the preferred orders are ranked according to C_i^* in descending order to choose the best alternatives. Fuzzy-TOPSIS method is another type of fuzzification for the TOPSIS method in fuzzy environment that is defined and investigated by credibility measure. In this method, trapezoid-fuzzy numbers are used for ranking all sub-criteria of website quality. Therefore, using fuzzy trapezoid numbers enabled us to change normal TOPSIS into F-TOPSIS which is more precisely as the result shows in the next paragraph.One of the characteristic of fuzzy numbers is fuzzy sets with special consideration for easy calculations. Trapezoid Fuzzy Numbers Let $\tilde{A} = (a, b, c, d)$, a<b<c<d, be a fuzzy set on $R = (-\infty, \infty)$. It is called a trapezoid fuzzy number, if its membership function is

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x-a}{b-a}, if \ a \le x \le b \\ 1, \quad if \ b \le x \le c \\ \dfrac{d-x}{d-c}, if \ c \le x \le d \\ 0, \quad otherwise \end{cases} \tag{9}$$

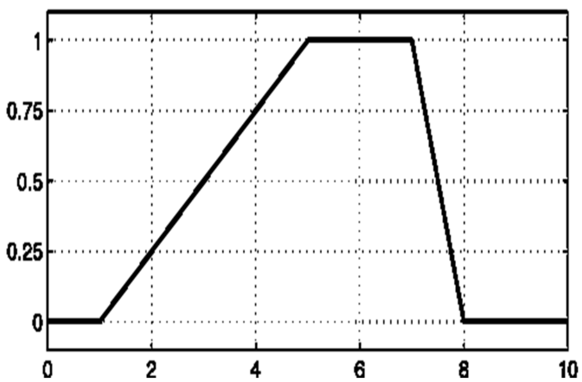

Figure3. Fuzzy Trapezoid Number

All process of F-TOPSIS will be calculated upon three of trapezoid numbers that average numbers of experts are shown in Table 3 and Figure 4:

Table 3: Fuzzy Trapezoid Number for Fuzzy TOPSIS Method

Linguistic Variable	Range of Fuzzy trapezoid number
Non Important	[0.6, 0.8, 1.6, 1.8]
Low Important	[1.4, 1.6, 2.5, 2.7]
Moderate	[2.3, 2.5, 3.8, 4]
Important	[3.6, 3.8, 4.6, 4.8]
Very Important	[4.4, 4.6, 5.2, 5.4]

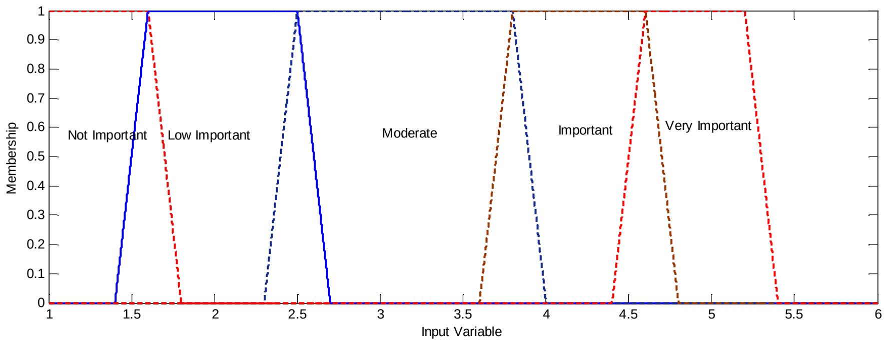

Figure 4: Illustrating Fuzzy Trapezoid Number for the Fuzzy TOPSIS Method

6. Fuzzy AHP

The Analytic Hierarchy Process (AHP) method was proposed by Saaty (1980,1994). Among MCDM techniques, it is a powerful approach to solve complex decision problems (Ibrahim et al., 2011; Nilashi et al., 2011a; Nilashi et al., 2011b). AHPrank and prioritizes the relative importance of a list of criteria in decision making problems. The elements for ranking can be critical factors and sub-factorswhich through pairwise comparisons amongst the factors by relevant experts using a nine-point scale are prioritized. Fuzzy Analytic Hierarchy Process (F-AHP) was proposed by Buckley (1985) withincorporating the fuzzy theory into the AHP. Buckley (1985) started the F-AHP derives more precisely results rather than AHP for vague and subjective decision making problems. Both quantitative and qualitative can be used in F-AHP.

In F-AHP, the uncertain comparison, judgment can be represented by the fuzzy number. There are several types of membership functions for F-AHP where triangular fuzzy number is the special class of the fuzzy number whose membership defined by three real numbers, expressed as (l, m, u). The triangular fuzzy numbers are represented as follows:

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x-l}{m-l}, if \ l \le x \le m \\ \dfrac{u-x}{u-m}, if \ m \le x \le u \\ 0, \quad otherwise \end{cases} \tag{11}$$

For constructing pairwise comparisons of alternatives under each criterion or about criteria from the experts, similar to the pure AHP, a triangular fuzzy comparison matrix is defined as follows (it can be any type of membership functions):

$$\tilde{A} = (\tilde{a}_{ij})_{n\times n} = \begin{bmatrix} (1,1,1) & (l_{21}, m_{12}, u_{12}) & (\\ (l_{21}, m_{21}, u_{21}) & (1,1,1) & (l \\ & & \\ (l_{n1}, m_{n1}, u_{n1}) & (l_{n2}, m_{n2}, u_{n2}) & \end{bmatrix} \tag{12}$$

Where $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}) = \tilde{a}_{ij}^{-1} = (1/u_{ij}, 1/m_{ij}, 1/l_{ij})$

Different methods can be used for total weighs and preferences of alternatives which one of the is Fuzzy Extent Analysis proposed by Chang (1996). The steps of Chang's extensive analysis can be summarized as follows:

First step: In this step we compute the normalized value of row sums (i.e. fuzzy synthetic extent) by fuzzy arithmetic operations presented in Equation 13.

$$\tilde{S}_i = \sum_{j=1}^{n} \tilde{a}_{ij} \otimes \left[\sum_{k=1}^{n} \sum_{j=1}^{n} \tilde{a}_{kj} \right]^{-1} \quad . \tag{13}$$

In Equation 13, $\otimes$ denotes the extended multiplication of two fuzzy numbers.

Second step: In this step, we compute the degree of possibility of $\tilde{S}_i \geq \tilde{S}_j$ by Equation 14:

$$V(\tilde{S}_i \geq \tilde{S}_j) = \underset{y \geq x}{\text{sub}}[\min(\tilde{S}_j(x), \tilde{S}_j(y))] \qquad (14)$$

Which can be equivalently expressed as,

$$V(\tilde{S}_i \geq \tilde{S}_j) = \begin{cases} 1 & m_i \geq m_j \\ \dfrac{u_i - l_j}{(u_i - m_i) + (m_j + l_j)} & l_j \leq u_i \quad i, j = 1, \ldots, n; \\ 0 & otherwise \end{cases} \qquad (15)$$

Third step: In this step, using Equation 16, we calculate the degree of possibility of $\tilde{S}_i$ to be greater than all the other (n-1) convex fuzzy numbers $\tilde{S}_j$.

$$V(\tilde{S}_i \geq \tilde{S}_j \mid j = 1, \ldots, n; j \neq i) = \min_{j \in (1, \ldots, n) j \neq i} V(\tilde{S}_i \geq \tilde{S}_j),\ i = 1, \ldots, \qquad (16)$$

Fourth step: In this step, using Equation 17, we define the priority vector $W = (w_1, \ldots, w_n)^T$ of the fuzzy comparison matrix $\tilde{A}$ as:

$$w_i = \frac{V(\tilde{S}_i \geq \tilde{S}_j \mid j = 1, \ldots n; j \neq i)}{\sum_{k=1}^{n} V(\tilde{S}_k \geq \tilde{S}_j \mid j = 1, \ldots n; j \neq k)},\ i = 1, \ldots, n \qquad (17)$$

7. Ranking Parameters Using Fuzzy Topsis

For applying F-TOPSIS method after gathering data from the respondents, Table 4 was organized. In Table 4, fuzzy trapezoid numbers have been multiplied to base the fundamental of the F-TOPSIS.

Table 4: Applying Fuzzy Number on Questionnaire Data

R_{ij}	Selected Option	Fuzzy Number1				Selected Option	Fuzzy Number2				Selected Option	Fuzzy Number3				Selected Option	Fuzzy Number4				Selected Option	Fuzzy Number5			
Q.No	1	0.6, 0.8, 1.6, 1.8				2	1.4, 1.6, 2.5, 2.7				3	2.3, 2.5, 3.8, 4				4	3.6, 3.8, 4.6, 4.8				5	4.4, 4.6, 5.2, 5.4			
1		0	0	0	0		28	32	50	54		138	150	228	240		360	380	460	480		528	552	624	648
2		0.6	0.8	1.6	1.8		14	16	25	27		69	75	114	120		284.4	300.2	363.4	379.2		792	828	936	972
3		6	8	16	18		28	32	50	54		46	50	76	80		360	380	460	480		660	690	780	810
4		6	8	16	18		56	64	100	108		115	125	190	200		360	380	460	480		440	460	520	540
5		36	48	96	108		56	64	100	108		103.5	112.5	171	180		198	209	253	264		440	460	520	540
6		15	20	40	45		35	40	62.5	67.5		345	375	570	600		360	380	460	480		435.6	455.4	514.8	534.6
7		1.2	1.6	3.2	3.6		28	32	50	54		184	200	304	320		417.6	440.8	533.6	556.8		360.8	377.2	426.4	442.8
8		0.6	0.8	1.6	1.8		1.4	1.6	2.5	2.7		110.4	120	182.4	192		540	570	690	720		440	460	520	540
9		2.4	3.2	6.4	7.2		22.4	25.6	40	43.2		184	200	304	320		288	304	368	384		528	552	624	648
10		6	8	16	18		28	32	50	54		46	50	76	80		360	380	460	480		660	690	780	810
11		6	8	16	18		56	64	100	108		115	125	190	200		360	380	460	480		440	460	520	540
12		3.6	4.8	9.6	10.8		21	24	37.5	40.5		202.4	220	334.4	352		435.6	459.8	556.6	580.8		308	322	364	378
13		3.6	4.8	9.6	10.8		112	128	200	216		27.6	30	45.6	48		511.2	539.6	653.2	681.6		264	276	312	324
14		6	8	16	18		30.8	35.2	55	59.4		92	100	152	160		280.8	296.4	358.8	374.4		660	690	780	810
15		6.6	8.8	17.6	19.8		42	48	75	81		46	50	76	80		320.4	338.2	409.4	427.2		660	690	780	810
16		20.4	27.2	54.4	61.2		84	96	150	162		207	225	342	360		129.6	136.8	165.6	172.8		352	368	416	432

A calculation between two fuzzy trapezoid numbers can be defined as:

$$\begin{matrix} D1 = (a_1, b_1, c_1, d_1) \\ D2 = (a_2, b_2, c_2, d_2) \end{matrix} \Rightarrow D1 + D2 = (a_1 + a_2, b \quad (10)$$

Therefore, Table 5 was calculated from Table 4 by summing of trapezoid numbers.In the next step, each cell of Table 5 will be divided by 300 in order to make the 16 fuzzy numbers for starting F-TOPSIS (see Table 6).

Table 5. The Sum of Four Trapezoid Numbers

Sum of Trapezoid Numbers			
1	2	3	4
1054	1114	1362	1422
1160	1220	1440	1500
1100	1160	1382	1442
977	1037	1286	1346
833.5	893.5	1140	1200
1190.6	1270.4	1647.3	1727.1
991.6	1051.6	1317.2	1377.2
1092.4	1152.4	1396.5	1456.5
1024.8	1084.8	1342.4	1402.4
1100	1160	1382	1442
977	1037	1286	1346
970.6	1030.6	1302.1	1362.1
918.4	978.4	1220.4	1280.4
1069.6	1129.6	1361.8	1421.8
1075	1135	1358	1418
793	853	1128	1188

Table 6. Sixteen Fuzzy Non Trapezoid Numbers

	$(R_{ij})^2$							
Q.No	**a**	**L1**	**L2**	**B**	**c**	**d**	**R1**	**R2**
1	12.34351	0.04	1.405333	13.78884	20.6116	22.4676	0.04	-1.896
2	14.95111	0.04	1.546667	16.53778	23.04	25	0.04	-2
3	13.44444	0.04	1.466667	14.95111	21.22138	23.10404	0.04	-1.922666667
4	10.60588	0.04	1.302667	11.94854	18.37551	20.13018	0.04	-1.794666667
5	7.719136	0.04	1.111333	8.870469	14.44	16	0.04	-1.6
6	15.75032	0.070756	2.111331	17.9324	30.15108	33.14305	0.070756	-3.062724
7	10.92523	0.04	1.322133	12.28736	19.27795	21.07422	0.04	-1.836266667
8	13.25931	0.04	1.456533	14.75584	21.66903	23.57103	0.04	-1.942
9	11.66906	0.04	1.3664	13.07546	20.02264	21.85251	0.04	-1.869866667
10	13.44444	0.04	1.466667	14.95111	21.22138	23.10404	0.04	-1.922666667
11	10.60588	0.04	1.302667	11.94854	18.37551	20.13018	0.04	-1.794666667
12	10.46738	0.04	1.294133	11.80152	18.83849	20.61463	0.04	-1.816133333
13	9.371762	0.04	1.224533	10.6363	16.54862	18.21582	0.04	-1.7072
14	12.7116	0.04	1.426133	14.17774	20.60555	22.46128	0.04	-1.895733333
15	12.84028	0.04	1.433333	14.31361	20.49071	22.34138	0.04	
16	6.987211	0.04	1.057333	8.084544	14.1376	15.6816	0.04	
Sum	135.7516	0.510756	16.57253	152.8349	235.7786	258.1897	0.510756	-19.44725733
SQRT	11.65125	0.714672	4.070937	12.36264	15.35508	16.06828	0.714672	0
1/SQRT	0.085828	1.399243	0.245644	0.080889	0.065125	0.062234	1.399243	0

Therefore trapezoid number will be (d,c,b,a) =(0.085828, 0.080889, 0.065125, 0.062234). Afterward, each cell in Table 6 should be multiplied by (0.085828, 0.080889, 0.065125,0.062234) that is trapezoid. Table 7 demonstrates result of this multiplication.

Table 7: The 14 Fuzzy Trapezoid Numbers For Fuzzy TOPSIS Processes

Q.No	n_{ij}				
	a	b	c	d	Area
1	0.768186	0.897998	1.667252	1.928349	0.964708
2	0.930467	1.077023	1.863683	2.1457	1.000946
3	0.836702	0.973691	1.716576	1.982974	0.944579
4	0.660046	0.778149	1.486377	1.727733	0.887957
5	0.480393	0.577689	1.168037	1.373248	0.741602
6	0.980205	1.167848	2.438891	2.844602	1.56772
7	0.679921	0.800214	1.559374	1.808758	0.943999
8	0.82518	0.960974	1.752786	2.023054	0.994843
9	0.726212	0.851539	1.619611	1.875557	0.958709
10	0.836702	0.973691	1.716576	1.982974	0.944579
11	0.660046	0.778149	1.486377	1.727733	0.887957
12	0.651427	0.768574	1.523827	1.769312	0.936569
13	0.583242	0.692689	1.338602	1.563428	0.813049
14	0.791094	0.923325	1.666762	1.927807	0.940075
15	0.799102	0.932174	1.657473	1.917516	0.921857
16	0.434842	0.526506	1.143576	1.34592	0.764074

In this step, for finding minimum and maximum fuzzy trapezoid number for A+ and A- , was tried to calculate the area under each of the curve. Each curve forms a trapezoid shape. Table 8 shows minimum and maximum trapezoid numbers with their membership functions.Therefore, the maximum and minimum vectors are for question number 6 and 5, respectively.

In Table 9 the square of the distance between the fuzzy number and the Ideal number, $(v_{ij^-} v_{j+})^2$, has been calculated. In the similar way, the square of distance between minimum point and each point was calculated that has been shown in Table 10.Finally , di+ and di- can be calculated as presented in Table 11.

Table 8. Maximum and Minimum of Fuzzy Trapezoid Numbers for A+ and A-

Max Vi	**No.6**			
A+	0.980205	1.167848	2.438891	2.844602
Min Vi	**No.5**			
A-	0.480393	0.577689	1.168037	1.373248

Table 9: The Square of Distance Between Maximum Point and Each Point

$(v_{ij^-} v_{j+})^2$	$(v_{ij^-} v_{j+})^2$	$(v_{ij^-} v_{j+})^2$	$(v_{ij^-} v_{j+})^2$
0.082825	0.102598	0.249215	0.308137
0.202567	0.249334	0.483923	0.596682
0.126956	0.156817	0.300895	0.371766
0.032275	0.040184	0.10134	0.12566
0	0	0	0
0.249812	0.348287	1.615069	2.164881
0.039811	0.049517	0.153145	0.189669
0.118878	0.146907	0.341931	0.422248
0.060427	0.074994	0.203919	0.252314
0.126956	0.156817	0.300895	0.371766
0.032275	0.040184	0.10134	0.12566
0.029253	0.036437	0.126586	0.156867
0.010578	0.013225	0.029092	0.036168
0.096535	0.119464	0.248727	0.307535
0.101576	0.125659	0.239548	0.296227
0.002075	0.00262	0.000598	0.000747

Table 10.The Square of Distance between Minimum Point and Each Point

$(v_{ij^-} v_{j-})^2$	$(v_{ij^-} v_{j-})^2$	$(v_{ij^-} v_{j-})^2$	$(v_{ij^-} v_{j-})^2$
0.044952	0.072819	0.595427	0.839519
0.002474	0.008249	0.330865	0.488463
0.020593	0.037697	0.521739	0.742402
0.102502	0.151865	0.907283	1.247396
0.249812	0.348287	1.615069	2.164881
0	0	0	0
0.090171	0.135154	0.773549	1.072972
0.024033	0.042797	0.47074	0.674941
0.064512	0.100051	0.671219	0.939047
0.020593	0.037697	0.521739	0.742402
0.102502	0.151865	0.907283	1.247396
0.108095	0.15942	0.837342	1.156247
0.15758	0.225776	1.210636	1.641406
0.035763	0.059791	0.596183	0.840513
0.032798	0.055542	0.610614	0.859488
0.297421	0.411319	1.67784	2.246045

Table 11: The Square Distance between Minimum and Maximum for Di+ And Di-

$di+$				$di-$			
0.082825	0.102598	0.249215	0.308137	0.044952	0.072819	0.595427	0.839519
0.202567	0.249334	0.483923	0.596682	0.002474	0.008249	0.330865	0.488463
0.126956	0.156817	0.300895	0.371766	0.020593	0.037697	0.521739	0.742402
0.032275	0.040184	0.10134	0.12566	0.102502	0.151865	0.907283	1.247396
0	0	0	0	0.249812	0.348287	1.615069	2.164881
0.249812	0.348287	1.615069	2.164881	0	0	0	0
0.039811	0.049517	0.153145	0.189669	0.090171	0.135154	0.773549	1.072972
0.118878	0.146907	0.341931	0.422248	0.024033	0.042797	0.47074	0.674941
0.060427	0.074994	0.203919	0.252314	0.064512	0.100051	0.671219	0.939047
0.126956	0.156817	0.300895	0.371766	0.020593	0.037697	0.521739	0.742402
0.032275	0.040184	0.10134	0.12566	0.102502	0.151865	0.907283	1.247396
0.029253	0.036437	0.126586	0.156867	0.108095	0.15942	0.837342	1.156247
0.010578	0.013225	0.029092	0.036168	0.15758	0.225776	1.210636	1.641406
0.096535	0.119464	0.248727	0.307535	0.035763	0.059791	0.596183	0.840513
0.101576	0.125659	0.239548	0.296227	0.032798	0.055542	0.610614	0.859488
0.002075	0.00262	0.000598	0.000747	0.297421	0.411319	1.67784	2.246045

As can be seen in Table 12 and Figure 5, first rank goes to the question number 2 with the area under the curve 2.39, the second rank is for question number 15 with the 2.3 area under the curve and so on.

Table 12. Ranked parameters by fuzzy TOPSIS

Parameters ranking by Fuzzy TOPSIS	
Area	Question No.
0.178	1
0.2	5
0.34	8
0.4	6
0.45	7
1.09	3
1.24	11
1.28	8
1.3129	4
1.32	10
1.61	9
1.8	16
2.0192	12
2.0643	13
2.1869	14
2.3	15
2.39	2

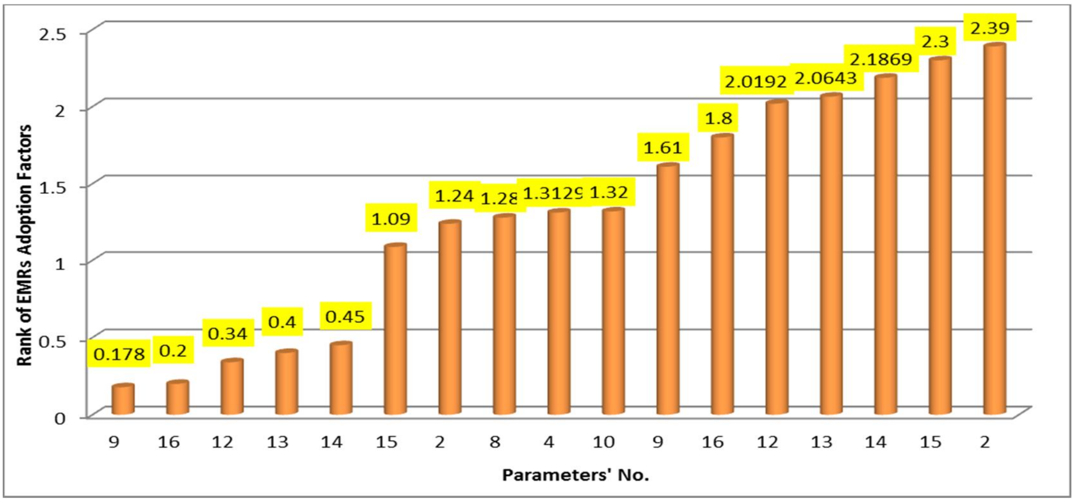

Figure 5: Illustrating Parametters' Rank Obtained by Fuzzy TOPSIS

8. Results of Fuzzy AHP

After comparing the results of the F-TOPSIS method and ranked theparameters and clarified seven of the most important criteria, it is time to choose them and make apairwise matrix in order to interview with experts and starting F-AHP.Finally, seven criteria which were the most important ones from F-TOPSIS has obtained,a second questionnaire adjusted just for experts that was a pairwise matrix, then using the matrixdata, all analyzed with the F-AHP. At the end weight of eightselected factors was calculated by F-AHP that is shown in Table 13 and Figure 6.

Table13. Weights of Parameters by Fuzzy AHP

Parameters ranking by Fuzzy TOPSIS	
Parameters	Area
9	0.1923
16	0.1945
12	0.2034
13	0.2289
14	0.2193
15	0.3473
2	0.3512

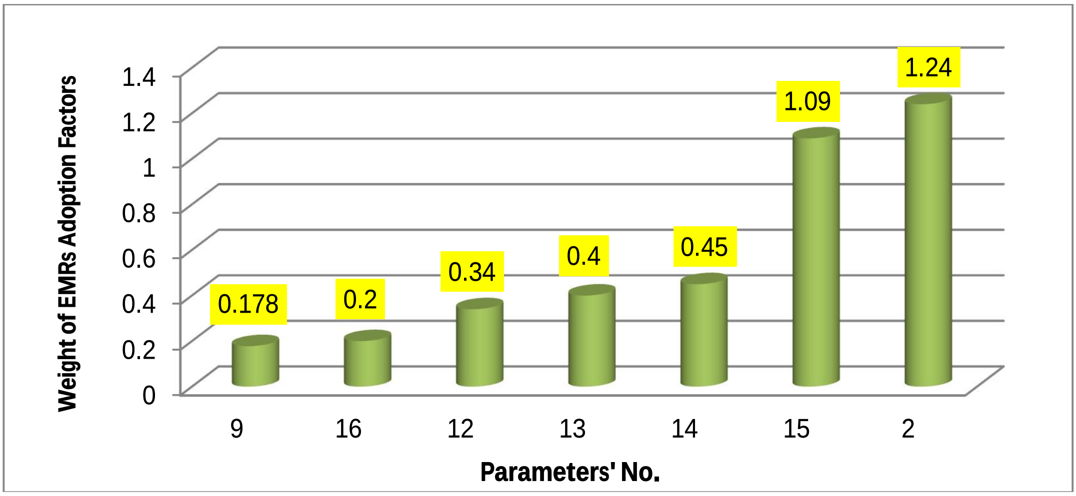

Figure 6: Illustrating Parametters' Weight Calculated by Fuzzy AHP

Table 14 shows the most important seven criteria that ranked at first with F-TOPSIS in the leftcolumn and in the second time ranked by F-AHP based upon their weight that first rank isTime Investment with the weight 0.3512,the second rank for Screen/Room withapproximately weight of 0.3473,Hybrid System with the weight of 0.2193, planning with the weight of 0.2289, resource training with the weight of 0.2034, workflow with weight almost 0.1945 and lastly value with weight of 0.1923.

Table14: Parameters Ranked by Fuzzy AHP and Fuzzy TOPSIS

Parameters	Rank by TOPSIS	Rank by AHP
9	7	7
16	6	6
12	5	4
13	4	5
14	3	3
15	2	2
2	1	1

9. Conclusion

The present study provides contextual analyses of the meso-level dimensionframework which can contribute to fosteringthe physicians EMRs adoption with regard to developing country specifically in Malaysia. It is hoped that this study can addsome knowledge concerning the behavioral science research with regard to new technology adoption in the health care industry.In this study, the criteria in meso-level dimension based on study of Lau et al. (2012) have been scrutinized and focused in purpose of identifying the most influentialfactors related to primary care physicians EMR adoption. The findings of the present study were used to address the adoptionof EMRs technology within the physician community in primary care setting. The findings indicated that Physicians tendeda positive perception towards some features related to technology adoption success and emphasized EMR had a positive impact on their HIS practice. The F-TOPSISand F-AHP method was used as new contribution which is based on MCDM to rank and weighting the critical factors in the adoption of technology innovation. The physician EMRs adoption model in meso-level dimension has been developed and the seven most influential factors found out in making sense of EMRs adoption among physicians.

Future study can gain more validation through testing of the proposed framework in the current study in developing countries with regard to fosteringthe adoption of such a new technology in individual level of health care industry.

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