mHealth applications to improve early detection of diseases

Mobile applications from the region and opportunities for Bhutan

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Ministry of Health, Thimpu, Bhutan

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IDRC CRDI

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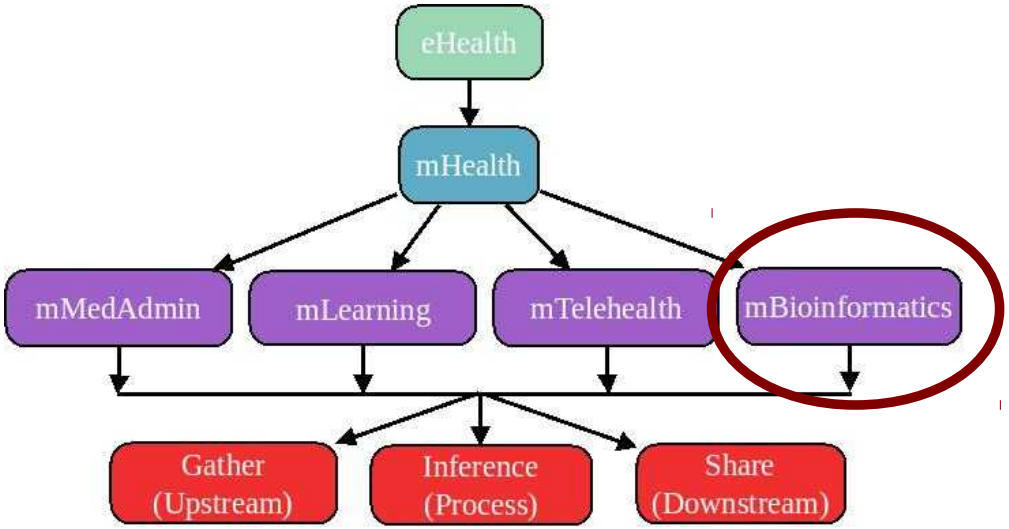
www.lirneasia.net

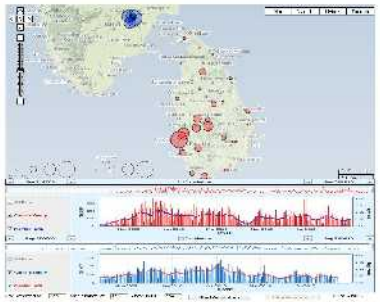
Mobile Health for evidence-based planning and cost-effective interventions



All disease surveillance and alerting
- Notifiable diseases
- all communicable diseases
- all noncommunicable diseases

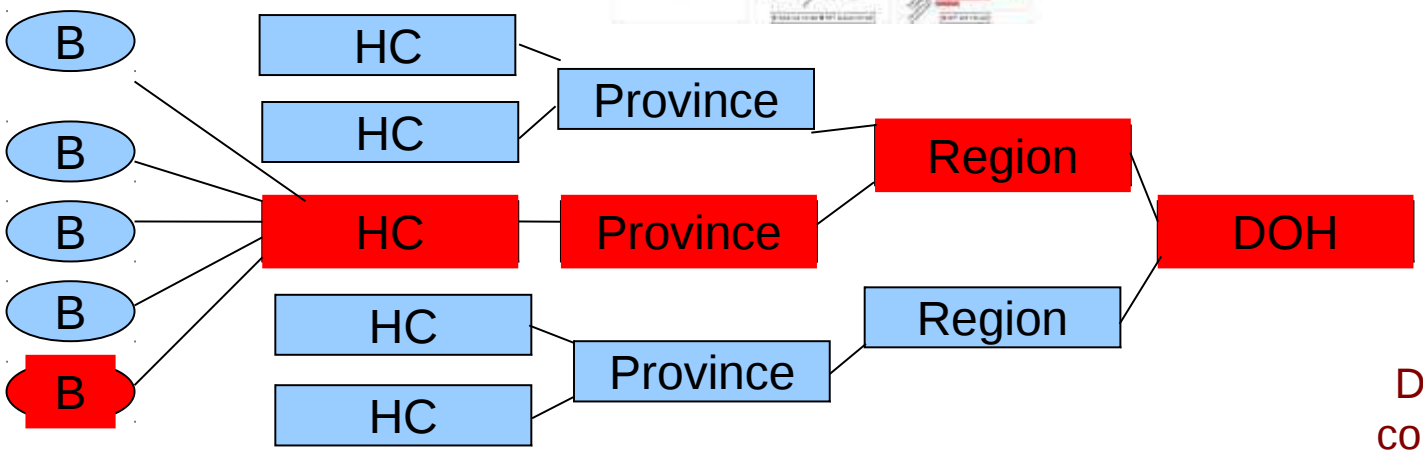
TCO to implement and operationalize a typical **RTBP mHealth program** is ~ **NU 500,000** per month

~ 0.1% of Bhutan's indicative total capital outlay for the health sector



How is this possible?
- Low end mobile phones
- Self-intuitive applications
- Free and open source software
- Cheap cellular communications
- Reduced labor and paper

District Health Information Software 2 – CHITS Philippines



- Philhealth
- Maternal Care
- Child Care
- Family Planning
- Leprosy
- Filariasis
- Schisto
- Patient
- Family
- Barangay

DHIS2mobile has

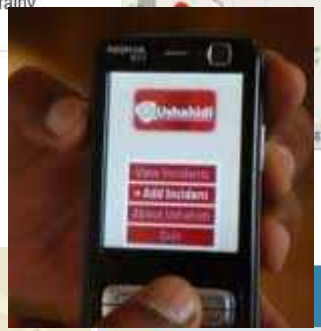
- built in forms for data collection and visualization
- Reporting capabilities for information dissemination
- Contains Browser based apps as well
- Works over GPRS but has SMS for areas that have no broadband
- solution relies on making custom made mobile apps
- framework is designed for low-end mobile phones

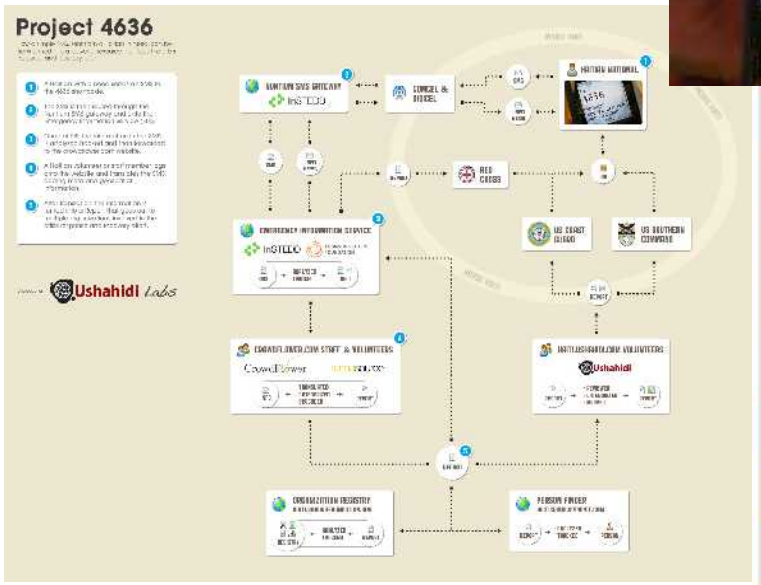
DHIS 2 is a tool for collection, validation, analysis, and presentation of aggregate statistical data, tailored (but not limited) to integrated health information management activities

Ushahidi Crowd Sourcing of Public Health Information

Public Health Information

Mapping Aedes mosquito (dengue) breading sites in Sri Lanka

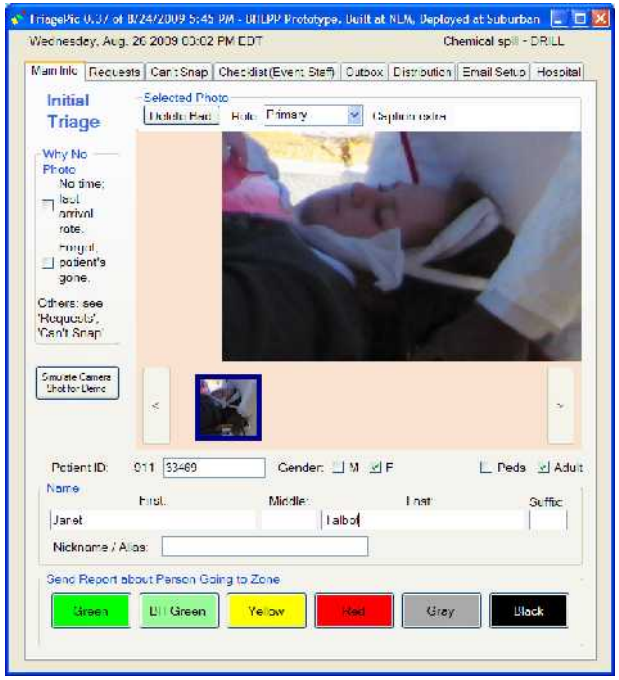




Project 4636 Haiti

Exchange of People Request with multiple agencies and platforms

Sahana Hospital Triage Management



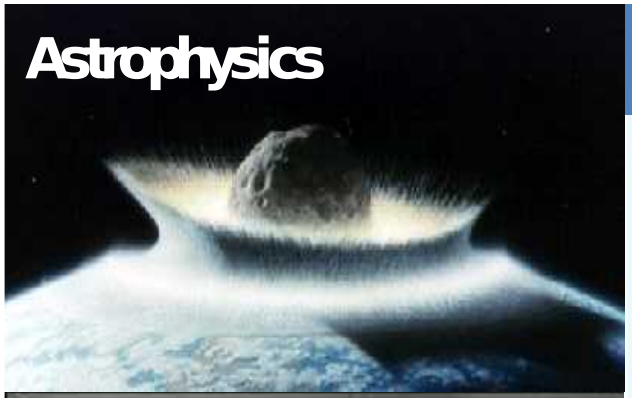
Tools to assist in local and remote hospital triage management including photo capture and electronic notification of patient intake to hospitals and the person locater registry

Currently used by the USA National Library of Medicine

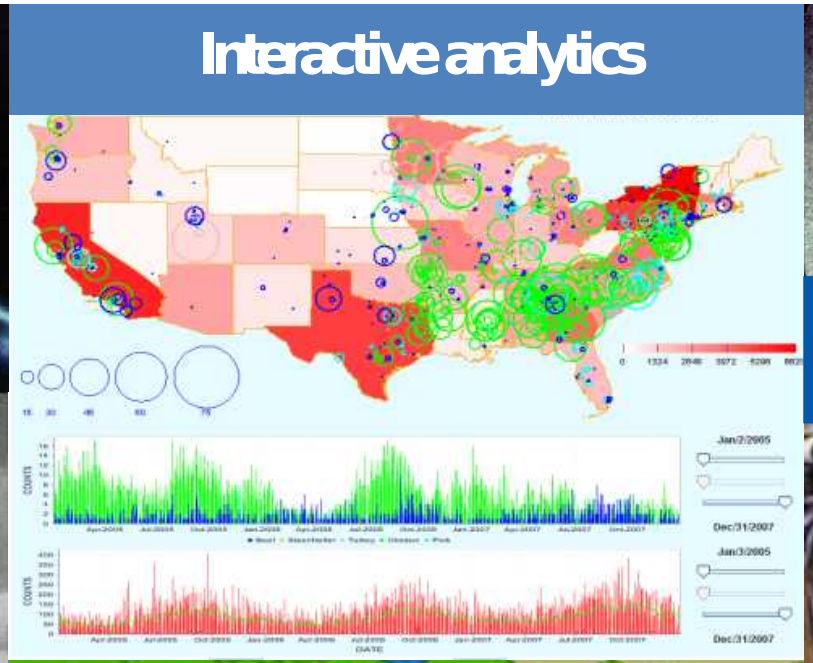
EDXL-HAVE Data Standard

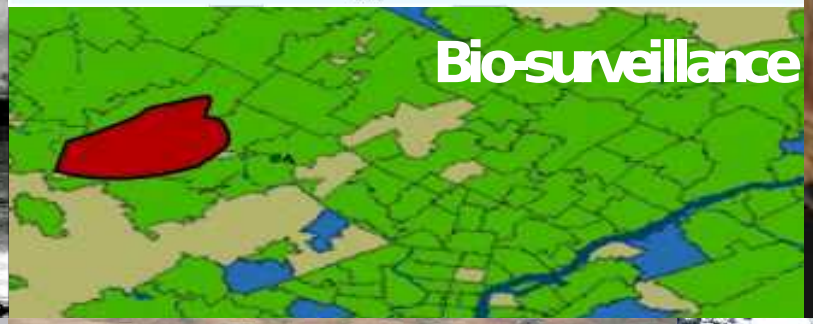
Hospital Info

- Bed Capacity
- Services


Astrophysics

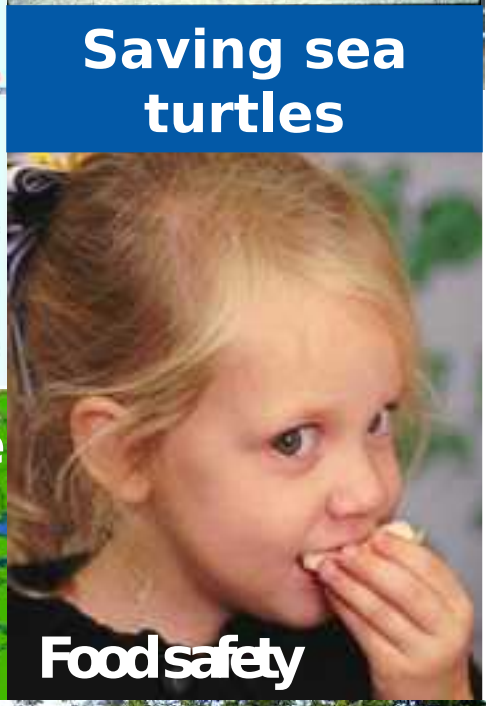

United Nations
CTBTO


Interactive analytics


Bio-surveillance


Nuclear
threat detection


Fleet prognostics

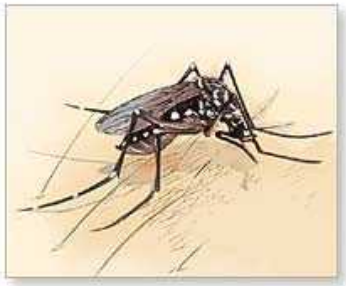

Saving sea
turtles
Food safety


Safety
of agriculture

Early detection and mitigation of common diseases and pandemics

Dengue fever is characterized by:

- Fever
- Rash
- Muscle and joint pains



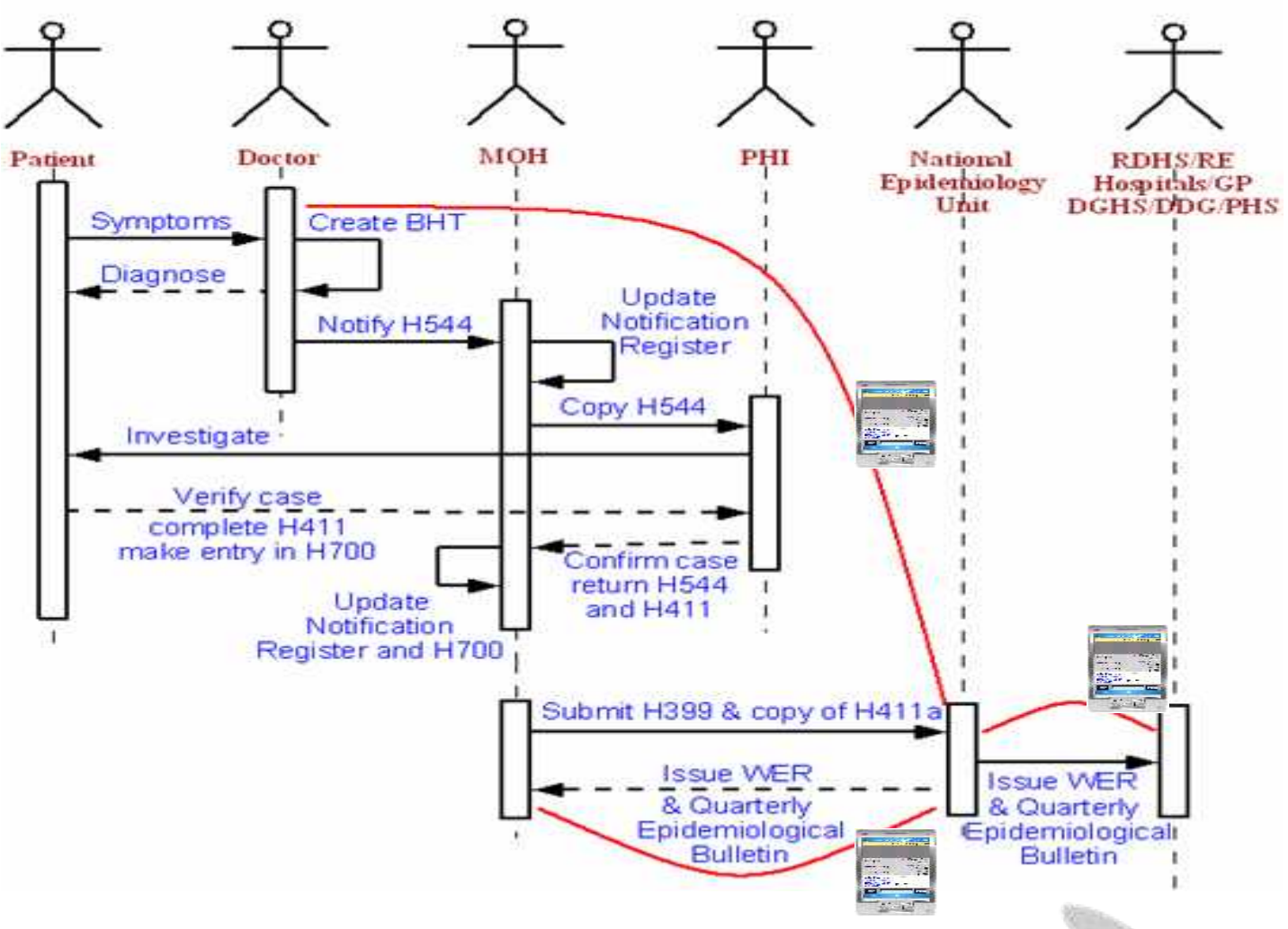
Aedes aegypti mosquito

Real-Time Biosurveillance Program to Revolutionize disease surveillance and notification

Problem the RTBP is trying to solve in Sri Lanka

Reduce 15-30 day delays to Minutes

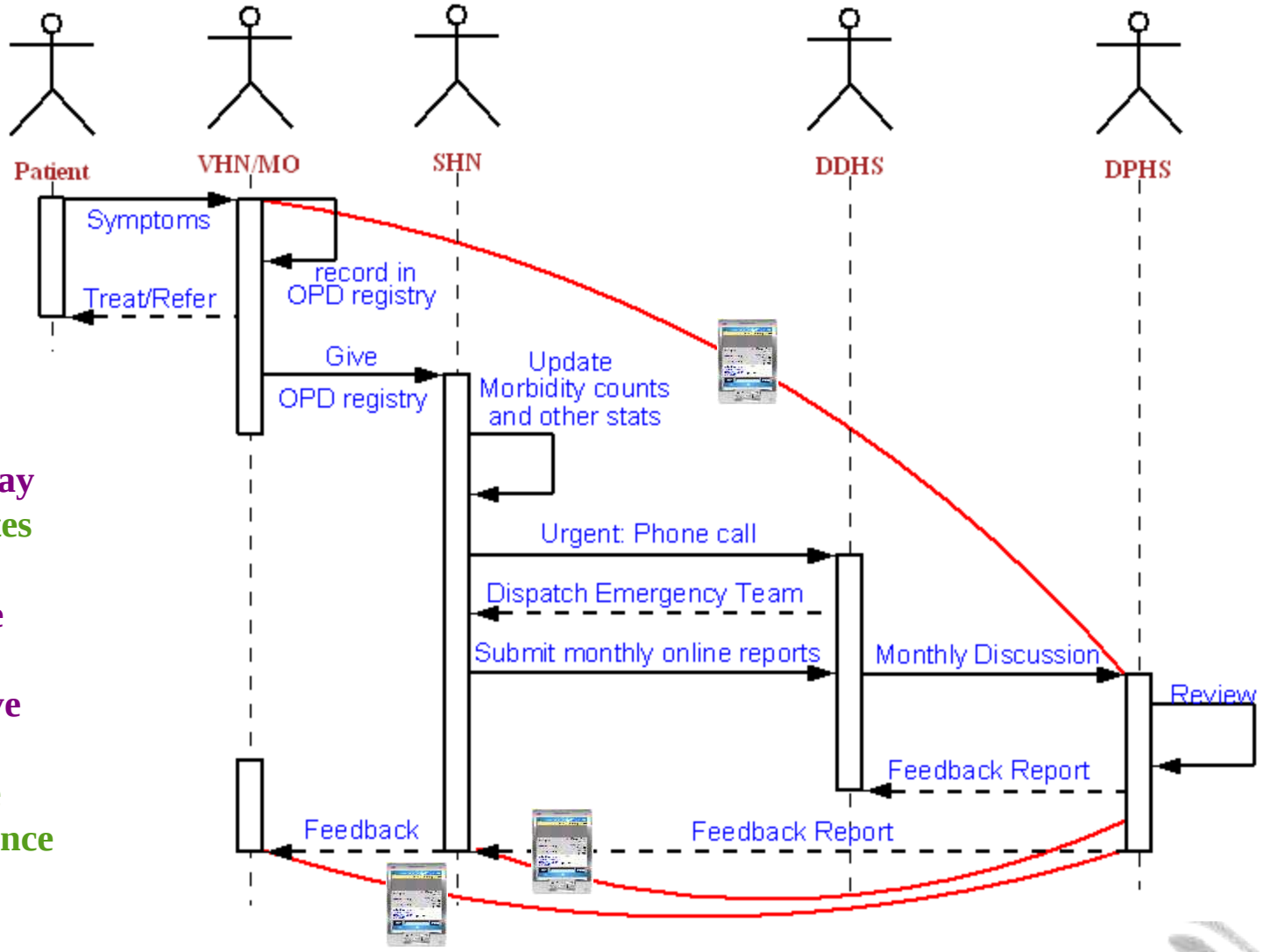
Re-engineer the limited disease activated passive surveillance to Comprehensive Active surveillance



Black arrows: current manual paper/postal system for health data collection and reporting

Red lines: RTBP mobile phone communication system for heath data collection and reporting

Problem RTBP is trying to solve in India



Reduce 07-15 day delays to Minutes

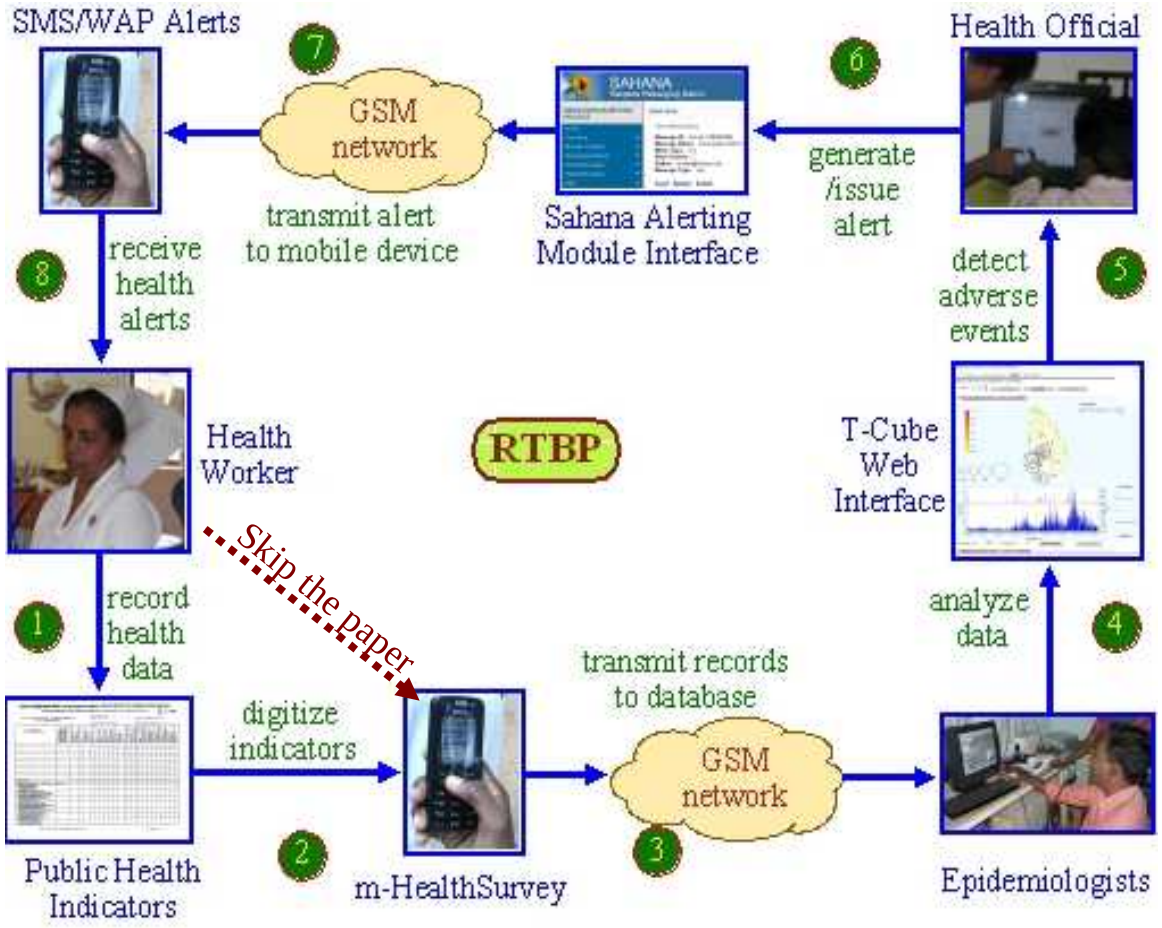
Re-engineer the limited disease activated passive surveillance to Comprehensive Active surveillance

Black arrows: current manual paper/postal system for health data collection and reporting

Red lines: RTBP mobile phone communication system for heath data collection and reporting

RTBP high level system diagram

Actors, processes, and information flow of the proposed data collection, event detection, and situational-awareness/alerting real-time program



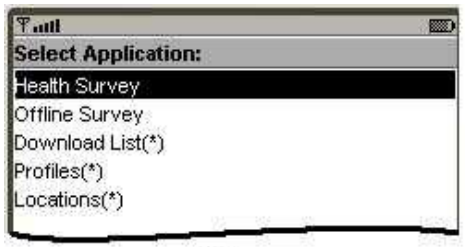
1. Health records digitized by health workers in Thirupathur block using mobile phones.
2. Disease, symptoms, and demographic information transmitted across GSM mobile network to central database.
3. Data analyzed by trained staff at the IDSP and PHC Departments.
4. Automated event detection algorithms process a daily ranked set of possible disease outbreaks, which are presented to IDSP and PHC staff.
5. List of possible outbreaks examined by IDSP and PHC staff to determine likelihood of an adverse event.
6. Confirmed adverse events disseminated to Medical Officers, HIs, nurses, and other health officials, within affected geographic area.
7. Condensed version of the alert pushed through SMS to get immediate attention of the recipients.
8. More descriptive message emailed and published on the web (also accessible through mobile phone).

The pilot in India and Sri Lanka

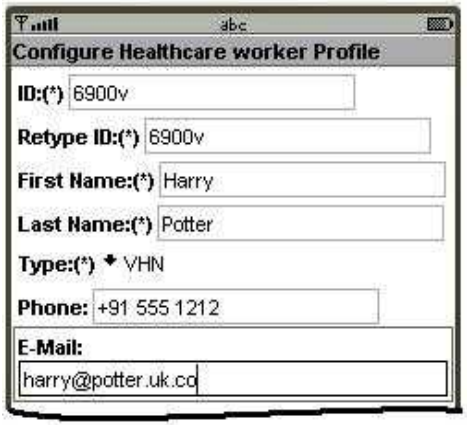
- 12 District/Base Hospitals and Clinics
- 15 Sarvodaya Suwadana Center Assistants
- 4 Medical Officer of Health divisions & 1 Regional Epidemiology Unit
- Kurunegala District, Wayamba Province, Sri Lanka

- 24 Health Sub Center Village Nurses
- 4 Public Health Center Sector Health Nurses, Health Inspectors, and Data Entry Operators
- 1 Integrated Disease Surveillance Program Unit of the Deputy Director of Health Services
- Thirupathur Block, Sivagangai District, Tamil Nadu, India

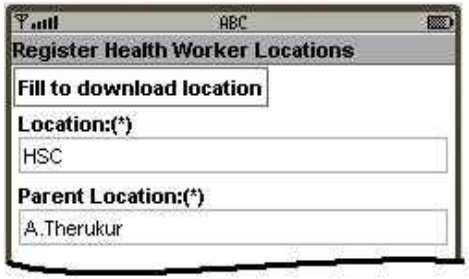
mHealthSurvey mobile phone software



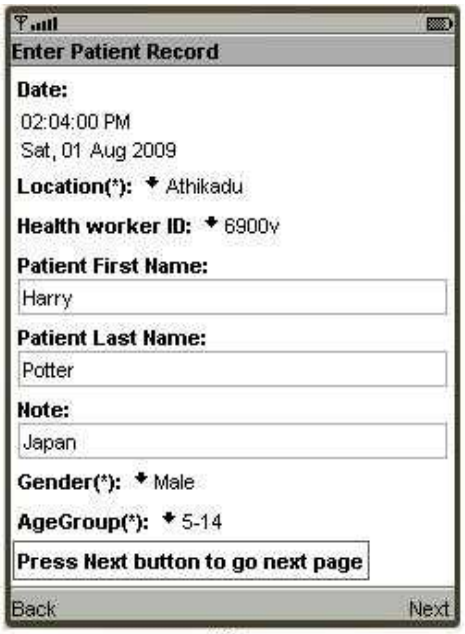
(a)



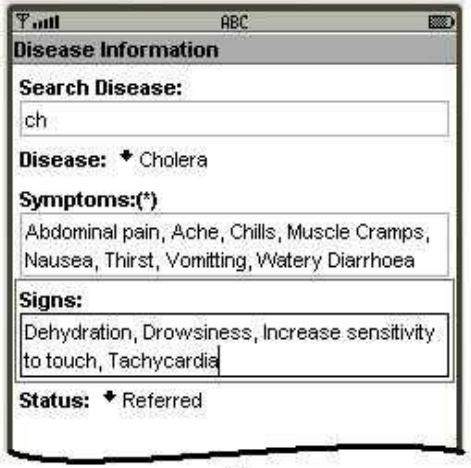
(b)



(c)



(d)

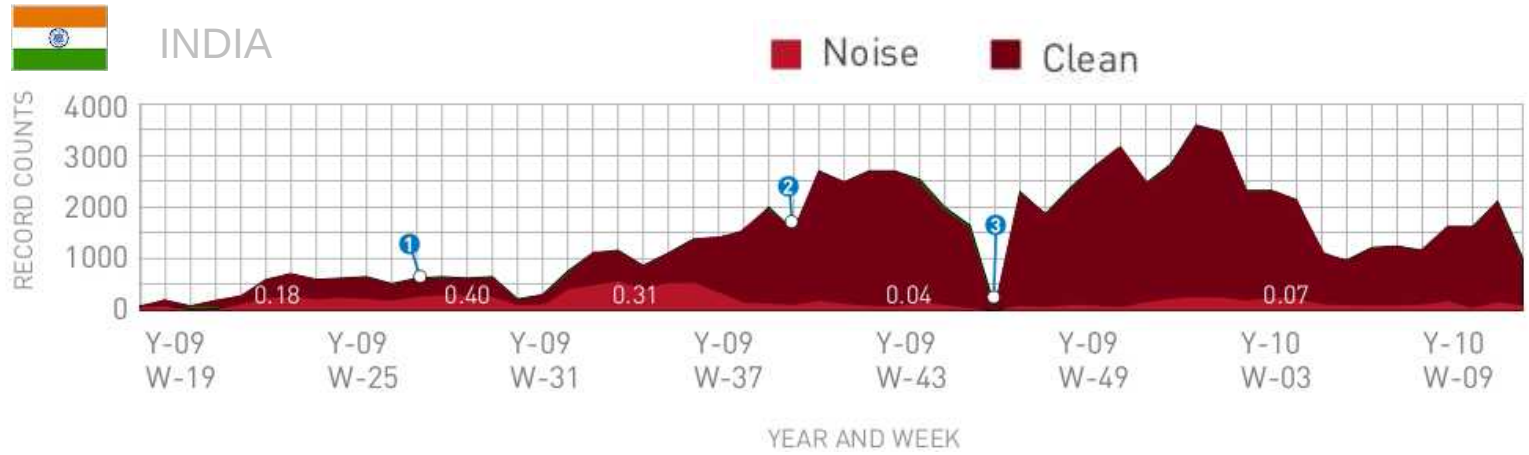


(e)

- (a) Main menu
- (b) Profile registration
- (c) Retrieve locations
- (d) Patient record screen I
- (e) Patient record screen II

Quality of the digitized data

Data quality = Signal to Noise Ratio (SNR); i.e. number records with errors/records submitted



The 23% noisy data in India subsided to less than 4% after informing the consequences of false detections (SNR for sub intervals: 0.18, 0.40. 0.31. 0.04, 0.07)

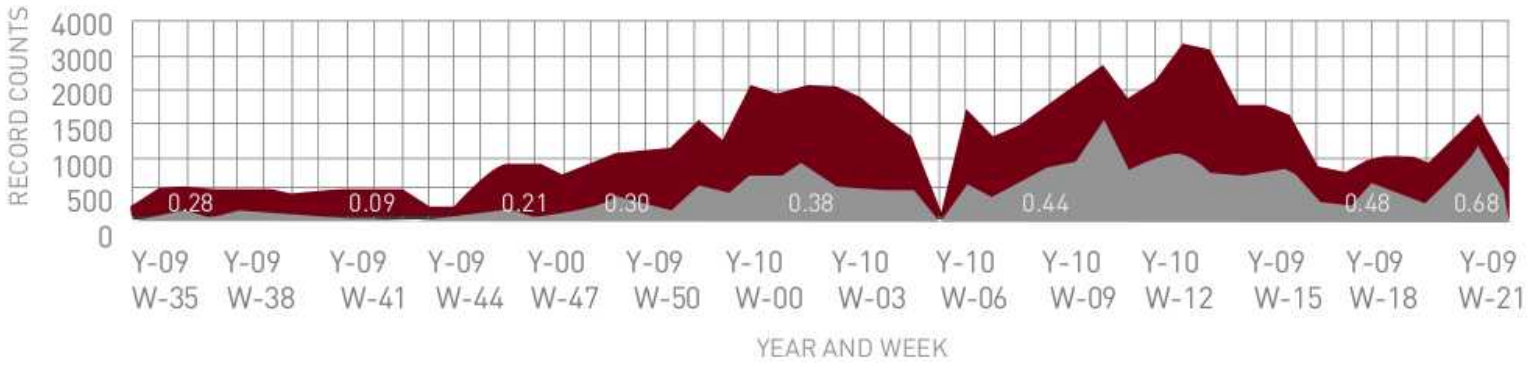
Assistants in Sri Lanka with no formal health training and no affiliation to the hospitals/clinics had no incentive to correct the 45% errors (SNR for sub intervals: 0.58, 0.30, 0.53, 0.57, 0.17)

[1] Low quantities of data received from Health Sub Centers
[2] Volume of records were better after including Primary Health Centers
[3] Holiday effect: no records received
[4] Learning curve getting medical officers to adopt to the new procedures of writing the diagnosis
[5] Release of mHealthSurvey v1.3 with better predictive text

Timeliness of data submission

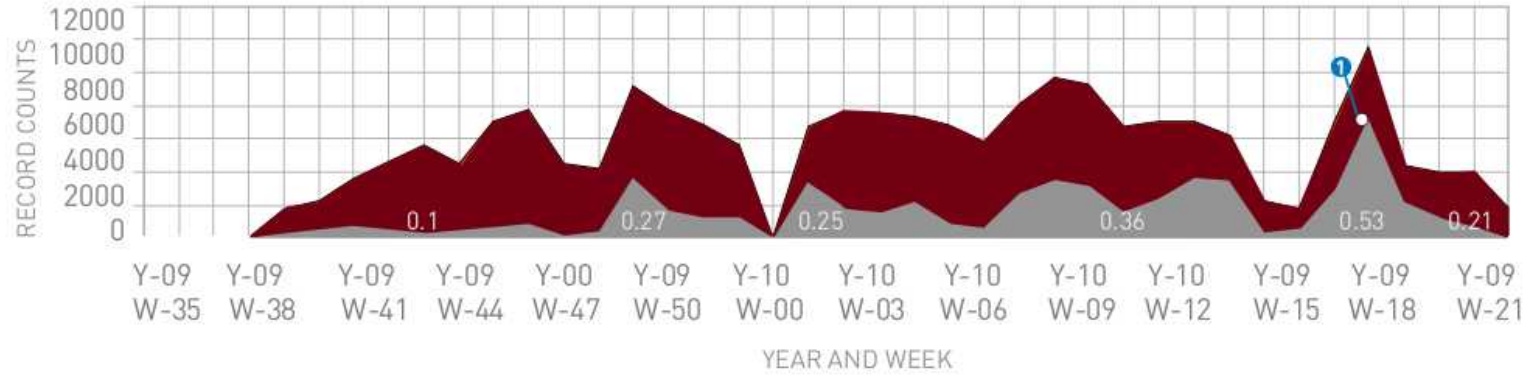
Timeliness = submitting the patient's record the same day as the patient visitation

INDIA



Finding time to complete the records without disrupting current work flow was a significant barrier for real- time data submission (sub interval delay rates 0.28, 0.09, 0.21, 0.38, 0.44, 0.48, 0.68)

SRI LANKA



Data entry assistants have no other role besides digitizing records but see delays proportional to the patient visitation counts (sub interval delay rates: 0.10, 0.27, 0.25, 0.36, 0.53, 0.21).

[1] Users with dysfunctional phones where sharing and were sending data on the weekends or when friends phone was available for borrowing

Data digitization: Some Feedback

"Integrated Disease Surveillance Program Data Entry Operator and Data Manager **fear they will lose their jobs** if mHealthSurvey and TCWI are introduced. At present these staff members receive phone calls from all health facilities and enter the data in spreadsheets of tabulation of weekly aggregates." - Senior Project Officer, RTBI, India (19.08.10).

"Data digitizing **nurses in India and assistants in Sri Lanka invest their own resources to repair and replace ill-fated mobile phones**." - Field Coordinator, Rural Technology and Business Incubator, India, consulted 18-December-2010 and Field Coordinator, Sarvodaya, Sri Lanka, consulted (26.04.10).

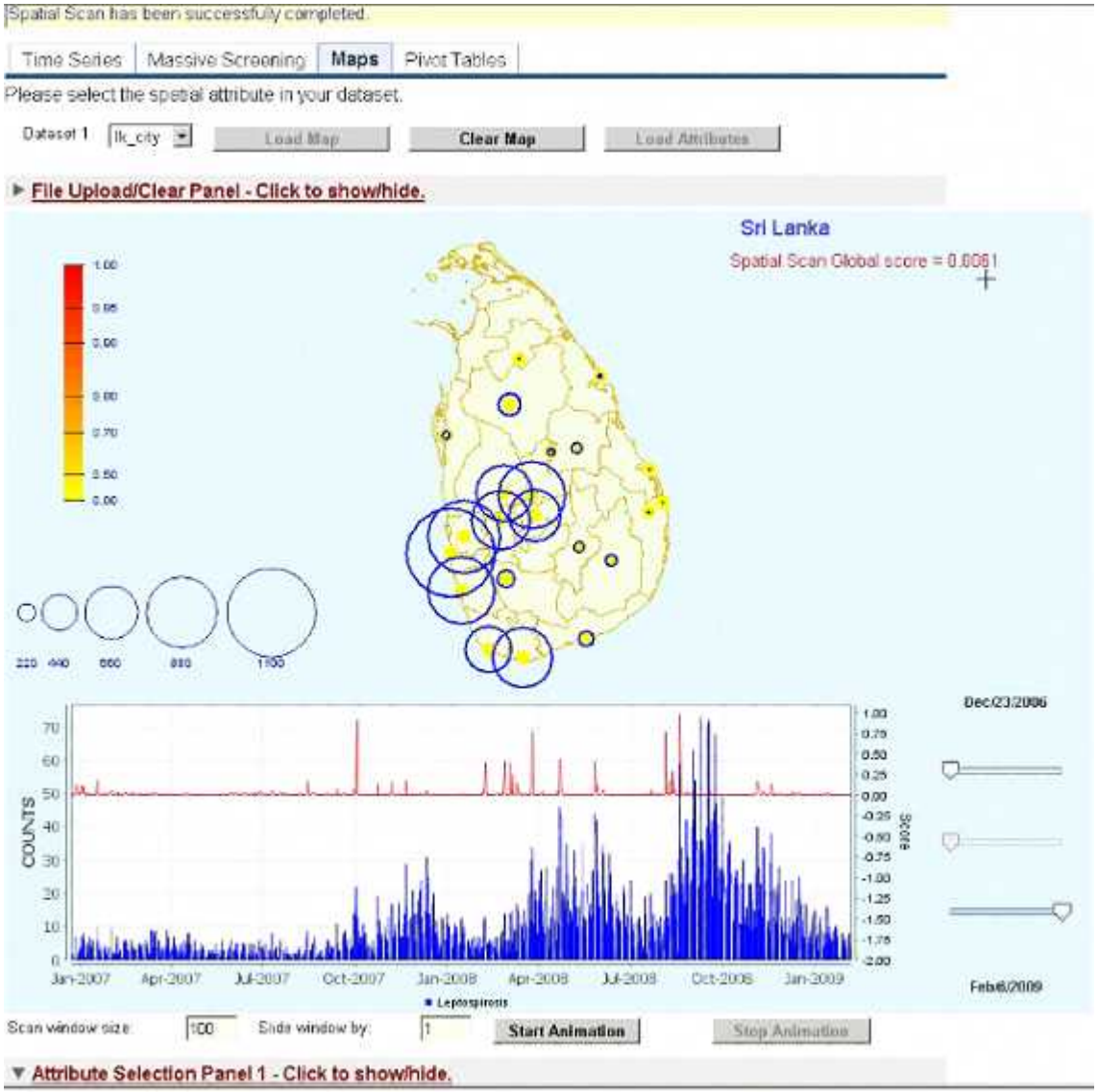
"In the present day setup in Sri Lanka, most of the surveillance data comes from Inward admissions and **it is important that the data collection is expanded to the Outpatient Departments** as in the case of this project." - Wayamba Provincial Director of Health Services, Sri Lanka, consulted (05.04.10).

"Sarvodaya Suwadana Center (primary health center) assistants in Sri Lanka have **formed a social network** to keep each other informed of escalating health situations in their communities" - Field Coordinator, Kurunegala District, Sri Lanka, consulted (06.10.10).

"For notifiable disease cases, **digitizing the patient's name and address is important** for house investigations." - Village Health Nurse (Keelsevalipatty), workshop report, Sivaganga District, India, consulted (01.10.10).

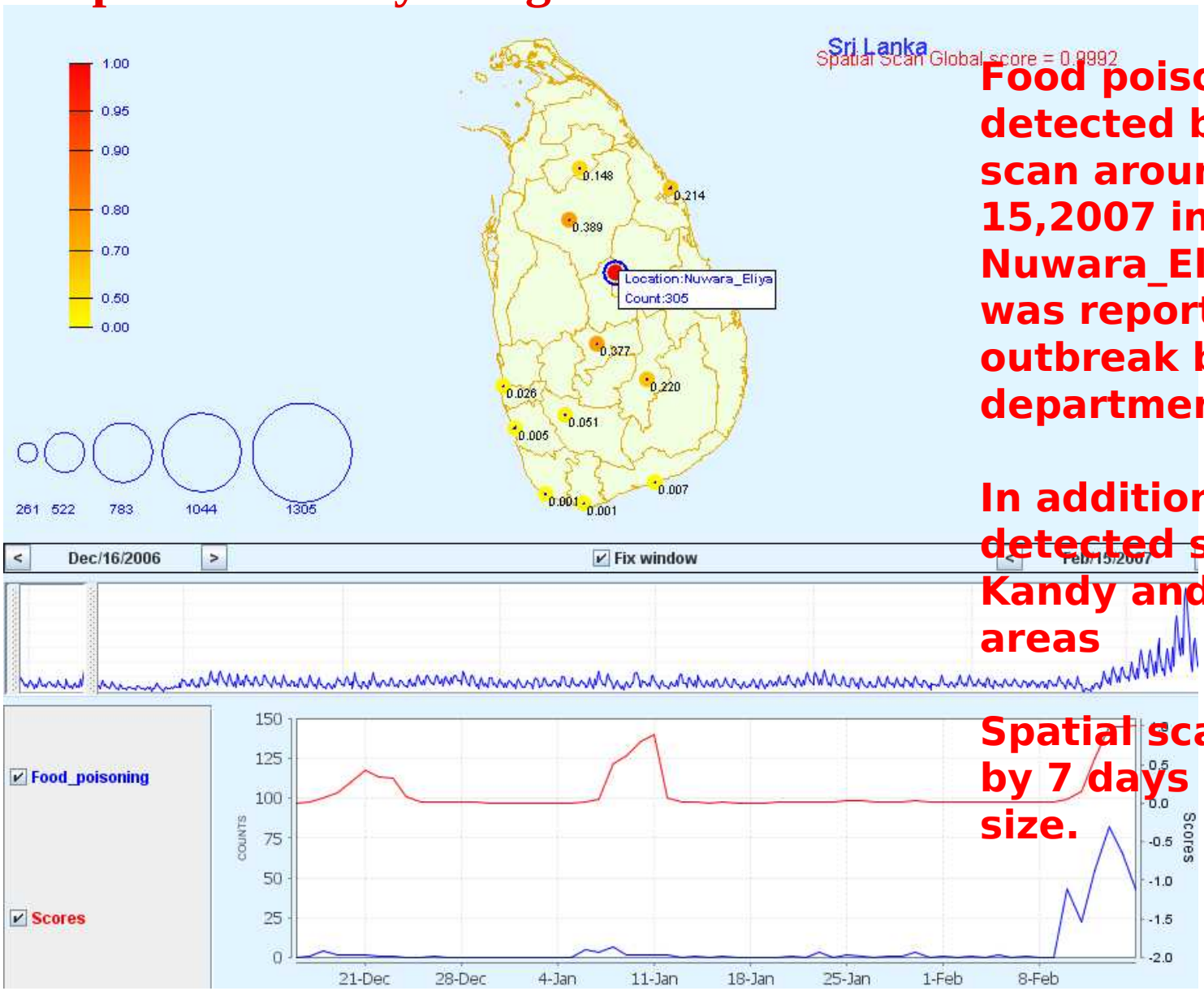
"It was easier for central officials in Chennai and New Delhi to **monitor our individual statistics and performance** opposed to scanning through paper or aggregated for the same; therefore, we are afraid to digitize data." - Village Health Nurses (Nerkupai), Sivagangaga District, India, consulted (29.09.10).

T-Cube Web Interface (TCWI)



- AD Tree data structure
- Trained Bayesian Networks
- Fast response to queries
- Statistical estimations techniques
- Data visualization over temporal and spatial dimensions
- Automated alerts

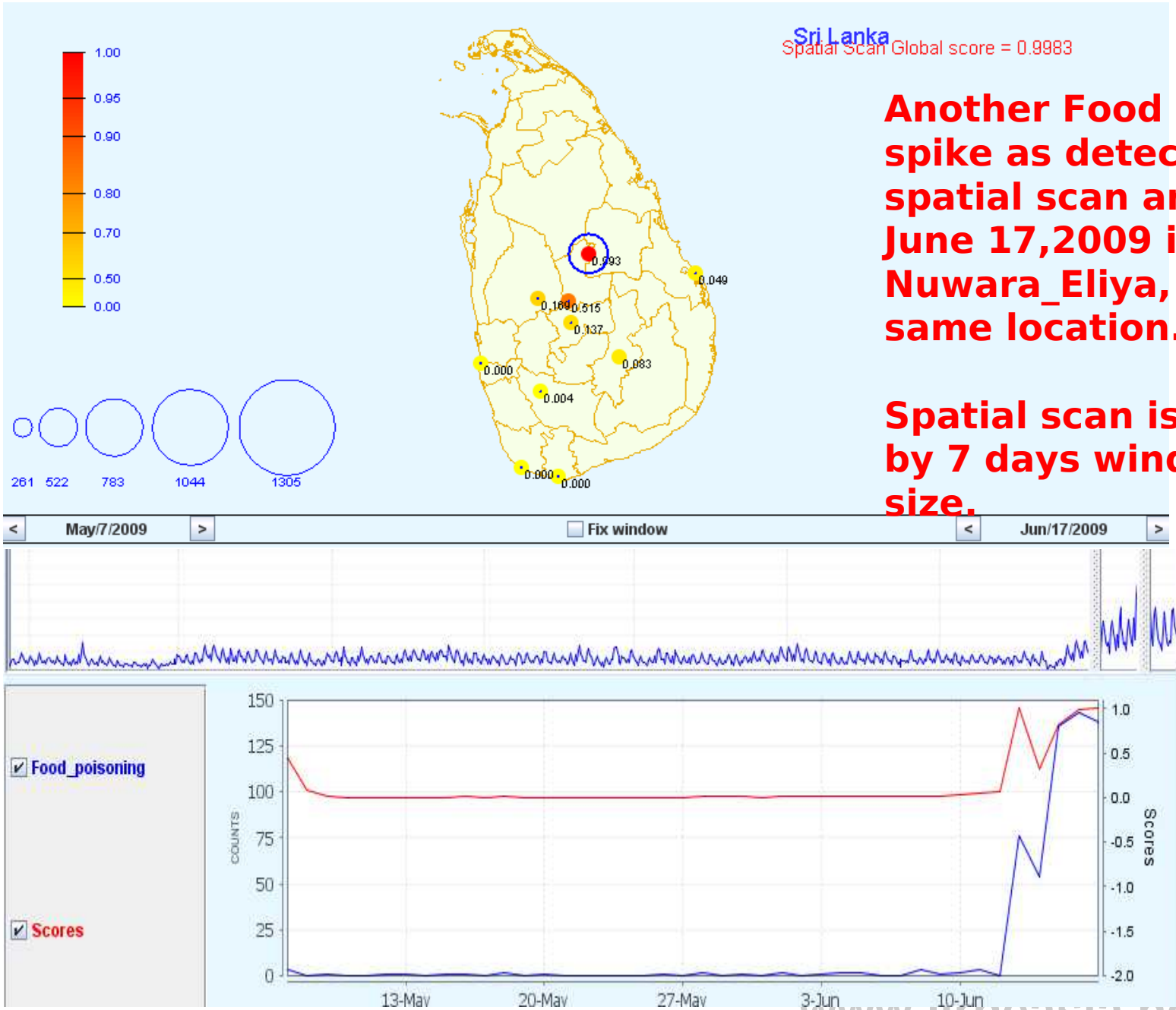
Replication study using Sri Lanka WER data 2007 - 2009



Food poison spike as detected by spatial scan around Feb 15,2007 in Nuwara_Eliya, which was reported as outbreak by health department.

In addition TCWI detected spikes in Kandy and Vauvniya areas

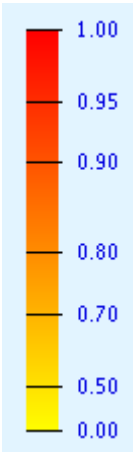
Spatial scan is run by 7 days windows size.

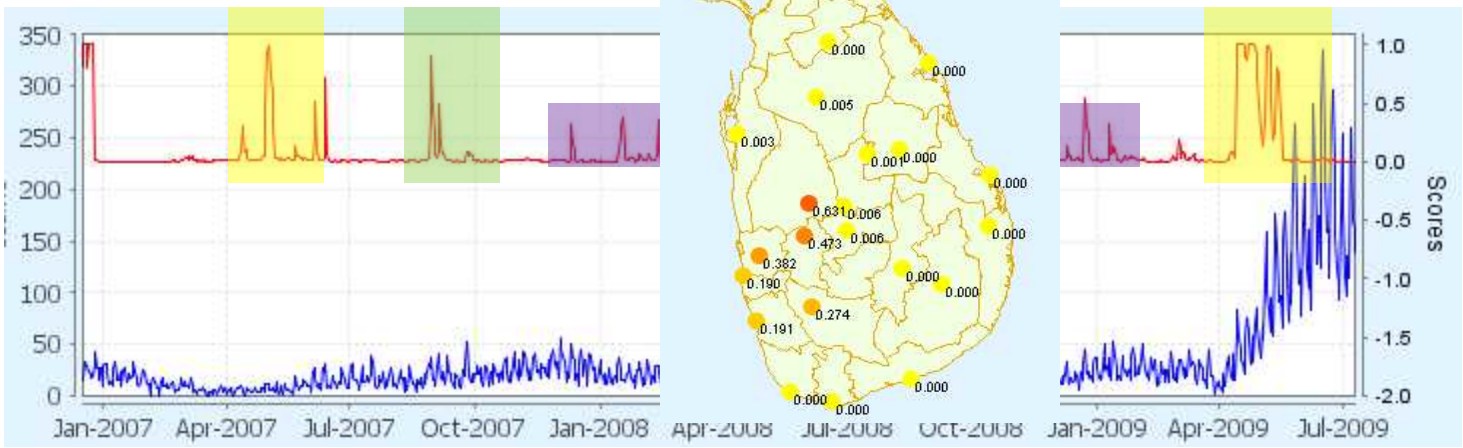


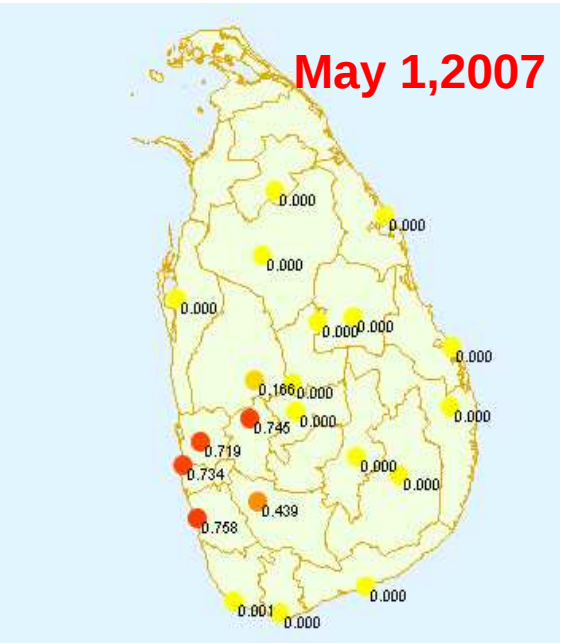
Another Food poison spike as detected by spatial scan around June 17,2009 in Nuwara_Eliya, the same location.

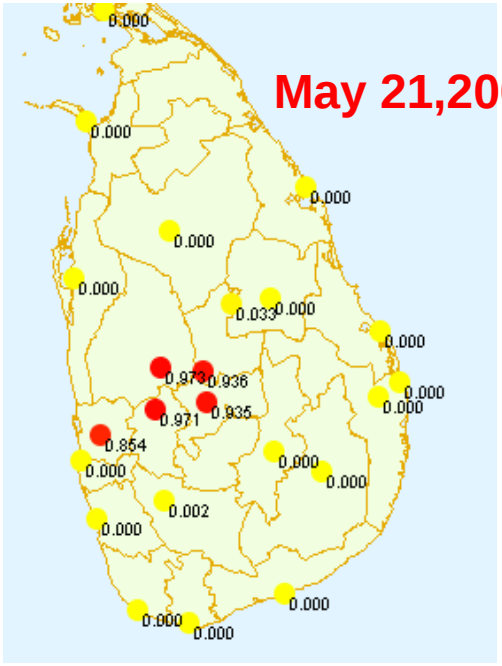
Spatial scan is run by 7 days windows size.

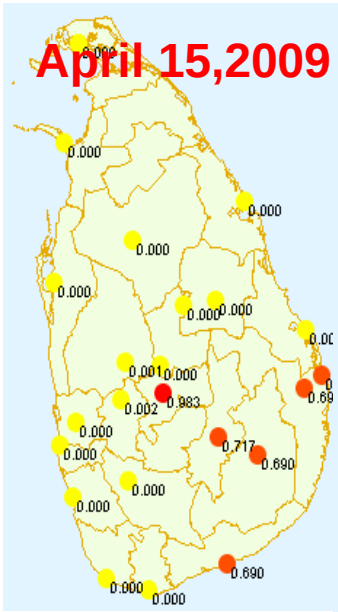
Dengue Fever
Seasonal and spatial pattern

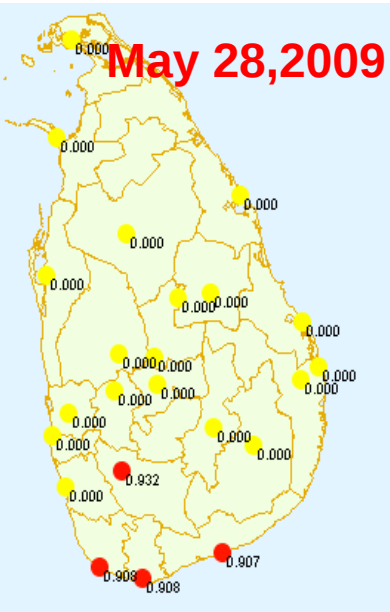




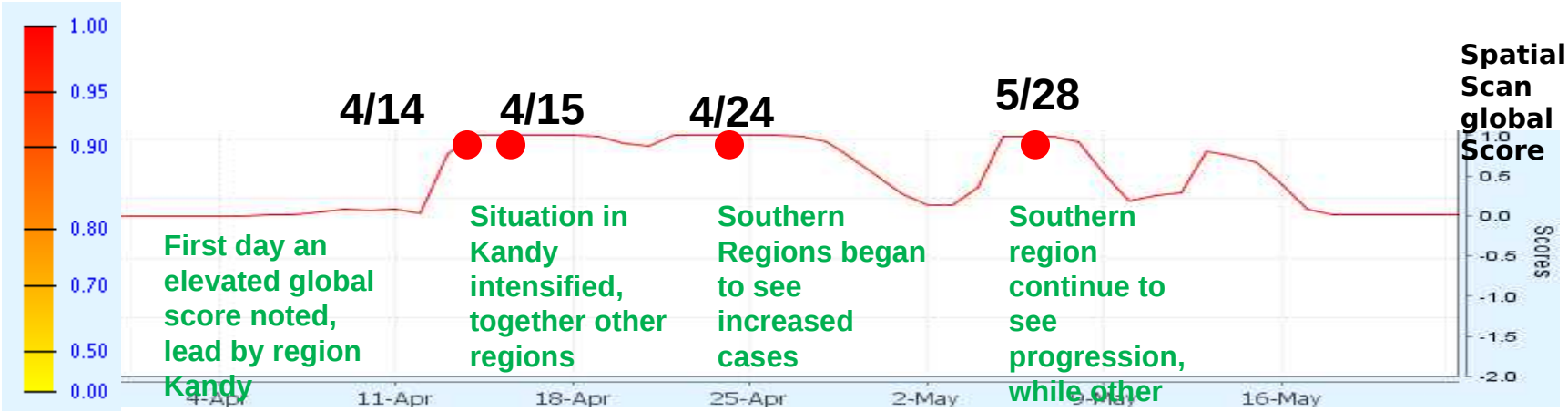


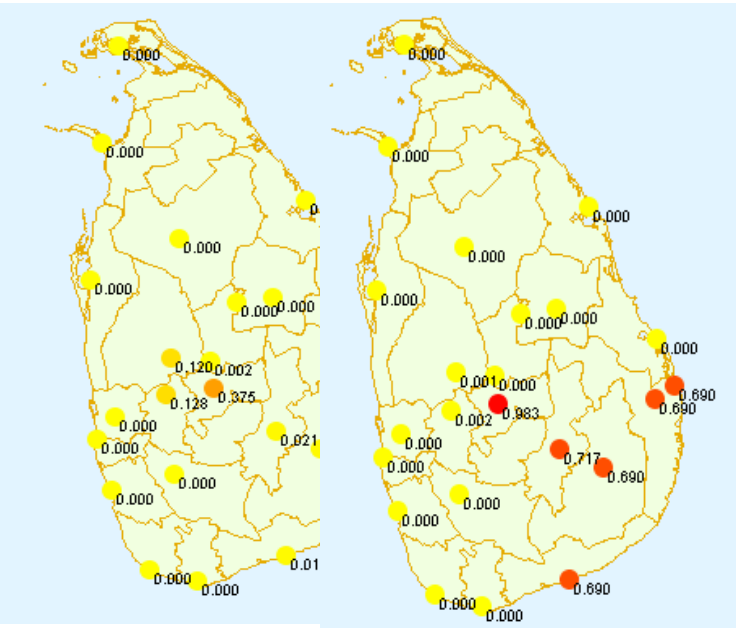


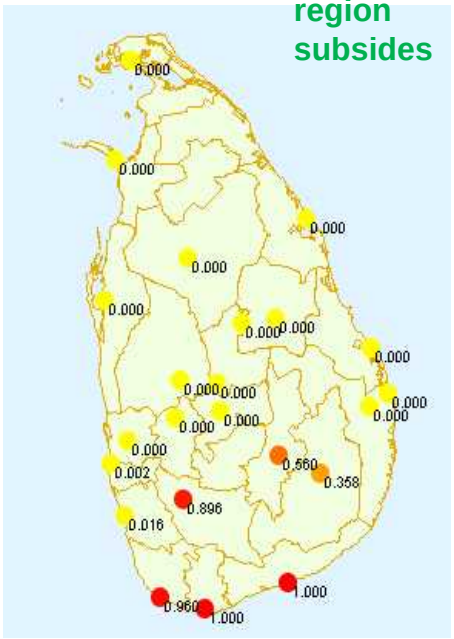


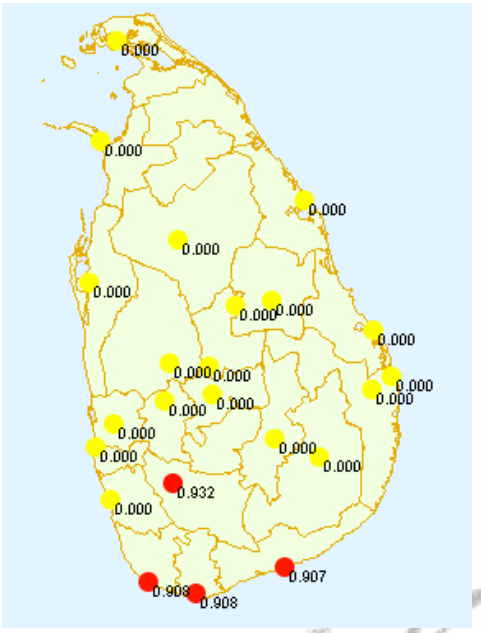


Progression of Dengue Fever outbreak in April – June 2009





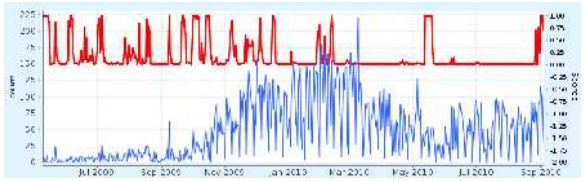




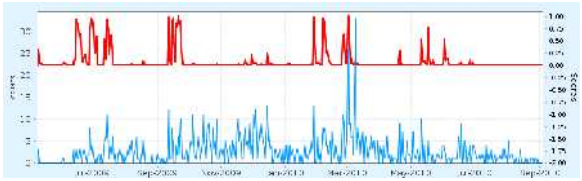
Most frequently occurring wide spreading infectious disease outbreaks

These findings are from TCWI's spatial scan algorithms

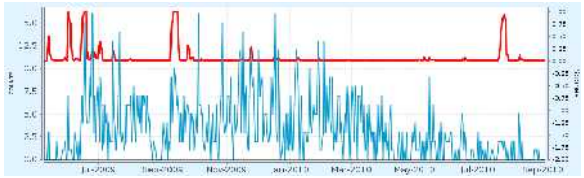
Common Cold, Sivaganga District – India, 18 outbreak episodes to date with over 23,188 cases.



Worm Infestation, Sivaganga District – India, 13 outbreak episodes to date with over 1,236 cases.

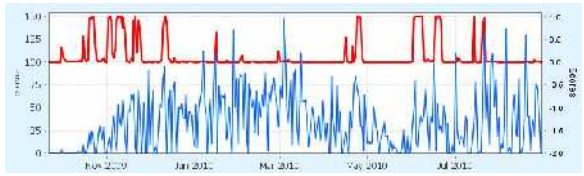


Dysentery, Sivaganga District – India, 5 outbreak episodes to date with over 1,541 cases.

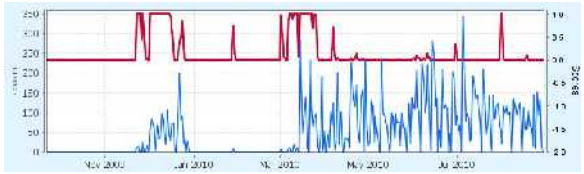


Common cold is the most popular but gastrointestinal infectious are, relatively, the most visible

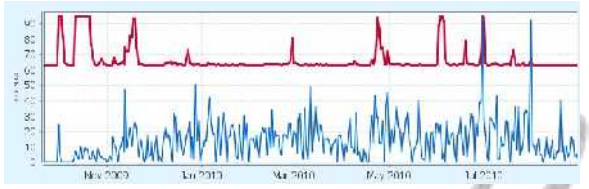
Cough, Kurnegala District – Sri Lanka, 11 outbreak episodes to date with over 12,100 cases.



Respiratory Tract Infection, Kurnegala District – Sri Lanka, 09 outbreak episodes to date with over 18,547 cases.



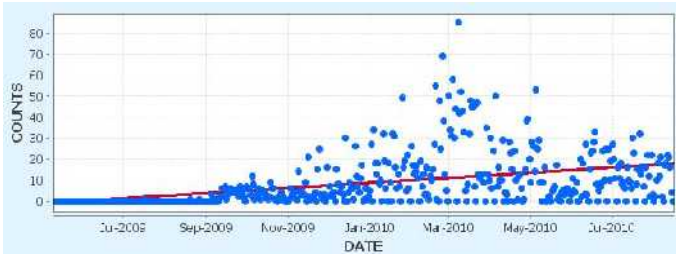
Tonsilitis, Kurnegala District – Sri Lanka, 07 outbreak episodes to date with over 5.086 cases

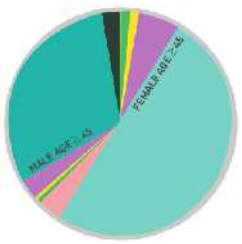


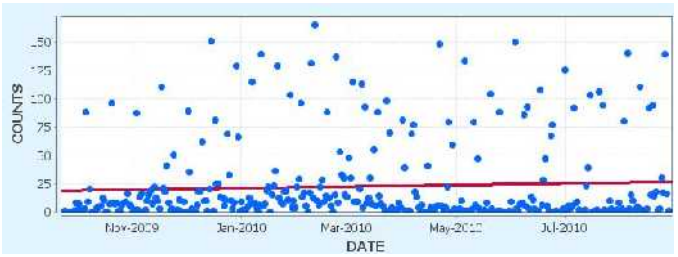
Respiratory infectious diseases, a correlated with environmental factors, are the most common

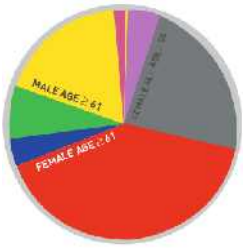
Trends in selected Chronic disease

These findings are from TCWI's statistical estimation and pivot table analysis methods

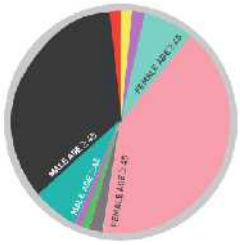


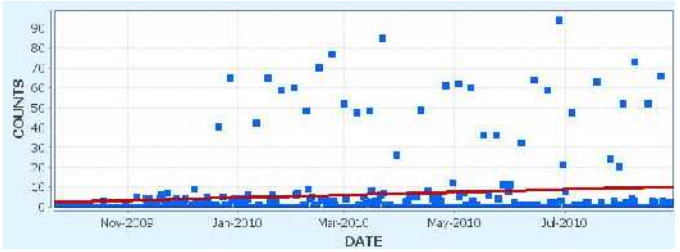


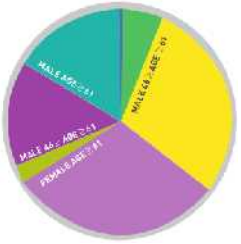




Hypertension (High Blood Pressure) has a linearly increasing trend over the one year period in both countries with Females and Males over 45 years of age showing to be the most vulnerable. The dtrend in India shows an unusual increase between March and May 2010; while the reported cases are consistent throughout the year in Sri Lanka.





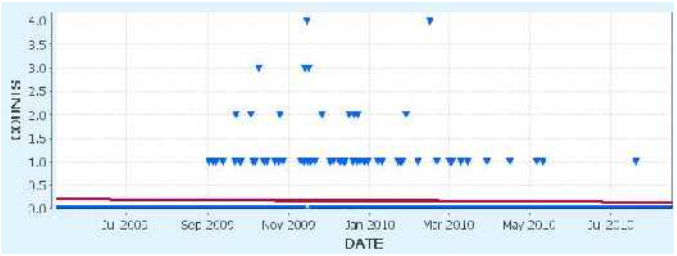


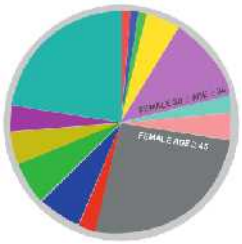
Diabetes-Mellitus has a linearly increasing trend over the one year period in both countries with Indians over 40 years of age and Sri Lankan over 45 years of age to be the most vulnerable groups.

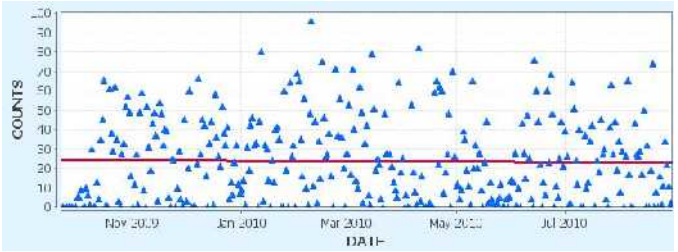
Given that the Male to Female ratios, approximately, in Tamil Nadu, India and Kurunegala, Sri Lanka are both 1 : 1; statistics to date show females to be more susceptible to the above mentioned life style diseases.

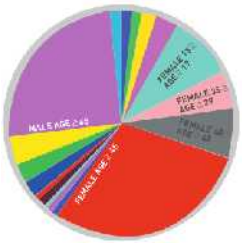
Trends in selected Chronic disease

These findings are from TCWI's statistical estimation and pivot table analysis methods

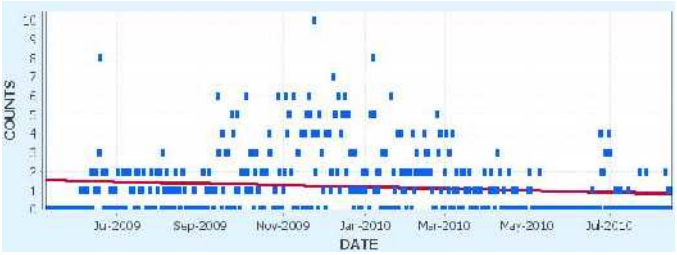


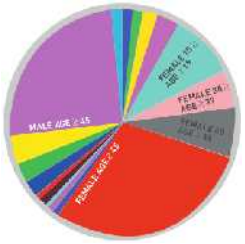






Arthritis and Rheumatoid-Arthritis has a linearly stagnate trend over the one year period in both countries with Males over 45 years of age and Females over 35 years of age to be the most susceptible in India; similarly Males over 45 and Females over 31 years of age to be the most vulnerable groups.





Asthma has a linearly decreasing trend over the one year period in both countries; the dtrend shows the counts to increase during the rainy season, India: Sept'09-Jan'10 and Sri Lanka: Nov '09-Jan '10. In India, only males over 45 years of age are affected but females in all age groups are affected. Both Male and Female over 31 years of age are in Sri Lanka are equally vulnerable.

Given that the Male to Female ratios, approximately, in Tamil Nadu, India and Kurunegala, Sri Lanka are both 1 : 1; statistics to date show females to be more susceptible to the above mentioned life style diseases.

T-Cube Web Interface: Some Feedback

"We can use this rich and comprehensive dataset and analysis tools for our annual planning, now our planning relies on professional perception and not necessary data."

- Deputy Director Planning, Kurunegala District, Sri Lanka, Consulted (06.10.09)

"Epidemiologists want TCWI to facilitate the old ways of monitoring outbreaks based on thresholds opposed to statistical significance. For example, a single case of Malaria is regarded as an outbreak in India, which requires response actions."

- Deputy Director of Health Services, Sivaganga District, India, Consulted (19.12.09).

"It is important to monitor escalating fever cases, notifiable disease cases, and common clusters of symptoms."

- Regional Epidemiologist, Kurunegala District, Sri Lanka, consulted (19.12.09).

"Medical Officers, Nurses, Health Educators, etc, who are interested in learning of outbreaks see the benefit and are happy with TCWI detection analysis methods but the staff at the Integrated Disease Surveillance Program are not ready to accept change and want to stick to the traditional system unless state or national level Authorities mandate it."

- Senior Project Officer, RTBI, India, consulted (19.08.10).

T-Cube Web Interface: Some Feedback

"Pharmacists' perceptions are such that a separate computer should be given for detection analysis and they do not want to share their computers, which are used for medicine and birth information."

- Senior Project Officer, RTBI, India, Consulted (08.07.2010).

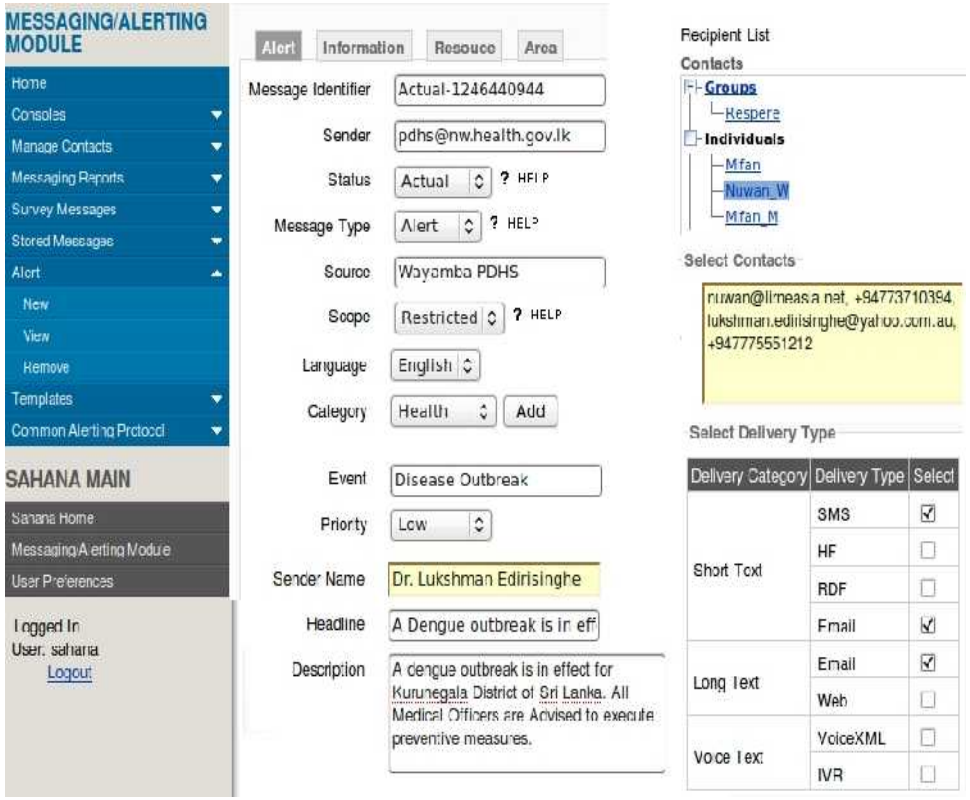
"RTBP's real-time biosurveillance capabilities will enhance the present day passive or non-active passive surveillance to an active surveillance system."

- Wayamba Provincial Director of Health Services, consulted (07.07.10).

"All cases can be viewed in TCWI in real-time for detecting outbreaks swiftly, which otherwise would take several days before the hospitals/clinics send the notification paper forms, by which time the patient may be dead or discharged."

- Public Health Inspector, Wariyapola, Sri Lanka, consulted (26.04.10).

Sahana Messaging/Alerting CAP/EDXL Broker by Respere



- Single input multiple output engine; channeled through multiple technologies
- Manage publisher /subscribers and SOP
- Adopt PHIN Communication and Alerting Guidelines for EDXL/CAP
- Relating the template editor with the SMS/Email Messaging module
- Do direct and cascading alert from a regional jurisdictional prospective
- Designing short, long, and voice text messages
- Addressing in multi languages

Example of style sheet template for SMS

<***headline***> : <***status***>

<***msgType***> for <***areaDesc***> area with <***priority***> priority <***event***> issued by <***senderName***>.

Msg: <***identifier***> sent on <***sent***>

Desc: <***description***>

More details

Web: <***web***>

Call: <***contact***>

Example output of style sheet generated SMS

Escalating mumps in Kurunegala district : ***Exercise Update*** for ***Wariyapola-PHI*** area with ***low*** priority ***notifiable disease outbreak*** issued by ***Dr Hemachandra***.

Msg : ***nwpdhs-1281246871*** sent on ***2010-08-08 11:08:57***.

Desc : ***2 cases of Mumps for 15-20 age group and all genders were reported in Munamaldeniya.***

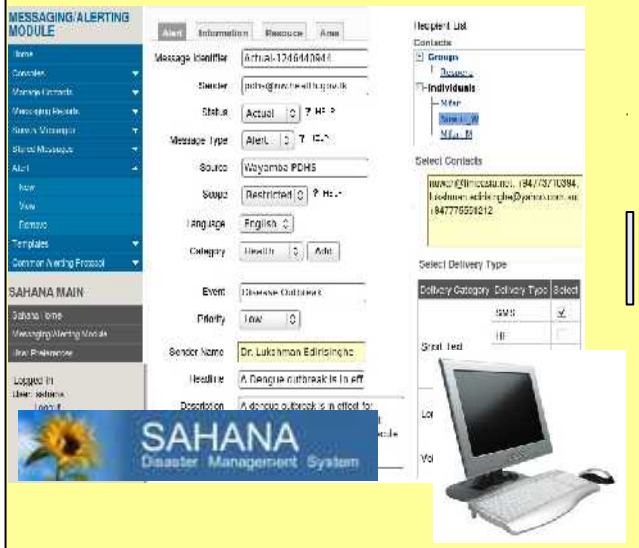
More Details

Web ***www.scdmc.lk***

Call ***2395521***

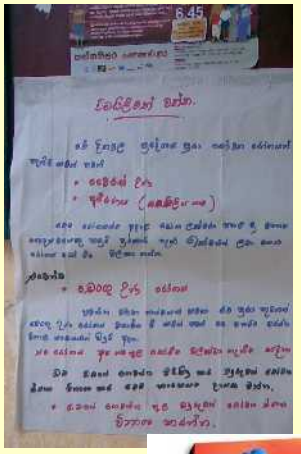
CAP short/long text Message delivery methods

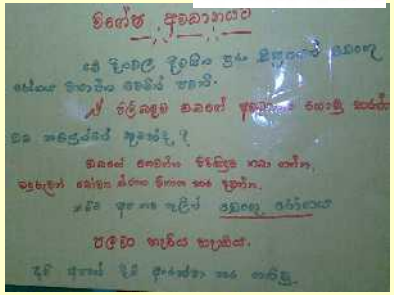
Government
Regional Epidemiology and Medical Officer of Health departments



Government
Regional Epidemiology and Medical Officer of Health departments

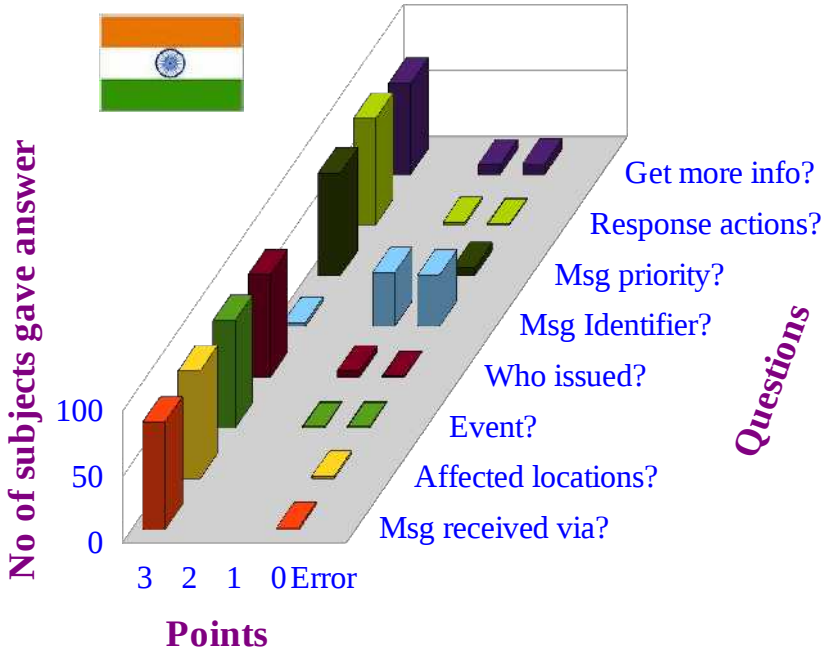
Community
Suwadana Health Centers

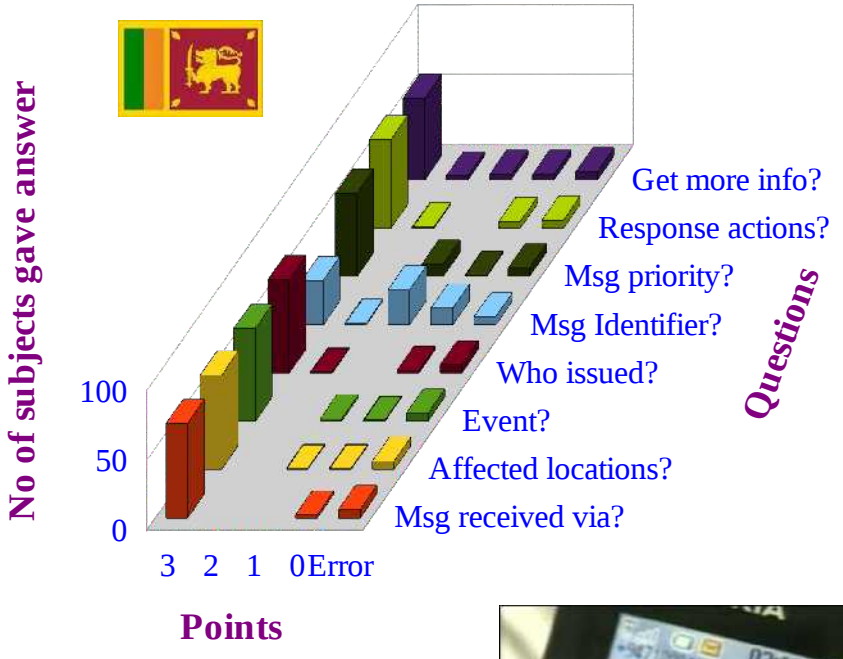




Single Input Multiple Output Mass Messaging; towards a publisher subscriber model

CAP SMS Alert/Situ-aware comprehension exercises





Assessment design

- Participants receive 4 SMS text with varying values of the CAP attributes
- India = 23 and Sri Lanka = 19 health workers participated in the exercise

Outcomes

- Everyone did quite well in the exercises except for 1 or 2 exceptional cases
- Both India and Sri Lanka having trouble with msg-identifier; could be because msg-identifier getting truncated by the 160 char SMS constraint
- Recommendation :: put msg- identifier in subject header (but may cutoff rest due to 160 char SMS); use the term “reference number” instead or both

Sahana Alerting Broker: Some Feedback

"Sahana messaging is a **quicker and easier method** for alerting multiple medical officer and public health inspectors at once, it is user friendly, and is capable of tracing the alerts to follow up." - *Public Health Inspector, Kurunegala District, Sri Lanka, consulted (15.05.10).*

"In addition to issuing outbreak alerts, Sahana Alerting is **being improvised to send notifiable disease investigation information** to Public Health Inspectors." - *Public Health Inspector, Kurunegala District, Sri Lanka, consulted (15.05.10).*

"Currently Medical Officer of Health departments already have a computer and Internet, also mobile phones are available with all Public Health Inspectors, Nurses, and Medical Officers, there is **no chance of misplacing the records** because it will be on the mobile; it is also very cost effective." - *Public Health Inspector, Kurunegala District, Sri Lanka, consulted (15.05.10).*

"Outbreaks such as Dengue Fever should be **disseminated to public and private general practitioners** in those areas because patients with fever like symptoms are not prescribed Non-steroidal Anti-inflammatory Drugs at the first visit and are subject to full blood counts on the 3rd day to confirm whether it is Dengue" - *Medical Officer (Kuliyapitiya), Kurunegala District, Sri Lanka, consulted (12.07.10).*

"Sahana alerting is **similar to "way2sms" free portal** used for disseminating SMS but Sahana alerting **is a comprehensive tool** for issuing standardize warning, alerts, and situational awareness messages." - *Data Entry Operator, Deputy Director of Health Services, Sivaganga, India, consulted (30.09.10).*

TCO macro level costs and the marginal differences

Monthly district macro-costs and percentages for existing paper-based and introduced RTBP

Macro-cost	Existing (IN)		RTBP (IN)		(IN)	Existing (LK)		RTBP (LK)		(LK)
	Cost USD	% of total	Cost USD	% of total	Diff %[2]	Cost USD	% of total	Cost USD	% of total	Diff %
System delivery	5.00	0.02	66.00	0.50	92.42	40.00	0.22	79.00	0.70	49.37
System Admin/support	400.00	1.50	470.00	3.57	14.89	60.00	0.32	525.00	4.62	88.57
Data center	130.00	0.49	236.00	1.79	44.92	283.00	1.53	189.00	1.66	-49.74
Health facility	3,158.00	11.82	8,168.00	61.98	61.34	2,370.00	12.81	8,433.00	74.23	71.90
Health department	16,652.00	62.31	2,359.00	17.90	-605.89	7,120.00	38.47	893.00	7.86	-697.31
Health worker	6,378.00	23.87	1,880.00	14.27	-239.26	8,633.00	46.65	1,242.00	10.93	-595.09

System delivery, system support, and data center costs are < 7% of overall cost; hence the focus of the economic analysis is on the bulk: health facilities, health departments, and health workers

Explanation of marginal difference of RTBP macro cost > 20% than existing system

System delivery :: unable to get actual program design, development, and implementation cost, most likely funded by INGO, however, the per district monthly cost is very small.

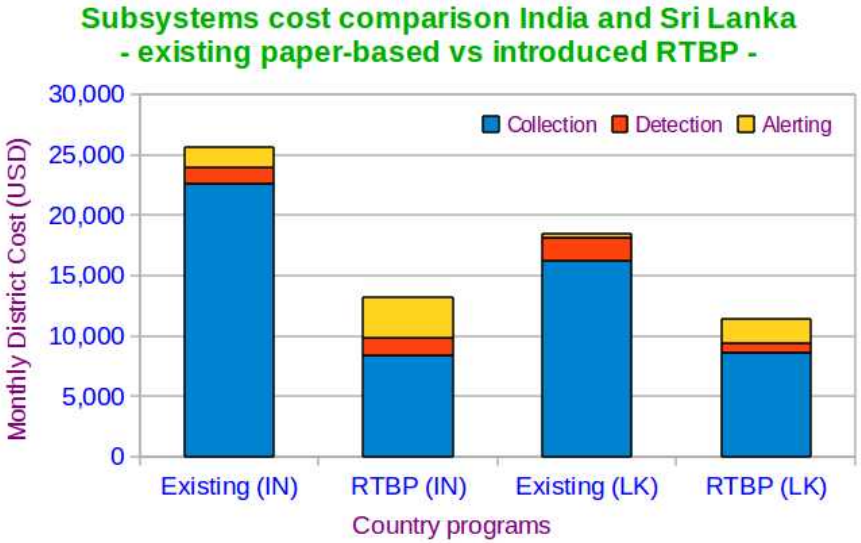
System Admin/Support :: no established budget, each department spends money for repairs as and when needed. RTBP accounts for it.

Data Center :: India – DPH&PM system is one component of several managed by the National Information Center, in comparison to decentralizing the data centers to be managed at districts

Health Facilities :: major portion of the cost is the new human resource bundled with technology for health record digitization

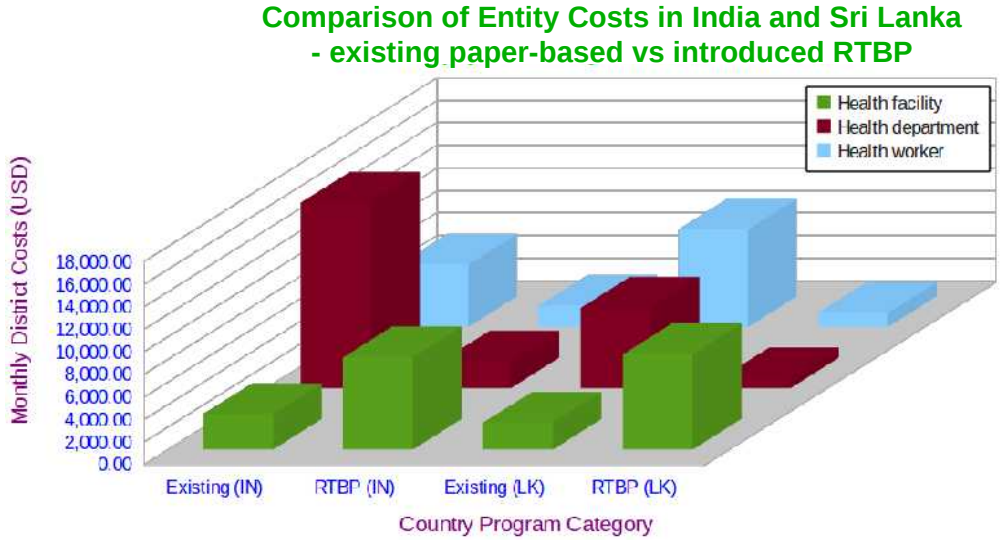
Total Cost of Ownership by function and by entity

Comparison of expenses in relation to the data collection, event detection, and alerting components



- Investments are very little or none on real-time event detection and alerting, ~ **88% in data collections**
- RTBP **can reduce TCO > 35%**, moreover, increase timeliness, and introduce rapid detection and alerting
- Existing trend analysis is for long term planning only but with a lot of **replicate data-entry at the various layers**.

Comparison of expenses in relation to the health facility, health department, and health workers



- Digitization at the point of care removes bulk of the work at health department.
- Health facility investments are higher in RTBP because of bundling mHealth with new resource person.
- However, health facility cost increase < health department money saved**; India: 61% < 86%, Sri Lanka: 72% < 87%**
- Introducing new concept of situational-awareness empowers health workers

[Existing (IN) = present system in India (Integrated Disease Surveillance Program); Existing (LK) = present system in Sri Lanka (Disease Surveillance and Notification Program); RTBP (IN), RTBP (LK) = Real-Time Biosurveillance Program in India and Sri Lanka, respectively]

Conclusions

- **RTBP costs are less, benefits are greater, and efficiency gains are higher** than the existing disease surveillance and notification systems
- It's a **comprehensive disease and syndromic surveillance and notification system**, covering communicable and noncommunicable diseases
- Some **laws and regulations must be changed** to replace the legal paper forms and registers with Electronic Health Records (EHR).
- Investing as little as **NU 1.00 per citizen per month** can operationalize and sustain a comprehensive activated disease surveillance and alerting mHealth system in Bhutan

Thank You