ISDS One Health Surveillance (OHS) Case Study

CASE STUDY TITLE			
Dengue Surveillance and Control: One Health Case Study			
PROJECT/ACTIVITY TITLE			
OH-Viewer: A Versatile One Health Surveillance Toolset for Epidemic Prediction, Counter-Measures Planning and Response Management			
CONTACT INFORMATION			
NAME:	Muhammad Asif Ali, Dr. Muhammad Naeem Ayyaz		
ORGANIZATION:	Centre for System Simulation and Visual Analytics Research (C-SVAR), UET Lahore		
COUNTRY:	Pakistan		
Email:	asif.ali@kics.edu.pk; mna@uet.edu.pk		
WHAT DOMAIN(S) DO YOU WORK IN?	_x__ Human health	_x__ Animal health	__ x _ Environmental health
OHS AREA(S) OF FOCUS ADDRESSED BY CASE STUDY	__x_ Cross-Agency Communication and Collaboration	__x_ Training and Resources	__x_ Technologies and Methodologies
	___Other: ____		

PROBLEM DESCRIPTION (150 word maximum)

Summarize the problem/situation that was addressed with a OHS approach.

Pakistan being a subtropical region is highly susceptible to water-borne, air-borne and vector-borne infectious diseases (IDs). Each year, millions of its people are exposed to, and infected with, deadly pathogens including hepatitis, tuberculosis, malaria, and now-a-days dengue fever (DF). Monitoring and response management to natural or man-made IDs is non-existent in the country due to lack of robust infrastructure for health surveillance. DF outbreaks in 2005-2011 alone resulted in more than 50,000 infections and about 1500 people lost their lives. The Government of Pakistan awarded C-SVAR, UET, Lahore, a research grant in order to develop a nation-wide one health surveillance (OHS) system--integrating humans, animals, vectors, and environment to combat future epidemic threats. The developed system aims at producing high-impact health surveillance by addressing challenges posed by OHS concerning geographical coverage, timeliness and multi-source integration. It relies on collaboration among partnering agencies for effective counter-measures planning and response management.

ACTION TAKEN (500 word maximum)

Describe how the problem was addressed and how the action taken was measured. Please include a description of the collaborators and the data sources used.

We developed a visual-analytics environment (VAE) for OHS employing desktop-cum-mobile computing for real-time ID data acquisition, followed by GIS-based spatio-temporal disease spread modeling, with interactive visualization for counter-measure planning and response management. The system is built to integrate time-evolving (streaming) data from the following collaborators in Lahore: Institute of Public Health (IPH), Government Veterinary Hospital, Mayo Hospital, Ganga-Ram Hospital, and IPH entomological surveillance teams.

OHS toolset captures ID data from emergency departments (EDs) of partnering hospitals, animals' health data from veterinary hospital, weather data from remote-sensing satellites, environmental parameters and vector concentration data from entomological teams. Data from far-flung rural areas is acquired by mobile apps. A centralized database at C-SVAR supports multi-source, multi-modality data capture, integration and analysis. The database stores space-and-time stamped patients' data, chief-complaints, travel-history, and lab-reports, along with the accompanying pets' health status. Environmental attributes encompass land-cover type, habitat location, and geographical risk zones identified in surveys and/or geo-tagged images assimilated from public via mobile apps. Regarding animals' health, information about cattle, poultry, sheep and goats is maintained in terms of their diseases, owner, location, vaccination status, and grazing zones.

VAE of the OHS supports the following:

1) Dynamic syndromic surveillance classifier (DSSC) for spatio-temporal outbreak detection
2) Healthcare resource management for disease control (HRM-DC) activities
3) Simulation models projecting host-vector, host-animal interactions
4) Statistical/Machine Learning models for spatiotemporal disease forecast

OHS work-flow:

For each chief-complaint reported at EDs, DSSC classifies/estimates the syndromic category, far earlier to confirmation by lab reports. Space-and-time specific early-warning hotspots are accordingly signaled. In the case of mild-outbreaks, surveillance teams rush towards the area for vector and larval eradication. For confirmed cases, locality and travel history of patient(s) is analyzed--identifying asymptomatic infections, veterinary inspection, environment and vector surveillance, to determine origin of the disease. We found, for instance, that veterinary inspection didn't reveal any significant signs for DF; however, other IDs were found prevalent in animals, e.g. influenza, asthma, bovine tuberculosis.

ID data, from EDs and simulation results, is fed to decision-support HRM-DC module of the OHS, which infers control activities (sprays, social-distancing, larval-eradication and environment-cleaning) and advises healthcare resources (hospitals, emergency camps, beds, staff and medicine).

Early warning system of OHS is built around advanced machine-learning cum simulation models that generate spatio-temporal alarms for possible vector sites and imminent ID hotspots, based on time-variant weather conditions, geographical risk-zones, and historical disease cases.

For sharing information among collaborators, ID data is routed to VAE at C-SVAR, whose interactive visualizations generate real-time GIS graphics, heat-maps, and choropleth. Evidence based geographical information is passed to the field epidemiologists and entomological surveillance teams that carry out counter-measure activities--like habitat destruction, veterinary inspection, larval and vector eradication.

ID surveillance and response system of the OHS was ready by 2012, and utilized by IPH in 2013 for dengue surveillance. It played profound role in mitigating the epidemic, resulting in much reduced patients' count in 2013 and 2014 (compared to 22,000 cases in 2011). For careful application of OHS, less than 10 cases reported for 2015.

FACILITATORS AND BARRIERS (100 words max each)

Please list and describe any factors that contributed positively to this project/activity.

Entomological and environmental surveillance in the vicinity of disease origin had a significant impact in mitigating disease spread.

Machine-learning and simulation models developed with the help of VACCINE center, Purdue University, USA, provided proactive paradigm for OHS. Consequently, disease control agencies attained advance awareness of the imminent ID threats, across space and time.

Mobile apps, designed to acquire real-time ID data from far-flung rural areas, provided in-time information about environmental hazards, disease prevalence and vector concentration.

Analyzing disease cases with GIS-based spatial queries; VAE successfully predicted and pinpointed geographical hotspots seeking urgent healthcare facilities.

Please list and describe any factors that were a challenge or barrier to overcome.

A major challenge faced by OHS system was lack of complete information pertaining to disease incidence. Some patients start self-medication and/or avail medical facilities from private clinics; as a result, the surveillance system may fail to capture true severity and origin of the disease. Consequently, the corresponding disease control activities may get delayed or misguided.

Currently, there exist no well-defined standards/protocols aimed at one health information sharing among collaborating hospitals, veterinary units and environment-specific organizations.

A reliable animal diseases surveillance system was non-existent in Pakistan, resulting in lack of sufficient information about IDs prevailing among stray animals.

LESSONS LEARNED (250 word maximum)

Please describe any lessons learned or best practices identified by this project/activity.

Surveillance activities, performed with collaboration among the data analysts at C-SVAR, health department epidemiologists, veterinary experts, and entomological survey teams, provide quite accurate picture of ID spread character, i.e. "who acquires infection from whom."

Real-time data acquisition and syndromic classification of chief-complaints (generated at the time of patient registration) alongside patient's travel history enables early outbreak detection, almost one-to-two weeks in advance. This proved useful in environmental surveillance and well-targeted, preemptive operations against disease agents.

Mobile apps allowing submission of geo-tagged images concerning environmental and/or geographical hazards--i.e. contaminated sites, stagnant water zones, and larval breeding sites, inculcated sense of responsibility among public and proved valuable for those responsible for disease control activities.

The GIS-based VAE powered by simulation models proved useful for analyzing multi-source, multi-modality Big data originating in OHS. VAE helps in spatio-temporal alerts generation, input/output information visualization, and efficient management of health resources. Its services to access supervised and unsupervised disease specific features at runtime--to look for their impact on daily life styles, disease spread patterns, and identification of risk groups--proved beneficial in hypothesis forming and testing.

ID specific information (i.e. streaming ED data along with deduced inferences) disseminated in the form of messages and media-alerts contributed positively to raising public awareness about potential epidemics.

In some scenarios, OHS led to profitable discoveries. For example, surveillance teams while tracking the origin of IDs identified some IDs in domestic pets and cattle that were timely cured to curb any further spread.

ADDITIONAL COMMENTS (75 words max)

Summarize the problem/situation that was addressed with a OHS approach.

In 2011, Pakistan saw a dire need to develop a robust and reliable one health surveillance and response infrastructure with capability to collect and analyze time-evolving ID data in real-time.
OH-Viewer is expected to play a key role during an epidemic, when the scarce resources are allocated to different jurisdictions in a data-driven manner. Such a system will strengthen Pakistan's ability to counter epidemic threats by providing novel tools for situational surveillance and response.