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**A CONCEPTUAL KNOWLEDGE MANAGEMENT SYSTEM MODEL
WITH EARLY WARNING SYSTEM IN CLINICAL DIAGNOSTIC
ENVIRONMENT OF DENGUE FEVER**

By

NORZALIHA BINTI MOHAMAD NOOR

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfillment of the Requirements for the Degree of Doctor of Philosophy**

May 2017

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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May 2017

Chairman : Professor Haji Rusli Haji Abdullah, PhD
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Knowledge management system (KMS) is an information technology (IT) based system that supports four common activities of knowledge management (KM) processes namely i) knowledge acquisition; ii) knowledge codification; iii) knowledge application; and iv) knowledge dissemination. Meanwhile, disaster management is the activities concerning the mitigation, risk reduction, prevention, preparedness, response and recovery can be related to early warning system for risk mitigation. Early Warning System (EWS) can aid in the early warning to reduce any damage or loss by facilitating the timely communication and response. EWS is referring to the collection of information that leads to timely decision-making processes in order to mitigate risk encompassed with four main components, namely i) risk knowledge; ii) monitoring and warning services; iii) communication and dissemination and iv) response capability.

Both KMS with EWS are also applicable in the clinical diagnostic (CD) environment during the CD activities to provide early warning and aid in decision facilitation of disease outbreak such as dengue. However, lack of proper data or information management and limited knowledge sharing and dissemination within the organization is the main issue during the EWS. Other problem that may relate to this issue is the timeliness for timely reporting and decision facilitation during CD activities.

Therefore, a conceptual of KMS model with EWS in the CD environment of dengue fever is formulated based on the existing components KMS with EWS. The CD activities and dengue fever components are also studied for the model implementation.

A pre survey was carried out to determine significant components for both KMS with EWS. Then these components are further verified by experts. Based on the pre survey results and analysis, the initial KMS model with EWS in CD environment of dengue fever is proposed.

The KMS model with EWS was then validated via prototype to verify the model reliability. Then, a post survey is used to evaluate the KMS prototype which is based on the KMS with EWS model in CD environment of dengue fever. The results of post surveys were divided into two categories of analysis. First analysis is the reliability of the proposed KMS with EWS model by comparatively analysed the overall surveys result against the existing previous models and secondly is the analysis on KMS prototype from the user's perspective based on the five main attributes address in this survey items. In which the analysis is based on reliability of the attributes in order to know the attributes ranking and significant to the proposed model. All the analysis of pre and post surveys was measure using Rasch Model.

The model which is the integration between KMS with EWS is known as KMS with EWS is to enable the capturing, storing, reusing and managing of knowledge in order to provide early warning and aid in decision facilitation of dengue fever.

Keywords: Knowledge management, knowledge management system, early warning system, clinical diagnostic, and dengue fever

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KONSEPTUAL MODEL SISTEM PENGURUSAN PENGETAHUAN DENGAN SISTEM AMARAN AWAL UNTUK PERSEKITARAN DEMAM DENGGI KLINIKAL

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Sistem Pengurusan Pengetahuan (KMS) adalah sistem berasaskan teknologi maklumat (TM) yang menyokong empat aktiviti lazim proses pengurusan pengetahuan (KM) iaitu i) pemerolehan pengetahuan, ii) pengekodan ilmu, iii) aplikasi pengetahuan, dan iv) pengetahuan penyebaran. Sementara itu, pengurusan bencana ada merangkumi aktiviti untuk mengurangkan risiko, pencegahan, penyediaan, tindakbalas dan baikpulih yang boleh dikaitkan dengan Sistem amaran awal (EWS). Sistem amaran awal boleh membantu bagi mengeluarkan amaran awal untuk mengurangkan kerosakan atau kemusnahan dengan menyediakan pembuatan keputusan tepat pada masanya. Sistem amaran awal ini merujuk kepada pengumpulan maklumat yang membawa kepada proses pembuatan keputusan yang tepat pada masanya untuk mengurangkan risiko merangkumi i) risiko pengetahuan; ii) pemantauan dan khidmat amaran; iii) komunikasi dan penyebaran and iv) keupayaan tindakbalas.

Kedua-dua sistem Pengurusan pengetahuan dan sistem amaran awal boleh digunapakai di dalam suasana diagnostik klinikal (CD) semasa aktiviti klinikal bagi menyediakan amaran awal dan membantu didalam pembuatan keputusan keatas penyebaran penyakit seperti demam denggi. Walau bagaimana pun, kekurangan pengendalian data atau pengurusan maklumat dan perkongsian dan penyebaran pengetahuan yang terhad dalam organisasi adalah merupakan isu utama semasa sistem amaran awal. Selain daripada itu terdapat juga masalah berkaitan penyediaan segera laporan dan pembuatan keputusan semasa diagnostic klinikal. Oleh itu, model konseptual KMS dengan EWS di dalam persekitaran diagnostic klinikal untuk demam denggi dibangunkan berdasarkan kepada komponen-komponen sediaada di dalam KMS, EWS, aktiviti CD dan demam denggi.

Pra kajian dijalankan untuk menentukan komponen-komponen penting untuk kedua-dua KMS dan EWS. Dimana kemudiannya, komponen-komponen itu disahkan seterusnya oleh pakar-pakar. Pembangunan awal model KMS dengan EWS dalam persekitaran CD bagi demam denggi adalah berdasarkan kepada keputusan dan analisa dari pra kajian.

Kemudiannya, model KMS dengan EWS ini disahkan dengan pembangunan prototaip. Seterusnya, pasca kajian dijalankan mengukur kepentingan prototaip KMS yang berasaskan kepada model KMS dengan EWS dalam persekitaran CD bagi demam denggi. Keputusan pasca kajian dibahagikan kepada dua kategori analisa. Analisa pertama adalah untuk pengukuran kepentingan cadangan model KMS dengan EWS melalui analisa perbandingan keputusan kajian keseluruhan dengan model-model lama sediaada. Analisa kedua keatas prototaip KMS ini adalah untuk mendapatkan maklumbalas ke atas lima jenis attribut yang digunakan dalam item-item kajian. Di mana analisa ini adalah berasaskan pengukuran kepentingan ke atas attribut ini bagi mengetahui susunan dan kebolehpercayaan attribut kepada model cadangan ini. Kesemua analisa pra dan pasca kajian adalah diukur dengan model Rasch. Integrasi di antara KMS dan EWS dikenali sebagai KMS dengan EWS adalah untuk membolehkan pengumpulan, penyimpanan, penggunaan semula dan pengurusan data dan maklumat bagi menyediakan amaran awal dan kemudahan keputusan.

Kata kunci: Pengurusan pengetahuan, sistem pengurusan pengetahuan, sistem amaran awal, diagnostik klinikal, dan demam denggi

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LIST OF ABBREVIATIONS

AM	Application Module
CD	Clinical Diagnostic
CDC	Centers for Disease Control and Prevention
CDE	Clinical Diagnostic Environment
CR	Component Requirements
D&C	Disseminate and communication
DIKD	Data, Information, Knowledge and Decision
DF	Dengue Fever
DHF	Dengue Hemorrhagic Fever
DM	Data Mining
DSS	Dengue Shock Syndrome
EWS	Early Warning System
FSD	Functional Specification Design
GDACS	Global Disaster Alert and Coordination System
GOARN	Global Outbreak Alert and Response Network
HKM	Healthcare Knowledge Management
HT	History Taking
ILI	Influenza Like Illness
ISDR	International Strategy for Disaster Reduction
IT	Information Technology
KA	Knowledge Acquisition
KB	Knowledge Base
KBS	Knowledge Based System
KC	Knowledge Categorization

KM	Knowledge Management
KMS	Knowledge Management System
KR	Knowledge Representation
MNSQ	Outfit Mean Square
M&WS	Monitoring and warning service
OKMS	Organizational Knowledge Management System
OM	Output Module
PE	Physical Examination
PMC	Point Measure Correlation
RC	Response capability
RK	Risk knowledge
SARS	Severe Acute Respiratory
SDLC	Software Development Life Cycle
SHDS	Strategic Healthcare Decision-Support Services
SRS	System Requirement Specification
SUMI	Software Usability Measurement Inventory
WHO	World Health Organization
ZSTD	Outfit z-standardized

CHAPTER 1

INTRODUCTION

1.1 Background

Knowledge Management (KM) is not a new concept and multi-disciplinary areas which include businesses, economics, information management, healthcare and psychology. Yu-N and Abidi (1999) from the healthcare discipline viewed KM as a convergence of systematic approach and procedure to promote the generation, establishment, acquisition, development, storage, distribution and application of the multi-faceted healthcare knowledge assets. Subsequently, Lin and Umoh (2002) stated that the healthcare industry is progressively incorporating the newest and latest information and communication technology to improve and strengthen the quality of care.

Likewise, Knowledge Management System (KMS) is an information technology (IT) based system used to assist the KM activities. These activities are the four generic cyclic processes known as knowledge acquisition, knowledge codification, knowledge application and knowledge dissemination (Alavi and Leidner, 2001). KMS as an IT based is very useful in disaster management which can be used for knowledge sharing reuse and decision making (Yates, 2011). Disaster management is the activity concerning the mitigation, risk reduction, prevention, preparedness, response and recovery (Dorasamy, 2013) that can be related to early warning system (EWS) for risk mitigation. EWS can provide early warning to reduce any damage or loss by facilitating the timely communication and response (Chaturvedi, 2016).

Meanwhile, the International Strategy for Disaster Reduction – Platform for the Promotion of Early Warning (ISDR–PPEW, 2006) emphasized that the basic requirement of EWS should constitute four fundamental components. The components are i) Risk Knowledge (RK); ii) Monitoring and Warning Services (MWS); iii) Dissemination and Communication (DC) and iv) Response Capability (RC). These components can also be applied in healthcare industry to aid in early warning and decision facilitation. EWS is related to data and information collected which can accelerate the decision making in order to risk mitigation.

Mutually, Clinical Diagnostic (CD) environment is a knowledge intensive that relies extremely on medical instinct, proficiency and to identify or to forecast and predict the right and suitable treatment (Fauci, 2008). The initial step in CD is based on knowledge and experience is referring to data acquisition that includes the elements of History Taking (HT), Physical Examination (PE) and Investigation (IV) results of laboratory testing and imaging (Bowen, 2006). Early warning and detection of disease outbreaks can be detected during the CD activities of history taking and physical examination.

Disease outbreaks such as dengue and malaria can be extremely serious threats to the public health which can cause a disaster (Bravata, 2004) in medical environment. There are lengthy studies from earlier researchers on the effectiveness of diagnosing, managing and observing the disease outbreaks. Earlier researchers (Victor and Madoff, 2004; Brownstein and Freifeld, 2007) highlighted timeliness as a crucial factor in preventing the spread of diseases. Furthermore, Choo (2009) looked at the validity of knowledge to determine the effectiveness of early warning. There are several studies of EWS to rapidly detect disease outbreak that had been made by earlier researchers (Lombardo, 2003; Damianos, 2006; Reis, 2007).

However, issues in providing timely detection and validity of knowledge are still regarded as crucial factors, since it can affect the decision facilitation in relation to the avoidance and alertness of the outbreak (Pavlin, 2003; Tsui, 2003). The timely detection and validity of knowledge can also influence the activities for responses, forecasting and preparedness (Pavlin, 2003; Buckeridge, 2007; Grasso and Singh, 2008). Other issues also concerning the lack of proper data or information management and limited knowledge sharing and dissemination within the organization are brought by Dorasamy and Raman (2011).

In CD environment, both KMS processes and EWS components are interrelated to each other. The KM activities and technologies are used to support in early warning by merging the benefits of KMS processes and EWS components. Therefore, this research is to present a conceptual of KMS model with EWS components in CD environment of dengue fever. The model combined of KMS processes and EWS components that can acquire, store, organize, apply and share information of dengue during CD activities.

For the above reason, KMS is crucial for EWS to manage knowledge in CD environment in order to provide early warning and aid in decision facilitation of dengue fever. In which it allows to obtain the right data, information and knowledge of dengue on the right time, hence improving the quality of care.

The inspiration of the research is to present a conceptual of KMS model with EWS in CD environment to accommodate the diagnosis and detection of dengue fever on the right time. This is to early warning and furnishes the decision facilitation responses. All activities concerning history taking, physical examination and investigation throughout the CD processes are capable to initiate early warning whenever an abnormality or distinctive disease trends and signs are discovered during the face to face communication between the patients and physicians. The detection of early warning sign when performing CD activities are very beneficial to the related parties such as practitioners, hospitals and health administration. Any immediate action and response can be carried out if there is any detected disease outbreak or potential disease outbreak situation.

1.2 Problem Statement

KMS are vital for EWS during the disaster detection, preparation, responses and management. Early warning is a main component of disaster risk reduction which is concerning the disaster management. It involved activities such as i) risk mitigation, reduction and awareness; ii) monitoring for state of preparedness and prevention; iii) communication and dissemination of messages; and iv) responses and recovery.

EWS can be seen as a tool that can manage data and information to support the prediction and detection of dengue fever. Choo (2009) classified EWS as the process of gathering, sharing and analysing information to identify a threat or disaster sufficiently in advance for a preventive action to be initiated. Recent researches regarded EWS as an information and knowledge system that are dedicated to protect against any disastrous damages or situations (Arru, 2016).

A KMS is crucial to manage and organize knowledge with EWS to ensure the right information is obtained timely. Currently, the generic EWS involves the process of collecting timely information, generating timely warning, communication and disseminating knowledge that deal with handling and managing of data, information and knowledge (Yi, 2016, Singh, 2016). The improper handling of data, information and knowledge can lead to the issues of timeliness and reporting in order to adequately prepare for the responses (Arru, 2016). The handling of data, information and knowledge can be seen as a process of data acquisition, codification, application and dissemination.

The lack of data in information management and limited knowledge sharing and dissemination within organization are main issues in disaster management (Dorasamy, 2013). Collecting relevant information, make the right judgement and conducting the proper plan of action are important activities during the decision making processes. In this context, knowledge can give the power to make reliable decisions and to act upon it.

Concurrently, CD activities are knowledge driven which deal with tacit and explicit knowledge, good communication skills, detailed history taking and physical examination techniques, and skills for analysing. Unfortunately, every physician may not have the same level of expertise and skills; even the most experienced physicians sometimes fail to diagnose the clinical condition correctly. The physicians may not be capable to diagnose it accurately (Shanthi, 2008). Then, this can cause for the delay and inaccuracy of the diagnosis (Vanisree, 2011) that can lead to diagnostic mistakes and this is the primary justification of medical errors. Prior studies (Lenz, 2007; Kellett, 2009) emphasized the need to improve the medical treatment processes in order to overcome the issues on delays and inefficiencies during the treatment assessment. Realdi, (2008) highlighted on disease detection and the best treatment that can be achieved with a correct and detailed collection of information are from the current and previous history taking with a thorough physical examination.

In summary, CD environment involved essential activities, namely history taking and physical examination, for early diagnostic which is performed by the physicians to get information from the patient to determine and detect the sign and symptom of the disease for the correct treatment. However, there would still issues on the timeliness and decision facilitation on the warning of epidemic (Pavlin, 2003; Tsui, 2003). The timeliness is a crucial issue to prevent the infectious disease outbreaks while the off-line, daily and weekly data reporting mode will impact the decision facilitation in transmission, processing and responses (Huang, 2007).

Thus, a KMS model is best to address the issues and challenges as highlighted above. Whereas, the integration with EWS components can provide early warning and aid in decision facilitation. Then, KMS model with EWS is proposed to resolve the above mentioned problems.

1.3 Research Questions

Based on the problem statement discussed above, it is necessary that a conceptual of KMS model with EWS in CD environment be formulated. The model will include and synthesize the required KMS processes and activities, EWS components, CD activities and dengue fever signs and symptoms.

The research questions that address the above problem statement are as follows:

- i. What are the main KM activities, KMS processes and EWS components required to form the conceptual of KMS model with EWS to manage data, information and knowledge in CD environment of dengue fever?
- ii. How shall the conceptual of KMS model with EWS be used in a prototype of KMS model to handle the knowledge acquisition, storage, sharing and dissemination in CD environment of dengue fever?
- iii. How competitive is the KMS model with EWS in providing early warning and aid in decision facilitation of CD environment?

1.4 Research Objectives

Based on the above research questions, the research objectives are described as follows:

- i. To propose a conceptual of KMS model with EWS for CD environment.
- ii. To evaluate the KMS model with EWS by using prototype for its competitiveness.

1.5 Research Scopes

This research is based on managing the medical domain knowledge of dengue fever during CD activities by applying KM system processes and EWS components. The CD processes are limited to activities of history taking and physical examination. The model will be using the dengue fever sign and symptom as a clinical parameters to provide early warning based on the threshold defined in World Health Organization (WHO) guidelines.

1.6 The Importance of the Research

The inspiration of the research is to present a conceptual of KMS model with EWS in CD environment to accommodate the diagnosis and detection of dengue fever on the right time. This is to provide early warning and aid in decision facilitation.

The significance of this research is to provide the following:

- i. Propose a conceptual of KMS model with EWS components in CD environment of dengue fever to provide early warning and aid in decision facilitation.
- ii. Promote automation for knowledge acquisition, storage and dissemination of KM processes with the application of EWS components.
- iii. Enhance decision facilitation with timely reporting and early warning messages.
- iv. Promote awareness of early detection for dengue fever.
- v. Serve as educational purposes for learning.

Importantly, this research will provide best approach for early warning of dengue fever detection in the context of KMS model with EWS. This will enable the communication and distribution of warning and reporting are well managed for decision facilitation.

1.7 Organization of the Thesis

This thesis contains seven chapters as follows:

- i. Chapter 1 includes the research background, problem statement, research questions, research objectives, scopes and the importance of the research.
- ii. Chapter 2 covers the literature reviews of KM, KMS, EWS, CDE and dengue fever. This chapter discusses various definitions, frameworks, and existing previous models. All related components and attributes such as processes, activities, technologies and elements of functionalities are compiled and summarized for the model formulation.
- iii. Chapter 3 describes the research methodology of the research which is divided into four main phases. Firstly, is Phase I which is synthesize existing previous

- models. Next, Phase II is to formulate KMS model with EWS. Phase III is the prototype development and finally Phase IV is the prototype evaluation.
- iv. Chapter 4 discusses the formulation of KMS model with EWS which address Research Objective 1 in Section 1.4. This chapter include the understanding KMS processes in relation to EWS components, understanding CD activities of dengue fever, propose components of KMS model with EWS and the expansion of model development. Also discusses the propose model and prototyping.
 - v. Chapter 5 discusses the research results in relation to Research Objective 2 in Section 1.4 to answer Research Questions 2 and 3 in Section 1.3. A post survey is conducted to evaluate the KMS model with EWS by prototyping for its competitiveness. The results are analysed using the Rasch model.
 - vi. Chapter 6 summarizes the research on the KMS model with EWS in a CD environment of dengue fever. Future works are also suggested, to enhance the model and address the drawbacks of the proposed model.

1.8 Summary

This chapter described the research background, the problem statement, research questions, research objectives, motivation, scopes of research and the organization of the thesis. This research identified the need of KMS model with EWS as an answer for early warning and decision facilitation. The model is to integrate the KM processes with the EWS components. The model implementation was proposed in a CD environment of dengue fever. The objective of this model is to provide early warning and aid in decision facilitation during CD activities of dengue fever. The organization of the thesis section described briefly all the chapters involved.

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