Real-Time Biosurveillance Program: *A Research Proposal*

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EXECUTIVE SUMMARY

Problem faced by the Epidemiology Unit Officials in India and Sri Lanka is receiving health information in a timely manner in order to prevent diseases reaching epidemic states as it was with the case of the Chickungunya viral fever in both countries in the recent past. The current Communicable Disease Notification Paper System for "situational awareness" does not provide the much needed "real-time" information flow and analysis. The real-time communication shortcomings can be easily overcome with reliable and robust Information Communication Technologies (ICTs) and Intelligent Software.

Proposed *Surveillance and Alerting System* will provide for the execution of decision analyses of the assessment and response problem faced by the epidemiology units. Government *Health-care Worker* based sensor system and deployment of *advanced detection algorithms* such as Spatial-Temporal Scanning, Bayesian modeling and Multi-Stream real-time monitoring of the collected surveillance data will provide the epidemiology units with the tools to combat the real-time detection and communication dilemma.

There are proven solutions in the world of implementations or research on the individual components of disease information acquisition technologies, differential diagnosis type analysis, and early warning communication systems. However, this will be the first project of this nature to field-test an integrated end-to-end operational system with mobile phones and intelligent software for real-time disease-surveillance and outbreak-early-warnings in the last-mile communities of a developing nation in the Asia region.

The pilot project will be carried out in a selected province in Sri Lanka and in the state of Tamil Nadu in India. Each country will nominate four healthcare divisional areas and four village level healthcare workers in each division to participate in the research. The healthcare workers will cover a total of thirty two villages in the respective areas.

This is a Multi-Partner Pilot Project to be carried out over a period of 2 years to accomplish the four research components –
      (I) Establish the mobile based communications system
      (II) Introduce computer based detection system
      (III) Implement the e-Health based surveillance and notification system
      (IV) Evaluate the system over a one year period

GOALS AND OBJECTIVES

An important aim for the study is to set up a prototype Information Communication System (ICT) to timely collect relevant health surveillance data and to process this data in order to reliably and quickly detect possible outbreaks of diseases. The envisaged pilot will be a comparative research between the two neighboring countries India and Sri Lanka on the introduction of a Real-Time Biosurveillance Program (RTBP). We will evaluate the technical and organizational abilities of the program and test it in a pilot deployment. Thereafter, summarize the results of the comparative study in the form appropriate for a wider scale deployment.

The proposed RTBP is being conducted as a pilot rather than an implementation. The RTBP will be deployed in sufficient number of government healthcare-worker divisions to evaluate the performance and outcomes in different geographical, infrastructural and socioeconomic contexts as well as compare the RTBP in the absence or presence of the proposed ICT system.

      List of objectives in point form
- Deploy mobile phone system for gathering health-related information through community-healthcare-workers (Public Health Inspector in Sri Lanka and Village Health Nurses in India)
- Train the community-healthcare-workers on using the technology and adopting new processes for submitting health-related information

- Evaluate the usability, adaptability, and effectiveness of the mobile phone based data acquisition process
- Deploy advanced detection software algorithms such as *spatio-temporal scanning*, *Bayesian modeling*, and *multivariate time series analysis* for statistical data mining for state/regional epidemiology units to detect possible disease outbreaks
- Train the state/regional epidemiology units with the tools and processes to analyze the gathered health-related data to detect disease outbreaks in near real-time
- Evaluate the ability of the detection system to assist the national/state/regional epidemiology units with their task of discovering outbreaks ahead of time, efficiently carrying out the analysis in a timely manner, reliably predicting disease outbreaks with minimal ambiguity, and interpreting the analyzed information with zero complexity.
- Deploy a disease outbreak notification software tool for state/regional epidemiology units to use for notifying divisional and community-healthcare-workers of a possible disease outbreak as well as monitor the situations with feedback reports on the response actions
- Train the State/Regional Epidemiology Units on the software tool and processes in notifying possible disease outbreak as well as instructions on protocols
- Evaluate the notification system for its usability, reliability, and effectiveness in managing communications with healthcare workers during and emerging disease outbreak emergency situation
- Disseminate the outcome of the research for policy makers, practitioners, and researchers to study the lessons learned

PROJECT DESIGN AND IMPLEMENTATION PLAN

Research design will allow us to compare the productivity in relations to performance (reliability and effectiveness) of mobile hand held devices and analytics algorithms. The control groups will shed light on the extent to whether having dedicated ICTs contribute to an effective data retrieval and detection system.

As in evaluating any program, we are keen in scrutinizing the stability and sustainability of the RTBP in the given environments. Specific objectives of the project are:

1) Evaluating the effectiveness of the e-Health RTBP for detecting outbreak
2) Evaluating the latencies of communicating disease information from remote areas
3) Contribution of village organization and gender participation
4) Developing a tool kit for assessing e-Health RTBPs
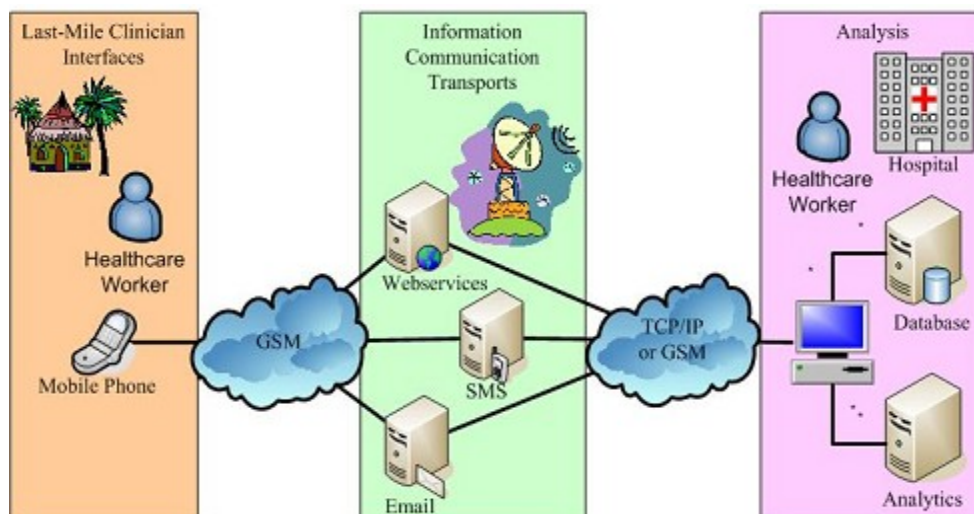
Illustration 1: Information Communication and Processing Architecture

Global Standard for Mobile (GSM) Terminal Devices will be evaluated in terms of a paperless *Upstream* Communication mechanism. The data acquisition software applications will be based on a menu driven Wireless Access Protocol (WAP) application and two SMS applets: Ping-Pong and Enum-Cards, which will be tested on mobile hand held devices. The collected data will be run through intelligent software algorithms for rapid detection of potential disease outbreaks. A Graphic User Interface (GUI) will be developed for the state/regional/national

epidemiology units to view the cases on geographical and temporal settings. Illustration 1 shows the associated networks, hardware, services, and entities associated with the ICT based RTBP.

The implementation process is governed by a participatory design process involving the stakeholders: healthcare workers, epidemiology units, public, experts and technology solution providers. At the very begining all the partners (stakeholder groups) will meet to discuss and commit to their roles and responsibilities as well as assess the viability of the project deliverable.

Two Research Assistants will be hired by the Indian and Sri Lankan epidemiology units. The research assistants will participate in all project activities including carrying out the necessary research activities to facilitate the forward progress of the design, development, implementation, and evaluation process. In addition, the research assistants will document the outcomes of the research findings with the supervision of the senior researchers with the aim of disseminating the results the practitioner and research community.

The first action of the ICT system design process involves the technology providers and healthcare-workers collaborating on developing a set of User Requirements specifications (URS). Upon completion of the URS the technology providers will demonstrate the prototypes to the healthcare-workers at a planning workshop to ensure that the URS have been captured and suits the healthcare worker requirements. The technology providers will then take the URS and the lessons learned from the demonstrated prototypes as a reference to develop a set of system requirements (or software requirement specifications – SRS). The SRS will be validated by the healthcare-workers and experts before actual development of the system can begin.

Once the technology providers finish developing the individual components they will be tested by the healthcare-workers and the other researchers. Upon acceptance the system components will be integrated. The technology providers will develop a set of User Manuals and the researchers will develop a set of Standard Operational Procedures (SOP). Through a series of training workshops, the user manuals and SOPs will be introduced to the healthcare-workers. The project manager and the research assistants will repeat the same training exercise on site in each of the healthcare-worker divisions and state/regional epidemiology units. The redundant on site training session will be followed by a series of silent-tests involving the healthcare-workers to ensure they can operate the technology as well as adhere to the newly introduced processes.

A similar approach of on site training workshops will be conducted in the divisions for village participants assisting with the research. They will also run through a round of silent-tests to get familiar with the exercises and protocols they need to carry out during the evaluation period.

MONITORING AND EVALUATION

A total of 16 government community-healthcare-workers (Public Health Inspectors in Sri Lanka and Village Health Nurses in India) will be used to test the system in 4 Divisions (Medical Officer of Health divisions in Sri Lanka and Deputy Director of Health divisions in India); where 8 community-healthcare-workers will be given access to a mobile phone and the remaining 8 community-healthcare-workers will be used as the control elements. It is expected that each community-healthcare-workers covers at least 2 communities in their designated area; as a result will include 32 villages to participate in the evaluation process. Illustration 2 describes the formulation of the research matrix.

|	Exposed to RTBP				Unexposed to RTBP			
	Division 1		Division 2		Division 3		Division 4	
+	C01	C05	C09	C13	C17	C21	C25	C29
	H01	H03	H05	H07	H09	H11	H13	H15
-	C02	C06	C10	C14	C18	C22	C26	C30
+	C03	C07	C11	C15	C19	C23	C27	C31
	H02	H04	H06	H08	H10	H12	H14	H16
-	C04	C08	C12	C16	C20	C24	C28	C32

Illustration 2: Research matrix with four MOH/DDH divisions, and sixteen community-healthcare-workers, covering thirty two communities. Notations: 'Hxx'-community-healthcare-workers and 'Cxx' - Village

The project will conduct mock drills (simulations) to evaluate the performance and outcomes of the proposed surveillance and analysis system. The 32 villages, 16 healthcare-workers, and the epidemiology unit staff will be actors in the exercises. Simulated drills will be conducted in 4 stages over a 1 year period. The criteria for evaluation will include the rapidity at which an action is taken, the organizational efficiency in coordinating collective action, and the proper functioning of the ICT and related technologies among others, and the acceptability of the RTBP in the respective Health systems for surveillance and notification.

Six research hypotheses in relation to the research matrix

1) Healthcare-workers in divisions 1 & 2 exposed to the RTBP will respond more effectively to communicating disease to the respective epidemiology centers than the healthcare-workers in the control divisions 3 & 4 unexposed to the RTBP.

2) Epidemiology units in divisions 1 & 2 exposed to the RTBP will detect disease outbreaks accurately and contain the outbreak efficiently than epidemiology units in control divisions 3 & 4 unexposed to the RTBP.

3) Healthcare-workers and epidemiology units in divisions 1 & 2 exposed to the RTBP will show interest and recognize the benefits in adopting e-Health programs opposed to the healthcare-workers and epidemiology units in the control divisions 3 & 4 unexposed to the RTBP.

4) Communities in Divisions 1 & 2 exposed to the RTBP will have confidence in the national disease surveillance and notification programs more than the villages in the control divisions 3 & 4 unexposed to the RTBP.

5) Healthcare-workers and epidemiology units in divisions 1 & 2 exposed to the RTBP in addition to their RTBP function will leverage ICTs in other areas to enrich their daily activities more than the healthcare-workers and epidemiology units in the control divisions 3 & 4 unexposed to the RTBP.

6) Villages that have non governmental community-based healthcare organizations will perform better in monitoring, communicating, and containing disease outbreaks than communities that do not have a formal non governmental community-based healthcare organization.

PROJECT PLAN
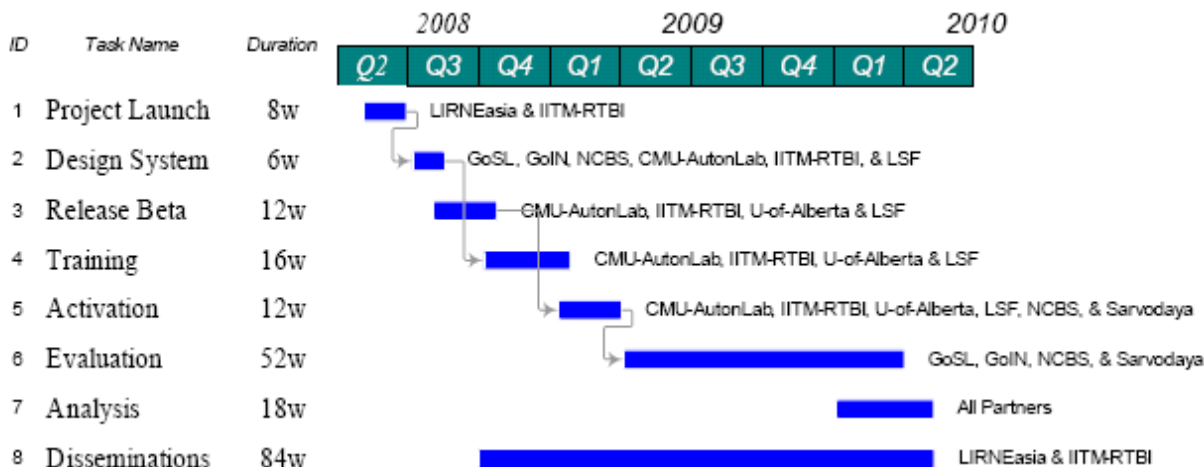
Description of the project actions

Project Launch – partner meeting to finalize research, recruit project staff and procure project staff equipment

Design System – Health Worker planning meeting to gather system requirements and develop a set of system requirement specifications;

Release Beta – preliminary demo version of the ICT system and processes for health-workers to test.

Training – workshops for Health Workers and village members to acquire the know how to operate system and engage in RTBP evaluation process.

Activation – fully implement ICT system and setup RTBP with SOP to begin evaluations.

Analysis – analyze the collected research data, discuss the research findings and draw conclusions.

Disseminations – web postings/forums, journals publications and conference proceedings to share the knowledge with practitioners and researchers.

PROJECT PARTNERS

<u>In alphabetical order</u>:

- **Carnegie Mellon University Auton Lab,** USA **(**http://www.autonlab.org/**)**

- **Epidemiology Unit**, Ministry of Health and Nutrition, Colombo, Sri Lanka (http://www.epid.gov.lk/)

- **Indian Institute of Technology,** Madras**,** India (http://www.rtbi.in/index.html)

- **Lanka Software Foundation**, Sri Lanka (http://www.opensource.lk/)

- **LIRNE*asia*,** Colombo, Sri Lanka (http://www.lirneasia.net)

- **National Center for Biological Science**, Banglore, India (http://www.ncbs.org)

- **National Institute of Communicable Diseases**, Ministry of Family and Welfare, Tamil Nadu, India (http://www.health.nic.in/NRHM/State%20Files/tamilnadu.htm)

- **Sarvodaya**, Moratuwa, Sri Lanka (http://www.sarvodaya.org)

- **University of Alberta,** Edmonton, Canada (http://www.extension.ualberta.ca/faculty/memb_gow.aspx)