World Academy of Science, Engineering and Technology
International Journal of Health and Medical Engineering
Vol:1, No:11, 2007

The Development of Taiwanese Electronic Medical Record Systems Evaluation Instrument

Y. Y. Su, K. T. Win, and H. C. Chiu

***Abstract*—**This study used Item Analysis, Exploratory Factor Analysis (EFA) and Reliability Analysis (Cronbach's α value) to exam the Questions which selected by the Delphi method based on the issue of "Socio-technical system (STS)" and user-centered perspective. A structure questionnaire with seventy-four questions which could be categorized into nine dimensions (healthcare environment, organization behaviour, system quality, medical data quality, service quality, safety quality, user usage, user satisfaction, and organization net benefits) was provided to evaluate EMR of the Taiwanese healthcare environment.

***Keywords*—**Instrument development, Reliability test, Validity test, Electronic Medical Record Evaluation.

I. Introduction

DEVELOPING, adopting and promoting electronic medical record (EMR) systems are national goals in Taiwan [1]. The development of health information system (HIS) and electronic medical records (EMR) helps health professionals to enhance patient care and clinical services [2]. Moreover, implementing EMR can potentially lead to better quality and more efficient healthcare [3]. However, investing EMR is a costly process in hospitals, making a decision in investing EMR is an important topic for healthcare managers. Accordingly, it is important to realize whether or not EMR could be accepted by its end-user, and whether EMR could provided actual data and information for patient care [4].

The Declaration of Innsbruck suggested that Evaluation studies should be grounded on scientific theory and rigorous approaches [5]. Accordingly, this research applies the issue of "Socio-Technical System" and User-centered perspective to establish a conceptual evaluation framework and design an instrument for evaluating Taiwanese EMR. In order to recognize the most appropriate factor/attributes in evaluating EMR system which selected by Delphi method, the purpose of this article demonstrated and identified the construct validity and reliability of this instrument, based on quantitative research approach.

Y. Y. Su is with the School of Information System and Technology, University of Wollongong, Wollongong NSW 2522, Australia (phone: +61-2-42272829; fax: +61-2-42214045; e-mail: yys949@uow.edu.au).

K. T. Win is with the School of Information System and Technology, University of Wollongong, Wollongong, NSW 2522, Australia (e-mail: win@uow.edu.au).

H. C. Chiu is with the Graduate Institute of HealthCare Administration, Kaohsiung Medical University, Kaohsiung 807, Taiwan (e-mail: chiu@kmu.edu.tw).

II. Background and Conceptual Framework

Based on the literature review, only a few empirical studies focus on HIS evaluation in Taiwan, and most of them implemented the "DeLone and McLean's IS success model (D&M IS model)" or the "updated DeLone and McLean's IS success model (updated D&M IS model)" to perform their research [6-10]. In Taiwan, the operational strategies of healthcare administration are affected by outer healthcare environment, such as health policies, and national health insurance. Moreover, in a hospital, EMR are customized to satisfy the requirements of clinical service, characteristics of hospitals, organization behaviours, and hospital culture. In addition, the net benefits of implementing EMR will affect the strategies of hospital management. Thus, the developers of EMR need to consider how to establish a useful system for storing patient data based on the feature of its hospital. Furthermore, regarding clinical data of EMR and the development of both intranet and internet, data quality [11] and safety quality [12] are both important issues in an electronic environment. Hence, it is essential to consider how to combine and integrate above issues in evaluating Taiwanese EMR.

HIS evaluation methods, and issues, were derived from IS evaluation [13]. In IS research, Ground Theory (GT) has been used widely [14] and can be regarded as a method to develop theory [15]. Accordingly, in order to identify and explain the relationships between the aspects of Environment, Technology, Human, and Net Benefits, this research adopted GT to generate a proposed conceptual evaluation framework for evaluating Taiwanese EMR (Fig. 1).

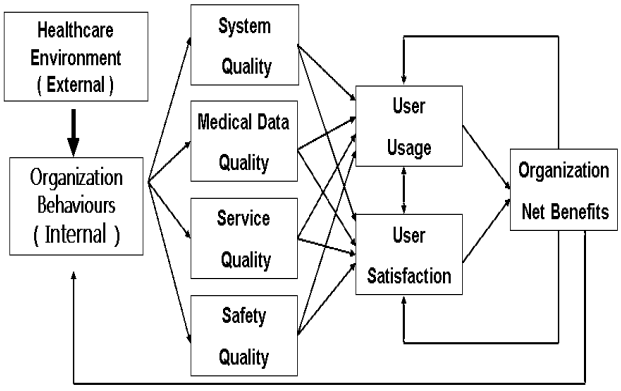

Fig. 1 Taiwanese Electronic Medical Record System Evaluation Framework

This framework considers that the aspects of Environment cover the dimensions of Healthcare Environment (HE) and Organization Behaviours (OB); the aspects of Technology cover the dimensions of System Quality (Sys_Q), Medical Data Quality (MDQ), Service Quality (Ser_Q), and Safety Quality (Safe_Q); the aspects of Human cover the dimensions of User Usage (UU) and User Satisfaction (US); the aspects of Environment cover the dimension of Net Benefits covers the dimensions of Organization Net Benefits (ONB). Therefore, we supposed that HE will have positive affects and enforce hospitals to implement EMR. Then, based on the operational strategies and OB of hospitals, they will have a positive affect on Sys_Q, MDQ, Ser_Q, and Safe_Q of EMR. Moreover, UU and US of implementing EMR will be positive affected by Syst_Q, MDQ, Ser_Q, and Safe_Q. Accordingly, there is also an interaction between UU and US. Furthermore, UU and US will have a positive influence on ONB by implementing EMR in clinical service. Finally, ONB will provide a feedback to influence on UU and US of its end-user, and OB of hospitals. Table I displayed detailed definitions of this evaluation framework.

TABLE I
DEFINITIONS OF THIS CONCEPTUAL USER-CENTERED EVALUATION FRAMEWORK

Dimensions	References	Operational Definitions
HE	[9],[7],[16]	Focus on realizing end-users' impression on national health policies of EMR.
OB	[9],[7],[16]	Concentrate on recognizing end-users' impression on the reasons and motivation to implement EMR in a hospital.
Sys_Q	[6],[17],[7] [16]	Concentrate on identifying end-users' opinions of the performance distinctiveness of the EMR processing it provides.
MDQ	[6],[18],[17] [7],[16]	Focus on identifying end-users' opinions of the output information produced by the EMR.
Ser_Q	[19],[7],[16]	Concentrate on considering how to provide accessible help to the stakeholders of EMR by the technological vender based on identifying end-users' judgment.
Safe_Q	[20],[12]	Focus on identifying end-users' opinions of the ability of risk management of the EMR it proves.
UU	[6],[17],[8], [16]	Focus on measuring the extension use of the EMR it proves based on identifying end-users' judgment.
US	[17],[7],[16]	Concentrate on measuring the consequences of users' response by using the output information of EMR.
ONB	[17],[8],[7], [9],[21],[16]	Focus on realizing the impact and goodness of implementing EMR in patient care performance based on identifying end-users' judgment.

III. METHOD

A. The Development of Questionnaire

A good questionnaire should include both closed and open-ended questions, and could be regarded as a significant tool to get an insight into what people consider and feel [22]. This research collected assessment criteria of EMR evaluation, based on literature review and previous evaluation researches in Taiwan [10,12,16,18,23]. In addition, three consultants (medical doctor, director of department of information management, and top level of healthcare administrator) were invited as an expert team to provide their professional experiences and research suggestions of EMR in the stage of searching references and creating an appropriate evaluation framework and tool.

For Delphi method, twenty-five participants (medical doctors, nurses, medical technicians, top healthcare administrators, and the director of the department of information management) were invited to join the Delphi group. Based on the results of two interaction of Delphi methods, an evaluation instrument contained 75 questions (includes a free-text) from 61 attributes (Table II) were developed to measure Taiwanese EMR. Furthermore, a pilot test of this questionnaire was performed to measure whether it could be accepted and realized by health professionals. Consequently, fifteen medical staffs (nine were medical doctors, and six were nursing staffs) were invited as participants in this pilot test to read the terms/wording/syntaxes of this questionnaire and helped us to revise it without using certain terms that they cannot understand.

TABLE II
EVALUATION ATTRIBUTES SELECTED BY THE DELPHI GROUP

HE	OB	Sys_Q
1.Government	1.Culture	1.Available
2.Competition	2.Strategy	2.Accuracy
3.Population serviced	3.Top management support	3.Easy access to help
4.Inter-organizational relationship	4.Medical staff sponsorship	4.Rigidity of system
5.Communication	5.Indefinite environment	5.Easy of use)
	6.Maturity of information system	6.Perceived easy of use
		7.Reliability
		8.Response time
		9.Usability
MDQ	**Ser_Q**	**Safe_Q**
1.Data accuracy	1.Technical competence of the DIM	1.Identification
2.Data accessibility	2.Time required for system development	2.Privacy
3.Data comprehensiveness	3.Processing of requests for system changes	3.Confidentiality
4.Data consistency	4.User's understanding of the systems	4.System security
5.Data currency	5. Attitude of the DIM staff	5.Consent
6.Data precision	6.Training provided to users	6.Disaster recovery
7.Data relevancy	7. Maintenance support	7.Storage
8.Data timeliness		8.Backup
9.Data definition		9.Medication
		10.Alerts
		11.Data entry
UU	**US**	**ONB**
1.Use of specific functions	1. Attitude	1. Direct benefits
2.Location of data entry	2. User friendliness	2. J ob effects
3.Number of entries	3. Expectations	3. Efficiency
	4. Overall satisfaction	4. Effectiveness
		5. Error reduction
		6. Intercommunication
		7. Cost

DIM: Department of Information Management

B. Data Collection

This research performed in a teaching hospital in the south of Taiwan. There are 498 general beds in it and has been using EMR to improve the quality of patient care for more than two years. For research design, we adopted cross-sectional research design with triangulation research strategies; physicians, nurses, and staffs who have to use this EMR in their daily work were invited as participants to join this research. Participants

were requested to fill out a research questionnaire anonymously. Data were collected from 16th December 2006 to 6th February 2007 in this sample hospital.

C. Analytic Methods

In order to examine the construct reliability and validity for identifying this evaluation instrument, it used "Statistic Package for the Social Science 15.0 (SPSS 15.0)" to perform Descriptive analysis, Item analysis, Exploratory Factor analysis (principal component analysis; PCA), and Reliability test (Cornbach's α value).

VI. Results

A. Sample

Three hundred and fifty three participants answered this instrument; however, four participants did not complete the entire questionnaire; therefore, three hundred and forty nine usable ones were used as research samples (Table III).

TABLE III
DEMOGRAPHIC CHARACTERISTICS OF THE STUDY SAMPLE (N=349)

Characteristic	n	%
Gender		
Male	61	17.48%
Female	288	82.52%
Age		
20 ~ 25	43	12.32%
26 ~ 30	140	40.11%
31 ~ 35	90	25.79%
36 ~ 40	43	12.32%
41 ~ 45	11	3.15%
46 ~ 50	9	2.58%
51 ~ 55	1	0.29%
Missing	12	3.44%
Job title		
Physician	79	22.64%
Nurse	216	61.89%
Others	53	15.19%
Missing	1	0.29%
Education		
Junior College	133	38.11%
Bachelor	183	52.44%
Master	28	8.02%
Doctoral	4	1.15%
Missing	1	11.11%
Seniority in this hospital		
Less than 12 months	31	8.88%
13 ~ 60 months	135	38.68%
61 ~ 120 months	156	44.70%
121 ~ 180 months	16	4.58%
181+ months	7	2.01%
Missing	4	1.15%

Missing: participant did not answer this question

B. Item Analysis and Reliability Analysis

The result of Item analysis displayed that there is no significant differences in overall score between the groups ($t=0.003 < \alpha=0.05$). The recommendation of reliability analysis indicated that the value of Cronbach's alpha needs to be grater than 0.80 (cut-off point) [24]. Accordingly, no matter within factors or between factors, all 74 questions should be kept in this instrument, based on the result of reliability analysis (Table IV).

TABLE IV
CONSTRUCT RELIABILITY

Factor	Within Factors			Between Factors		
Questions	(1)	(2)	(3)	(1)	(2)	(3)
HE1	0.677	0.907		0.580	0.982	
HE2	0.825	0.877		0.577	0.982	
HE3	0.818	0.877	0.908	0.600	0.982	
HE4	0.784	0.885		0.631	0.982	
HE5	0.744	0.893		0.541	0.982	
OB1	0.714	0.902		0.567	0.982	
OB2	0.636	0.910		0.658	0.982	
OB3	0.740	0.900		0.573	0.982	
OB4	0.728	0.901	0.913	0.641	0.982	
OB5-1	0.768	0.898		0.583	0.982	0.982
OB5-2	0.768	0.898		0.531	0.982	
OB5-2	0.761	0.898		0.650	0.982	
OB6	0.644	0.909		0.542	0.982	
Sys1	0.709	0.932		0.611	0.982	
Sys2	0.726	0.931		0.675	0.982	
Sys3	0.767	0.928		0.725	0.982	
Sys4	0.728	0.931		0.648	0.982	
Sys5	0.799	0.926	0.936	0.703	0.982	
Sys6	0.766	0.928		0.687	0.982	
Sys7	0.803	0.926		0.735	0.982	
Sys8	0.724	0.931		0.655	0.982	
Sys9	0.809	0.926		0.754	0.982	
MDQ1	0.775	0.952		0.683	0.982	
MDQ2	0.802	0.951		0.688	0.982	
MDQ3	0.859	0.949		0.714	0.982	
MDQ4	0.813	0.951		0.704	0.982	
MDQ5	0.874	0.948	0.956	0.752	0.982	
MDQ6	0.833	0.950		0.732	0.982	
MDQ7	0.852	0.949		0.711	0.982	
MDQ8	0.819	0.951		0.745	0.982	
MDQ9	0.769	0.953		0.737	0.982	
MDQ10	0.692	0.956		0.656	0.982	
Ser1	0.777	0.923		0.550	0.982	
Ser2	0.818	0.919		0.574	0.982	
Ser3	0.811	0.920		0.591	0.982	
Ser4	0.767	0.924	0.933	0.614	0.982	
Ser5	0.765	0.924		0.584	0.982	
Ser6	0.795	0.922		0.618	0.982	
Ser7	0.757	0.925		0.601	0.982	
Safe1	0.673	0.930		0.572	0.982	
Safe2	0.636	0.931		0.550	0.982	
Safe3	0.790	0.924		0.650	0.982	
Safe4	0.700	0.928		0.593	0.982	
Safe5	0.762	0.925		0.612	0.982	
Safe6	0.681	0.929	0.933	0.540	0.982	
Safe7	0.797	0.924		0.631	0.982	
Safe8	0.853	0.922		0.677	0.982	
Safe9	0.712	0.928		0.588	0.982	
Safe10	0.706	0.928		0.583	0.982	
Safe11	0.643	0.930		0.628	0.982	
UU1-1	0.694	0.897		0.656	0.982	
UU1-2	0.656	0.900		0.656	0.982	
UU1-3	0.757	0.891		0.701	0.982	
UU1-4	0.803	0.887	0.908	0.725	0.982	
UU2-1	0.575	0.909		0.470	0.982	
UU2-2	0.678	0.898		0.557	0.982	
UU3-1	0.748	0.892		0.718	0.982	
UU3-2	0.764	0.891		0.703	0.982	
US1	0.729	0.929		0.680	0.982	
US2	0.729	0.929		0.689	0.982	
US3	0.753	0.928		0.669	0.982	
US4-1	0.798	0.925		0.711	0.982	
US4-2	0.787	0.926	0.935	0.667	0.982	
US4-3	0.792	0.926		0.691	0.982	
US5-1	0.758	0.928		0.720	0.982	
US5-2	0.739	0.929		0.679	0.982	
US5-3	0.744	0.928		0.678	0.982	
ONB1	0.783	0.932	0.940	0.734	0.982	
ONB2	0.845	0.926		0.690	0.982	

ONB3	0.866	0.924	0.702	0.982
ONB4	0.866	0.924	0.703	0.982
ONB5	0.802	0.930	0.707	0.982
ONB6	0.756	0.934	0.692	0.982
ONB7	0.696	0.939	0.621	0.982

(1) Corrected Item-Total Correction;
(2) Cornbach's α (if item deleted)
(3) Average Cornbach's α

C. Exploratory Factor Analysis

This research implemented PCA of Exploratory Factor Analysis (EFA) with promax rotation to classify questions in this instrument. If the value of community is less than 0.4, the value of Kaiser-Mayer-Olkin (KMO) is less than 0.70, and the value of Bartlett's Test is greater than 0.05 ($p < 0.05$), it needs to be deleted from this instrument [24]. Based on the results of EFA, Table 5 displayed all detail value of community, KMO, and Bartlett's Test within and between factors. In addition, the sample in this research is 349, so we only kept items that had a factor loading greater than 0.4 (cut-off point) in this instrument. The detail information of factors loading within factors was displayed in Table VI and Table VII displayed factors loading between factors.

TABLE V
ITEM-AVERAGED SCORE, STANDARD DEVIATION, AND VALVE OF COMMUNITY

Questions	Mean (SD)	Within Factors		Between Factors	
		(1)	(2)	(1)	(2)
HE1	3.71(0.64)	0.62		0.64	0.95**
HE2	3.80(0.63)	0.80		0.80	
HE3	3.80(0.69)	0.80	0.88**	0.81	
HE4	3.73(0.70)	0.75		0.75	
HE5	3.89(0.65)	0.70		0.71	
OB1	3.68(0.63)	0.61		0.65	
OB2	3.53(0.69)	0.51		0.67	
OB3	3.63(0.62)	0.65		0.64	
OB4	3.58(0.66)	0.63	0.89**	0.66	
OB5-1	3.72(0.57)	0.70		0.73	
OB5-2	3.81(0.59)	0.70		0.79	
OB5-2	3.74(0.62)	0.69		0.72	
OB6	3.78(0.67)	0.53		0.59	
Sys1	3.57(0.66)	0.59		0.62	
Sys2	3.66(0.66)	0.62		0.69	
Sys3	3.61(0.68)	0.68		0.75	
Sys4	3.52(0.68)	0.62		0.66	
Sys5	3.46(0.71)	0.72	0.92**	0.76	
Sys6	3.47(0.71)	0.67		0.77	
Sys7	3.49(0.69)	0.72		0.74	
Sys8	3.43(0.72)	0.61		0.71	
Sys9	3.52(0.70)	0.73		0.71	
MDQ1	3.69(0.59)	0.68		0.74	
MDQ2	3.68(0.61)	0.71		0.74	
MDQ3	3.64(0.61)	0.79		0.79	
MDQ4	3.62(0.60)	0.73		0.75	
MDQ5	3.66(0.61)	0.82	0.95**	0.85	
MDQ6	3.64(0.66)	0.76		0.78	
MDQ7	3.64(0.62)	0.78		0.80	
MDQ8	3.67(0.60)	0.73		0.73	
MDQ9	3.60(0.64)	0.65		0.72	
MDQ10	3.55(0.68)	0.55		0.66	
Ser1	3.30(0.77)	0.70		0.76	
Ser2	3.32(0.75)	0.75		0.80	
Ser3	3.30(0.74)	0.75		0.77	
Ser4	3.46(0.68)	0.69	0.91**	0.74	
Ser5	3.48(0.68)	0.69		0.75	
Ser6	3.45(0.67)	0.73		0.76	
Ser7	3.44(0.74)	0.68		0.69	
Safe1	3.60(0.71)	0.54	0.92**	0.60	
Safe2	3.82(0.58)	0.49		0.62	
Safe3	3.67(0.61)	0.70		0.72	
Safe4	3.45(0.67)	0.57		0.70	
Safe5	3.60(0.63)	0.65		0.71	
Safe6	3.55(0.65)	0.55		0.59	
Safe7	3.63(0.62)	0.71		0.77	
Safe8	3.62(0.61)	0.79		0.82	
Safe9	3.64(0.64)	0.59		0.71	
Safe10	3.62(0.61)	0.58		0.66	
Safe11	3.58(0.61)	0.49		0.66	
UU1-1	3.51(0.83)	0.61		0.77	
UU1-2	3.66(0.68)	0.56		0.80	
UU1-3	3.52(0.76)	0.69		0.80	
UU1-4	3.52(0.71)	0.75	0.85**	0.78	
UU2-1	3.29(0.85)	0.43		0.77	
UU2-2	3.37(0.75)	0.55		0.78	
UU3-1	3.50(0.69)	0.68		0.75	
UU3-2	3.49(0.67)	0.70		0.78	
US1	3.50(0.71)	0.61		0.68	
US2	3.47(0.70)	0.62		0.72	
US3	3.50(0.65)	0.66		0.71	
US4-1	3.53(0.65)	0.73		0.78	
US4-2	3.62(0.62)	0.72	0.88**	0.85	
US4-3	3.61(0.61)	0.73		0.84	
US5-1	3.52(0.72)	0.65		0.80	
US5-2	3.49(0.74)	0.63		0.82	
US5-3	3.66(0.65)	0.64		0.68	
ONB1	3.62(0.70)	0.71		0.75	
ONB2	3.59(0.72)	0.80		0.81	
ONB3	3.58(0.73)	0.83		0.88	
ONB4	3.58(0.74)	0.83	0.91**	0.85	
ONB5	3.45(0.78)	0.73		0.75	
ONB6	3.55(0.71)	0.67		0.71	
ONB7	3.51(0.72)	0.59		0.68	

(1)Value of Communality;
(2) Value of KMO and Bartlett's Test (**p<α= 0.05)

TABLE VI
FACTOR LOADING WITHIN FACTORS

Factor / Questions	1	2	3	4	5	6	7	8	9
Q1	0.78	0.78	0.77	0.82	0.84	0.73	0.78	0.78	0.84
Q2	0.90	0.72	0.79	0.84	0.87	0.70	0.75	0.78	0.89
Q3	0.78	0.81	0.82	0.89	0.87	0.83	0.83	0.81	0.91
Q4	0.87	0.80	0.79	0.85	0.83	0.76	0.86	0.85	0.91
Q5	0.84	0.84	0.85	0.90	0.83	0.81	0.65	0.85	0.86
Q6		0.84	0.82	0.87	0.86	0.74	0.74	0.85	0.82
Q7		0.83	0.85	0.88	0.82	0.85	0.83	0.80	0.77
Q8		0.73	0.78	0.86		0.89	0.83	0.79	
Q9			0.86	0.81		0.77		0.80	
Q10				0.74		0.76			
Q11						0.70			
Variance explained (%)	7336	6291	6630	7205	7142	6056	6195	6635	7363
Eigenvalues	367	503	597	721	500	666	496	597	515

1: HE; 2: OB; 3: Sys_Q; 4: MDQ; 5: Ser_Q; 6: Safe_Q;
7: UU; 8: US; 9: ONB

TABLE VII
FACTOR LOADING BETWEEN FACTORS

Factor / Questions	A	B	C	D	E	F	F	H	I	J
Question1								0.56		
Question2								0.73		
Question3								0.73		
Question4								0.65		
Question5								0.64		
Question6				0.69						
Question7				0.42						
Question8				0.64						
Question9				0.56						

Question10		0.73								
Question11		0.81								
Question12		0.62								
Question13		0.57								
Question14			0.45							
Question15	**0.41**									
Question16										
Question17			0.62							
Question18			0.66							
Question19			0.67							
Question20	**0.42**									
Question21			0.64							
Question22			0.48							
Question23	0.67									
Question24	0.63									
Question25	0.74									
Question26	0.74									
Question27	0.75									
Question28	0.71									
Question29	0.78									
Question30	0.61									
Question31	0.50									
Question32	0.54									
Question33				0.78						
Question34				0.79						
Question35				0.75						
Question36				0.71						
Question37				0.74						
Question38				0.74						
Question39				0.69						
Question40		0.65								
Question41		0.54								
Question42		0.71								
Question43		0.64								
Question44		0.71								
Question45		0.68								
Question46		0.71								
Question47		0.75								
Question48		0.62								
Question49		0.60								
Question50		0.50								
Question51							0.50			
Question52							0.63			
Question53							0.61			
Question54							0.54			
Question55								0.77		
Question56								0.71		
Question57										
Question58										
Question59										
Question60										
Question61					0.56					
Question62					0.62					
Question63					0.78					
Question64					0.74					
Question65		**0.59**								
Question66	**0.63**									
Question67						0.49				
Question68	0.61									
Question69	0.81									
Question70	0.84									
Question71	0.83									
Question72	0.67									
Question73	0.50									
Question74	0.52									
Variance Explained(%)	32.55	4.13	3.65	2.86	2.55	2.05	1.63	1.39	1.31	1.23
Eigenvalues	43.98	5.59	4.94	3.86	3.45	2.77	2.20	1.87	1.77	1.66

V. Discussion

This research applied Triangulation research strategies (theory, method, investigators, and data triangulation) [25] to identify its conceptual instrument. Based on the results of statistical analysis, the final instrument consist of 71-questionnaire (with a free-text question). Due to the National Health Insurance (NHI) and Hospital Accreditation Program in Taiwan, the feature and golden standard of Taiwanese medical environment is centralization.

For quantitative research approach, this research adopted statistical analysis to examine the construct reliability and validity in this instrument. The result of Cronbach's alpha within and between factors suggested that all the questions of the instrument should be kept for Factor analysis. In addition, EFA was implemented to classify questions into suitable factor [24]. For within factors, each question was satisfied the requirements of their own factors. For between factors, comparing the result of Delphi method and the original definitions of our evaluation framework, we consider that user-centered is one of the main issues and we needed to stress on it in this research. Consequently, based on the result of factor analysis between factors, and after we discussed with our expert team, we decided that: ***Factor A*** means **HE**, ***Factor B*** means **OB**, ***Factor C*** means **Sys_Q**, ***Factor D*** means **MDQ**, ***Factor E*** means **Ser_Q**, ***Factor F*** means **Safe_Q**, ***Factor G*** means **UU**, ***Factor H*** means **US**, and ***Factor I*** means **ONB** to confirm the contents in this instrument.

As the definition of ***Sys_Q*** in this instrument is to identify end-users' opinions of the performance distinctiveness of the EMR processing it provides. Hence, ***Question 15*** (*Accuracy*: This EMR consistently correctness respond to your commands in the same way), and ***Question 20*** (*Reliability*: It is confident of the capability of this EMR to perform your transactions of patient care) still needed to be classified into the dimension of Sys_Q. Furthermore, based on the cut off criteria of factor analysis, ***Question 55*** (*Location of data entry*(1):The locations of computers where they stand are convenient for users to operate this EMR); ***Question 56*** (*Location of data entry(2)*: The numbers of computers are adequate enough for you to use this EMR) should be deleted from this instrument. However, we consider that the definition of **UU** is to measure the extension use of the EMR it proves based on identifying end-users' judgment, and these two questions try to realize

whether location and numbers of computer will effect user' usage of EMR without measuring their satisfaction. Hence, these two questions are important for our research and still needed to be kept, combined and classified into the dimension of UU. In addition, ***Question 65*** (Overall satisfaction (1): This EMR indeed helps you to write the patient records right (efficiency); ***Question 66*** (Overall satisfaction (2): This EMR indeed helps you to save your time in writing patient records). As the same reason as ***Question 55-56***, and ***c***omparing the definition of **US** and **ONB**, we considered and classified them into the dimension of **US,** the main question of it was: Please display your overall satisfaction with this EMR and they focused on measuring users' individual satisfaction of EMR.

In addition, four questions were deleted from this instrument because the values of factor loading were less than 0.4: ***Question 57*** (Number of entries (1): The interface of this EMR needs users to type/key-in numbers of patient data); ***Question 58*** (Number of entries (2): The interface of this EMR is convenient for user to type/key-in patient data); ***Question 59*** (*Overall satisfaction (1)*: This EMR is very easy to use and you are happy to use it); ***Question60*** (*Overall satisfaction (2)*: The EMR provides a user-friendly operating interface to show you how to use it).

Finally, following the definitions of each dimension in our conceptual evaluation framework and results that we discussed with our expert team, this instrument was modified and ready for evaluating Taiwanese EMR for the next stage of our research.

VI. Conclusion

Based on the results of two-iterative Delphi method of quantitative approach; conducting by Item analysis, Exploratory Factor analysis, and Reliability analysis of quantitative research approach, this research provided an appropriate instrument and could be regarded as a local culture perspective instrument for evaluating Taiwanese EMR in decision-making. Hence, we consider that the category of this instrument could help us to design a suitable tool to achieve the target of our research. However, due to possible response bias, this instrument still needs to be examined in different kinds of ownership hospitals in Taiwan.

Acknowledgment

We thank all experts who helped us to revise and finalized this evaluation questionnaire; all participants who cooperated and helped us to fill out this research questionnaire.

References

[1] DOH. Online Health Services Promotion Plan—Progress Report. 2007 2004/12/29 [cited 2007 1 April]; Available from: http://www.doh.gov.tw:8080/jKM/DBSearch/result_1_EN.jsp?uid=39756.

[2] Wan, T.T.H., Healthcare informatics research: from data to evidence-based management. Journal of Medical Systems, 2006. 30(1): p. 3-7.

[3] Schiffman R. N., Brandt C. A., Liaw Y., and C.G. J., A design model for computer based guideline implementation based on information management services. Journal of the American Medical Informatics Association, 1999. 6(2): p. 99-103.

[4] Mohd, H. and S.M.D. Mohamad, Acceptance Model of Electronic Medical Record. Journal of Advancing Information and Management Studies, 2005. 2(1): p. 75-92.

[5] Ammenwerth, E., J. Brender, P. Nykanen, H.-U. Prokosch, M. Rigby, and J. Talmon, Visions and strategies to improve evaluation of health information systems: Reflections and lessons based on the HIS-EVAL workshop in Innsbruck. International Journal of Medical Informatics, 2004. 73(6): p. 479-491.

[6] Tsay, Y.-J., S. Wu, and B.-C. Chiang, The Research on the Model of Information Systems Success for the Hospitals. Information Management, 2001. 18(6): p. 289-309.

[7] Sher, M.L., Y.S. Hsueh, and H.G. Hwang, An Empirical Study of Key Factors Affecting the Performance Evaluation of Hospital Information Systems: Executives' Perspective. Taiwan Journal of Public Health, 2005. 24(1): p. 22-32.

[8] Lee, T.-T., Evaluation of computerized nursing care plan: Instrument development. Journal of Professional Nursing, 2004. 20(4): p. 230-238.

[9] Chang, I.C., H.-G. Hwang, D.C. Yen, and J.W. Lian, Critical factors for adopting PACS in Taiwan: Views of radiology department directors. Decision Support Systems, 2006. 42(2): p. 1042-1053.

[10] Chen, C.H. and L.H. Yu. The Study of Constructing the Evaluation Model of Hospital Information Systems. in Nternational Conference of Digital Technology and Innovation Management. 2006. Taipei, Taiwan R.O.C.

[11] Moczygemba, J. and B. Hewitt, Managing Clinical Data in an Electronic Environment. The Health Care Manager, 2001. 19(4): p. 33-38.

[12] Win, K.T., H. Phung, L. Young, M. Tran, C. Alcock, and K. Hillman, Electronic health record system risk assessment: a case study from the MINET. Health Information Management, 2004. 33(2): p. 43-48.

[13] Burkle, T., E. Ammenwerth, H.U. Prokosch, and J. Dudeck, Evaluation of clinical information systems. What can be evaluated and what cannot? Journal of Evaluation in Clinical Practice, 2001. 7(4): p. 373-385.

[14] Akbar, A.A., 'Pay-per-use' concept in healthcare: a grounded theory perspective, in Proceedings of the 36th Annual Hawaii International Conference on System Sciences, 2003. 2003.

[15] Taylor, G.R., ed. Integrating quantitative and qualitative methods in research. 2nd ed ed. 2005, University Press of America: Lanham, Md, Friedman, C.P., Evaluation methods in biomedical informatics / Charles P. Friedman, Jeremy C. Wyatt; foreword by Edward H. Shortliffe. 2nd ed ed. 2006, New York: Springer..

[16] Maryati, M.Y., J.P. Ray, and K.S. Lampros. Towards a Framework for Health Information Systems Evaluation. in Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06). 2006. Hawaii.

[17] Van Der Meijden, M.J., H.J. Tange, J. Troost, and A. Hasman, Determinants of Success of Inpatient Clinical Information Systems: A Literature Review. J Am Med Inform Assoc., 2003. 10(3): p. 235-243.

[18] Jackie, M. and H. Barbara, Managing clinical data in an electronic environment. The Health Care Manager, 2001. 19(4): p. 33.

[19] Li, E.Y., Perceived importance of information system success factors: A meta analysis of group differences. Information & Management, 1997. 32(1): p. 15.

[20] Ball, M.J., C. Weaver, and P.A. Abbott, Enabling technologies promise to revitalize the role of nursing in an era of patient safety. International Journal of Medical Informatics, 2003. 69(1): p. 29.

[21] Liu, C.-T., P.-T. Yang, Y.-T. Yeh, and B.-L. Wang, The impacts of smart cards on hospital information systems--An investigation of the first phase of the national health insurance smart card project in Taiwan. International Journal of Medical Informatics, 2006. 75(2): p. 173-181.

[22] Ammenwerth, E., F. Kaiser, I. Wilhelmy, and S. Hofer. Evaluation of user acceptance of information systems in health care--the value of questionnaires, in Proceedings of Medical Informatics Europe (MIE 2003). 2003. St. Malo, France: Oxford: IOS.

[23] DeLone, W.H. and E.R. McLean, The DeLone and McLean model of information systems success: a ten-year update. Journal of Management Information Systems, 2003. 19(4): p. 9-30.

[24] Davis, N., SPSS explained, ed. P.R. Hinton. 2004, London: Routledge, Saunders.

[25] Maxwell, J.A., Qualitative research design: an interactive approach / Joseph A. Maxwell. 2nd ed. 2005, Thousand Oaks, CA: Sage Publications.