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A GIS-BASED ENVIRONMENTAL HEALTH INFORMATION SOURCE FOR MALAYSIAN CONTEXT

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Abstract
In this paper, we propose a GIS-based system for collection and targeted distribution of latest alerts and real-time environmental factors to the Malaysian population. We call it the Environmental Health Management System (EHMS). This GIS-based system is designed to facilitate and encourage research into environmental health quality issues by providing a comprehensive tracking and monitoring tool. This GIS-based system is embedded with Google Maps API and Geocoding API services to visualize the location and environmental health reports from the aggregated online newspaper and social media news feeds. We introduce the design and implementation of EHMS, including the web frontend, backend, ontology, database, data acquisition, classification engine, and the standard news feeds.

Keywords:
Environmental Health, Wellness Program, Geographic Information Systems, Information System, Maps

1. INTRODUCTION

Environmental Health (EH) agencies exist at all levels of government, and the partners that support them such as universities, non-profit organization, IT vendors and consultants are rapidly increasing the use of Geographical Information System (GIS) technology to improve the accessibility of information about environmental issues and public health trends of the population. There are a number of web-based resources, such as online newspapers, social media, blogs, and government health portals. These can be used as sources of useful data for environmental health tracking. Marking both environmental issues and health problems on Google Maps helps the population, the government and the environment enthusiast. Therefore, it is necessary to explore the potential of GIS-based EHMS for environmental health data aggregation, potentially to provide early alarms.

The aim of this research is to describe a web based Environmental Health system for collecting and reporting latest alarm reports and real-time environmental factors surveillance to Malaysians. An outstanding GIS-based EHMS solution can fulfill the task of clustering the spatial and uncharted electronic based sources regarding to Malaysia environmental issues and health effects. In later section, we will describe the system architecture and how it classifies alarm report by location and environmental health and then overlays them on an interactive geographic map.

2. ENVIRONMENTAL HEALTH ISSUES IN MALAYSIA

The past decade of rapid economic growth and industrialization has caused serious environmental challenges in Malaysia. The most prominent at the moment are considered to be air pollution from industrial emissions, solid waste management, ensuring long-term sustainability of the water supply and sewerage services industry and overall improvements of energy efficiency to re-establish a clean Malaysia [15]. These conditions led to continued alarms about environmental issues and potential health effects on the Malaysia population. According to [15] the country's social and economic transformation has resulted in both positive and negative environmental effects on the health and safety of its people. However, further degradation of our environment will threaten not just plants and animals but also our own ability to survive and sustain ourselves. Hazardous environmental exposure can lead to various health problems; with short-term exposure humans will get choking, coughing, burning eyes and nasal and respiratory irritation; with prolonged exposure to elevated levels humans will get damage to lung tissues, respiratory issues and decreasing lung function; with repeated exposure humans will have a diminished ability to fight the respiratory infections and may link to scarring of lung tissue. Therefore, humans may adapt themselves to different environmental effects by having a constant and deliberate effort on prevention in able to stay healthy.

Environmental health or wellness refers to the health impact of the air we breathe, the water we drink, the homes we live in, the soil growing the food we eat and the many other environmental hazards, exposure and contaminations that expose to human being in daily lives [26],[5]. Environmental Health study can be referred back to ancient civilizations, and it was common in large towns long before the industrial revolution [11]. In the past, tracking the environmental issues was tough due to scarce information, low awareness from public population and insufficient Information Technology support. Although Malaysia is geographically relatively secure from natural environmental threats, the impact of mass economic development can and has caused environmental health issues which have overtaken the efforts towards environmental protection [15].

According to the [25] and the [14], there are priority environmental issues – siltation caused by agro-based activities, logging and mining and infrastructure development, deteriorating river water and ground quality, marine pollution,

toxic and hazardous waste, solid waste, deforestation and destruction of biodiversity caused by logging and conversion to other land use, rapid growth in water demand, more efficient use of energy required, coastal pollution, trans-boundary air pollution. Apart from that, there is also another set of concerns [25] which involve emerging and re-emerging infectious diseases, regulation of private water companies, coordination of occupational health agencies, and implementation of environmental health impact assessment (EHIA) and relevant databases. All these environmental health issues have been identified and acknowledged to be important in Malaysia based on the latest data sheet in [25] and the [14].

There are other related sectors and issues [25]. The Agriculture Sector involves issues such as pesticide poisoning, irrigation runoff laden with fertilizer and pesticides, contamination of water resources, pesticide residue on vegetables. The Energy Sector involves air pollution, noise, thermal pollution, fly ash and sludge disposal, nuclear wastes. Industry Sector involves air and water pollution, chemical emergencies, hazardous waste management. Transport Sector such as road safety, traffic crashes, ambient air pollution, and noise. Urban/Rural development sector involves water supply systems, sanitary facilities, sewerage system, safe and adequate drinking water, solid waste management, drainage and flood control, good housing design and location, safe recreational waters. Cross-cutting issues involve health care waste, infectious/communicable diseases, vector-borne diseases, effects of climate change.

3. GIS-BASED ENVIRONMENTAL HEALTH MONITORING

There is growing scientific evidence [18] that environmental factors are strongly linked to many chronic diseases such as asthma, birth defects, and cancers. However, there is a gap in critical knowledge in understanding the prevalence and incidence of chronic and potentially associated environmental factors. Malaysia lacks critical knowledge about the possible links between environmental hazards (which are present in air, water, soil, dust, food, or other environmental media) and chronic diseases. Currently, we do not have many comprehensive systems at state or national level to track many of the exposures and health effects that may be related to environmental hazards.

The environmental health system in Malaysia is Air Pollutant Index Management System [13]. Air pollutant index management system is designed to monitor and detect the air pollution index of special concern to the Malaysia border region in the context of this research. Other existing surveillance systems such as National environmental public health tracking network [3], The HealthMapper [26], TOXMAP [22], European Environmental agency [6] and California EHTP [5] are designed to monitor and detect a larger scale of environmental health including the spread of environmental hazards, exposure and health problems in US and European countries respectively such as Centers for Disease Control and Prevention [3], World Health Organization [26], US Environmental Protection Agency [22], European Environment Agency [6] and Environmental Health Investigation, Branch California [5]. The HealthMap is the only surveillance system which monitors and detects environmental health globally and locally but the domain content is limited to epidemics disease [7].

Due to the increase in patients' healthcare knowledge, expectation and access to web search engine [19] - [20] many internet users would rather go online to seek the latest health information. Some people may search for second opinions prior to or after doctor's consultation [19], [12]. This trend has changed us from passive receivers to active consumers of health information [19]. This new trend has changed people's mindset of seeking health information. However, searching for health information through traditional medical search engines is difficult. This is due to the information structure, increasing amount of published materials, multiple publication indexing, and complexity and readability of search results and different searchers' requirements [20], [19].

4. POTENTIAL ADVERSE HEALTH EFFECTS

Many of these environmental health hazards, exposures and health's effects might lead to various significant health problems. Some environmental hazards, exposure and health's effects may lead to significant death or normal illness. If we discover any sign and symptom that occur on one's health, there are some possibilities that can caused by the environmental health hazards, exposures and health's effects that release surroundings from chemicals and contamination. Table.1 shows an example categorized by environmental dimension, environmental health categories, and possible reactions that is symptoms and signs.

Table.1. Example of potential adverse health effects

Environmental dimensions	Environmental health categories	Possible reactions
Air pollution Water pollution Illegal dumpsite	Allergens Arbovirus Molds	Stuffy nose, itching, sneezing. Fever, Headache, rash, or epidemic disease Neurological problems, itchy eyes, a chronic cough, tiredness.

According to [5], chemicals and other contaminants have become a part of everyday life. They exist in every aspect of our lives before we are born. Some contaminants, like mold, are found naturally in the environment; other contaminants (like chemicals) are created by humans. Pressures for economic growth and development often result in failure to prevent and control environmental issues, which also failed to prevent and control the leak of chemicals and contaminations caused by human negligent act. Human's health reaction to the chemicals and contaminations will end up with cancer, neurological problems, respiratory problems, and reproductive problems. Regardless, there are always health risks relevant to certain countries, and Malaysia is no exception. Malaysia has had avian influenza, dengue, H1N1, hand, foot, and mouth disease, swine flu and others that can transmit from air, water, soil, etc.

5. ONTOLOGY-BASED MODEL AND SYSTEM ARCHITECTURE

The Ontology-based modeling approach [17], [4] is proposed to support the design of EHMS. It is the most promising approach, as it enables a formal analysis of the domain knowledge, promoting contextual knowledge sharing and reuse in a ubiquitous computing system, and context reasoning based on semantic web technologies [8]. This latter ontology represents environmental health care resources coming from different online media news and social media. We have referenced existing environmental health ontologies from Freifeld and Brownstein [7], NCBO BioPortal and BioPortal Rest Services [16], Centers for Disease Control and Prevention [3], Malaysia Department of Environment [13], US Environmental Protection Agency [22], European Environment Agency [6], Environmental Health Investigation California [5], Wisconsin Department of Health Services [24] and World Health Organization [26].

In this section, we describe the main design of the ontology-based modeling approach [17], [4] for our EHMS. As already mentioned, we extended an ontology-based model that indicates conceptual level and relations for model representation.

The Fig.1 illustrates the classes of the EHMS. There are 8 classes: Public User, FeedURL, MapFeed, Source, Marker, Location, State and District. The Class Public User is the general users who access the Web. The Class MapFeed indicates the qualified news feed. The Class Source is specialized by subclasses: FeedUrl to supply numerous online data. The Class Marker is a locked pin located on the Google Map. The Class Location is specialized by two subclasses: state and district to identify precise location on the map.

The Fig.2 shows the EHMS's layered architecture with Web Frontend access, Process, and News Feed Source. In Web Frontend, the web page with Google map [9], search features of environmental health topic categories, online media news categories, date, location, and news title will be loaded in user's browser.

The user can search by location in order to find the latest report that contains environmental health issues. The user can also search by environmental health topic categories in order to identify reported alerts. The news title search is also available for non-environmental health keywords search. The online media news source search is provided for users to choose and narrow down the search results. The date search is provided for users to choose from the earliest reports until the latest reports. The users are able to add news, which is approved by administrator. The users are given opportunity to bookmark, share and even comment via the social media networks.

In Process, this level is where it handles user request from Web Frontend, data acquire from news feed sources, and text classifications. The request from user will be received and converted into a database query. The database then returns the alarm reports that match these queries. The query results will be displayed on Google Map with built-in markers.

Data acquisition allocates data from News Feed Source based on several criteria. In general, the system will identify and convert each source of news feed into a standard report format, containing 7 main fields: title, link, description, location, and date.

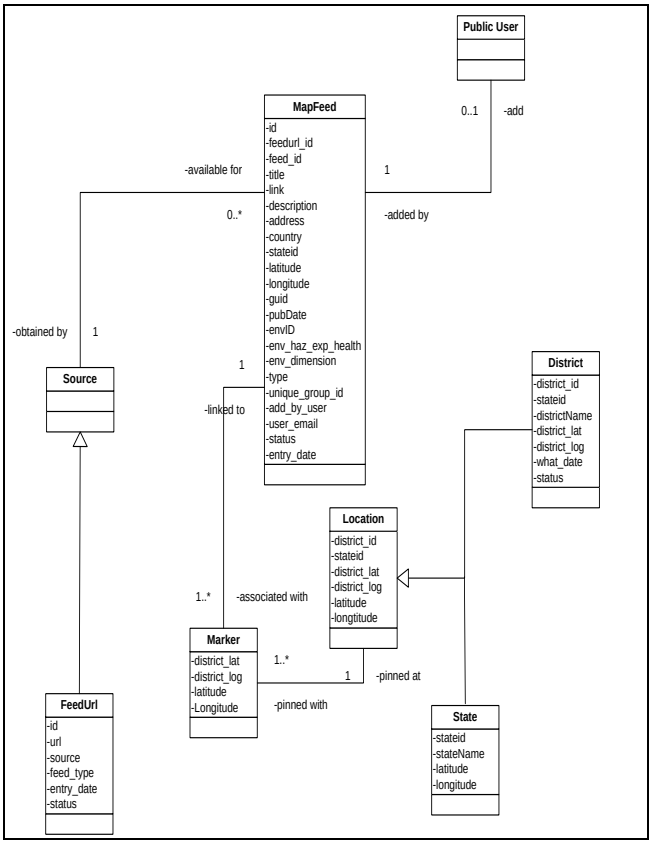

Fig.1. Classes of EHMS

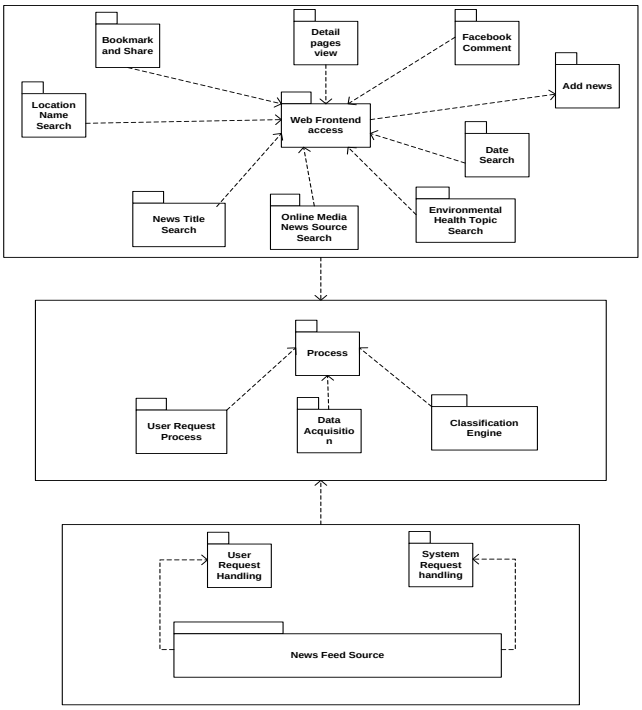

Fig.2. Architecture of EHMS

The title is the report title, link is the URL, location is the specific position in physical place, date is the date of issue of the report and description is a brief summary of the report. The

parsing process involves extracting the elements from the documents that is useful. For instance, with Star Online News, the system will extract the parts according to the 7 main fields and remove the rest of the original publication. The Classification engine decides the primary locations and environmental data (exposure, hazard and health) associated with each report acquired from web sources.

The classification engine has two modules that process the raw input and final output, which are the Reader module and Parser module. While the Reader module takes the raw input from the web source, segments and prepares it for input to the parser, the Parser module takes segmented input and produces location and environmental data as output.

Reader module uses multi-tier architecture, also known as N-tier approach [10] as a classifier to identify location and Environmental Health Data for each web sources and Geocoding web services will later generate coordinates for the identified location. In general, the Classifier will examine every sentence and paragraph in the reports in order to match location name and Environmental Health categories against existing taxonomy of known patterns. This may cause multiple locations and multiple environmental health categories to be allocated to a single report.

Parser module uses a word-level N-gram approach [1] - [2] to match input against dictionary of known patterns. After the initial data acquisition, the parser receives the input text, strips it of non-alphanumeric characters and splits it into word tokens. It then converts all capital letters to lowercase, except for those tokens that are only one or two characters in length. The parser then compares the input to its dictionary of place and environmental health category, mapping text patterns to the database IDs of all locations, environmental health categories, possible reactions and environmental dimensions known to the system. The dictionary patterns are stored in memory as a tree, where each node is a hash table that maps single tokens to either sub nodes or IDs (leaves), the system can look up each input token in constant time.

In News Feed Source, once the web sources are determined with location and environmental health data, the system stores them in a relational database (MySQL). User Request handling is to process any request from public users. System request handling is to process internal request by the system.

6. PROTOTYPING

EHMS has been implemented fully in this research; some of the user interfaces are shown below. In Fig.3, the web frontend access is shown, which enables public users to check the latest environmental health alerts on Google Maps. In Fig.4, public users are allowed to select a marker to view the results of a specific location. In Fig.5, public users can view more details, bookmark and share them through social media networks, and leave a comment for a particular environmental health alert. In Fig.6, the search features enable public users to search by News, Online Media News Source, Environmental Health Topic, Location Name, and Date. In Fig.7, public users are able to submit any news that is relevant to Environmental Health topic but which was not captured by the system itself. The submission will be approved and verified by the administrator of the system prior to releasing to the public.

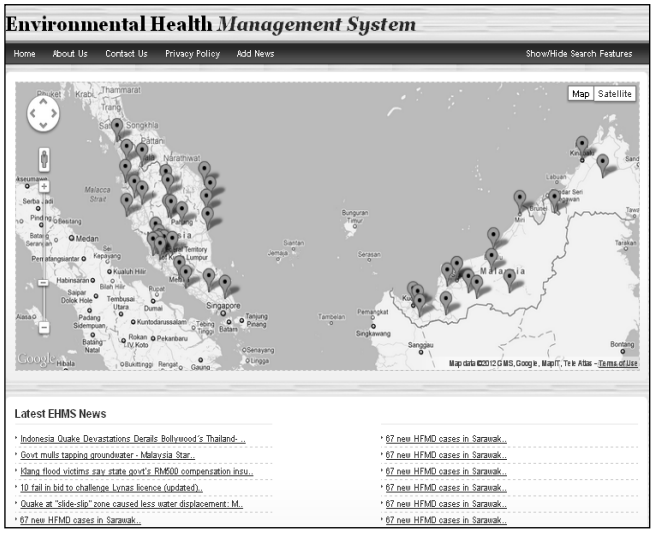

Fig.3. Main page

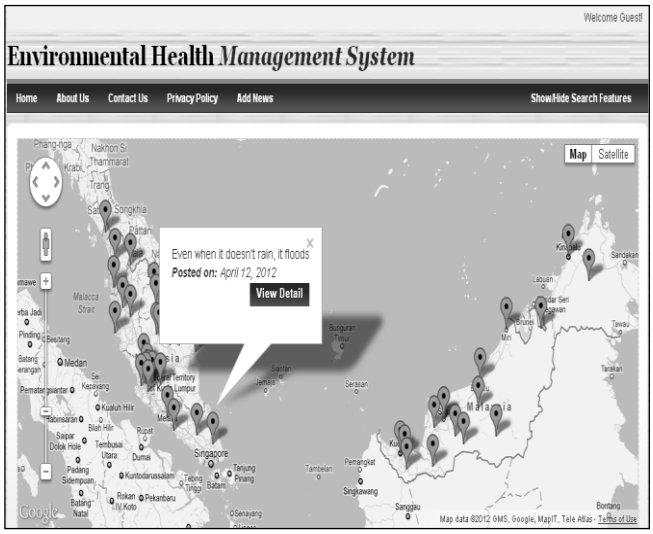

Fig.4. View the results

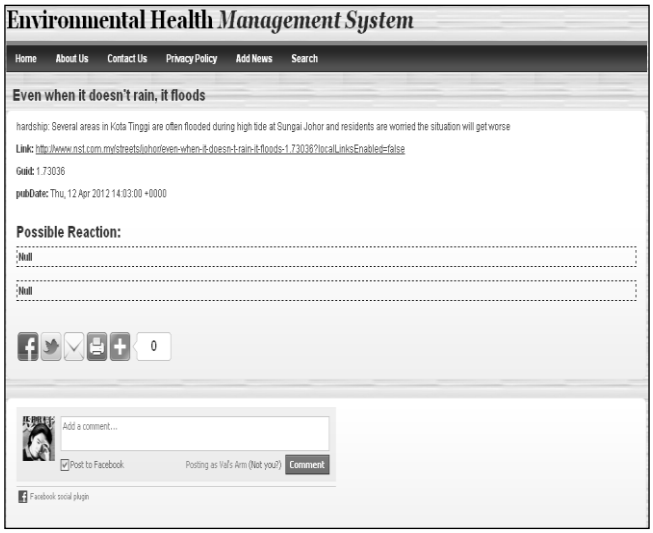

Fig.5. View, bookmark, share and comment

Fig.6. Search the information

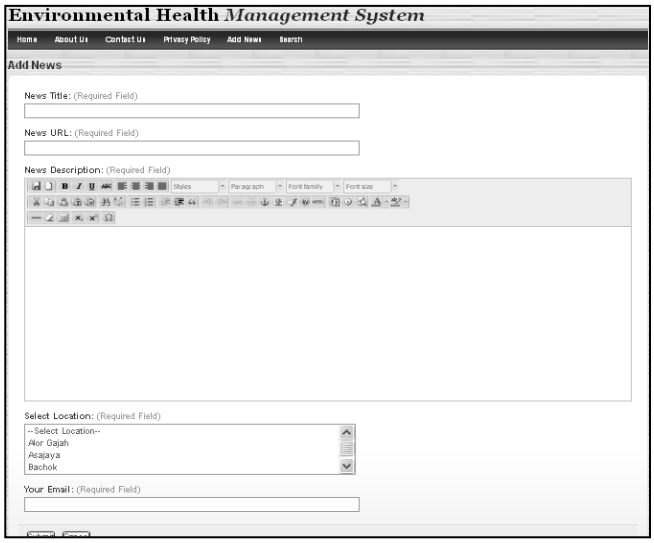

Fig.7. Submit the news

7. USER EVALUATION

A performance testing was discussed in [28], the testing was conducted through validating the inputs from online media news and social media to determine the accuracy of data entries, then the taxonomy of keywords was refined to increase the accuracy of database entries. It was proven that minor change on keywords may increase DB entries (better than standalone keyword). It has also indicated that the news patterns from real time web sources may vary with different keywords applied in taxonomy. Regular keywords refinement in ontological model could help to avoid high level of irrelevant and junks news.

In this paper, the evaluation on the quality of EHMS is discussed. The quality of environmental health ontological model for Malaysian context is evaluated through how EHMS was perceived by users in assisting their acquisition of information of environmental health. We gathered the participants' demographic information and their perceptions on the quality attributes like usefulness, suitability, security, understandability, accurateness, interoperability and learnability.

The evaluation was conducted by allowing the participants to have practical sessions using EHMS followed by answering the prepared survey questions. We invited thirty Malaysians selected randomly. There were 15 males and 15 females involved in testing EHMS. The overall participants' selection criterion involved: understanding brief or simple instruction of English language, Malaysian, has great interest/concern to find out the latest and nearest environmental health outbreaks in their locations, has a great enthusiasm in online media news and social media networks, has a constant illness bothers and has a great environmental health wellness practices.

Some personal information like age, gender, highest level of school, primary language, states/federal territories, area live in, internet usage, access the web from places, and area of employment are gathered. Table.2 shows a summary of their personal information.

Table.2. Demographic information of the participants

INDICATORS	15 MALES	15 FEMALES
Gender	11 participants age between 22 to 34, 2 participants age between 35 to 44, 2 participants age between 45 to 54	11 participants age between 22 to 34, 3 participants age between 35 to 44, 1 participant age between 45 to 54
Ethnicity	4 chinese, 3 malay, 3 indian, 5 others	7 chinese, 3 malay, 1 indian, 4 others
Level of school	2 dotorate, 8 bachelor's degree, 5 diploma	1 doctorate, 1 master, 9 bachelor's degree, 2 diploma, 2 high schools
Primary language	9 english, 3 malay, 1 chinese, 2 iban	8 english, 4 chinese, 2 malay
State of living	7 sarawak, 5 kuala lumpur, 1 pahang, 1 labuan, 1 perak	7 sarawak, 4 kuala lumpur, 2 selangor, 2 kuantan
Stay area	14 urban, 1 suburban	13 urban, 2 suburban
Internet usage	5 participants use 1 to 3 years, 8 participants use between 4 to 6 years, 2 participants use 7 years or more	2 participants use 1 to 3 years, 10 participants use 4 to 6 years, 2 participants use 3 years or more
Places of web access	4 from home, 5 from work, 3 from public, 3 from school	3 from home, 7 from work, 5 from school,
Employment fields	3 students, 2 Government and Public administration, 1 Real estate, rental, or leasing, 2 Education - college, University, or adult, 1 Telecommunication, 1 Utilities, 1 Wholesale, 2 Others (self-employed), 1 Hotel and Food Services, 1 Information - services and data	3 Finance and Insurance, 4 students, 1 Broadcasting, 3 Others (self-employed), 2 Health Care and social assistance, 1 Government and Public administration, 1 Education - college, University, or adult

For the evaluation of usefulness of EHMS, the results Table.3 showed that this experiment has received both positive and negative feedbacks from participants. Most of the participants rated "agree" and "strongly agree" on the "system help to detect diseases, injuries, adverse or protective exposures of public importance, and provide estimates of the magnitude of morbidity and mortality related to the environmental health issues events under surveillance, including the identification of factors associated with the event", except they highly rated "disagree" at the "system may help them in a timely way to

permit accurate diagnosis or identification, prevention or treatment and handling of contacts when appropriate". Some questions remained doubtful whether the system can serve better clinical practice, better behavior practices, better social practices and environmental practices and stimulate research on prevention or control. This problem can be related to individual's practices and system's attributes. The assessment for the usefulness of EHMS contains several questions regarding to the usefulness of the system. For example, it may ask the user to rate about if the system may help the participant to detect the diseases. The participant is given rating scale in 5: "strongly disagree", "disagree", "neither agree nor disagree", "agree" and "strongly agree".

Table.3. Perceptions on the usefulness of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
The environmental health alerts have met your expectation	4.67	0.49	4.00	0.53	130	8.67	0.61
The locations names have met your expectation.	4.67	0.50	4.00	0.53	130	4.33	0.61
The system may help you to detect the diseases	4.67	0.49	4.27	0.46	134	4.47	0.51
The system may help you to detect injuries	4.13	1.36	4.00	0.93	122	4.07	1.14
The system may help you to detect the adverse or protective exposures of public importance	4.20	0.68	4.13	0.35	125	4.17	0.53
The system may help you in a timely way to permit accurate diagnosis or identification, prevention or treatment, and handling of contacts when appropriate	2.00	1.46	2.60	1.40	69	2.30	1.45
The system may provide estimates of the magnitude of morbidity and mortality related to the environmental health issues events under surveillance, including the identification of factors associated with the event	3.67	0.49	3.93	0.26	114	3.80	0.41
Did you think that the system provides great tools of sharing the environmental health issues across different channels/social media networks?	4.73	0.46	4.27	0.46	135	4.50	0.51
Did you think that the built-in Google Maps provide great visualization of event-related location than plain text feature?	4.60	0.51	4.27	0.46	133	4.43	0.50
Did you think that the system leads you to a better clinical practice?	3.93	0.80	3.87	0.64	117	3.90	0.71
Did you think that the system lead you to a better behavioral practices?	4.00	0.65	4.07	0.70	121	4.03	0.67
Did you think that the system leads you to better social practices?	3.93	0.70	4.07	0.70	120	4.00	0.69
Did you think the system lead you to better environmental practices?	4.20	0.41	4.00	0.53	123	4.10	0.48
Did the system stimulate research intended to lead to prevention or control	4.20	0.68	3.60	0.51	117	3.90	0.67

In the evaluation of each system attribute by users, the experiments were divided into eight different parts: suitability in Table.4, accurateness in Table.5, interoperability in Table.6, security in Table.7, understandability in Table.8, learnability in Table.9, operability in Table.10 and timeliness in Table.11. Results showed that participants have given both positive values and negative values on the system attributes.

In suitability, it involved questions that evaluating and validating the appropriateness of a set of functions for its intended specified tasks. For example, it may ask to rate if the navigational menu meets the users' expectation or not. Overall the result was satisfactory except for the overall colors used, the quality and appropriateness of information, the quantity of information and a strong design impact. There were few participants thought that the volume of the information is slightly inadequate to meet their expectations.

Table.4. Perceptions on the suitability of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
The navigational menu meets the users' expectation	4.60	0.51	4.13	0.35	131	4.37	0.49
The Google Map meets users' needs	4.40	0.83	4.13	0.35	128	4.27	0.64
The layout structure meets the users' needs	4.60	0.51	4.13	0.35	131	4.37	0.49
The background meets the users' needs	4.60	0.51	4.13	0.35	131	4.37	0.49
The overall colors used meets the users' needs	4.33	0.90	4.20	0.41	128	4.27	0.69
The quality and appropriateness of information meets the users' expectation	4.20	1.01	4.00	0.53	123	4.10	0.80
The quantity of information meets the users' expectation	4.20	1.01	4.00	0.53	123	4.10	0.80
Have a strong design impact that meets the users' needs	4.47	0.74	4.13	0.35	129	4.30	0.60

In accurateness, it aimed to evaluate the correctness of returned value of the system after the data input. Participants were satisfied with the data output returned by the system. In Table.5, it indicates that the standard deviation is close to 5%.

In interoperability, it evaluated the ability of the system to operate successfully by sharing and bookmarking information with social media networks and online media news. An interesting fact about testing interoperability of the system was most of the participants owned more than a social media account, but they will make their preference based on the social media traffic. The more traffic they have on a particular social

media account, the more likely they will share the information on it.

Table.5. Perceptions on the accurateness of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
EHMS search feature works correctly as described in the task instructions	4.67	0.49	4.27	0.45	134	4.47	0.51
EHMS add news feature works correctly as described in the task instruction	4.67	0.49	4.27	0.46	134	4.47	0.51
EHMS embedded Google Map works correctly as described in the task instruction	4.67	0.49	4.27	0.46	134	4.47	0.51
EHMS share/bookmark feature works correctly as described in the task instruction	4.67	0.49	4.27	0.46	134	4.47	0.51
EHMS navigational menu works correctly as described in the task instruction	4.67	0.49	4.27	0.46	134	4.47	0.51
EHMS comment feature works correctly as described in the task instruction	4.67	0.49	4.27	0.46	134	4.47	0.51

Table.6. Perceptions on the interoperability of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
The system is able to interact with other channels/social media networks, including sharing or bookmarking the environmental health alerts.	4.8	0.41	4.13	0.35	134	4.47	0.51
The system is embedded with Google Maps API for better location visualization, including to operate the function without failure	4.67	0.49	4.13	0.35	132	4.4	0.50
Select from options such as Facebook, Gmail, Twitter, Email etc.							
After using the system, what channels/social media networks did you use to share/bookmark the environmental health alert?	Subtotal of male: 6 Facebook, 5 Twitter, 2 LinkedIn, 2 Pinterest		Subtotal of female: 10 Facebook, 4 Twitter, 1 LinkedIn		Total: 16 Facebook, 9 Twitter, 3 Pinterest and 1 LinkedIn		

In security, the results remained positive and consistent. The system provided anti-spam services, secure user personal details and admin log in feature. As far as the participants were concerned, the protection of users' profiles and spamming issues by unethical users were the main consideration for the use of the system.

Table.7. Perceptions on the security of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
Report news through add news feature is secure from spamming	4.6	0.51	4.13	0.35	131	4.6	0.50
Comment at each environmental health alert is secure from spamming	4.6	0.51	4.13	0.35	131	4.6	0.50
The system does not disclose public user personal details nor record their activities for third party use	4.6	0.51	4.13	0.35	131	4.6	0.50
The system can be monitored by authorized admin to ensure the various activities is ethical and controlled, including to avoid any messages that are obscene, vulgar, sexually-oriented, hateful, threatening, or otherwise violation of any laws	4.6	0.51	4.13	0.35	131	4.6	0.50

Table.8. Perceptions on the understandability of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
The system is small and simple	4.6	0.51	4.131	0.351	131	4.37	0.49
The task and its procedures are self-evident	4.6	0.51	4.13	0.35	131	4.37	0.49
Map size, white space area and group titles indicating the purpose of the respective interface, element	4.6	0.51	4.13	0.35	131	4.37	0.49
The English language of explanation/instruction/error message written in the system is understandable	4.6	0.51	4.13	0.35	131	4.37	0.49
There are no implicit or tacit assumptions about how users are expected to behave, particularly none that contradict users' expectations	4.6	0.51	4.13	0.35	131	4.37	0.49

Table.9. Perceptions on the learnability of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
I learned to use it quickly	4.6	0.50	4.13	0.35	131	4.37	0.49
I easily remember how to use it	4.6	0.50	4.13	0.35	131	4.37	0.49
It is easy to learn to use it	4.6	0.50	4.13	0.35	131	4.37	0.49
I quickly became skillful with it	4.6	0.50	4.13	0.35	131	4.37	0.49

Table.10. Perceptions on the operability of EHMS

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
It is easy to use	4.60	0.50	4.13	0.35	131	4.36	0.49
It is simple to use	4.60	0.50	4.13	0.35	131	4.36	0.49
It is user friendly	4.60	0.50	4.13	0.35	131	4.36	0.49
It requires the fewest steps possible to accomplish what I want to do with it	4.60	0.50	4.13	0.35	131	4.36	0.49
It is flexible	4.60	0.50	4.13	0.35	131	4.36	0.49
Using it is effortless	4.60	0.50	4.13	0.35	131	4.36	0.49
I can use it without written instructions	4.06	1.33	3.66	0.72	116	3.86	1.07
I don't notice any inconsistencies as I use it	4.60	0.50	4.13	0.35	131	4.36	0.49
Both occasional and regular users would like it	4.46	0.74	3.73	0.96	123	4.1	0.92
I can recover from mistakes quickly and easily	4.60	0.50	3.53	1.12	122	4.06	1.01
I can use it successfully every time	4.60	0.50	3.93	0.88	128	4.26	0.78
Search feature	4.26	0.96	4.13	0.35	126	4.2	0.71
Add news form feature	4.26	0.96	4.13	0.35	126	4.2	0.71
Share/bookmark feature	4.26	0.96	4.13	0.35	126	4.2	0.71
Comment feature	4.26	0.96	4.13	0.35	126	4.2	0.71
Built-in Google Maps feature	4.26	0.96	3.86	0.63	122	4.06	0.82

Table.11. Assessment for the EHMS attributes (Timeliness)

PARTICIPANTS	15 MALES		15 FEMALES		30 PARTICIPANTS		
QUESTIONS (Y)/ INDICATORS (X)	Avg.	Std. Dev.	Avg.	Std. Dev.	Tot.	Avg.	Std. Dev.
Did you think that you would be able to complete the same tasks with faster time?	3.53	1.18	3.86	1.24	111	3.70	1.20
Did you think that you would be able to complete the same tasks with faster time?	5.00	0.00	5.00	0.00	150	5.00	0.00

8. DISCUSSIONS

In this research, the usefulness of EHMS might be affected by the participants' demographic characteristics. For example, participants with better experiences believed that improved suitability might promote a greater opportunity for identifying injury cases in the population under surveillance.

Three participants with better experience such as having a doctorate degree, English as primary language, living in an urban area, 7 years or more internet usage, and currently working in educational, college, university or adult. Participants with better experiences believed that the quality and quantity of information in EHMS are average in meeting the objectives of usefulness. EHMS is expected to sort and classify the information into different categories that help to determine and detect the injuries.

Improved suitability enables EHMS to focus more accurately on resources for better diagnosis, identification, prevention or treatments and handling of contacts when appropriate. It is assumed that the proposed environmental health ontological model can be improved by adding additional indicators such as health injuries related keywords to solve this problem.

It is also believed that with the support of online media news and social media network, they can track the potential amount of injury or even death that caused by environmental health hazards, exposures and health. In this stage, participants expected EHMS to provide greater classified information so they can be informed with shocking alerts. For example, the increased number of deaths caused by diseases in nearby location, participants would be alerted to the seriousness of diseases and takes any necessary prevention.

Besides, there were some participants disagreed with the question "the system may help you in a timely way to permit accurate diagnosis or identification, prevention, or treatment, and handling of contacts when appropriate". According to results gathered in user testing, male participants constituted 10 (62.5%) out of 16 participants that disagreed in this question while 6 (37.5%) out of female participants disagreed in this question. The common characteristic among all these participants is they lived in urban area except 1 male participant who lived in suburban area. It is believed that people who live in urban areas are likely to be exposed to the risk of environmental health issues due to various factors such as adverse effect of economic development, unaware of bad lifestyle and inappropriate environmental practices.

Similarly, suitability has to be improved so that it enables environmental health management system to focus more accurately on resources for accurate diagnosis, identification, prevention or treatments and handling of contacts when appropriate. In this case, overall participants "the quality and appropriateness of information" and "the quantity of information meets the users" as medium. They believed that the quantity and quality of information is average in meeting the objectives of usefulness.

Apart from written and verbal instruction on paper, some female participants suggested to implement interactive and recover message on the system when the participant accidentally performs some mistakes on tasks. This may help to improve operability quality attribute in the system. Young participants also believed that a monitoring tool with interactive map services may provide greater advantages than traditional environmental health surveillance systems with non-interactive map.

It is assumed that by developing a comprehensive networks information technology to cooperate with environmental health management system that is consistent with national standards and architecture may help to improve this problem. A strategic solution is to set up a collaborative program and partnerships with local and state level public health professionals and organizations would provide better resources that help for diagnosis, prevention, treatment and emergency contacts [23]. Participants also expected a greater access of explicit and constructive information on how to get initial preparation and make ideal decision when emergency like WebMD [23]. For example, when an earthquake strikes nearby, it is expected that EHMS should suggest a quick self-help guide.

9. CONCLUSIONS AND FUTURE WORKS

The analysis, design, implementation and user evaluation of EHMS for the Malaysian context have been described. We have also designed an environmental health ontological model for our EHMS. In this paper, we presented the proposed EHMS enhanced by integrating ontological models, web-based tools, and GIS technology. Overall results from the user evaluation showed that EHMS is perceived as being able to assist in monitoring environmental health related issues in Malaysian context. Through EHMS, participants would be able to share the alerts across different channels/social media networks as fast as any incident occurs to guarantee the safety of the public. Moreover, while it might take weeks for general hospital, insurance company and health care centre to report environmental health related issues; EHMS can help participants to anticipate demand for health services more quickly. However, it cannot be denied that EHMS still needs to be improved especially for some parts that involve detection of injury and provides more explicit and constructive information on how to get initial preparation and ideal decision during emergencies. The future works may involve development of mobile-based environmental health system to support more ubiquitous access of our EHMS.

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