Factors Affecting Medical Incident Care on WBAN

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Abstract

The WBAN(Wireless Body Area Network) supplies mobile convenience to our medical services. But if we have few effective control variables across this service deployment, the hidden distortions or defects of the system might threaten the lives and rights of the stakeholders. Therefore we need to increase the service credibility, to get WBAN effective.
This study proposes a governance mechanism using feasible variables that are currently in use in practices in WBAN environments against medical incidents. Control variables were tested in Seoul National University hospital and related medical industries of South Korea. We assume that WBAN systems would be open based on integrating patients, medical employees and law enforcements to get smart theater operations against medical incidents by implementing proposed MJA(Multilateral Joint Analysis) model.
MJA model also contributes to the convergence of computer systems and medical services by demonstrating flexible SOA(Service Oriented Architecture) dashboard of healthcare services with credibility factors in medicine.
The important components in MJA model across WBAN, were found to be "Safety, Accuracy and Reliability" in priority order.
Factor analysis, correlations and ANOVA were used to evaluate this model and an IT dashboard with a realization of mobile application, was used to support participants' decision-making.

Keywords: Control Variables, Healthcare System, Medical Incident Care, WBAN Governance, Mission Critical System, Information Technology Supervision

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1. Introduction

In this age of ubiquitous surroundings, a major challenge is maintaining business integrity or accountability by establishing the controls [1] especially over the mission critical behaviour of systems, built on IT(Information Technology) convergent products. A failure to the service integrity would hurt the vital information or human lives directly or indirectly under today's RTE(Real Time Enterprise) responses [2]

Design defects or frequently occurring changes are known to be the root causes of system vulnerability[3] in ubiquitous environment, and medical accidents can always be blamed on natural occurrence or human error. However it is hard to expect this kind of expertise in every medical field because the medical incidents investigation team which generally operates under a law enforcement agency, tends to take a stand-alone approach that mainly depends on individual experience and knowledge. The maintenance of accountability and admissibility of evidence for the court in the case of medical product vulnerability of WBAN, would have major impact if it could be assured. [4][5][9]

To mitigate these u-Healthcare issues, a "Multilateral Joint Analysis" model, in which experts in various fields participate in the improvement [10][11] of medical incident investigation within the existing stand-alone approach, has been recommended. This suggestion arose after analysis of a case study involving an implementation of suggested control variables across mobile application development for u-Healthcare and WBAN [2] with the supporting guideline for the small business of Ministry of Knowledge Economy of South Korea. Using this model, the medical incidents investigation team can increase their productivity and the medical employees get high utilization ratio of u-Healthcare and WBAN products and services by applying the control mechanism of malfunction in medical products. The components are representatively as in "Safety[6][8], Accuracy and Reliability[1][7]", by which we can secure human lives and rights against hidden defects of the WBAN products.

We would need control variables on a WBAN convergent environment, because the WBAN deals with sensing vital information or signs of humans and it is known from actual suit cases that, if medical employees acquires wrong data from sensors to analysis system across medical decisions, their prescriptions lead to severe damage or death to the human body. This kind of case is called as the medical incidents and medical employees must have the responsibilities on them. **Table 1**. shows the summary of related WBAN technologies.

Table 1. A comparison of WBAN and WPAN technologies.

Technology	**BAN**	**Wireless PAN(Personal Area Network)**			**WMAN**
	WBAN 802.15.6	Bluetooth 802.15.1	ZigBee 802.15.4	UWB (Ultra Wide Band) 802.15.3a	WiFi etc. (IEEE 802.11x)
Frequency band	3.1GHz ~ 10.6GHz	2.4GHz	868,915MHz / 2.4GHz	3.1GHz ~ 10.6GHz	2.4 / 5GHz
Data rate (b/s)	10K~10M	1~20M	250K	100~500M	11M
Coverage area (meter)	3	10	10~100	20	50 ~ 100
Network topology	Ad-hoc, etc.	Ad-hoc, 1:1, 1:M	Ad-hoc, Star, Mesh, 1:1	Ad-hoc, Mesh	Ad-hoc, etc.

Application	u-Healthcare, Consumer electronics, Military	Headset, Multimedia for PC	Home automation, Sensor communication	Disaster response, Remote control, Home network, Military	VoIP

Accounting the priority to get operation excellence across governance value chain to secure ubiquitous services like u-Healthcare, South Korea established a basis for accountability and guarantee of integrity of mobile product from requirements to implementations for real-time business. [13] This initiative demonstrated leadership in world e-government by achieving the progress in significant development and provision in cross sector mobile applications for citizens [14]

This paper is organized into five major sections. Section 1 introduces why we propose MJA model in WBAN. Then Section 2 presents related study. Section 3 defines the procedures, roles and responsibilities with key factors design as model components. Section 4 gives evaluations on the factors of medical incidents governance by statistical analysis with implementation. Final Section 5 is the conclusion.

2. Related Work

Since the first academic research papers for wireless body area networks for health monitoring applications were published a decade ago [15], the mobile communications have advanced providing more reliable and higher services. And today, smart phones emerged as a dominant computing platform with performance and storage capabilities [16] sophisticated custom applications, messaging, e-mails, full-fledged Internet access. [17] Convergence of all these enabling technologies creates great new opportunities for better healthcare and improved quality of living. [18] Recently to support convergence opportunities SOA(Service Oriented Architecture) based healthcare systems and related control variables were tried [19] And the broad adoption of social media has also been followed by the privacy issues of personal health record systems such as Google Health [20] , Microsoft Health Vault [21], Dossia [22] and Health 2.0. SOA is also adopted to integrate different sources and institutions. [19] In hospitals to learn from mistakes and improve patients' safety, the incident reporting system (IRS) was studied to identify medical errors in order. The WHO has developed the International Classification for Patient Safety (ICPS) in order to enable comparison of incident reports from different sources and institutions. [2]

But current medical practices still suffer from few control variables across the chain of custody arising from a medical incident which is delivered in the shape of evidence to the court. Recently, during medical investigation of an actual suit case of South Korea, attempts were made to apply distributed incidents response models [24] with remote factors. Other recent studies to evaluate the performance of ad hoc networks has used mobility measures which proved to be flexible and consistent enough to support autonomous systems of mobile nodes connected by wireless links. [25] And enabling technologies for Wireless Body Area Networks was also surveyed. [4] There was a bright comprehensive survey of the fundamental mechanisms of WBAN at PHY, MAC, and Network layers with numerous WBAN applications. [23] An investigation on the channel variations in WBAN was also conducted to propose a ray solution for multiple closed surfaces in which the human bodies were represented as closed cylindrical surfaces with constitutive parameters. [26] And an augmentation protocol for the physical layer of the medical implant communications service

was also presented to support the correct delivery of the vital physiological signs of the patient along with the energy management in lower constrained devices [27]. As a cooperation model Multilateral Joint Analysis model has also been validated with selected representatives of digital investigators from district police agencies across South Korea but without high level of industry understanding. [10] Today more practical models are needed for future convergence cases and in this study the characteristics of medical incidents response and of securing mobile WBAN in real time appliances have been combined to determine set key factors to guarantee the chain of e-discovery(securing of evidence from the scene of incident to the court), rather than physical layer factors affecting medical incidents as in previous works.

Table 2. Factorsc comparison assumed IT convergence and medical Incidents care

Scope	Variables (Factors)	Factors applied on medical incidents across WBAN	Dependent Variable
Related Work	Architecture & Mobility	Enabling technologies for Wireless Body Area Networks is also surveyed. [4]	Productivity
	Wearability, Ease of use, Privacy & Security	Acceptance of ubiquitous health monitoring systems is and will continue to be determined primarily by Wearability, Ease of use, Meaningful feedback to the users, Price, Privacy & Security. [18]	
	Energy Efficiency	The human body's augmentation protocol proposed to support less CPU and low complexity, and to overcome the reliability and power cost concerns in tiny implantable sensors. [26][27]	
	Flexible Development & Reliability	Flexible Development of Healthcare Services using a Service-Oriented Architecture [19]	
	Integration & Convergence	The data collected from various sources in different data formats are integrated by using SOA and web service technology [36]	
	Auditability & Evidential Integrity	The Courts are yet to confirm what actually constitutes data in relation to computer systems. [30]	
This Study	Safety	IT convergence medical incidents cases on WBAN appliances, the controls in qualifying chain of custody to the court are suggested.	
	Accuracy		
	Reliability		

Table 2. illustrates the control variables which have been used in various fields to achieve better credibility for IT medical incident care. Previous studies have been more focused on the physical factors which are related to implementing secure u-Healthcare products. However, this study focused on determining factors which will guarantee secure u-Healthcare appliances through examining the practice of medical incidents care.

This study has proposed a set of control variables for medical incident care in WBAN : "Accuracy, Reliability, Safety" as shown in **Table 2**. "Accuracy" refers to the business integrity across ad hoc appliances, especially when allocating accountability across real time appliances. "Reliability" is a metrics for how strongly the chain of custody is protected against medical vulnerability, thus securing admissibility of evidence for court in priority order. The

final variables “safety” is included to build up safety environments and to visualize the movement of management decisions across medical incidents care on general WBAN appliances. The control variables of proposed model are from the public framework. “Accuracy” and “Reliability” were from ISO9126 sub-characteristics and proved feasible.[7][10] And “Reliability” is also a component of SOA to build up convergence environments. “Safety” was from OHSAS 18001 (Occupational Health and Safety Advisory Services) which became more transparent by taking results of investigations and turning them into action plans to minimize incidents. Fewer incidents and injuries lead to reductions in liability claims and lower insurance premiums.[6][8]

In this study IT (Information Technology) convergent services are examined and the feasible medical incident care variables are derived using a flexible and secure mobile-product development approach, incorporated in a WBAN circumstance. The dashboard is adopted support convergence for flexible deployment as in SOA. [19] The proposed control variables, are then tested and evaluated through statistical analysis using a mobile application prototype to visualize the progress of decision-making.

3. Multilateral Joint Analysis Model on Medical Incidents Care

With changes in various aspects of counter-cyber-disaster, an understanding has evolved that the cyber-attacks by smart criminals may make use of vulnerabilities created by requirements changes or design defects, rather than mounting a full attack. This means that the security of WBAN-connected medical facilities is threatened by malignant codes, hackers, insider threats and cyber-terrorism. This situation creates a need for real-time information exchange and situation awareness between a nation’s medical facilities to support correct, fast and clear decisions in the face of any kind of medical incidental situation including cyber-attack. Therefore, it is assumed in this study that the government and its allies have constructed an emergency medical management system [29] by linking up with the MJA model, by adopting good medical incident care practices, and making by the governance a priority on SCADA (Supervisory Control And Data Acquisition) system for the nation’s major medical facilities and utilities across WBAN appliances as in u-Healthcare services.

Based on this hypothesis, this study first defined the procedures, roles and responsibilities before moving on to model recommendations. This was done through discussion with medical incident carers in each field using cross-functional communication as a mean to ensure responsibility and accountability and provide supportive functions among the doctors, nurses, medical staffs, u-Healthcare engineers etc. An effort was then made to determine control variables and evaluate the feasibility of the MJA model.

3.1 Application of Procedure in Medical Incidents Care

Multilateral Joint Analysis for medical incidents care, includes the stages of Decision-making about a meeting and Priority assignment(DP), Meeting Preparation(MP), Case outline for Architecture support(CA), Briefing(BF), Joint Analysis(JA), and Review for finalization and Categorization for future reference(RC). This procedure is drawn from the case study of the Seoul National University Hospital of South Korea 2012 and reflects the drive for improvement among the medical carers against medical incidents. Reference to procedures described in previous studies are provided as in **Table 3**. [10][30][31]

Table 3. Multilateral Joint Analysis Procedure Applied in Medical Incidents Care

Phase	Role	Procedure
Decision-making about meeting & priority assignment (DP)	Accountable for Medical Incident Investigation	Define the priority of the case, then summarize how to analyze it, and then decide whether or not to apply remote joint analysis. This step includes industry experts under the chain of custody.
Meeting preparation (MP)	Responsible for Medical Incident Investigation	First, load the image copy of the case and the application to be analyzed into the MJA system. Then create accounts for the participants according to the existing access control policy. Prepare the image copy of the case, provision for recovery of deleted files, a hash code for each file, information on the operating system, an Internet connection log, etc., to prevent lag time from occurring.
Case outline for architecture support (CA)	Responsible for Medical Incident Investigation	Call on specialists in the specific industry, operating systems, DBMS, programming languages, and network analysis. Then invite investigators who have experience in similar cases and a digital-forensics standards specialist to participate.
Briefing (BF)	Supportive, Consulted & Informed about the Case	Initiate cross-functional communication across roles in the value chain of custody to the court. Brief the participants on the case summary, progress, requests for analysis, etc., to support responsibility and accountability.
	Responsible for Medical Incident Investigation	Brief the participants on the basic information collected and its purpose and how to keep the accountable, supportive, and consulted parties informed during cross-functional communication across the value chain of custody to the court performing e-discovery.
Joint analysis (JA)	All attendee	Discuss the suggestions of each specialist and the operation of the remote analysis application with the participants.
Review and finalization & categorization for future reference (RC)	All attendee, Accountable for Medical Incident Investigation	After collaborative work by remote analysis, the case can be closed with the digital signature of each participant if a mutually acceptable executive summary can be developed. If more resources are needed, a subsequent meeting will be scheduled for further analysis. The digital forensics investigator who is responsible in the case should clear every basic analysis in advance before the next meeting.

3.2 Control Variables of Multi-lateral Joint Analysis Model

After the Remote Joint Analysis procedure has been completed, participants are divided into groups according to their roles and responsibilities of proposed model as shown in **Table 4**. [10]

Table 4. Control Variables Proposed in IT convergence and Medical Incidents Care

Phase	Control Variables		Roles & Responsibilities			
			Doctors	Nurses	Medical Staffs	u-Healthcare Engineers
DP	DP1.Position of participant	Reliability	●			
	DP2.Specialty of participant	Accuracy	●			
MP	MP1.Original disk integrity	Reliability			●	●
	MP2.Image copy of the original disk	Reliability	●			●
	MP3.Forensic tools(HW, SW)	Accuracy			●	●
CA	CA1.Access control through authentication and authorization	Reliability	●	●	●	●
	CA2.Multi-lateral joint analysis connectivity	Reliability	●	●	●	●
BF	BF1.Personal information about the accused, suspect and witnesses	Reliability	●	●	●	
	BF2.Case briefs and request for analysis	Reliability	●	●	●	●
	BF3.Investigation summary before attendance	Accuracy	●	●	●	●
	BF4.Basic investigation history before attendance	Reliability	●	●	●	●
	BF5.Conference call solution	Safety	●	●	●	●
JA	JA1.Original disk integrity	Reliability				●
	JA2.Image copy of the original disk	Reliability	●		●	●
	JA3.The remote monitoring for joint analysis	Reliability	●	●	●	●
	JA4.Digital forensic tools	Safety			●	●
	JA5.File image extract during analysis	Reliability			●	●
	JA6.Transaction log of other participant	Reliability	●	●	●	●
	JA7.Administrative command other than digital forensic tools	Safety			●	●
	JA8.Extra data gathered	Safety			●	

RC	RC1.Check list for standard analysis	Safety	●	●	●	
	RC2.Executive summary for final joint analysis	Reliability	●	●	●	●

4. Evaluations on Factors of Medical Incidents Governance

4.1 Hypothesis on Application of Multilateral Joint Analysis Model

To ensure objectivity in this study, initially the "Policy [13], Standard [32], Architecture [8][33] " was adopted. Then to visualize management decision flow, mobile application and dashboard implementation was used [34][35] which has already been proven to be feasible way to draw questionnaires, as shown in **Table 4**. The questionnaire was then administered to the four groups of medical employees.

We choose the Delphi method to obtain consensus on the opinion of qualified experts through a questionnaire. All experts in our study were representative people who had been actively involved in a number of WBAN, medical services and digital investigation.

To achieve a better determination of the factors affecting medical incidents care on WBAN, the representatives were divided up into groups of doctors, nurses, medical staffs and u-Healthcare engineers in medical services considering the roles and responsibilities across the procedure of medical incidents care as shown in **Table 4**.

Three initial variables as in the questionnaire forms shown in **Table 5**, optionally with the mobile application as shown in **Fig. 1** and **Fig. 2**, dashboard appliances as shown in **Fig. 3** and **Fig. 4** [10] were presented to these groups as a self-diagnostic check across the Seoul National University Hospital and medical product industry network. Factor analysis was used to analyze the principal components of the problem under study, and ANOVA was used for statistical analysis. The survey research described below was conducted across the South Korea including representatives from Seoul National University Hospital and u-Healthcare product engineering firms. The representatives were doctors, nurses, medical staffs and u-Healthcare ICT(Information Communication) specialists in related fields.

The first round of the Delphi survey was to find important factors of high impact. Then analysis reliability was achieved through independent categorisation by three researchers followed by several rounds of modification.

In second round, a total of 150 questionnaires were sent via e-mail and 110 usable replies were collected. We use factor analysis method for major ingredients findings, and ANOVA for statistical analysis.

Table 5. Key Factors on Questionnaire

Measurements (Variables)		**Measures applied to questionnaire**	**MJA Dashboard**
Existing Analysis System	Safety	Satisfactory safety environments and management commitment. Timely participation of medical incidents responses.	Policy A
		Satisfactory on safety compliance, rules and procedure. Identifying hazards and evaluating for incident response.	Standard A
		Satisfactory on safety training and communication, preparing no-experience-case analysis. Cost effectiveness for safety measures.	Architecture A

	Accuracy	Self-satisfaction with accuracy on traceability for medical incident responses	Architecture B
		Defendant-satisfaction with accuracy. The accountability for requirements against medical incidents.	Architecture C
		Presence or absence of complaints about accuracy.	Standard B
	Reliability	Unscrupulously obtained results which are out of compliance with the enterprise code of conduct.	Standard C
		Theoretical or legal misjudgement of the evidence collection procedure, like wrong evidence gathering or covering infringement of the patent.	Standard D
		Subjective substantiation to support performance priority under stated conditions for a stated period of time.	Policy B
Joint Analysis Model	Safety	Expected satisfaction with the contribution to providing a safer, healthier environment at joint analysis.	Policy C
		Phase BF5. Conference call solution.	Standard F
		Phase JA4.Digital forensic tools.	Standard G
		Phase JA7.Administrative command other than digital forensic tools.	Architecture E
		Phase JA8.Extra data gathered.	Architecture F
		Phase RC1.Check list for standard analysis	Standard H
	Accuracy	Expected satisfaction with the accuracy on medical incidents by multilateral joint analysis.	Architecture D
		Phase DP2.Specialty of attendee.	Policy D
		Phase MP3.Forensic tools(HW, SW)	Standard I
		Phase BF3.Investigation summary before attendance	Policy E
	Reliability	Expected satisfaction with the reliability on medical incidents by multilateral joint analysis.	Standard E
		Phase DP1.Position of attendee.	Policy F
		Phase MP1.Original disk integrity.	Architecture G
		Phase MP2.Image copy of the original disk.	Architecture H
		Phase CA1.Access control through authentication and authorization.	Architecture I
		Phase CA2.Multilateral joint analysis connectivity.	Architecture J
		Phase BF1.Personal information of the accused, suspect and witness.	Architecture K
		Phase BF2.Case briefs and request for analysis.	Policy G
		Phase BF4.Basic investigation history before attendance.	Architecture L
		Phase JA1.Original disk integrity.	Architecture M
		Phase JA2.Image copy of the original disk.	Architecture N
		Phase JA3.The remote monitoring for joint analysis.	Architecture O
		Phase JA5.File image extract during analysis.	Architecture P
		Phase JA6.Transaction log of other attendee.	Architecture Q
		Phase RC2.Executive summary for final joint analysis.	Policy H

Factor analysis gives a set of components of control variables in priority order. Then cause-and-effect relationships among the components listed drawn in **Table 8**. were verified later by postprocessing on the basis of **Table 5**.

4.2 Preparation & Quick Implementation

A summary and comparison of the proposed control variables is shown in **Table 2**. The experimental structure established for questionnaire design is shown in **Table 5**. The

participants groups from the Seoul National University Hospital and the related industry of South Korea, identified a set of proposed control variables and then filled in each questionnaire using Likert-type scale as shown in **Table 5**. **Fig.1** shows the MJA medical mobile application to support flexible component deployment as in SOA.

Fig. 1. MJA Medical Care Mobile Application

Fig. 2 is MJA connectivity dashboard to deploy proposed component in collaborative works

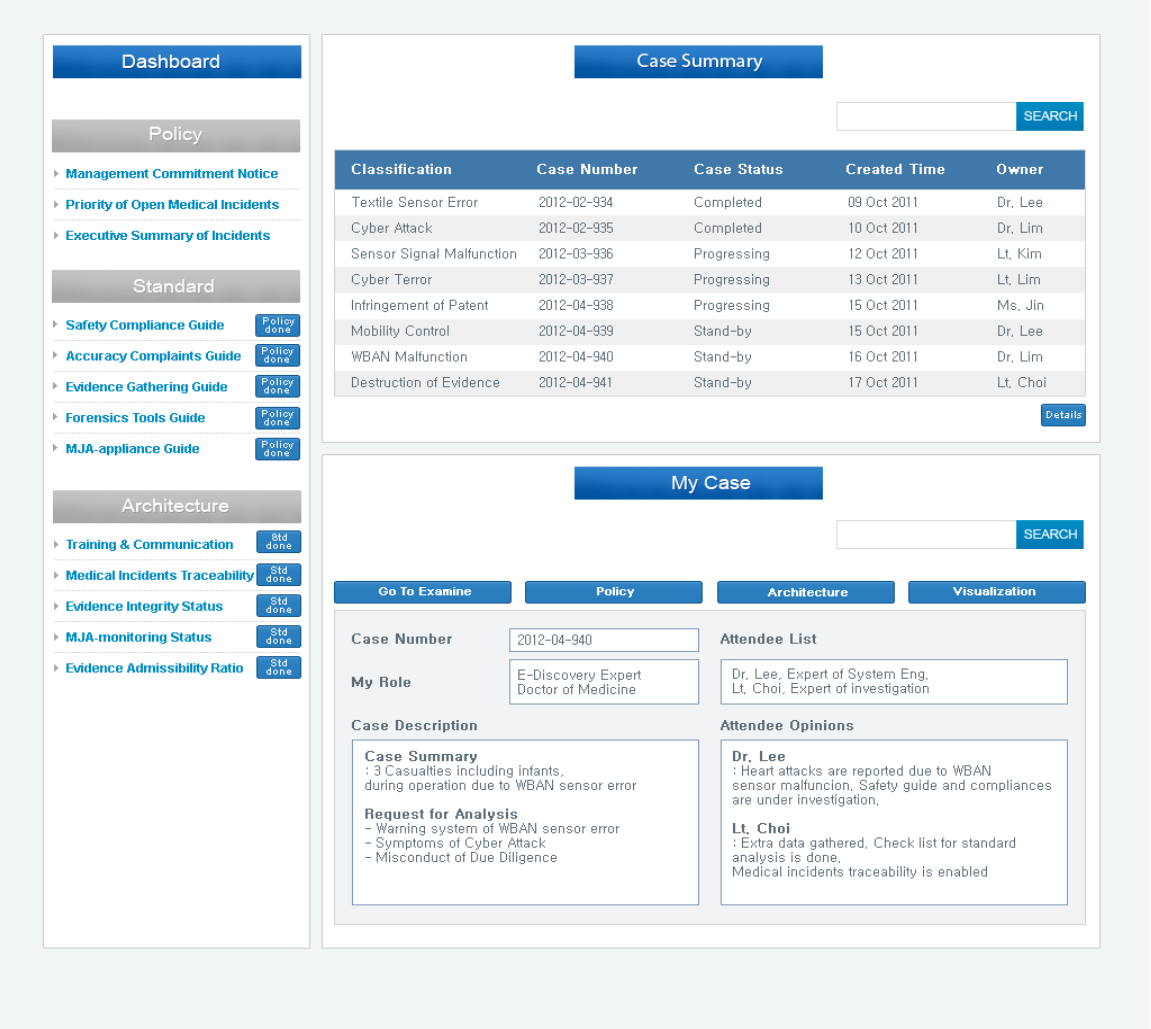

Fig. 2. MJA Connectivity Dashboard Page in Mobile App

① This outline includes the medical investigator's acts of duty or priority of open medical incidents, minimum ratio of timely assessment on the allocated case and the executive summary of medical incidents and a minimum degree of compliance with MJA policy. See **Tables 4** and **5**

② This outline includes a set of proposed standard guidelines and procedure etc. to maintain the admissibility of evidence from the fields to the court across medical incidents care. See **Tables 4** and **5**

③ This outline includes architectural achievement metrics across the MJA procedure. See **Table 4**. These metrics are automatically calculated from the actual procedure conducted and analyzed to evaluate. See **Tables 4** and **5**

④ Click to see weather recent policy has been applied to each compliance standard or guideline.

⑤ Click to see weather standards or traceability guidelines have been applied to various architecture metrics

⑥ Click here to see participants and their login status and to enable “report writing, report viewing and digital signatures of the participants in the case under review. The related sub-page is shown in

Fig. 3 as below

⑦ Click to see policies applied to this case

⑧ Click to see standards applied to this case

⑨ Click to see architecture applied to this case

Fig. 3 is to convege various sources with credibility. PKI(Public Key Infrastructure) is adopted as private signature validation.

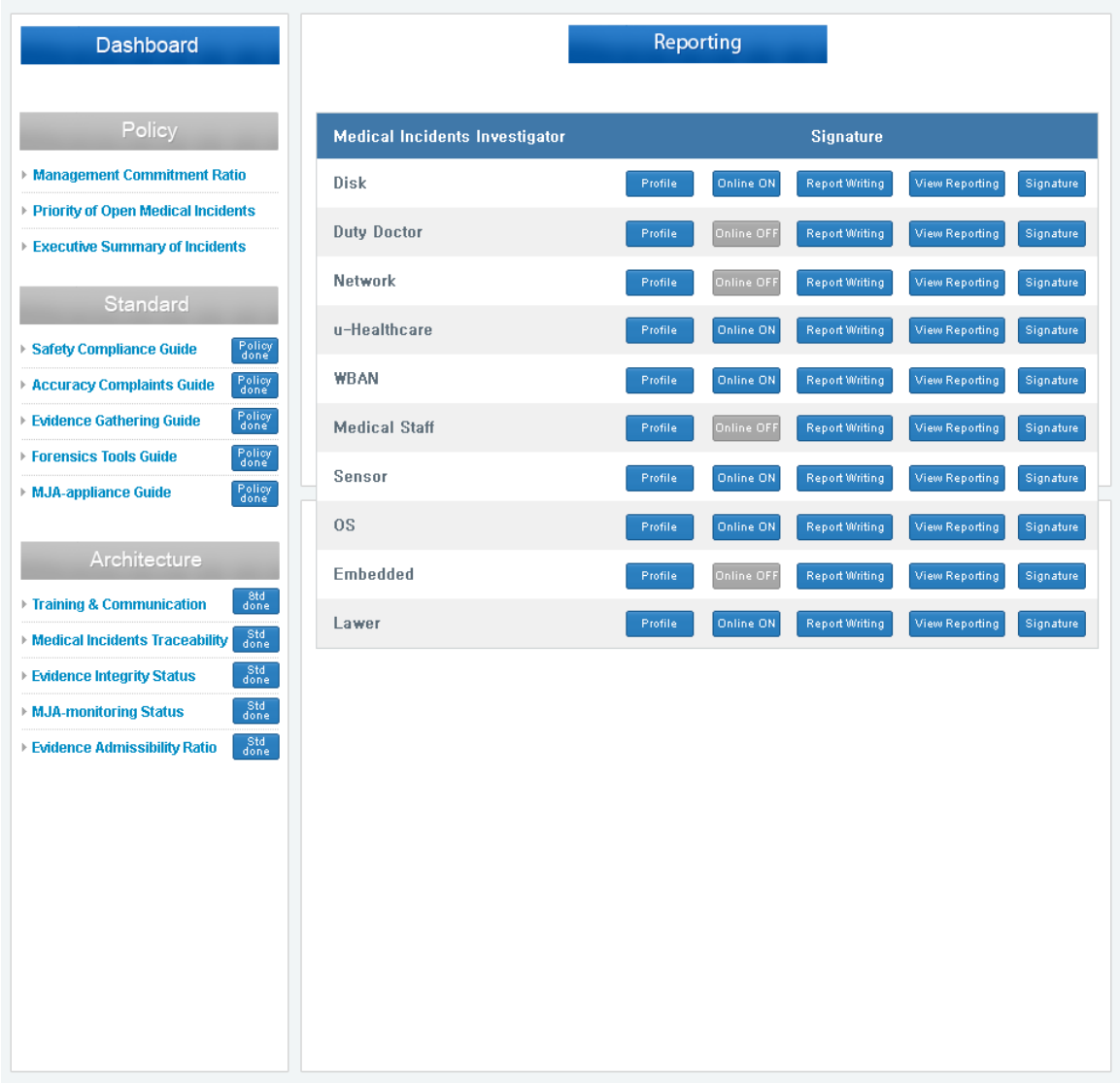

Fig. 3. MJA Connectivity Dashboard Reporting Page in Mobile App

4.3 Evaluation

The next step was to find the causal relationships among the proposed control variables which were first determined “Reliability, Accuracy, Safety” and second as a mapping to “Policy, Standards, Architecture ”. To improve productivity in applying medical incidents care

practices, including the identification of non-functional design defects in u-Healthcare product as in the WBAN, it is easier to visualize a decision-and-use case because the proposed variables are based on roles and responsibilities in cross-function communication. The non-functional requirements generally move through the cross-functional value chain [32] Three control metrics and a quick implementation of mobile application and dashboard properties were presented to the four groups of participants who played the role of medical incidents care using the self-diagnostic check list summarized in **Table 4**. and **5**.

Each participant weather medical incidents investigator or a profiler identified his or her assigned role for each MJA phase, then filled out each questionnaire using Likert-type scale. The survey results are shown in **Table 6**.

Table 6. Survey Results Summary

Classification	Mean	Standard Deviation	Classification	Mean	Standard Deviation
Policy A	2.02	0.878	Architecture A	2.13	1.101
Policy B	3.22	0.913	Architecture B	2.13	0.768
Policy C	3.93	1.209	Architecture C	2.66	0.901
Policy D	3.84	1.009	Architecture D	4.34	0.901
Policy E	4.55	0.584	Architecture E	3.61	0.665
Policy F	4.44	0.796	Architecture F	3.26	0.945
Policy G	3.11	1.266	Architecture G	4.24	0.753
Policy H	4.42	0.882	Architecture H	3.74	1.02
Standard A	2.15	0.859	Architecture I	3.8	0.876
Standard B	1.83	0.752	Architecture J	3.8	0.764
Standard C	3.62	1.125	Architecture K	3.48	1.038
Standard D	3.67	1.182	Architecture L	4.52	0.57
Standard E	4.24	0.928	Architecture M	3.85	0.969
Standard F	3.58	1.104	Architecture N	3.54	1.123
Standard G	3.57	0.953	Architecture O	3.48	0.955
Standard H	3.96	0.888	Architecture P	3.61	1.05
Standard I	4.72	0.544	Architecture Q	4.64	0.7
Rank	2.85	1.132	Medical Incident	1.61	0.49
Role	2.64	1.073	U-Healthcare	1.55	0.499

After the reliability analysis with redundancy eliminated the results were acceptable according to Cronbach's Alpha based on the value “0.668”, as shown in **Table 7**.

Table 7. Reliability Analysis of Variables

Cronbach’s Alpha	Cronbach's Alpha Based on Standardized Items	Items
0.668	0.661	38

The next step was factor analysis, which revealed that the principal factors in the priority order, which can be summarized as “Accuracy”, “Safety” and “Reliability” in this study model and “Reliability” in general, have the meaningful influence on our study model, as indicated in **Table 8**.

Table 8. Factor Analysis of Variables

Classification	MJA Control Factors	MJA Dashboard	Component		
			1	2	3
Existing Analysis System	Safety	Policy_A	0	0.023	0.093
		Standard_A	0.013	0.217	0.17
		Architecture_A	0.054	-0.151	0.164
	Accuracy	Architecture_B	0.083	-0.036	-0.058
		Architecture_C	-0.018	0.127	0.114
		Standard_B	0.017	0.056	0.114
	Reliability	Standard_C	-0.022	0.083	0.048
		Standard_D	0.783	0.1	-0.146
		Policy_B	0.794	0.161	-0.217
Joint Analysis Model for this case	Safety	Policy_C	0.799	-0.094	0.012
		Standard F	-0.109	0.024	0.106
		Standard G	-0.016	-0.021	0.885
		Architecture E	-0.096	0.735	0.189
		Architecture F	0.042	0.677	0.116
		Standard H	0.088	0.778	-0.058
	Accuracy	Architecture_D	0.668	0.006	0.061
		Policy D	0.155	0.201	0.11
		Standard I	0.024	0.173	0.041
		Policy E	0.077	-0.06	-0.095
	Reliability	Standard_E	0.657	-0.042	0.297
		Policy F	0.081	-0.008	-0.076
		Architecture G	-0.087	-0.011	-0.034
		Architecture H	0.027	-0.089	0.014
		Architecture I	0.045	0.221	-0.069
		Architecture J	0.066	0.03	0.044
		Architecture K	-0.08	-0.066	0.218
		Policy G	-0.039	-0.084	-0.02
		Architecture L	0.06	-0.059	-0.056
		Architecture M	0.052	-0.062	0.039
		Architecture N	0.056	0.082	0.296
		Architecture O	0.009	-0.005	0.686
		Architecture P	-0.1	0.255	0.726
		Architecture Q	-0.03	0.16	0.261
		Policy H	0.096	0.661	-0.005

Also for the groups of classes as “before MJA metrics application” and “after MJA metrics done”, F value which means equality for variances and significance value is analyzed. Then significance values are $0.000 < 0.05$ for each MJA metrics, consequently we have meaningful differences between “before and after MJA metrics done”.

And as a result of correlation analysis, several variables show significance in values as in **Fig. 4** The "Accuracy and Reliability" of legacy system are mainly linked up with "Accuracy, Safety and Reliability" factors of MJA model, in priority order.

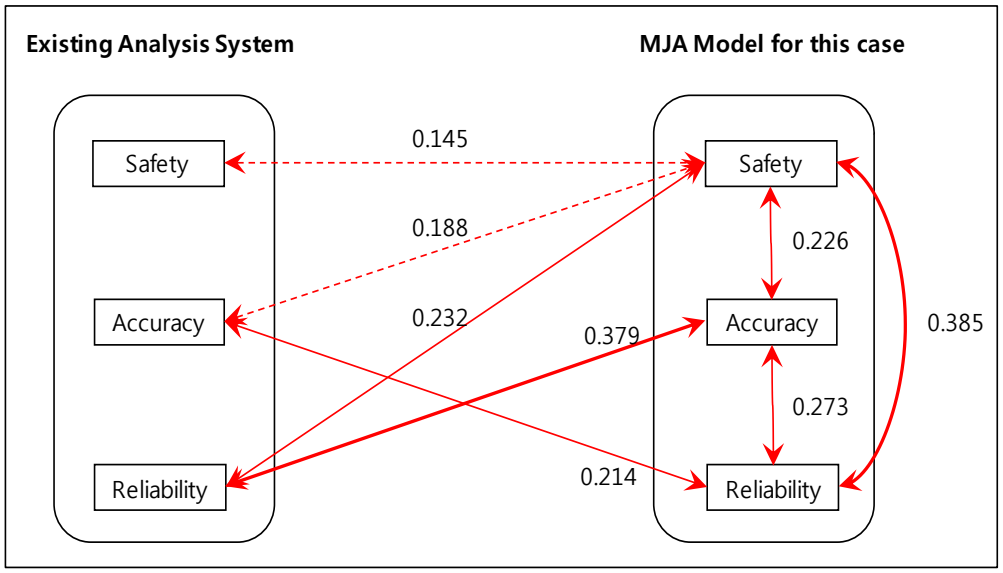

Fig. 4. Correlations of variables

An attempt was also made to test the homogeneity of variances using Levene statistic; the significance value was greater than 0.05 as shown in **Table 9**.

Table 9. Test of Homogeneity of Variances

Classification	Levene Statistics	df1	df2	Sig.
Safety	1.654	3	106	0.181
Accuracy	0.522	3	106	0.668
Reliability	1.965	3	106	0.124

Table 10. shows the results of ANOVA; the significance value is less than 0.05, indicating differences among the role and responsibility groups across the proposed control variables.

Table 10. ANOVA Results

Classification		Sum of Squares	df	Mean Square	F	Sig.
Impact of Safety	Between Groups	2.183	3	0.728	5.696	0.001

	Within Groups	13.542	106	0.128		
	Total	15.725	109			
Impact of Accuracy	Between Groups	1.683	3	0.561	5.123	0.002
	Within Groups	11.605	106	0.109		
	Total	13.288	109			
Impact of Reliability	Between Groups	2.95	3	0.983	11.556	0
	Within Groups	9.02	106	0.085		
	Total	11.97	109			

To provide further support for the result, the Dunnett test was performed, with the results shown in **Table11**. These test results also indicate differences in role groups across the control variables. The group 1 is for doctors role, the group 2 is for nurses role, the group 3 is for medical staffs and the group 4 is for u-Healthcare engineers as in **Tables 10**. and **11**.

The participants of each functions (doctors, nurses, medical staffs, u-Healthcare engineers) proved the MJA model as a convergence platform to deal with the credibility information from various sources of medical sensors.

Table 11. DUNNETT

Defendant Variables	(I) MJA Role	(J) MJA Role	Difference of Sum(I-J)	Std. Error	Sig.
Impact of Safety	1	4	-.3740740600*	0.10318	0.001
	2	4	-.3037037033*	0.092287	0.004
	3	4	-0.15556	0.092287	0.229
Impact of Accuracy	1	4	-.3523809483*	0.095517	0.001
	2	4	-.2301587800*	0.085433	0.023
	3	4	-.2190476400*	0.085433	0.032
Impact of Reliability	1	4	-.4537036517*	0.08421	0
	2	4	-.3393245867*	0.07532	0
	3	4	-.2648148033*	0.07532	0.002

5. Conclusion

This study proposed control variables for use in medical incident care practice with respect to WBAN characteristics. A case study based on an actual case of problem has been examined.

Control variables were tested with Seoul National Hospital and related u-Healthcare industry of South Korea under the assumption that their systems would be open systems based on integrating WBN systems and u-Healthcare to achieve smart theater operations against medical incidents.

Recent researches have focused on specific factors related implementing secure and cost efficient WBN products, however in this study, by looking at the practice of MJA and understanding the drive for improvement in the medical care field, key factors were used, to guarantee the smart appliances of the WBN across the chain of e-discovery(securing of evidence for the court). No similar studies have been found to date which combine medical incidents cares and WBN or u-Healthcare characteristics across e-discovery.

To perform this study, questionnaires with a dashboard implementation of u-Healthcare application were used followed by factor analysis and ANOVA. First, a medical incidents care procedure was drawn up from a case study with reference to previous work. Then participants were divided into four groups according to their roles and responsibilities in the proposed model in medical industry. The impacts and supporting components of proposed control variables were then analyzed in priority order.

The proposed medical incidents care procedure across WBN appliances was also followed by the drive for improvement of medical incidents care investigators both before and after an actual case. For this reason, the MJA components have been practically demonstrated that this model has impacts in a real environment.

Future research is needed to adjust this model to the practice of medical incident care around the world. Medical incidents with the characteristics of Information Technology (IT), greatly influence the lives and rights of stakeholders when they work together with u-Healthcare appliances with WBAN.

In this case study, we proposed feasible control variables as affecting factors assuming that they would be connected to WBAN with a smart phone application that has appropriate governance dashboard of the MJA model. Without appropriate control variables in the acquisition, design and delivery of convergent WBAN, medical incidents always are blamed for the malpractice or casualties. [37]

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