International Journal on New Computer Architectures and Their Applications (IJNCAA) 1(3): 743-756
The Society of Digital Information and Wireless Communications, 2011 (ISSN: 2220-9085)

Integrated KMS@EWS of Conceptual Implementation Model for Clinical Dengue Fever Environment

Norzaliha Mohamad Noor, Rusli Abdullah, Mohd Hasan Selamat
Faculty of Computer Science and Information Technology,
Universiti Putra Malaysia, 43400 Serdang, Selangor
norzalihaster@gmail.com,{rusli,hasan}@fsktm.upm.edu.my

ABSTRACT

Early warning system (EWS) is a technology to mitigate risk is used to disseminate timely information. Then knowledge management system (KMS) is used to support for decision facilitation will integrate with EWS to disseminate timely information with proactive early warning. Issues on timeliness for timely reporting and decision facilitation are regarded as main challenge for mitigation of risk. Therefore in this paper, we suggest the model of integration between KMS and EWS known as KMS@EWS as a solution to support early warning for timely reporting and to guide on decision facilitation. The integration model is to combine the knowledge management (KM) processes, activities and technologies with the EWS functionalities. The proposed model is based on empirical study by using literatures on EWS and KMS. In which we synthesize the analysis and findings of both EWS and KMS for the integration. We propose the implementation model in clinical diagnostic (CD) environment of dengue fever (DF) manifestation. This model is intended to provide early warning when any abnormalities or peculiar pattern of DF and symptoms arise and detected during the interaction between physicians and patients in the CD environment. Thus, this paper attempts to integrate relevant enabling KM technologies and processes with EWS components and functionalities into an environment that would support activities for early warning thru organizational knowledge creation, use and management for timely reporting and detection by providing decision facilitation and initiate early warning of DF during CD processes.

KEYWORDS

Early warning system, Knowledge management, Knowledge management system, Dengue fever, Clinical diagnostic.

1 INTRODUCTION

EWS is a technology to mitigate risk is used to disseminate timely information can be integrated with KM processes, activities and technologies. In which KM is regarded as confluence of processes, activities and techniques to facilitate the creation, codification, dissemination and application of knowledge that can be integrated with EWS functionalities to enable the knowledge flow in CD environments. CD environment which comprises activities for interaction between physician and patient to obtain a diagnosis of the disease and to select therapy [1] is used for implementation of integrated model between KMS and EWS known as KMS@EWS. The idea of using CD environment for the implementation is due to the activities involved during CD process namely history taking (HT), physical examination (PE) and investigation (IV) can provide early warning of disease

outbreak. In order to realize the implementation, DF manifestation were opt to address the disease outbreak.

Disease outbreaks can be extremely serious threats to the public health that can cause a sudden disaster. Bravata et al (2004) [2] emphasized the significant of early warning in disease outbreak for preparation, tracking and monitoring outbreak. Extensive research and study has been carried out to provide effective detection, controlling and monitoring of disease outbreak, but still timeliness and validity of knowledge are crucial factors as it will impact the decision for response, forecasting and preparedness [3] [4] [5]. Madoff (2004) [6] and Brownstein (2007) [7] highlighted timeliness as a crucial factor in preventing the spreading of diseases. Simultaneously Choo (2009) [8] looked at the validity of knowledge to determine the effectiveness of early warning. Several research studies have been made on EWS to detect disease outbreak rapidly [9] [10] [11]. However, issues providing timely detection and validity of knowledge are still regarded as main concern as it can influence the decision facilitation regarding the prevention and preparedness pertaining outbreak [3] [12].

Therefore, we propose a model of KMS@EWS that can support the managing of data and information for timely reporting and detection by providing decision facilitation and to initiate early warning during the CD process. Since KMS is an IT based system to support activities for knowledge creation, codification, dissemination and application, then EWS as a technology to mitigate risk is used to disseminate timely information. In relation to this, we integrate KMS processes and technologies with EWS functionalities to proactively provide timely reporting, detection and response of decision facilitation couple with knowledge validity. By providing early warning during CD process, medical practitioners and hospitals administration can be notified of the outbreaks and potential outbreak situation and thus can accelerate decision facilitation with appropriate knowledge and implementation of actions to deal with the outbreaks.

This paper is organized as follows; Section 2 is a literature review on EWS components and functionalities; KMS processes, technologies and techniques; overview of CD processes and DF manifestation. Section 3 discussed methodology used to derive the model of KMS@EWS. Subsequently, Section 4 will explain the integration model in CD environment of DF. Finally Section 5 is the conclusion and discussion on the direction and future works of the study.

2 LITERATURE REVIEW

2.1 Early Warning System

EWS as a technology to mitigate risk is used to disseminate timely information in multi-disciplinary area [13]. Austin (2004) [14] defined EWS as a mean to obtain knowledge and to use that knowledge to assist in the mitigation of conflict. In relation, he also emphasized that response to any conflict situation require knowledge to facilitate a common awareness regarding problems or risks and thus accelerate decision making with appropriate implementation action to deals with the risks. While from the healthcare perspective, Ebi and Schmier (2005) [15] identified the main components of EWS should include

identification and forecasting of the event, prediction of the possible health outcomes, an effective and timely response plan and an ongoing evaluation of the systems and components. To be effective, EWS implementation should comprises four main components namely i) risk knowledge (RK), ii) monitoring and warning service (M&WS), iii) disseminate and communication (D&C) and iv) response capability (RC) [16]. The relationship of each component is illustrated in Figure1.

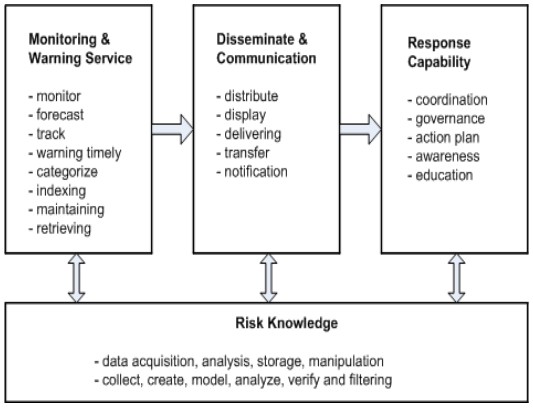

Fig. 1. Relationship of EWS Four Main Components.

Risk knowledge which is known as risk assessment is related to knowledge identification and acquisition, analysis storage, detection and manipulation. In second component, the monitoring and warning service deals with technical capacity to track and forecast that can provide timely estimation of the potential risk faced by the communities. The dissemination and communication means delivering, sharing and distribute warning messages to alert the communities with a reliable, synthetic and simple message for preparedness of action. Finally, response capability involves coordination, good governance for timely and appropriate action plan by authorities. These components can be further classified into four main EWS functionalities as shown in Table 1.

Table 1. EWS Functionalities

Components	Functionalities	Motivation
RK	Detecting	Knowledge acquisition/creation
M&WS	Prediction	Knowledge codification
D&C	Warning	Knowledge dissemination
RC	Response	Knowledge application

There are many research studies have been made on EWS that are associated to natural hazard, aquaculture and disease outbreak. For instance, disasters such as the Indian Ocean tsunami in 2004 and Katrina hurricane in 2005, highlighted inadequacies in early warning process towards disaster mitigation lead to the development of alert system known as GEAS [5]. Moreover, the risk of misdiagnosis, incorrectly treatment or over-treatment that exists after disease outbreak is a motivational factor to develop a knowledge-based EWS for fish disease [17]. While TeCoMed is the EWS telecommunication on medical events development was inspired due to the inadequacies of information system to confront the healthcare worker timely on communicable disease [18].

For the purpose of this study, we reviewed and analyzed several previous research studies pertaining disease outbreaks which adopted EWS approach and functionalities. There are numerous research studies that can be referred for successfully and effectively implement the EWS for disease outbreak. Hence, we came out with seven types of different research studies which provide early warning with KM activities to invoke or initiate early warning. Table 2 summarizes the related study with KM activities and Table 3 aggregate the literature studies according to EWS functionalities namely detection,

prediction, warning and response to address the significant of EWS.

Table 2. EWS with KM activities from the literature

Author/ System	Functions	Activities
Automatic online new monitoring (AONM) [19]	- collect - representation & selection - classification & evaluation	- web crawler to spider news articles from internet - news document are transformed - conduct online new classification task and performance are evaluated
AEGIS [11]	- collect - modeling - detection - alerting - investigation	- daily visit data from Emergency Department are collected - the historical models are constructed for total daily visit counts for each syndrome group - compares current visit levels with predicted models and generate alarms - disseminate visits and alarm information to users
Brownstein [7]	- acquire - display	- data source is the news acquired automatically hourly - collected data are aggregated and then overlaid in an interactive map
ProMED-mail [6]	- collect - review - verify - disseminate	- receipt information from email subscribers - review and filtering the information - document representation & selection - finalized reports and distribute to subscribers
RODS [12]	- collect - model - detection - alerting -display	- data source from EmergencyDepartment - classifiy free text complaint into one of the syndromic categories - detection algorithm - when trigger alert, send email to users - display using geographical screens and temporal information screens
ESSENCE II [9]	- collect - detection - alerting - notification - distribution	- data source from hospital emergency rooms, private practice groups, over counter pharmaceuticals, veterinary reports, school absenteeism, sales promotion, weather events and external surveillance system - detection of abnormal health condition - deliver alerts and surveillance via web-site - notify of special events or environmental conditions that trigger warrant changes in detection parameters
MiTAP [10]	- collect - analyze - distribute	- data source from news posting, web spider, emails, epidemiological reports - data filtered, translated and categorized - distribute via newsgroup, search engine, web server

Table 3. EWS functionalities address by literature studies

Author \ Function	Detection	Prediction	Warning	Response
Murphy et al (2007) [20]	/		/	/
Ebi and Schmier (2005) [15]	/	/	/	/
Jebara (2004) [21]	/		/	/
Thomson & Connor (2001) [22]	/		/	/
Myers (2000) [23]	/	/	/	

2.2 Knowledge Management System

Before pursue into KMS perspective, there is a need to understand the distinction between data, information and knowledge in the context of this study. It has been pointed out by other researchers that data, information and knowledge are not the same and is defined differently. Data is referring to raw numbers and facts, information is processed data and knowledge is 'information made actionable'.

While, KM is viewed as a process of turning data into information and forming information into knowledge that can lead to decision making. In which this process is subdivided into creating internal knowledge, acquiring external knowledge, storing knowledge as well as updating the knowledge and sharing knowledge internally and externally. Then KMS is referring to a class of information systems applied to manage organizational knowledge and to support the organizational processes of knowledge creation, storage, transfer and application [24]. There are four common activities of KM which are cyclic process namely knowledge creation or acquisition, knowledge codification or storing, knowledge dissemination or sharing and knowledge application. Table 4 depicted the example of KM cycle from the related studies which are based on four common activities as mentioned earlier [25] [26] [27] [28] [29] [30]

Table 4 KM Processes from literature studies

Choo (1996)	Davenport & Prusak (1998)	Zack (1999)	Bukowitz (2000)	Alavi (2001)	Bose (2003)
Sense making	Generation	Acquisition	Get	Creation	Creation
Knowledge creation	Codification /Coordination	Refinement	Use	Storage	Structuring
Decision making	Transfer	Store/retrieve	Learn	Transfer	Dissemination
		Distribution	Contribute	Application	Application
		Presentation	Access		
			Build /sustain		
			Divest		

From the technical perspective, KM can be viewed in terms of how the KM processes can be applied using IT as a tool to facilitate knowledge sharing collaboratively. KM tools is defined as technologies to support and facilitate knowledge sharing of communities for the performance of application, activities or actions such as knowledge generation, knowledge codification and knowledge transfer [31]. Meanwhile, Alavi (2001)

[29] listed few supporting technologies for KM processes such as data mining (DM), knowledge repositories, databases, discussion forums, knowledge directories, expert system (ES) and workflow systems. Then Liao (2003) [32] classified KM technologies and application into six categories namely knowledge-based system (KBS), data mining, information communication technology (ICT), artificial intelligent (AI), database technology and finally modeling.

2.3 Overview of Clinical Diagnostic Environment

Generally CD environment deals with interaction between patient and physician involves three main processes known as history taking, physical examination, and investigation [33] [34] [1] [35]. History taking (HT) is the initial process in CD where the conversation between patient and physician is captured to obtain general idea of the patient's personality, the kind of disease and the degree of severity. HT process is important in obtaining a series of information from patient in determining the etiology or cause of a patient's illness. Then, the physical examination (PE) is to identify the physical sign of the disease. PE process requires physician studies or examines carefully a patient's body to determine the presence or absence of physical problems. Hence, in this process, skill and experience of the physician is crucial in eliciting sign of disease. Finally, investigation (IV) is to further perform a laboratory test or screening test to solve clinical problems and to complement the history taking and physical examination.

CD process is a face-to-face communication and observation between patients and physicians in obtaining information for diagnosis and treatment. CD process is knowledge driven and depends heavily on the medical knowledge, intuition, expertise and judgment to diagnose or prognosis and to determine appropriate treatment. Data is collected during a HT, and information is obtained during the PE. Meanwhile, IV by laboratory or screening test will also provide data and information for analysis and comes to a conclusion. Therefore, a CD environment can be used as a platform to facilitate EWS because each of the CD process can be used to initiate early warning for disease outbreak. Figure 2 illustrate the process flow of CD environment.

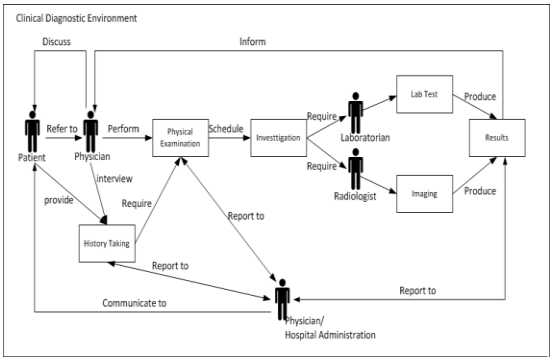

Fig. 2. CD Environment Process Flow

2.4 Overview of Dengue Fever

Dengue is an infectious disease, transmitted by Aedes mosquito that can cause high rates of morbidity and mortality. This infectious disease can causes a severe flu-like illness known as DF, and sometimes a potentially lethal complication called haemorrhagic fever (DHF). Studies had shown few factors that can contribute to the spread of DF and DHF among the communities. Such

factors include demographic and society changes that is closely related to substandard housing, crowding, and deterioration in water, sewer, and waste management system have created ideal conditions for increased transmission of mosquito-borne disease in tropical urban centers. Additionally, lack of effective mosquito control in areas where dengue is endemic is also one of the factors for increase of the DF or DHF cases [36]. Specifically during the fogging or spraying with insecticides to kill adult mosquitoes required proper method.

DF is an acute febrile viral disease with frequently presenting of headaches, bone or joint and muscular pains, rash, nausea and vomiting. While, DHF is defined as an acute febrile illness with minor or major bleeding, thrombocytopenia, and evidence of an increased vascular permeability result in loss of plasma from the vascular compartment. When plasma loss becomes critical, it may result in Dengue shock syndrome (DSS) which may cause death. Figure 3 adopting from Mairuhu et al (2004) [37] depicted the symptomatic dengue virus infection. Accurate and efficient diagnosis of dengue is important for clinical care, surveillance support, pathogenesis studies, and vaccine research. Moreover, the diagnosis is also significant for case confirmation of DF, DHF and DSS [38]. Hence, early detection and management of DF is essential to prevent death. In relation to this, we study the clinical manifestation of DF as a sample disease outbreak use for integration system of KMS@EWS in CD environment. Whereby, all the dengue symptoms can be obtain during the CD processes which include the HT, PE or IV. At each of the processes, early warning can be initiated when one or all the symptoms exist.

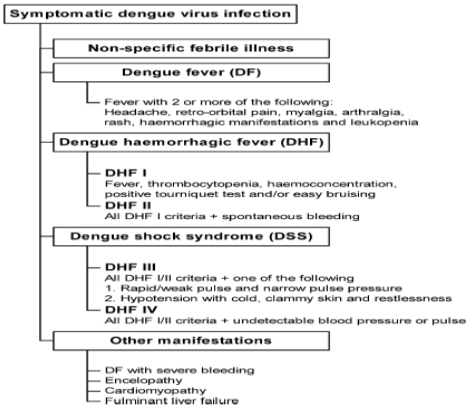

Fig. 3. Knowledge Map of Dengue Fever Manifestation
(Adopted source from Mairuhu et al (2004))

3 RESEARCH METHODOLOGY

For this study, we are currently performing an initial study to propose the model of the integration between KMS and EWS known as KMS@EWS. We conduct a literature reviews (LR) that collect and understand the existing knowledge or information about the title to research. Compile and analyze related topic to learn from others knowledge, showing the paths of previous research and how the study can be related to it. The reviews and analysis are on academic journals, articles, books and information search on tools, technologies and techniques used that relate to the research. Based on the seven types of different research studies from Section 2.1, we segregated into two processes in order to map and combine between KMS and EWS. Firstly, we mapped the EWS four key components to KM processes. The mapping is to identify appropriate matching of KM processes and technologies to EWS four key components. Then, the second process is to identify critical function of EWS to be combined into KM processes and activities. Thus, the results from both processes will be used to construct

the framework and model for KMS@EWS.

The LR is divided into four main steps as illustrated in Figure 4. Step 1 is the framework construction which is the synthesizing between the reviews and analysis from EWS, KMS, CD processes and DF manifestation literature, articles and books. This step is the initial step towards the framework development. We adapt Bose KM cycle to complement the KMS@EWS cycle for the integration. Next, Step 2 is the model formulation which obtained information from the reviews and analysis of general information about KM, EWS, CD processes and DF. In this step, definition and theories of EWS, KMS, and CD environment are analyzed and seek for common or identical functionalities between KM and EWS. In order to get an overview of the DF, we studied DF manifestation. Analysis on CD environment is to get an overview of CD process workflow in order to use as a platform for model implementation. Besides the definition, we also analyze the technologies and techniques used or required for the application of KM and EWS. We looked and identified the technical perspective requirement in terms of knowledge acquiring, codification and dissemination for the integration between KM and EWS. Then, Step 3 is the development model of KMS@EWS for the CD environment. For the model development, we identified the integration components and provide its functionalities based on the EWS framework reviewed earlier. Finally in step 4, we synthesize and map the analysis and findings of KMS and EWS to model the integration. We perform empirical analysis on the EWS functionalities in order to evaluate and rank the EWS components requirements. Then, we derived a model of the integration between KMS and EWS known as KMS@EWS for clinical diagnostics environment.

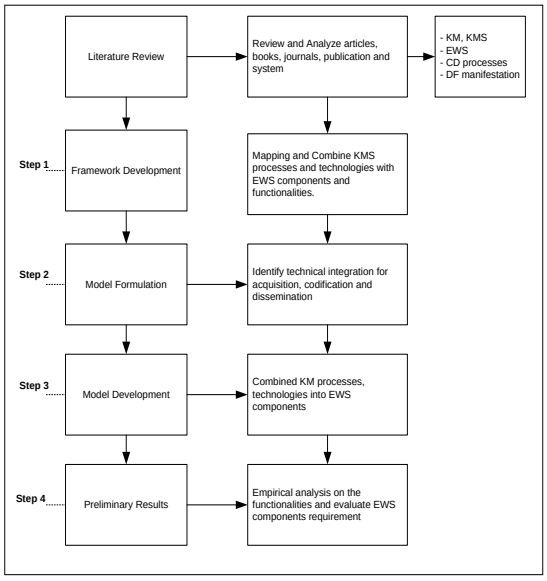

Fig. 4. Research Methodology Design Framework

4 A MODEL OF KMS AND EWS FOR CD ENVIRONMENT OF DF

The concept of KM has been strongly supported as a process for acquiring, organizing and dissemination knowledge in order to promote effectiveness and efficiency [24]. Due to this concept, this study attempt to integrate the KM processes and technologies with EWS four main components and functionalities. Therefore KM is a solution chosen to address the principles of building integrated model of KMS and EWS in CD process to provide proactive early warning for decision facilitation to react and respond on the outbreak. KMS@EWS will provide early warning when any abnormalities or peculiar pattern of disease and symptoms arise and detected during CD

process of DF. In which this system seek to provide proactive early warning of DF symptom obtain from patients visit to clinic or hospital for treatment. Moreover, this also can assist physician to make right decision pertaining the diagnosis and treatment.

4.1 EWS and KMS Conceptual Integrated Proposal

KM deals with how best to leverage knowledge involves the strategies and processes for identifying, capturing, structuring, sharing and applying knowledge in order to promote effectiveness and efficiency [39] [40]. While, EWS is a process of gathering, sharing and analyzing information to identify a threat or hazard timely and sufficiently in advance for preventive action to be initiated [14] [5]. Hence, KM processes and tools can help strengthen the EWS to facilitate the acquisition, codification and dissemination of knowledge in order to identify and forecast the event, prediction of possible outcomes and timely reporting on the risks for immediate response. Derived from the ISDR guidelines, a complete and effective development of EWS should include four main interacting components as mention in Section 2.1. The purpose of these components can be combined into KM processes and technologies to provide a KMS environment as depicted in Figure 5. We propose the KMS environment with the concept for knowledge sharing system organize and distribute knowledge.

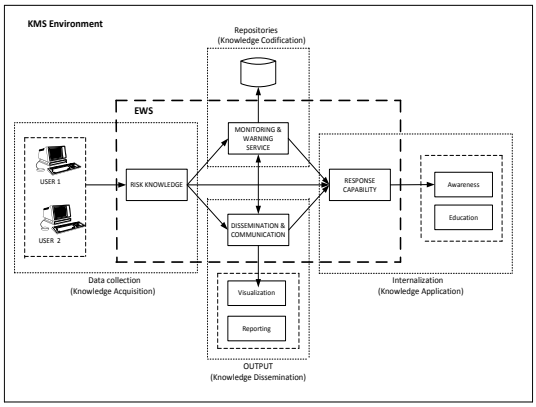

Fig. 5. EWS in KMS Environment Conceptual Proposal

4.2 Expansion of Conceptual Implementation Framework Development

Both EWS and CD processes are knowledge driven, where EWS requires knowledge in order to notify and initiate warning. While, CD processes deals with interaction between patients and physician requires communication and knowledge in order to identify symptoms for proper and right treatment. So KMS can support activities for both EWS and CD processes to initiate early warning and to facilitate decision making by providing capabilities for identifying, capturing, structuring, sharing and applying knowledge. A well designed KMS@EWS shall provide physician a clinical information and knowledge where, when, and how pertaining the disease. Further, it also can help to report any occurrence of disease timely by early identifying and detecting at any level of CD processes. Furthermore, this framework will indicates the critical KM activities with EWS components and functionalities in CD processes using IT technologies to support the integration.

A KMS design framework should integrate business processes and the needed IT with the related function to facilitate the KMS design [24] [30]. KMS@EWS is an IT based system developed to enhance the knowledge creation, codification, sharing and application to facilitate decision and initiate early warning. Based on the review and analysis of EWS, KMS, CD process and DF manifestation, we combine and match the critical KM processes, technical functions and enabling IT with EWS components and functionalities to support the CD processes. Table 5 summarizes the matching results. We synthesize and combine the analysis reviews from Section 2 for the framework development as shown in Table 5.

Table 5. A framework using enabling IT technologies to support integration of KMS@EWS in CD processes

EWS components	CD Processes	EWS Functions	KM Activities	KM Technical Functions	Enabling IT
RK	HT	Detection Prediction Warning	K_Creation K_Codification K_Transfer	Collection Creation Modeling Analyzing Verifying Filtering Classification Profiling Alerting	K_mapping K_directories K_repositories Databases Rule base Case base Agent
M&WS	PE	Detection Prediction Warning	K_Creation K_Codification K_Application K_Transfer	Categorizing Indexing Maintaining Retrieving Alerting	K_based system Expert system Data warehouse Data mining Rule based Case based Data mining Agent
D&C	IV	Detection Prediction Warning	K_Creation K_Aapplication K_Transfer	Distribution Displaying Delivering Visualization Notification	K_based system Expert system Discussion forums Agent
RC	KMS@EWS	Response	K_Transfer K_Application Ccollaboration	Coordination Governance Awareness Education	Intranet/extranet Wodcflow system Groupware Discussion forums Agent

4.3 Conceptual Implementation System

Based on LR in Section 2 on KMS processes and technologies jointly with EWS components and functionalities and CD processes, we proposed an implementation integrated model of KMS@EWS in CD processes as depicted in Figure 6. KMS@EWS will generate alert at every stage of CD process. Each of the alerts will indicate the severity of the risks. Figure 7 illustrate a conceptual model of KMS@EWS.

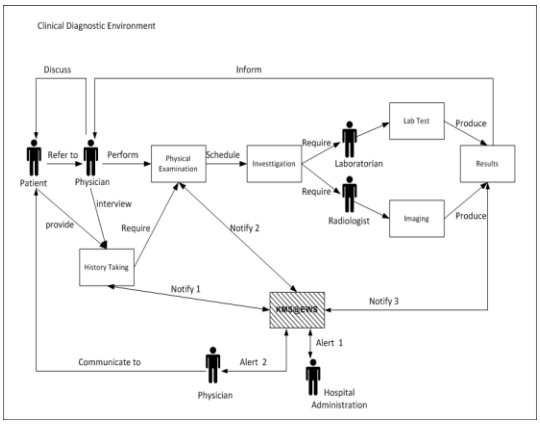

Fig. 6. Implementation proposed model of KMS@EWS in CD processes

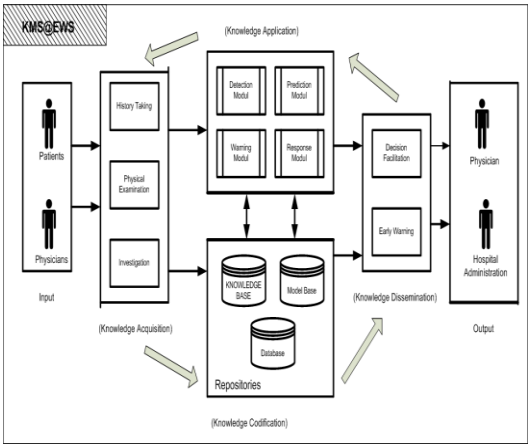

Fig. 7. Conceptual model of KMS@EWS Architecture

From Figure 7, the input or source of data is obtained from patients and medical practitioner. First component of KMS@EWS is knowledge creation which is map to risk knowledge plays

important function for data acquisition, analysis, storage and manipulation. The CD process that relate to this component is HT, PE and IV. Second component in KMS@EWS deals with continuous monitoring to generate warnings timely is known as knowledge codification. This component is to support functionalities for identification and detection; prediction and forecasting; warning and finally response with activities for categorize, indexing, maintaining and retrieving information. This component comprises databases and knowledge repositories. Third component known as knowledge dissemination is related to disseminate and communication deals with functionalities to visualize, distribute, display, delivering and transfer information for notification and alerting. Finally the fourth component is knowledge application is link to response capability with functionalities for decision facilitation and early warning capability. In conjunction, KMS@EWS is looked as a response capability for collaboration to promote good coordination and be used as an education platform and finally to promote awareness within the community or organization.

4.4 Preliminary Results and Findings of EWS Processes and Functionalities

We found two significant findings from the analysis and reviews of the previous research as discussed in Section 2. First is the mapping of KM processes with EWS four main components to construct the integrated model. Secondly is EWS functionalities to be incorporated into the model.

Drawing from Table 2, we grouped the EWS processes into EWS four main components that later to be map can combine with KM processes as shown in Table 6. The total and percentage from the Table 6 exhibit the overall requirements of EWS components based on the EWS activities. From the matrix in Table 6, we conduct an empirical analysis on the EWS to look for the most salient component to develop EWS. The result shown that risk knowledge and monitoring & warning are equally important (on average about 33 %) for the EWS development. Both components are critical requirement for knowledge creation or acquisition and knowledge codification to timely identify, detect and forecast a potential risk. The communication & warning service with average of 20 % is for delivering and distribute warning messages with the support of good infrastructure. The average of 13 % is the response capability which involves good coordination, governance for appropriate action plan. Figure 8 exhibit the EWS component requirements that map to KM processes.

Table 6. Matrix of EWS Components and activities

Components / Activities	Risk Knowledge	Monitoring & Warning Service	Communication & Dissemination	Response Capability
Collect	/			
Review	/			
Verify	/			
Analyze	/			
Modelling	/			
Characterization		/		
Classification		/		
Evaluation		/		
Detection		/		
Prediction		/		
Alerting			/	
Notification				/
Investigation				/
Display			/	
Distribution			/	
Total	5	5	3	2
Percentage	33.33	33.33	20.00	13.33

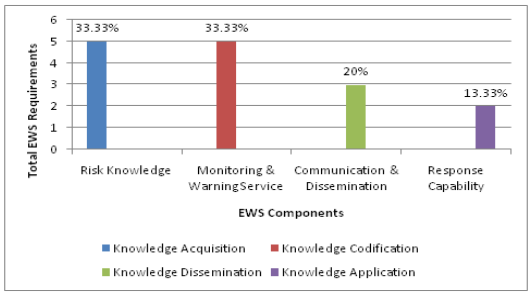

Fig. 8. EWS Components Requirements

Next, we also perform empirical analysis on the EWS main functionalities namely i) detection; ii) prediction; iii) warning and iv) response. From Table 2 we also grouped the EWS processes into EWS main functionalities as in Table 7. The total percentages from Table 7 demonstrate the significant of EWS functionalities to address early warning. Functionality for detection with 100 % is the highest requirement to address early warning. It shows that detection is an initial requirement during the process for data creation and acquisition. Meanwhile, functionality for warning to address the dissemination and communication shows 86 % of the requirement in early warning. This functionality is to distribute, display, delivering and transfer of information for notification. The functionality for prediction about 43 % indicates that not all early warning required prediction or forecasting. But still, this functionality is significant to address early warning for the purpose of planning and precaution. Lastly is the functionality for response to address early warning which takes only 14 % of the requirement. Although response functionality is the least importance, it cannot be eliminate from the requirement. This function is to furnish the awareness and education on risk mitigation. Figure 9 demonstrate the ranking of EWS functionalities to address the criticality of the EWS functions requirement.

Table 7. Aggregation according to EWS functionalities

Function / System	Detection	Prediction	Warning	Respond
MiTAP	/		/	
ESSENCE II	/	/	/	
RODS	/	/	/	
ProMED	/		/	
HealthMap	/		/	
AEGIS	/	/	/	
AONM	/			/
Total	7	3	6	1
Percentage	100	43	86	14

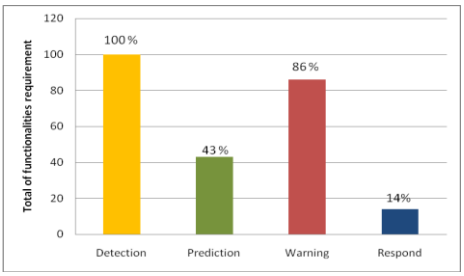

Fig. 9. EWS Functionalities

5 CONCLUSION AND FUTURE WORK

The use of EWS in KM has some significant process that can strengthen EWS to enable knowledge flow effectively and efficiently. Response to any conflict situation needs knowledge to facilitate a common awareness regarding problems or risks and thus accelerate decision making and to initiate early warning with appropriate implementation of actions to deal with problems or risks. The adoption of technology is improving information access and dissemination, also is increasing the need to better understand how information can be managed and utilized to improve the performance of EWS.

To our knowledge which based on the LR, there is currently no specific design of the integration model between KMS

and EWS that combine KMS processes and technologies with EWS four main components and functionalities. Therefore, in this paper, we proposed an integrated model between KM processes and technologies with EWS components and functionalities. We will be using CD environment as a platform for the model implementation. Then, we use DF manifestation to address disease outbreak for model validation.

The aim of this proposed model is to provide proactive early warning when any abnormalities or peculiar pattern of DF and symptoms arise and detected during the interaction between physicians and patients in the CD environment. Thus, this model can support the managing of data and information for timely reporting and detection by providing decision facilitation and initiate early warning of DF during the CD processes. The contribution of this study is two-fold. First, the model can be used as a guide to assist physician to early identify any abnormalities or peculiar pattern of DF during the CD process. Secondly, this model can be used as an enhancement learning platform to cultivate novel medical practitioner to understand DF manifestation at early state. This model with its ability to provide better access to knowledge for decision making and initiating early warning would make it possible for the physician and hospital administration to respond promptly.

Furthermore, in order to strengthen the integration and to demonstrate the knowledge flow and data processing, we suggest the proposed model to be design as a web based and the use of Multi-agent System (MAS) to address the integration between KMS and EWS for smooth knowledge flow. We also propose in future work to validate EWS functionalities against research problems that been highlighted as well as research question in order to achieve the total set of research objective. The criteria of future validation include the reliability, suitability and reusability in enhancing the capability of KMS@EWS. Finally, it is hope that the insight study of this integration model could offer a good perspective on the relation of KM processes and technologies with EWS four main components and functionalities.

6 REFERENCES

1. Realdi, G., L. Previato, and N. Vitturi, *Selection of diagnostic tests for clinical decision making and* translation *to a problem oriented medical record.* Clinica Chimica Acta, 2008. **393**(1): p. 37-43.
2. Bravata, D.M., et al., *Systematic Review: Surveillance Systems for Early Detection of Bioterrorism-Related Diseases.* Annals of Internal Medicine, 2004. **140**(11): p. 910-922.
3. Pavlin, J.A., *Investigation of disease outbreaks detected by syndromic surveillance systems.* Journal of Urban Health: Bulletin of the New York Academy of Medicine, 2003. **80**(Supplement 1): p. i107-i114.
4. Buckeridge, D.L., *Outbreak detection through automated surveillance: a review of the determinants of detection.* Journal of Biomedical Informatics, 2007. **40**(4): p. 370-379.
5. Grasso, V.F. and A. Singh, *Global Environmental Alert Service (GEAS).* Advances in Space Research, 2008. **41**(11): p. 1836-1852.
6. Yu, V.L. and L.C. Madoff, *ProMED-mail: an early warning system for emerging diseases.* Clinical infectious diseases, 2004. **39**(2): p. 227.
7. Brownstein, J.S. and C.C. Freifeld, *HealthMap: the development of automated real-time internet surveillance for epidemic intelligence.* Euro Surveill, 2007. **12**(48): p. 3322.

8. **Choo, C.**, ***Information Use and EarlyWarning Effectiveness: Perspectives and Prospects*** JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE AND TECHNOLOGY 2009.
9. Lombardo, J., et al., *A systems overview of the electronic surveillance system for the early notification of community-based epidemics (ESSENCE II).* Journal of Urban Health: Bulletin of the New York Academy of Medicine, 2003. **80**(Supplement 1): p. i32-i42.
10. Damianos, L.E., *The MiTAP system for monitoring reports of disease outbreak*. 2006, DTIC Document.
11. Reis, B.E.N.Y., et al., *AEGIS: A Robust and Scalable Real-time Public Health Surveillance System.* Journal of the American Medical Informatics Association, 2007. **14**(5): p. 581-588.
12. Tsui, F.C., et al., *Technical description of RODS: a real-time public health surveillance system.* Journal of the American Medical Informatics Association, 2003. **10**(5): p. 399.
13. Basher, R., *Global early warning systems for natural hazards: systematic and people-centred.* Journal of Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2006. **364**(1845): p. 2167.
14. Austin, A., *Early Warning and The Field: A Cargo Cult Science?* 2004.
15. Ebi, K.L. and J.K. Schmier, *A stitch in time: improving public health early warning systems for extreme weather events.* Epidemiologic reviews, 2005. **27**(1): p. 115.
16. ISDR, *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters.* 2005.
17. Li, N., et al., *Developing a knowledge-based early warning system for fish disease/health via water quality management.* Expert Systems with Applications, 2009. **36**(3): p. 6500-6511.
18. Gierl, L. and R. Schmidt, *Geomedical warning system against epidemics.* International journal of hygiene and environmental health, 2005. **208**(4): p. 287-297.
19. Zhang, Y., et al., *Automatic online news monitoring and classification for syndromic surveillance.* Decision Support Systems, 2009. **47**(4): p. 508-517.
20. Murphy, K., et al., *Effective early warning systems for new and emerging health technologies: Developing an evaluation framework and an assessment of current systems.* International journal of technology assessment in health care, 2007. **23**(03): p. 324-330.
21. Jebara, K.B., *Surveillance, detection and response: managing emerging diseases at national and international levels.* Rev Sci Tech, 2004. **23**(2): p. 709-15.
22. Thomson, M.C. and S.J. Connor, *The development of malaria early warning systems for Africa.* Trends in parasitology, 2001. **17**(9): p. 438-445.
23. Myers, M.F., et al., *Forecasting disease risk for increased epidemic preparedness in public health.* Advances in Parasitology, 2000. **47**: p. 309-330.
24. Alavi, M. and D.E. Leidner, *Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues.* MIS quarterly, 2001: p. 107-136.
25. Choo, C.W., *The knowing organization: How organizations use information to construct meaning, create knowledge and make decisions* 1.* International Journal of Information Management, 1996. **16**(5): p. 329-340.
26. Davenport, T.H. and L. Prusak, *Working Knowledge - How Organizations Manage What They Know*. 1998: Harvard Business School Press.
27. Zack, M.H., *Managing codified knowledge.* Sloan management review, 1999. **40**(4): p. 45-58.
28. Bukowitz, W.R. and R.L. Williams, *The Knowledge Management Fieldbook*. 2000: London: Prentice Hall.
29. Alavi, M. and D.E. Leidner, *Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues.* MIS quarterly, 2001. **25**(1): p. 107-136.
30. Bose, R., *Knowledge management-enabled health care management*

systems: capabilities, infrastructure, and decision-support. Expert Systems with Applications, 2003. **24**(1): p. 59-71.
31. Rudy L. Ruggles, I., *Knowledge Management Tools*. 1997: Butterworth Heinemann.
32. Liao, S.-h., *Knowledge management technologies and applications--literature review from 1995 to 2002.* Expert Systems with Applications, 2003. **25**(2): p. 155-164.
33. Nkanginieme, K.E.O., *Clinical diagnosis as a dynamic cognitive process: Application of Bloom's taxonomy for educational objectives in the cognitive domain.* Medical Education Online, 1997. **2**.
34. Siegenthaler, W., ***Differential Diagnosis in Internal Medicine***. **2007**: Thieme New York.
35. Podgorelec, V., B. Grasic, and L. Pavlic, *Medical diagnostic process optimization through the semantic integration of data resources.* Computer methods and programs in biomedicine, 2009. **95**(2): p. S55-S67.
36. Gubler, D.J., *Dengue and dengue hemorrhagic fever.* Clinical microbiology reviews, 1998. **11**(3): p. 480.
37. Mairuhu, A.T.A., et al., *Dengue: an arthropod-borne disease of global importance.* European Journal of Clinical Microbiology & Infectious Diseases, 2004. **23**(6): p. 425-433.
38. Guzman, M.G. and G. Kouri, *Dengue diagnosis, advances and challenges.* International journal of infectious diseases, 2004. **8**(2): p. 69-80.
39. Abidi, S.S.R., *Knowledge management in healthcare: towards [] knowledge-driven'decision-support services.* International Journal of Medical Informatics, 2001. **63**(1-2): p. 5-18.
40. Satyadas, A., U. Harigopal, and N.P. Cassaigne, *Knowledge management tutorial: an editorial overview.* Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 2001. **31**(4): p. 429-437.