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

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ABSTRACT

Knowledge management system (KMS) support the activities of knowledge management (KM) in early warning system (EWS) to provide early warning and aid in decision facilitation. 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 a main challenge for mitigation of risk. In which the problem that may relate to this challenge is the timeliness for timely reporting and decision facilitation during CD activities. Therefore, a conceptual of KMS model with EWS in CD environment of dengue fever is formulated based on the existing components of KM, KMS with EWS. Then, the components of CD activities and dengue fever are also identified and studied for the model implementation. A pre survey and the analysis of five existing previous models were carried out to determine the significant components of KMS and EWS. The pre survey results analysis and gaps drawn from the analysis of these five models are used as a basis to the initial proposed of KMS model with EWS in CD environment of dengue fever. Next, the KMS model with EWS was then validated via prototype to verify the model reliability and is evaluated via a post survey. 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, Dengue Fever*

1. INTRODUCTION

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 [1]. 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 [2]. 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.

EWS can be seen as a tool that can manage data and information to support the prediction and detection of dengue fever. Other researcher, [3]classified EWS as the process of gathering, sharing and analyzing 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 [4]. 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 [5]. 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 [4]. 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 [6]. Collecting relevant information, make the right judgment 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 especially in clinical diagnostic (CD) environment.

Mutually, 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 (Macdonald, 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 [7]. Early warning and detection of disease outbreaks can be detected during the CD activities of history taking and physical examination. The 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 analyzing. 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 [8]. Then, this can cause for the delay and inaccuracy of the diagnosis [9] that can lead to diagnostic mistakes and this is the primary justification of medical errors. Prior studies [10][11] emphasized the need to improve the medical treatment processes in order to overcome the issues on delays and inefficiencies during the treatment assessment. The 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 [12].

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 [13][14]. 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 [15].

Therefore, this paper aim to propose KMS model with EWS in CD environment 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.

This paper is also organized as follows; Section 2 covers the literature reviews of KM, KMS, EWS, CDE, dengue fever and five existing previous models. In which all related components and attributes such as processes, activities, technologies and elements of functionalities are compiled and summarized for the model formulation. Next, Section 3 describes the research method of the work which is divided into four main phases. The pre survey and the analysis of five existing previous model are also presented. Subsequently, Section 4 presents the formulation of KMS model with EWS to propose model and prototyping. Then, Section 5 is the analysis of post survey to evaluate the KMS model with EWS by prototyping for its competitiveness. Finally, Section 6 summarizes the work 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.

2. LITERATURE REVIEW

2.1 Knowledge, KM, KMS

Knowledge is to know when, why and which information is required, how information could be acquired and processed, and where information can be created. In this work, data is referring to raw data without any processing that is input feed in or acquired into the model which is referring to dengue fever sign and symptoms. On the other hand, information is referring to the data that is stored, organized and indexed. Then, knowledge is generated from information processed and applying rules to generate messages and reporting for sharing and dissemination. In which, this related knowledge is used to aid in decision facilitation and plan for the action taken or response.

The reviews on KM framework [16][17][18][19][20][21] is to identify and understand the processes involved for knowledge creation, codification, application and dissemination. The analysis of these frameworks shown that people, processes and technologies are significant components to ensure the successful implementation of KM, regardless of any domains; people play important roles in strategizing, managing, evaluating, creating and acquiring knowledge. The second component is the processes that are referring to the activities involved with knowledge creation, application, codification and dissemination. Finally, technologies are used to support the strategies, processes, methods and techniques to better create, codify, disseminate, share and apply the best knowledge, anytime and anywhere.

Earlier studies emphasized the basic components of KMS should consist of people, technology and knowledge content. Three KMS components established earlier comprising of technologies, functions and knowledge [22]. The technologies are referring to tools required to support the functions of knowledge processes, while knowledge is referring to knowledge content that includes the know-how, know-what, know-why and converting tacit knowledge. Then, the six KMS components [23] comprising the architecture, application and functionality, taxonomy and process, psychological, socio-culture and audit. Meanwhile, from healthcare perspectives, the KMS components are grouped into two categories; namely KM infrastructure and KM processes. KM infrastructure includes the structure and technology, while KM processes is the acquisition, conversion, application and protection (security) [24].

Thus, KMS components can be referred to groups of attributes which include the processes, activities and technologies that relate to KM. This study will address the KM processes (acquisition, codification, application and dissemination) and activities as main KMS components for the model formulation that will be integrate with EWS components.

2.2 Early Warning System

EWS is a powerful system for on time distribution and sharing of information for risk mitigation of possible disastrous threats for any precautionary action to be commenced immediately [25]. In conjunction, EWS is not limited to disaster preparedness, but also concerns the public health in infectious disease outbreaks. There are four main components of EWS identified during the Hyogo conference in Japan, 2005 namely risk knowledge; monitoring and warning services; dissemination and communication; and lastly response Capability.

The EWS components is summarized as follows [4][5][6]: Risk knowledge is an evaluation which is associated to the identification and collection, analysis, storage, detection and handling of knowledge. Monitoring and Warning Service is a second component that is concerned with technical capabilities to track and detect in order to provide timely reporting of the possible risk that might be facing in the communities. Next is the Dissemination and Communication which is referring to the delivering, distribution and sharing of alert notices to alarm the communities or publics with a good and easy message for immediate action and preparedness. Finally, the Response Capabilities is referring to the coordination with good governance and suitable action planned by the authorities. So, data acquisition concerning risk knowledge, monitoring, forecasting, warning with disseminating alerting messages and response are the attributes that should be incorporated during the activities of EWS [26]. Acquisition forecasting, response and recovery are the components required for the disaster management processes [27].

2.3 Clinical Diagnostic Environment

Generally, CD environment is dealing with the interaction between physician and patient seeking for treatment that involves three main processes known as history taking, physical examination and investigation. The making of medical diagnosis depends on three things: i) the history obtained from the patient, ii) the signs noticed on physical examination, and iii) the results of laboratory investigations [28]. CD process is a face-to-face communication and observation between patients and physicians in obtaining information for diagnosis and treatment. Clinical process activity involves a very high degree of knowledge acquisition and creation. The interactions between physicians and patient are the drivers of knowledge creation.

CD environment is a diagnostic–therapeutic cycle which comprises of observation, reasoning, and action [10]. Hence, the CD environment can be used as a platform to support EWS in which every CD activity promotes early warning for disease epidemic. In summary, Figure 1 illustrates the three levels of CD activities process flow namely, history taking, physical examination and investigation which is derived based on the understanding of CD activities from the literature review [20].

2.3.1 Application of KMS with EWS in CD Environment

Drawing from Figure 1 of the CD environment process flow, it can be concluded that KMS with EWS are applicable in CD environment during the interaction between physician and patient. Knowledge acquisition and creation are the main activities during history taking and physical examination. This is the initial point to capture data and information for further analysis. Specific and general data or information regarding the disease will be obtained during the history taking. Performing the physical examination is to further check the symptom and sign in order to determine if there is a physical problem. The scheduling for investigation is to further check and confirm the types of disease. Knowledge codification is used to codify, store and organize the data and information obtained during the knowledge acquisition.

The application of early warning and signs are applicable to both history taking and physical examination activities, in which any deformity and unexpected pattern of disease and signs emerged can be discovered or identified during CD activities. This shows that EWS is also applicable during CD activities. The knowledge application is concerning the prediction and detection of the abnormality or distinctive patterns. Knowledge dissemination is used to report, share, transfer and disseminate notifications or reports of decision facilitation.

2.4 Dengue Fever

The reporting and publication of disease outbreaks such as SARS, anthrax attacks, avian flu, malaria and dengue have indicated the significance of information and knowledge for the risk alleviation of disease outbreaks. To date, dengue is still regarded as one of the infectious diseases that can cause high rates of morbidity and mortality. In recent years, there has been an increasing amount of literature on dengue fever and dengue haemorrhagic fever (DHF). A very earlier reporting and studies on dengue fever and DHF [29][30] had shown that dengue continues to be a major health threat. Numerous studies have attempted to explain, diagnose and develop a system in order to combat the infection of dengue fever and DHF [31][32][33][34][35][36].

Dengue fever is an acute febrile viral disease with frequent presenting of headaches, bone or joint and muscular pains, rash, nausea and vomiting. Meanwhile, DHF is defined as an acute febrile illness with minor or major bleeding, thrombocytopenia, and evidence of an increased vascular permeability which results in loss of plasma from the vascular compartment. When plasma loss becomes critical, it may result in the Dengue shock syndrome (DSS) which may cause death. The early detection and management of dengue fever is essential to prevent death. In relation to this, the clinical classification of dengue fever is used for the operation of the integration KMS model with EWS in CD environment, whereby all the dengue symptoms can be obtained during the CD processes which include history taking and physical examination. At each of the process, early warning can be initiated when one or all the symptoms exist.

2.5 Existing of Previous Models and Its Gap Analysis

Five existing previous models were selected and reviewed in order to identify the KMS processes and EWS processes. As a results, Table 1 summarizes the KMS processes and EWS processes from these existing previous models.

The scoring for KMS processes and EWS processes were derived for the above Table 1. This scoring is to indicate the significance of the KMS process and EWS processes in the models. Table 2 and Table 3 summarizes the related scoring respectively.

Based on the above scoring, it is concluded that acquisition (100%) and dissemination (80%) are the most significant KMS processes. None of the model has the KMS process for application. Meanwhile, the scoring for codification is 40% and this indicated that the existing previous models emphasized less important on the data storing and management.

In summary, the EWS processes for detection is only applied 40% in previous models. Response also plays a significant role for the EWS processes with the scoring of 80%. However, prediction and warning are not used in these models. The models that having equally 20% of EWS processes applied to EDDF, DSSMD, DMDHF and e-Diagnosis except e-DCS with 40% of the EWS processes.

There are few strengths and limitation obtained from the reviews of the five existing previous models. Table 4 summarized all the strengths and limitation of these previous models.

Most of the existing previous models from Table 4 is used to provide early detection and diagnosis of dengue fever. Although all the models provide early detection and diagnosis of dengue, but the element of early warning on dengue is still lacking. Table 5 consolidate all the KMS processes with EWS processes to shows the distribution of the processes in all the existing previous models. Scoring is assigned to these models in order to know which model is having highest scoring for the application of KMS with EWS processes in the model.

Hence, in order to demonstrate the model integration of KMS model with EWS, all the KMS processes and EWS processes should be used and applied to provide the full spectrum of the model integration.

3. RESEARCH METHOD

This study was carried out in four phases as illustrated in Figure 2 Research Method. Phase I is to identified the initial components for the conceptual of KMS model with EWS. These components are formulated based on the literature reviews and analysis of KM, KMS, EWS, CD, dengue fever and five existing previous models. In this phase, the initial components for conceptual of KMS model with EWS were verified by experts and lay publics via pre survey, questionnaire survey and expert judgment. This is to ensure the required components that are important to the model formulation. Next, Phase II is to formulate KMS model with EWS. Subsequently, Phase III is to develop the model prototype from Phase II. Phase IV is to present the results of the evaluation in model prototype via post survey.

3.1 Phase I – Synthesize Existing Models

This phase is to identify components for the model formulation. Activities in this phase are performing literature reviews, reviewed the existing previous models, summarize components, pre survey and expert judgment. The homogeneous KM and KMS processes, activities, technologies from earlier researchers are studied and summarized. Then detail EWS elements is analyzed to seek for components compatibility for the KMS model formulation. Likewise, CD environment is reviewed to get better understanding on the activities and process flow involved in order to use as a platform for the model implementation. Then the review on dengue fever is to identify the clinical parameters and the level of severity of the dengue fever in order to address early warning and aid in the decision facilitation.

The existing models which are related to KMS with EWS are reviewed and analyzed to compile KMS with EWS components and attributes in each of these models. The attributes are referring to the processes, activities, technologies and functionalities that relate to the KM and EWS in CD environment of dengue fever. The detail attributes were listed and group in common categories according to the important of the components. Then these grouping were used as a baseline to the construction of the questionnaires. The expert verification is to verify the attributes required for the model formulation based on the compiled components.

A set of questionnaire is developed to verify the synthesized components of the model together with expert verification. The pre survey questionnaires were distributed to three categories of participants, namely a government hospital, private hospital and lay publics. The group of specialist from the medical domain with KMS experts reviewed the KMS components with EWS components that relevant to the model formulation in CD environment of dengue.

3.1.1 Data Evaluation

The main survey questionnaire consists a statements pertaining to the KMS processes, EWS processes, CDE activities and DF information. This was to identify the important components for the KMS with EWS formulation. The survey questionnaires were synthesized for the data analysis. The data analysis of the required components is measured using the Rasch Model which can exactly categorize and tabulate the KMS with EWS components via the Person and Items on a Distribution Map (PIDM), based on their significant requirements.

The summary of the Person item statistic which summarized the persons and items involved was to determine data reliability. Figure 3 shows the summary statistics for persons and items for the assessment. The Cronbach Alpha = 0.91 which was excellent and this verified that the model was justifiable. The analysis showed that the Person Reliability is 0.90, which is good and the Item Reliability is 0.92, which is slightly higher with the status of ‘very good’. The value of person separation is 2.98 logit and identified two groups of respondents; with 56% respondents who are above the threshold (Item Mean = 0.00) and 44% were below the threshold. This showed the more able a person is likely to agree with the items. Meanwhile, the Item reliability indicated that the questions is reliable in measuring the proper item of the component requirements (CR). The spread of items can be calculated using the difference between Item max and Item min, where 1.98 – (-1.95) = 3.93 logit which indicated that the item is reliable in measuring the components requirement of the model.

The Rash Model analysis established the PIDM that detailed out the exact position of each respondent in relation to the respective items components requirements. The Rasch Model tabulated the persons; i.e. respondent on the left side and the item component requirement (CR) were plotted on the right side of the map in the same logit scale.

The item mean for PIDM is a threshold which is zero on the logit scale as shown in Figure 4. The items are ranked from more difficult to agree and much easier to agree on the significance of the CRs. Likewise, the person distribution also tended to give high significance ratings to most of the questions item that are located at the top of the map while the person who tended to rate lower will be located at the bottom of the map.

The person S01 with the value score of 3.78 logit as being the highest in PIDM, has the tendency to give a higher significance rating to most of the questionnaire items, whilst person N03 tended to give lower rating with the value score of -2.08 logit. The Person mean value 0.5 which is slightly above the threshold value, Item mean = 0. In total, 56% (n=25) respondents are found to be above the Item mean threshold. These indicate that the overall respondents tend to give high rating to most of the questionnaire items (CRs). In contrast, about 44% (n=20) are located below the threshold that tended to give low rating to the questionnaire items (CRs). On the item side, DFi2 are the most difficult questionnaire items and the item labelled KMa1 is the easiest questionnaire items. The questionnaire items are rated into five categories. The categories are ‘Strongly Disagree’, ‘Disagree’, ‘Neutral’, ‘Agree’ and ‘Strongly Agree’. This indicate the agreeableness on the high importance of the CRs.

Point Measure Correlation (PMC) showed further analysis on the CRs validity as depicted in Table 6. Rasch analysis considered the item value as misfit only when all three rules (PM, MNSQ and ZSTD) for the related CRs item were out of range. The PM for EWf2 = 0.39 was< 0.4. Hence, it required an additional inspection because the tolerable value for PM was in between $0.4<x<0.8$. Next, is to verify the respondent by looking at the Outfit Mean Square (MNSQ), where the value must be in the range of $0.5<y<1.5$. The MNSQ value from this table is also not in the fit range for both I0011 and I0016. Eventually, the checking on Outfit z-standard (ZSTD) should have the range between $-2<z<2$. Otherwise, more checking is required. Based on this table, the ZSTD values are out of the fit range for both EWf5 and KMa4. In conclusion, all CRs are fit range because none of the CRs values is having the values for out of fit range for the three rules item as mentioned above. Therefore, the items review is not necessary.

3.1.2 Synthesized Analysis

In order to develop the KMS model with EWS in CD environment of dengue fever, this research adopts the technique of knowledge map. This is to identify the components require for the model formulation.

Knowledge map is defined as a visual representation of the organization’s knowledge to find how, what to find and where to find useful knowledge within the organization [37][38].

A knowledge map methodology from Eppler [37] is used to visualize the components used for the model formulation. Eppler,[37] outlined five types of knowledge map that include source, asset, structure, application and development. There are 5 sequential steps by Eppler [37] that required to establish knowledge map; i) identified knowledge processes, problems or issues; ii) conclude and summarize the knowledge elements from the above process or problems; iii) codify these elements which is accessible; iv) integrate the codified elements and v) provide method or ways for the knowledge map updating.

This research adopting the 5 sequential steps by Eppler [37] in order to identify components of KMS processes, EWS components of functionalities, CD environments components activities and dengue fever components of sign, symptoms and severity for the whole of model formulation.

Then, by adopting the above knowledge map methodologies, the attributes identified and compiled in literature reviews and the results from pre survey are grouped and arranged according its relevance to each of components for KMS, EWS, CD environment and dengue fever and are referred as main components of the model. The first component is the data source which refers as a data source or input to the model. It contained the dengue classification and the level of severity for dengue fever. Next, CD environment as second components comprises the diagnostic activities namely, history taking; physical examination and investigation. Thirdly, EWS components namely risk knowledge,

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monitoring and warning service, dissemination and communication and finally the response capabilities were applied in KMS model. Then KMS which is the IT based system is used to support the process of acquisition, codification, application and dissemination of knowledge. Thus, the acquired input (data source) obtained via CD activities are well managed and organized can be applied with EWS components to provide early warning and aid in decision facilitation using the KMS processes and technologies. Figure 3-12 depicts the knowledge map on literature reviews for model formulation.

3.2 Phase II – Model Formulation

In this phase, the man activity is the formulation of KMS model with EWS in CD environment of dengue fever. This model formulation is based on the components and sub components derived as above. This activity is derived from the sequential five steps of knowledge map by Eppler [37] and divided into two processes. The first process is to map the KMS component with EWS components mainly for the KMS processes, activities and technologies with the EWS four main components. Firstly, is the mapping of EWS' four main components to KM processes which adopted the Bose KM cycle to complement the integration cycle of KMS. The mapping is carried out to identify the appropriate matching of KM activities and techniques to EWS functionalities. Then, the second process is to identify the critical function of EWS to be merged with KM processes and activities.

3.3 Phase III – Prototype Development

In this phase, a prototype of KMS model with EWS is designed and developed based on the proposed conceptual model formulation. The activities involved in this phase is the module design, database design rule based and develop the specification design.

The prototype consists of four main components; i) input or knowledge acquisition, ii) repositories, iii) application module and iv) output and reporting for knowledge dissemination. The input or knowledge acquisition was to facilitate the creation and capture the data. Next, the repositories which were referring to database and knowledge based were used to store, organize and codify the input data. Then, the application modules which consisted of a series of sub modules applied the EWS functionalities in order to initiate early warning. Finally, the output and reporting were to facilitate the decision making. User friendly interactive screens were also designed to accommodate the components.

The prototype was developed based on the prototype design. The development is divided into four stages:

- **i.** Input screens to capture data. There were few types of input screens based on the DF clinical parameters.
- **ii.** Database with a series of tables for storing, organizing and codifying input data. The rules base was applied for the knowledge base application.
- **iii.** Collection of modules to apply the prediction and detection for early warning.
- **iv.** Reporting and messages in order to facilitate early warning and decision facilitation.

In order to successfully implement the prototype, a series of testing are performed iteratively. During the iterative testing, any changes or modifications that are required is reworked and carried out. Several amendments are required in order to stabilize the prototype. A user guide to this prototype is prepared to aid in the prototype usage. The implementation of the prototype provides early warning and aid in decision facilitation in CD environment of dengue fever.

3.4 Phase IV – Evaluate Prototype

Phase IV is to evaluate whether the model is successful providing KMS components with EWS element of functionalities. The model is evaluated by the post survey and the analysis of its competitiveness based on the reviewed existing previous models. The post survey questionnaires were also distributed to the same respondents that participated in the pre survey. This model is cross reference with existing previous models to evaluate its competitiveness against the reviewed models. Through this comparative analysis, the model strengths and limitations will be identified and thus can suggest that the model is best used compare to other existing models.

3.4.1 Post Survey and Comparative Analysis

The post survey attributes are adopted from SUMI 50 item questionnaire. This questionnaire is to assess and measured the five main attributes, namely affect, efficiency, learnability, helpfulness and control.

The five subscales or attributes are defined as follows:

i. Efficiency - The degree in which user can accomplish the objectives to interact with the tool at the right time.
ii. Affect the users emotionally - To see how the product or tool influences
iii. Helpfulness - The degree which the product can assist the user.
iv. Control - The degree to which the user feels or setting the pace on the product or tool.
v. Learnability - The friendliness and simplicity to used and learned the tool.

This model is cross reference with several existing models to evaluate its competitiveness against the reviewed models. Through this comparative analysis, the model strengths and limitations will be identified and thus can suggest that the model is best used compare to other existing models.

RASCH measurement model was used for the post survey analysis. The analysis was based on the reliability and the validity of the 5 aspects, in which these five aspects were to measure user satisfaction and acceptance of the system. Each of the aspects was measured separately and also combined. The results of the survey were analyzed in three parts: data reliability, fitness of respondent data and questionnaire items data. The Rasch measurement was to determine data reliability using three measures: Cronbach Alpha, Person Reliability and Item Reliability. These reliability indexes will reveal the acceptable level of the system in terms of the five aspects.

4. THE CONCEPTUAL KMS MODEL WITH EWS IN CD ENVIRONMENT OF DENGUE FEVER

4.1 The Initial Propose Model

EWS components is summarized as follows [4][5][6]. Risk knowledge is an evaluation which is associated to the identification and collection, analysis, storage, detection and handling of knowledge. Monitoring and Warning Service is a second component that is concerned with technical capabilities to track and detect in order to provide timely reporting of the possible risk that might be facing in the communities. Next is the Dissemination and Communication which is referring to the delivering, distribution and sharing of alert notices to alarm the communities or publics with a good and easy message for immediate action and preparedness. Finally, the Response Capabilities is referring to the coordination with good governance and suitable action planned by the authorities.

EWS components is identified and mapped to the KMS activities which is derived from above relationship. EWS components are based on the EWS framework by ISDR. The EWS processes were derived from the reviewed of the EWS models from earlier scholars. The activities obtained from these models are referred as KM activities. While, KMS components are referring to the KM cyclic processes. Table 7 is the relation of KMS with EWS components and its processes. The components are integrated and to be used for the model formulation

Based on the analysis above, the initial KMS model with EWS in CD environment of dengue fever is proposed. Figure 6 exhibit the initial propose of KMS with EWS in relation to CD environment of dengue fever.

4.2 Finalize Propose of KMS Model with EWS in CD Environment of Dengue

The conceptual of KMS model with EWS in CD environment of dengue fever is based on the four main components grouping as in the initial proposed of the model.

Component Grouping 1 is the KMS processes and technologies as the foundation to the KMS with EWS framework. The component of KM technologies is to support the activities of KM processes for knowledge acquisition, codification, application and dissemination.

Components Grouping 2 refers to the CD environment with the CD activities that used to support the knowledge acquisition. Data and information are obtained via history taking and physical examination.

Component Grouping 3 is the component for dengue manifestation with two main processes namely the process of symptom classification and process for severity grading. Both processes are to provide early warning and aid in decision facilitation.

Component Grouping 4 refers to EWS main components and EWS processes. The EWS main components were synthesized with KM processes to support the acquisition, codification, application and dissemination of knowledge. Then the EWS processes are to provide early warning and decision facilitation using the components of dengue classification and severity grades. Each of the components will be used for the model formulation.

The proposed model encompassed this main components of KMS, EWS, CD environment and dengue fever. Then, the proposed model is also extended with details of sub components for each of the main components for further refining the model. Figure 7 exhibit the finalized propose of KMS model with EWS in CD environment of dengue fever.

The derived CD activities in CD environment will be extended to incorporate the KMS model with EWS. The extended process flow is depicted in Figure 8. The KMS model with EWS will activate the alert notification, indicating the severity levels at every stage of CD activities processes.

5. RESULTS AND ANALYSIS

The analysis of post survey is also measured using the Rasch Model and produced summary person item statistic, person-item distribution map and item validity table. Figure 9 shows the summary person item statistic that indicated the data reliability. The figure shows that the Cronbach Alpha = 0.94, which was excellent and validated that this model was acceptable. Both the Person and Item Reliability with 0.93 and 0.91 respectively were good measurements. The person separation was 3.61 logit with 58% of the respondents were above the threshold (Item Mean =0.00) and 42% were below the threshold. This indicated that the respondents were more likely to agree with the items. The spread of items was 3.79 logit (max 1.90 – (- min 1.89)). This suggested that the item was reliable in measuring the usability of the model.

Next is the analysis of PIDM as shown in Figure 10, in which this map detailed out the correct position of the respondent that was match to the components items respectively. The Rasch Model showed the persons on the left and the items usability on the right side of the map. In PIDM, the item means was a threshold which was a zero logit scale. From Figure 10, the items were ranked from more difficult to agree and much easier to agree on the components of the model. Likewise, the person distribution also tended to give high significance ratings to most of the questions item and were located at the top of the map while the person who tended to give a lower rate will be located at bottom of the map.

Person S01 with the value score of 3.68 logit and being the highest in PIDM, had the tendency to give higher significance rating to most of the questionnaire items, whilst person N03 tended to give lower rating with the value score of -2.15 logit. The Person mean value was 0.46, which was slightly above the threshold value, with the Item mean = 0. A total of 58% (n=26) respondents were found to be above the Item mean threshold. This indicated that the overall respondents tended to give high ratings to most of the questionnaire items usability. In contrast, about 42% (n=19) were located below the threshold that tended to give low ratings to the questionnaire items usability. On the item side, Ctr2 was the most difficult questionnaire items and the item labelled Ctr5, Eff1 and Eff2 were the easiest questionnaire items.

Table 8 showed the PMC for the items' validity and the PM values for both Aff3 and Lnt5 = 0.4 which was equal to 0.4. Hence, it required additional verification since the tolerable value for PM was in between $0.4<x<0.8$. Next was to verify the respondent by looking at the Outfit Mean Square (MNSQ), where the value must be in the range of $0.5<y<1.5$. From the table, it shows that Ctr1 MNSQ was not in the fit range with the value of 1.6. Finally, the outfit ZSTD value should be in the range of $-2<z<2$. Ctr1 was also having the ZSTD that was not in the specified range (2.6). Thus, only CTR1, ZSTD value was out of the fit range. In conclusion, the item attributes values were out of the fit range for the three items rules mentioned earlier. Thus, all these attributes were in the fit range and no additional item review was required.

From Figure 9, it shows that the Cronbach Alpha is 0.94 which was excellent and validated that this model was acceptable. Accordingly, the items reliability is 0.91 is very good and verified the components were also acceptable. The KMS with EWS components were address as an overall items survey.

These components were comparatively analyzed against the selected existing models [33][34][39][40][41] from literature review. The KMS components and EWS processes were compiled and listed had indicated the significant of these components in KMS model. However, not all the reviewed existing models use the KMS components and EWS processes. The most components used in these existing models were acquisition, dissemination and responses.

The overall survey results showed that all KMS with EWS components were reliable and acceptable with items reliability is 0.91 as shown in Figure 11. Thus, the result indicated that the initial proposed

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KMS with EWS model is acceptable in CD environment of dengue fever.

Based on this analysis, the initial proposed KMS with EWS model is refined and formulated to include detail processes and activities as the proposed conceptual KMS model with EWS.

6. CONCLUSION AND FUTURE WORK

Related works pertaining to KMS, EWS, CD environment and dengue fever are presented and discussed. The aim is to understand the various processes, activities, technologies and elements of functionalities from earlier studies leading to the initial model formulation.

During the reviews, all related components and attributes such as processes, activities, technologies and elements of functionalities are compiled and summarized for the model formulation. The analysis of existing previous models that related to KMS with EWS are performed to identify the strengths and limitation in order to justify for the needs of integration for both KMS with EWS. The initial KMS model with EWS in CD environment of dengue fever is proposed based on this analysis.

This conceptual of KMS model with EWS was to merge the relevant KMS processes with EWS primary components into an environment that would assist the activities for early warning and decision facilitation. KMS model with EWS were the answer for on time reporting and guidance for decision making with early warning capabilities. The model was realized through the application in the CDE of DF classification, in which the purpose of this model was to promote early warning and alertness if any uncertainty and instability of DF sign was diagnosed throughout the CDE.

The motivation of this work 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. Importantly, this work 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.

In future, KMS model with EWS could be enhanced to include existing medical data base in order to furnish the reporting for the decision facilitation. Aligned with the current technology, then, KMS model with EWS prototype to be enhanced for more flexibility in managing early warning by automatically conveyed via emails and SMS using mobile phone.

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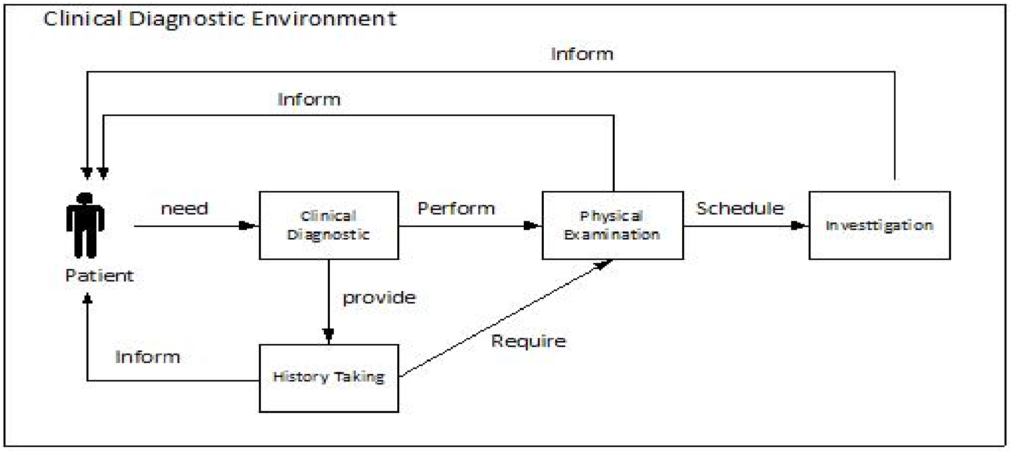

Figure 1: CD Environment Process Flow

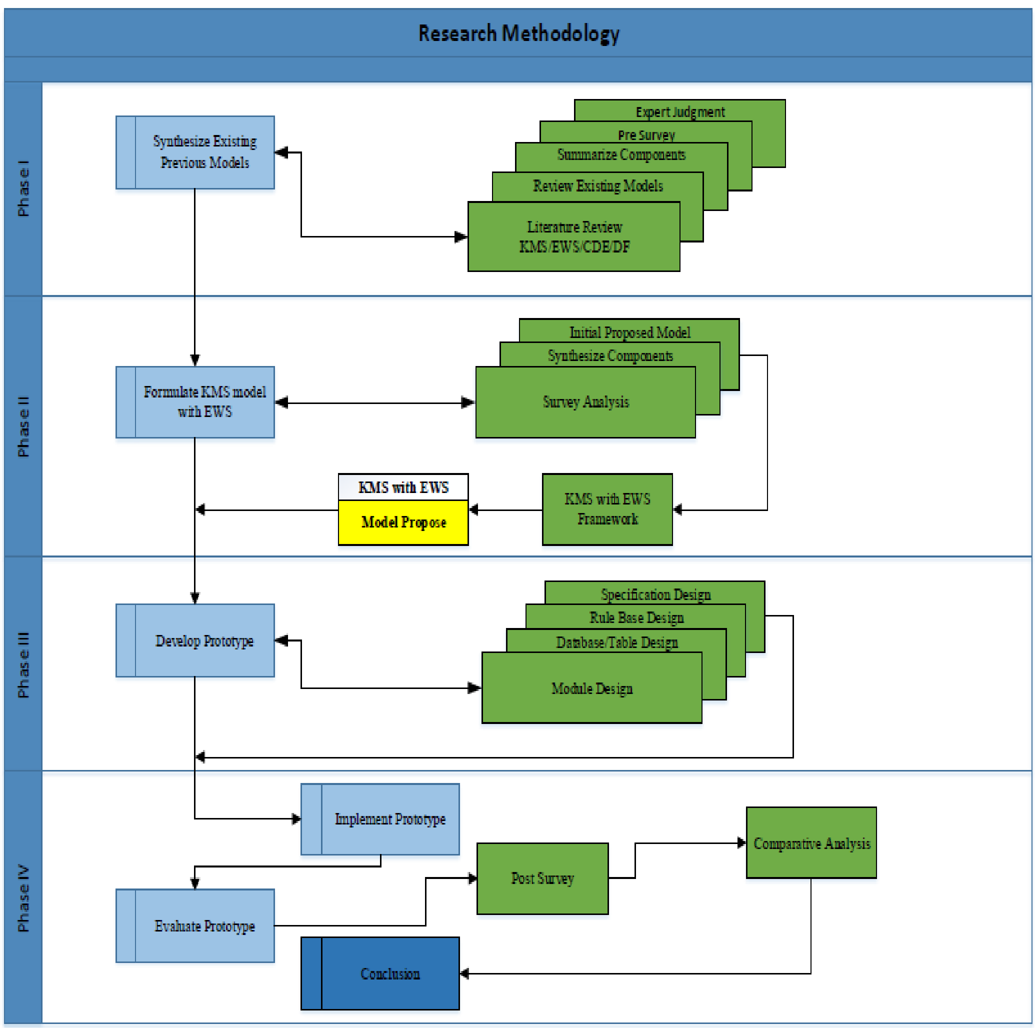

Figure 2: Research Methodology

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SUMMARY OF 45 MEASURED Persons

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	65.6	18.0	.50	.44	.99	-.1	1.00	-.1
S.D.	7.8	.0	1.49	.01	.46	1.4	.47	1.4
MAX.	82.0	18.0	3.78	.49	2.24	2.9	2.23	2.8
MIN.	52.0	18.0	-2.08	.43	.26	-3.1	.25	-3.2

REAL RMSE	.48	ADJ.SD	1.41	SEPARATION	2.98	Person RELIABILITY .90
MODEL RMSE	.44	ADJ.SD	1.43	SEPARATION	3.25	Person RELIABILITY .91
S.E. OF Person MEAN = .22						

Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE RELIABILITY = .91

SUMMARY OF 18 MEASURED Items

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	164.0	45.0	.00	.28	.99	-.1	1.00	-.1
S.D.	13.3	.0	1.02	.00	.30	1.5	.31	1.5
MAX.	189.0	45.0	1.98	.29	1.55	2.4	1.58	2.4
MIN.	138.0	45.0	-1.95	.27	.59	-2.2	.58	-2.3

REAL RMSE	.29	ADJ.SD	.98	SEPARATION	3.33	Item RELIABILITY .92
MODEL RMSE	.28	ADJ.SD	.98	SEPARATION	3.54	Item RELIABILITY .93
S.E. OF Item MEAN = .25						

Figure 3 : Component Requirements Assessment: Person Item Statistic

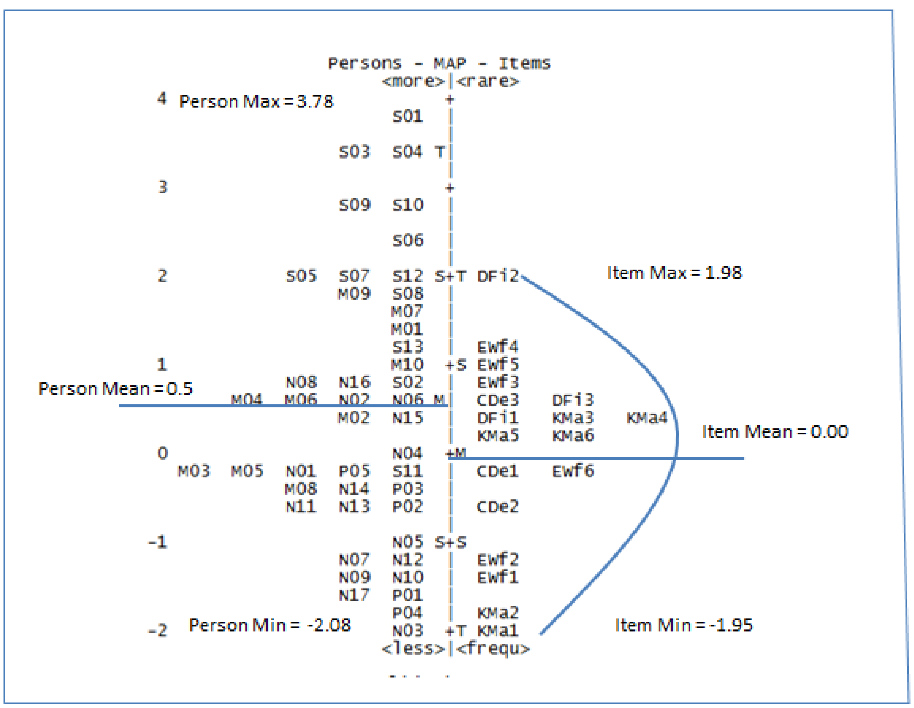

Figure 4: Person-Item Distribution Map (PIDM) for Pre Survey

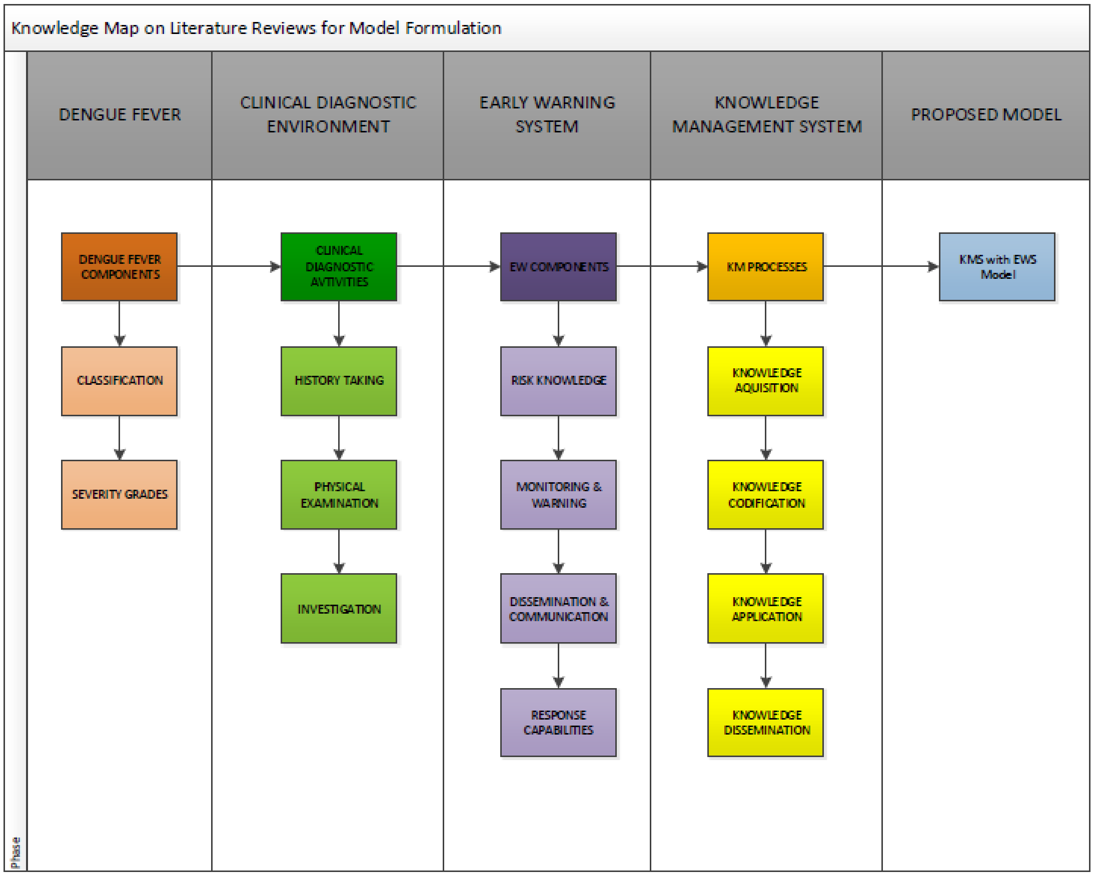

Figure 5: Knowledge Map of the Components for the Model Formulation

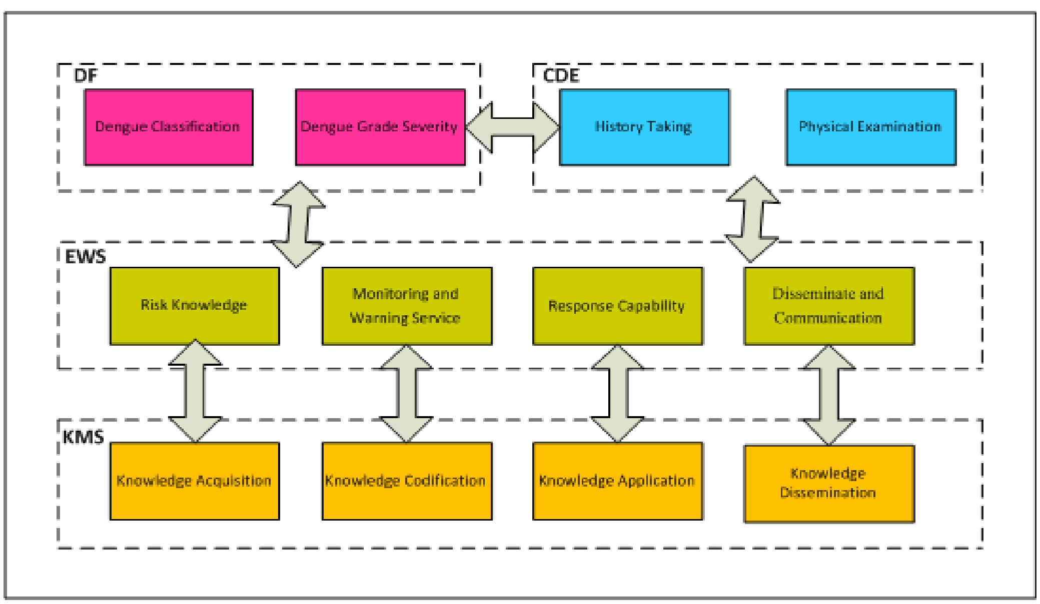

Figure 6: Initial Propose Model

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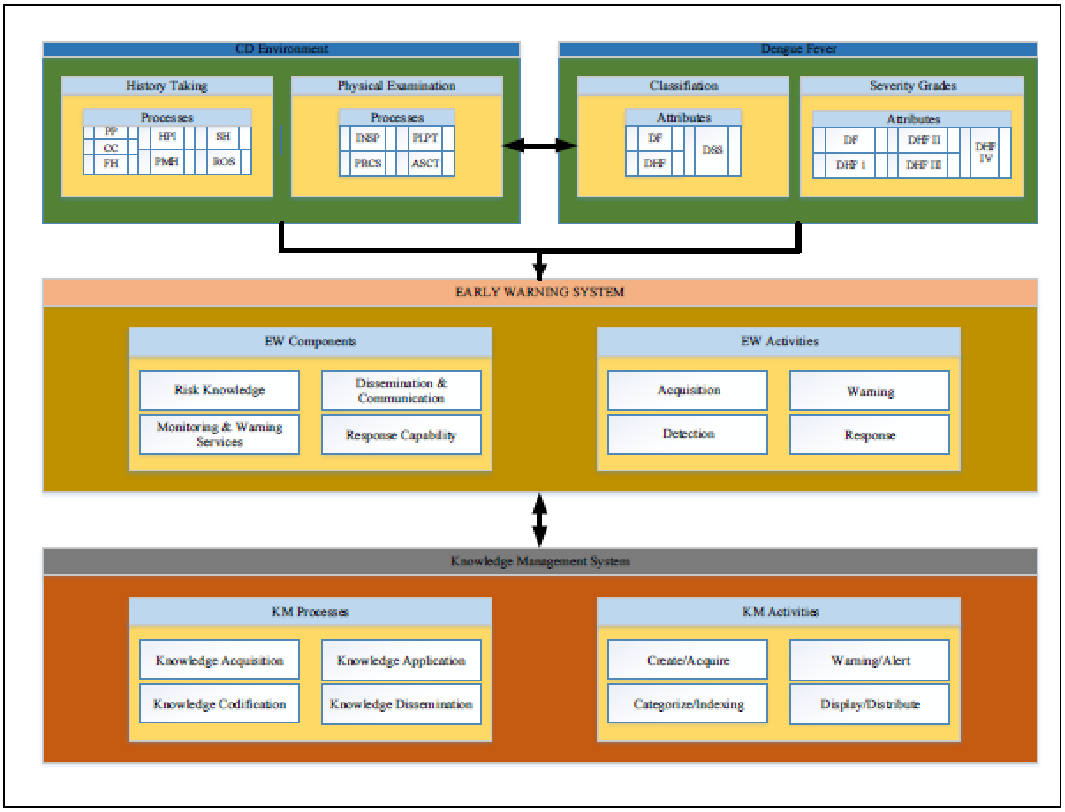

Figure 7: Finalized Propose of KMS Model with EWS in CD Environment of Dengue Fever

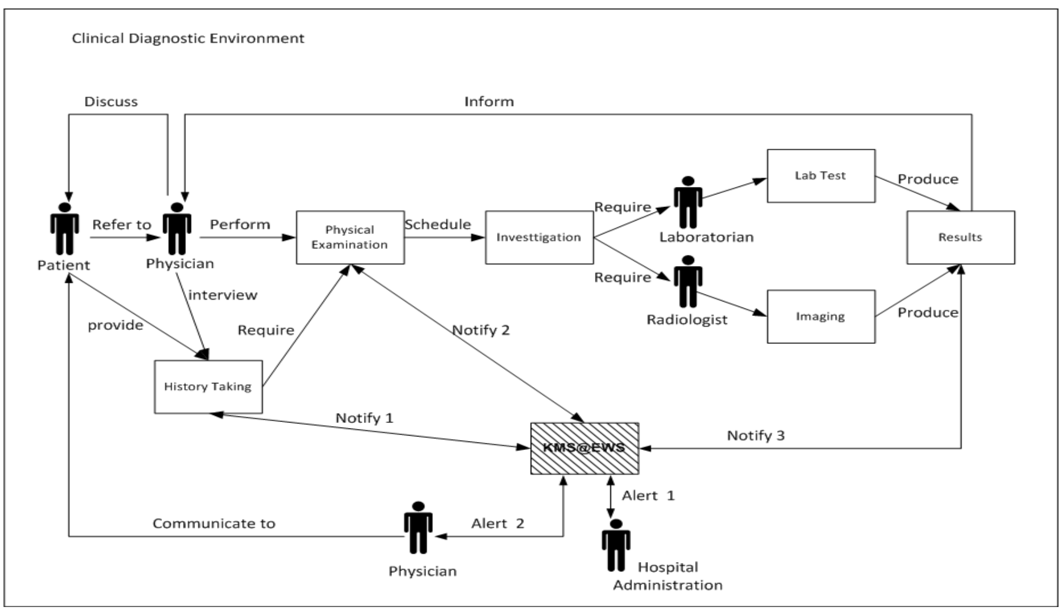

Figure 8: Proposed of KMS Model with EWS Implementation in CD Environment of Dengue Fever

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SUMMARY OF 45 MEASURED Persons

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	91.2	25.0	.46	.37	.99	-.2	1.00	-.2
S.D.	11.2	.0	1.49	.01	.49	1.7	.51	1.8
MAX.	114.0	25.0	3.68	.41	2.34	3.6	2.36	3.7
MIN.	71.0	25.0	-2.15	.36	.23	-4.0	.23	-4.0

REAL RMSE .40 ADJ.SD 1.44 SEPARATION 3.61 Person RELIABILITY .93
MODEL RMSE .37 ADJ.SD 1.45 SEPARATION 3.96 Person RELIABILITY .94
S.E. OF Person MEAN = .23

Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE RELIABILITY = .94

SUMMARY OF 25 MEASURED Items

	RAW SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	164.2	45.0	.00	.27	.99	-.1	1.00	-.1
S.D.	13.3	.0	.98	.01	.28	1.4	.29	1.4
MAX.	189.0	45.0	1.90	.29	1.58	2.5	1.60	2.6
MIN.	138.0	45.0	-1.89	.27	.58	-2.4	.59	-2.3

REAL RMSE .29 ADJ.SD .94 SEPARATION 3.27 Item RELIABILITY .91
MODEL RMSE .27 ADJ.SD .95 SEPARATION 3.47 Item RELIABILITY .92
S.E. OF Item MEAN = .20

Figure 9: The Summary of the Person Item Statistic of the Post Survey

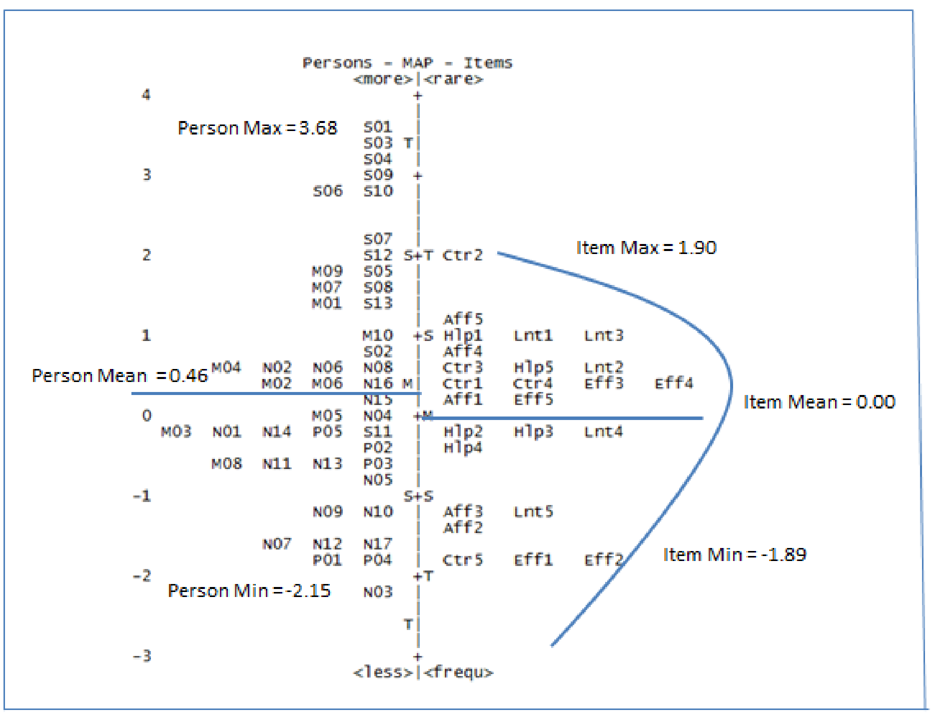

Figure 10: Person-Item Distribution Map for Post Survey

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    SUMMARY OF 25 MEASURED Items
 -------------------------------------------------------------------------------
|          RAW                          MODEL         INFIT        OUTFIT      |
|         SCORE      COUNT    MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD   |
|------------------------------------------------------------------------------|
| MEAN    164.2       45.0       .00     .27        .99    -.1   1.00    -.1   |
| S.D.     13.3         .0       .98     .01        .28    1.4    .29    1.4   |
| MAX.    189.0       45.0      1.90     .29       1.58    2.5   1.60    2.6   |
| MIN.    138.0       45.0     -1.89     .27        .58   -2.4    .59   -2.3   |
|------------------------------------------------------------------------------|
| REAL RMSE    .29  ADJ.SD     .94  SEPARATION  3.27  Item   RELIABILITY  .91  |
|MODEL RMSE    .27  ADJ.SD     .95  SEPARATION  3.47  Item   RELIABILITY  .92  |
| S.E. OF Item MEAN = .20                                                      |
 -------------------------------------------------------------------------------
UMEAN=.000 USCALE=1.000
```

Figure 11: Item Distribution Map for Post Survey

Table 1: Summarized of KMS Processes and EWS Processes from Previous Models

Year, Author	Models	Objectives	KMS Processes				Knowledge Based	EWS Processes			
			Acquisition	Codification	Application	Dissemination		Detection	Prediction	Warning	Response
2007, Karim	Expert System to Diagnosing Dengue Fever (EDDF)	To design a prototype of expert system for diagnosing dengue fever based on the indication of disease, theory and expert knowledge.	√				Decision Tables, Decision Tree				√
2013, Sharma	Decision Support System for Malaria and Dengue Disease Diagnosis (DSSMD)	To design the decision support system for fever diagnosis	√	√		√	Fuzzy logic	√			
2013, Suharyanto	Clinical Decision Support System for Diagnosis and Management DHF (DMDHF)	To solved the issues of misdiagnosis of dengue hemorrhagic fever since it has similarities with other disease	√			√	Rule based (IF/THEN)				√
2013, Tunmibi	e-Diagnosis: a rule based expert system for diagnosis of fever (e-Diagnosis)	To design and develop a rule based expert system for diagnosis of fever	√			√	Rule based (IF/THEN)				√
2014, Alexander	e-Dengue Control System (e-DCS)	To manage outbreaksthrough early detection, rapid verification and appropriate response to dengue	√	√		√	Rule based (IF/THEN)	√			√

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Table 2: Summarized Scoring for KMS Processes

	EDDF	DSSMD	DMDHF	e-Diagnosis	e-DCS	KMS Processes Scoring %
Acquisition	√	√	√	√	√	100
Codification		√			√	40
Application						0
Dissemination		√	√	√	√	80
Model Scoring %	20	60	40	40	60	

Table 3: Summarized Scoring for EWS Processes

	EDDF	DSSMD	DMDHF	e-Diagnosis	e-DCS	EWS Processes Scoring %
Detection		√			√	40
Prediction						0
Warning						0
Response	√		√	√	√	80
Model Scoring %	20	20	20	20	40	

Table 4: Summarized Strengths and Limitations on Previous Models

Year, Author	Models	Strengths	Limitations
2007, Karim	Expert System to Diagnosing Dengue Fever	Overcome the issues of limited experts in giving preliminary diagnosis in remote areas.	The low low certainty of the diagnostic due to different information provided and different characteristic of symptoms between the user and the stored information. Thus, the inefficiency of knowledge codification.
2013, Sharma	Decision Support System for Malaria and Dengue Disease Diagnosis : DSSMD	Provide early detection of disease and diagnose the disease immediately via identical symptoms.	The diagnosis of disease is solely based on the non clinical symtomps.
2013, Suharyanto	Clinical Decision Support System for Diagnosis and Management DHF	Overcome the problems and limitation in diagnosis and management of dengue hemaorrhagic fever. Support decision making and increase the konowledge to diagnosis and management of dengue.	There is no element of early warning and detection of disease
2013, Tunmibi	e-Diagnosis: a rule based expert system for diagnosis of fever	Demonstrate the significant of rule based expert system for diagnosis sick patients.	The rule based is extracted form experts in medical fields. There is no element of early warning for disease, it only alerts if important data are omitted.
2014, Alexander	e-Dengue Control System : eDCS	Provide integrated tools to assist in data collection, analysisng, monitoring, managing and reporting.	The system is only based on the principles of manual disease surveillance, it does not provide early warning based on the clinical symtomps.

Table 5: Distribution of KMS with EWS Processes from Previous Models

	EDDF	DSSMD	DMDHF	e-Diagnosis	e-DCS
Acquisition	√	√	√	√	√
Codification		√			√
Application					
Dissemination		√	√	√	√
Detection		√			√
Prediction					
Warning					
Response	√		√	√	√
Scoring %	25	50	37	37	63

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Table 6: KMS with EWS Item Measure

No	Item	Description	Score	Measure	S.E.	Infit		Outfit		Pt. Mea. Corr
						MNSQ	ZSTD	MNSQ	ZSTD	
Knowledge Management Processes										
1	KMa1	Support acquisition activities	189	-1.95	0.29	0.68	-1.6	0.65	1.7	0.74
2	KMa2	Effective techniques to capture knowledge	187	-1.78	0.29	0.74	-1.3	0.71	-1.4	0.76
3	KMa3	Knowledge classification	160	0.31	0.27	0.63	-2	0.62	-2.1	0.75
4	KMa4	Knowledge application	159	0.39	0.27	0.59	2.2	0.58	-2.3	0.77
5	KMa5	Knowledge repositories	162	0.16	0.27	0.63	-2	0.64	-2	0.77
6	KMa6	Collaborative sharing and transferring	162	0.16	0.27	0.71	-1.5	0.72	-1.5	0.75
Early Warning Functionalities										
7	EWf1	Computer-based prediction minimize errors	182	-1.37	0.28	1.15	0.8	1.22	1.1	0.48
8	EWf2	Collaborative self-detection	180	-1.22	0.28	1.2	1	1.25	1.2	0.39
9	EWf3	Automatic prediction for clinical parameters	154	0.76	0.28	0.92	-0.3	0.9	-0.4	0.51
10	EWf4	Online reporting support decision facilitation	148	1.22	0.28	1.19	0.9	1.18	0.9	0.53
11	EWf5	Web based technology support immediate response	151	0.99	0.28	1.49	2.1	1.5	2.1	0.64
12	EWf6	Multiple alert and warning messages	168	-0.29	0.27	0.98	-0.1	0.99	0	0.57
Clinical Diagnostic Activities										
13	CDe1	Information captured during clinical activities	168	-0.29	0.27	1.32	1.5	1.33	1.6	0.49
14	CDe2	Computer-based clinical activities minimize errors	171	-0.52	0.28	0.98	0	1	0.1	0.62
15	CDe3	System support clinical workflow	157	0.54	0.27	1.33	1.5	1.36	1.6	0.75
Dengue Fever Knowledge										
16	DFi1	Additional references for quick access	160	0.31	0.27	1.55	2.4	1.58	2.4	0.66
17	DFi2	Insufficient information	138	1.98	0.28	0.91	-0.4	0.91	-0.4	0.66
18	DFi3	Errors during assessment	156	0.61	0.27	0.82	-0.8	0.83	-0.8	0.51

Table 7: Relation of KMS with EWS Components and Its Processes

KMS Processes	KM Activities	EWS Components	EWS Processes
Knowledge acquisition/creation	Create, acquire, model, classification	Risk Knowledge	Acquisition
Knowledge codification/application	Detect, categorize, alert, warning	Monitoring & Warning Services	Detection
Knowledge dissemination/sharing	Display, notification, distribute	Dissemination & Communication	Warning
Knowledge dissemination	Display, alert, warning	Response Capability	Response

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Table 8: KMS with EWS Item Measure

No	Item	Description	Score	Measure	S.E.	Infit		Outfit		Pt. Mea. Corr
						MNSQ	ZSTD	MNSQ	ZSTD	
Efficiency										
1	Eff1	I would recommend this system to my colleagues.	189	-1.89	0.29	0.68	-1.6	0.65	-1.7	0.73
2	Eff2	I enjoy my session with this system	187	-1.72	0.29	0.7	-1.5	0.67	-1.6	0.77
3	Eff3	I find that information given by this system is very useful.	160	0.32	0.27	0.62	-2.1	0.62	-2.1	0.74
4	Eff4	It does not takes too long to learn the system commands.	159	0.39	0.27	0.58	-2.4	0.59	-2.3	0.76
5	Eff5	Learning to operate this system is not a problems.	162	0.18	0.27	0.64	-2	0.65	-1.9	0.73
Affect										
6	Aff1	Using this system is satisfying.	162	0.18	0.27	0.64	-2	0.65	-1.9	0.73
7	Aff2	It was simple to use this system.	182	-1.32	0.28	1.15	0.7	1.22	1	0.48
8	Aff3	I feel confident when operating this system.	180	-1.16	0.28	1.18	0.9	1.23	1.1	0.4
9	Aff4	The way the system information is presented is clear and understandable.	154	0.75	0.27	0.87	0.6	0.87	-0.6	0.52
10	Aff5	The system information and messages are very informative.	148	1.18	0.27	1.06	0.4	1.04	0.3	0.57
Helpfulness										
11	Hlp1	Using this system is satisfying.	151	0.97	0.27	1.23	1.1	1.23	1.1	0.7
12	Hlp2	It was simple to use this system.	168	-0.25	0.27	0.95	-0.2	0.95	-0.2	0.57
13	Hlp3	I feel confident when operating this system.	168	-0.25	0.27	1.31	1.4	1.31	1.5	0.48
14	Hlp4	The way the system information is presented is clear and understandable.	171	-0.48	0.27	0.99	0	1.03	0.2	0.6
15	Hlp5	The system information and messages are very informative.	157	0.54	0.27	1.23	1.1	1.25	1.2	0.75
Control										
16	Ctr1	It is easy to manage information using this system.	160	0.32	0.27	1.58	2.5	1.6	2.6	0.61
17	Ctr2	I will learn to use all that is offered in this system.	138	1.9	0.27	0.89	-0.5	0.91	-0.4	0.64
18	Ctr3	Learning how to use new functions is not difficult.	156	0.61	0.27	0.88	-0.5	0.9	-0.5	0.46
19	Ctr4	It is relatively easy to move from one part of the menu to another.	159	0.39	0.27	0.58	-2.4	0.59	-2.3	0.76
20	Ctr5	The organization of the menus and information seems quite logical.	187	-1.72	0.29	0.7	-1.5	0.67	-1.6	0.77
Learnability										
21	Lnt1	The system has a very attractive presentation.	151	0.97	0.27	1.23	1.1	1.23	1.1	0.7
22	Lnt2	It is relatively easy to move from one menu to another.	157	0.54	0.27	1.23	1.1	1.25	1.2	0.75
23	Lnt3	Learning the use of this system does not require long training.	151	0.97	0.27	1.23	1.1	1.23	1.1	0.7
24	Lnt4	It was easy to learn to use this system.	168	-0.25	0.27	1.31	1.4	1.31	1.5	0.48
25	Lnt5	I don't have to look for assistance most times when I use this system.	180	-1.16	0.28	1.18	0.9	1.23	1.1	0.4