Nivārana: Converting information to action through ICT in communicable disease surveillance

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Abstract: This paper describes the need and proposed architecture for a communicable disease surveillance, analysis and alerting system, "Nivārana", for the Epidemiology Unit of the Ministry of Health, Sri Lanka. The Epidemiology Unit (EU) is the principal governmental organization responsible for disease surveillance in Sri Lanka and possesses a wealth of disease related data collected over a period of several decades. The Unit continuously monitors the occurrence of communicable diseases in the country and implements prevention and control programmes for a multitude of diseases. Since early recognition of impending outbreaks followed by **rapid response** is the mainstay of controlling a communicable disease in a community, acquiring the ability for; collection of complete data island wide in a timely manner, collation and analysis of such data, timely dissemination of analyzed data as well as guidelines on appropriate interventions, will no doubt strengthen the EU's capacity to implement disease prevention and control activities more efficiently and effectively. Proposed software solution "Nivārana" aims to; 1) assists translation of information available through data collection, to action, and 2) minimize the time gap between data collection and action by the EU and the other preventive health care institutions, thereby minimizing the disease spread and subsequent burden.

Keywords: Nivārana, Epidemiology, Preventive Care, Communicable Diseases, Disease surveillance, Rapid response, Mobile Technologies, Web Technologies, Short Messaging Service

1.0 Introduction

Communicable diseases are diseases that can be transmitted from one person to another, directly or indirectly through various modes (through food, water, air, insects etc) and caused mainly by micro organisms (WHO, n.d). The terms "outbreak or epidemic" are often used to describe situations where, a particular communicable disease occurs in increased numbers compared to the usual occurrence of the disease in a given geographical area. Therefore, significance of communicable disease surveillance in ensuring public health is marked by the transmittable nature of communicable diseases.

Disease surveillance is an ongoing activity consisting of data collection, analysis and interpretation of data and is intended to be used in planning, implementing and evaluating public health policies and practices. Communicable disease surveillance systems serve two key functions; early warning of potential threats to public health and programme monitoring functions which may be disease specific or multi-disease in nature (WHO, 2006). The main focus of establishing a disease surveillance system is to identify disease outbreaks early and thereby take proactive measures to control.

The Epidemiology Unit (EU) is the organization in the Ministry of Health - Sri Lanka, responsible for carrying out surveillance, prevention and control of communicable diseases in the country (except for a few communicable diseases for which special control programmes have been established). Current surveillance system in place is a combination of a paper based system for data collection and reporting at divisional and district levels and an electronic database for data entry, storage and analysis at the national level. Dependence on a paper-based system has resulted in delays in receiving, processing, analysis and dissemination of data, thereby causing undue delays in identification of outbreaks at an early stage and initiation of interventional activities.

There are several factors that hinder the capability of epidemiological unit in disease surveillance activities. Information and Communication Technology (ICT) could be used as means in breaking the barriers in disease surveillance. If the surveillance system at present is reengineered using an ICT solution, countless opportunities could be gained. Therefore, the information system *Nivārana,* the communicable

disease surveillance, analysis and alerting system was proposed as the solution for communicable disease surveillance in Sri Lanka.

Nivārana is conceptualized having the saying "prevention is better than cure" in mind. It is expected to facilitate swift public health action to minimize communicable disease burden in Sri Lanka thereby preventing ill health and suffering in the community and conserving much needed resources.

This paper is organized as follows. The second section of this paper discusses the background of the project, prevailing system and its issues. Section 3 presents the rationale behind this project and section 4, the goals and objectives. Section 5 describes the design of the project together with a discussion about the potential opportunities and threats.

2.0 Background

2.1 Current surveillance system

According to the current system related data are collected only form the inpatients of state hospitals. The disease related data are collected from the Bed Head Ticket (BHT) form a patient. These gathered data are forwarded to the relevant Medical Officer of Heath (MOH) officials. Public Health Inspectors (PHIs) are assigned by MOH officials to investigate the cases related to their regions for confirmation. The investigation results are sent back to the MOH offices. MOH offices prepare "Weekly return of communicable diseases" containing the summery of the reported cases during a particular week incorporating the confirmation data. This summery is sent weekly to the Epidemiology Unit (EU) and to the Regional Director of Health Services.

Upon receiving the "Weekly return of communicable diseases", the data are fed in to the electronic disease surveillance database that resides at the EU. This data are used in compilation and analysis. Epidemiologist at the EU make decisions rooted in the analysed information and device action plans to mitigate any outbreaks detected. The information is published weekly and quarterly, in the Weekly Epidemiological Reports (WERs) and quarterly epidemiological bulletins respectively. EU sends these

reports to every MOH offices, every hospital (state and private) and other medical institutions (WHO, 2003).

There are over 300 MOH areas in the country which are functioning under 26 regional directors of health services. Current data and information flow is illustrated in Figure 1.
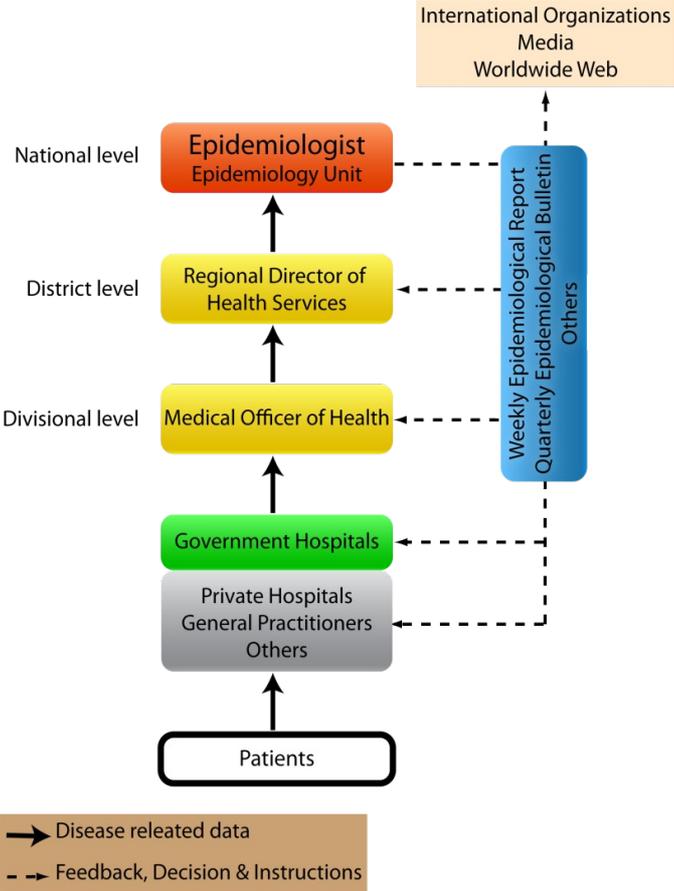

Figure 1: Data and information flow in disease surveillance in Sri Lanka

2.2 Current Issues

There are several issues that hinder the performance of the EU in the prevailing system.

2.2.1 Limitations in data collection

There are significant delays in the data collocation process. The delay experienced in arriving weekly communicable disease related data to the EU is more than seven days. Before analysis data are fed in to the communicable disease database, which

takes about a day. The validity, relevance and value of the collected data are questionable because of the undue delays in the process.

Furthermore, current system gathers data only from the government hospitals. Patients who are admitted to the private sector hospitals are not considered in current data collection process and thus suffering from data completeness, arousing the question whether the actual situation is reflected from the data collected.

2.2.2 Limitations in data analysis

Manual nature of data analysis causes adverse impact in timely decision making. All the data analysis is done centrally at the EU. Hence peripheral level outbreaks are only noticeable when significant number of cases reported due to low granularity of data analysis. Furthermore, data incompleteness directly affects results of the data analysis process.

2.2.3 Limitations in quick decision making

The presentation of information is an important factor in decision making. Analyzed information must be represented in a way that is suitable for quick decision making. Currently the presentation is only in the forms of graphs and tables. Therefore, extra effort has to be put in to enhance the quality of decision making by incorporating other relevant factors.

For instance, if the data could be plotted on a map, spatial dimensions could also be introduced to the information, which will leads to more relevant decisions, especially about a spread of a disease.

2.2.4 Shortage of proactive measures

Being proactive is utmost important in communicable disease prevention. Limitations and inefficiencies in data collection and analysis processes have induced adverse effects on taking proactive measures, resulting inefficiencies in early outbreak identification.

2.2.5 Delays in quick dissemination of information, decisions and instructions

The information is sent mainly as WERs are posted to MOH offices. Thus information would be reached to their destination with a delay, reducing the value of the information. For proper control of communicable diseases the quick dissemination of information is essential.

All of these issues have an adverse impact on the opportunity to control the disease. The Figure 2 shows this adverse effect in outbreak detection and response. The Figure 3 shows the expected level of performance of the processes and this clearly depicts that rapid detection and response to an outbreak can reduce the magnitude of the outbreak, thereby reducing the disease burden within the population.
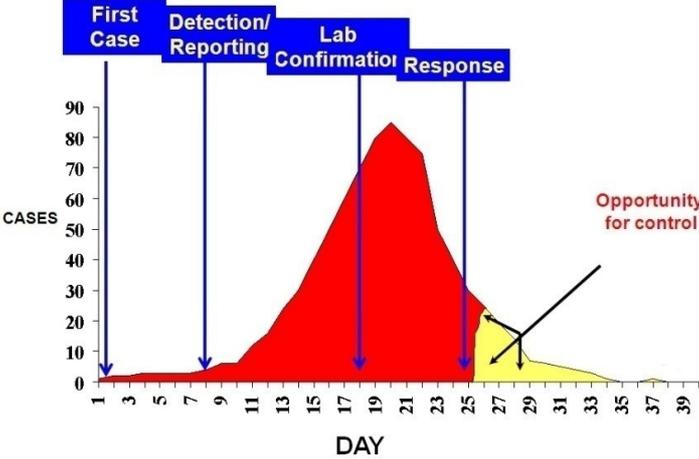
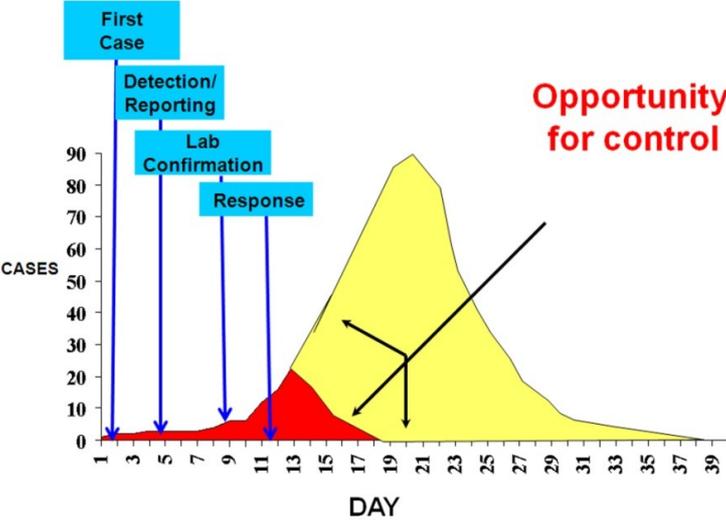**Figure 2: Outbreak Detection and Response - the outcome of a delayed process**

Figure 3: Outbreak Detection and Response - the outcome of a rapid process

3.0 Rationale

Early recognition of impending outbreaks followed by rapid response is the mainstay of controlling a communicable disease in a community. Acquiring the ability for; collection of complete data island wide in a timely manner, collection and analysis of such data, timely dissemination of analyzed data as well as guidelines on appropriate interventions will no doubt strengthen the EU's capacity to implement disease prevention and control activities more efficiently and effectively.

With the issues described as in the section 2.2, the capabilities of the EU have been reduced to a considerable level. These issues could be addressed effectively by increasing the data quality, improving data analysis capabilities, facilitating decision making and by information dissemination through the use of Information and Communication Technology (Chaudhry & et.el, 2006).

4.0 Goals and Objectives

Goals of this project include reducing the time taken in data collection, analysis and investigate on methods to disseminate the information swiftly to the relevant parties through Information and Communication Technologies (ICT), thereby increasing the response time. This project is aimed at reducing the impact of the outbreak and to make the community free from communicable diseases.

There are nine specific goals of this project as stated below;

1. Reduce the time taken to collect communicable disease related data from MOH offices around the Island.

2. Efficiently analyze the collected data.

3. Support for quick decision making.

4. Disseminate information, guidelines and feedback as quickly as possible to the relevant authorities and officials.

5. Increase the quality of the data gathered and decisions by monitoring the data entry and form the MOH offices and enforcing rules for data entry.

6. Gathering information from private sector hospitals which are not accounted in the current data gathering process.

7. Develop a strategy for early warning system.

8. Facilitating MOH officials to analyze the information and increase their involvement and contribution in disease prevention activities in regional level.

9. Monitoring the regional officials involvement in disease prevention activities

Currently the data collection and decision making has a huge time gap, which is about two weeks. Project objectives are to reduce this time gap to two days and thereby increasing the ability to identify disease outbreaks rapidly and increase the ability to take proactive measures thereby increasing agility in controlling diseases outbreaks.

Mainly there are eight objectives of this project as stated below;

1. Reduce the time taken between weekly data collection and decision making to two days compared to two weeks in the current system.

2. Using e-mails and SMS (Short Message Service) messages to send information, alerts, feedbacks and guidelines in order to disseminate information as soon as possible.

3. Granting access to online information and analysis tools for regional officials such as regional epidemiologists and MOH officials.

4. Device a mechanism to gather data electronically regarding communicable diseases form the private sector hospitals.

5. Develop an early warning system to facilitate detection of epidemic outbreaks.

6. Logging user activity of the system so as to monitor the involvement of regional officials in disease prevention activities.

7. Enforcing rules for data entry forms to increase the quality of data and hence the quality of decisions.

8. Generating computable data, that were entered in the current system, to

a. reduce the input of invalid data.

b. increase the reliability, consistency and integrity.

c. efficient the data gathering process.

5.0 Design methodology

This project will have two major components, research component and a development component.

5.1 Research component

Research questions to be addressed during the project are stated below.

1. How mobile technologies effectively be used to prevent disease outbreaks in Sri Lanka?
2. How to use the web technologies in disease surveillance activities in Sri Lanka?
3. What strategy should be used in detecting the alarming events for the early warning system?
4. What is the most effective method in dissemination information among MOH and PHI officers?
5. How to extend the data collection to private sector hospitals?

To carry out the research mainly mixed method will be used and usage of action research method (Baskerville, 1999) will also be considered.

In researching the use of web technologies in Sri Lankan context, a self administrated survey would be carried out with two objectives, namely 1) familiarity of internet and web usage of MOH officers and PHI officers and 2) to find the most effective method in information dissemination among MOH and PHI officers. Questionnaire will be distributed among PHI officers and MOH officers and use of interviews will also be considered for better clarification. To investigate on the usage of the mobile technologies and mobile devices, self administrated questioner would be distributed among the PHI officers.

Prior to design the early warning system, literature research and analysis of past data will be considered to identify a suitable strategy for the identification of early warning situations. Expert knowledge of the domains related will be used according to the necessity.

5.2 Development component

5.2.1 Proposed architecture

This project will have a very comprehensive set of tools to analyze data and uses various technologies to inform the decisions to the relevant authorities timely and will act as an early warning system for disease outbreaks. *Nivārana* is expected to be developed mainly using web and mobile technologies. The use of the other technologies will be considered as the project evolves. The proposed architecture for the system, *Nivārana* is as in the *Figure 4*.

This is to be implemented in a fully decoupled manner to achieve easy maintenance, extendibility and to be fault tolerance. The core system is responsible for executing all the functions or the business logic. The support of e-mailing service and the SMS will be used for information dissemination. There will be four interfaces to interact with the system having variety of features and suitable for verity of scenarios. The web interface will be the primary interface and desktop interface will be mainly useful where there is limited internet connectivity. The users will be able to enter the data locally and then the system could update the remote server with the information when the internet connection is established. Mobile interface will be used to access the information with mobile devices and when there are limited resources available.

The SMS facilities will be used in this system to disseminate information to the relevant parties such as PHI officials and MOH officials especially about outbreaks reported requiring their attention and about alarming situations (Stone et al., 2003; Kafeza, 2004).
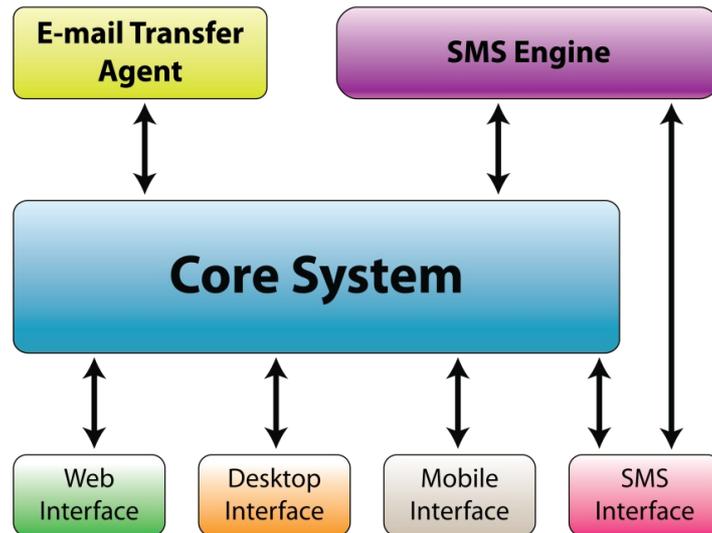
Figure 4: Proposed architecture of *Nivārana*

The need to collect the data from the private sector hospitals is essential to achieve data completeness and accuracy. Webservice technology is at its best in connecting two heterogeneous systems to work together. Therefore, Use of webservices has to be investigated in collecting information directly from the information systems deployed in private sector hospitals (Papazoglou, 2003). Low cost methods to collect information directly from the hospitals are to be investigated to uplift the usefulness of the system; particularly current focus is on mobile technologies, specifically mobile applications.

5.2.2 How issues have been addressed

Data collection

Nivārana incorporate a data collection module, which collect data from the MOH offices directly. Data collected will be with high completeness, because of the incorporation of private sector hospitals in the process. The ability to enforce data input rules on the system will lessen the invalid input of data thereby increasing the data quality.

Data analysis

Online tools will be provided for data analysis. Comparison capability will also be incorporated to these tools for easy analysis. These tools will enable regional level

public health officers to analyze the data and monitor their regions, other than the monitoring and evaluation done by the EU at a higher level. These tools will provide the ability to drill down through the data to get information about MOH areas very effortlessly.

Decision making

The decision taken will be more accurate and relevant due to the high accuracy, quality and increased capabilities in data analysis. This will leverage the capabilities of EU in disease prevention.

This project is intended to encourage and empower the regional officers such as Regional Epidemiologists and MOH officials to take decision regarding their region. This will lead to more accurate decisions for respective regions without relying on more general decisions taken by the EU.

Information dissemination

E-mails are used to disseminate content rich information and those do not need quick attention. The alerts will be sent using SMSs to take quick action. Since recipients will receive the SMS's on to their mobile phones, no computer is needed to access the information.

Proactive measures

The incorporated early warning system will warn the officials on abnormal situations. The EU will be able to alert the regional officials promptly and device necessary action plans with them for controlling the outbreak.

5.2.3 Integration

Nivārana intends to function on all the layers of the data and information flow of the current system, which would enable data analysis at all levels and eliminate duplication of data entry and compilation. Data could be fed directly to *Nivārana* at MOH level and be accessible by anyone who uses the system according to their user privileges; at divisional, district and national level. This will enable respective authorities to mount a rapid response in the event of an unusual occurrence of a disease.

5.3 Opportunities and Threats

5.3.1 Opportunities

Importance rapid response to disease outbreak is the major opportunity in favour of implementation of this system and this could lead to conserve resources otherwise would have to be spent on curative practices. There is at least one computer in MOH offices and most of them are having internet connections and this no doubt an opportunity and this will lead to using the existing resources optimally. The decreasing internet chargers are another motivational factor in system implementation.

When the MOH offices and PHI offices get familiar with Web based applications and using SMS features, this could create new opportunities for other areas in EU to introduce such systems or evolve the *Nivārana* to the standard of enterprise application.

5.3.2 Threats

Any information system will have to face the acceptability issues by the users of the system (Davis, 1989). The system will be used by MOH offices and PHI officers at the regional level. The shortage in computer literacy and internet literacy of the MOH and PHI officials may result poor acceptability of the *Nivārana*. Therefore, self administrated questionnaire will be used to identify such training needs as a measure.

For the system to be effective the users must have the required level of mobile phone usage since the alerts are sent as SMSs. The e-mail usage is another factor to be considered. Since e-mails are used to send information, if the users are accessing e-mails rarely the effectiveness of e-mails as a medium for information dissemination will be questionable. To measure the users' attitudes about e-mails and frequency of accessing emails, the self administrated questioner will be used.

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