A Social Media-based Participatory Epidemiology Approach for Vector-borne Disease Prevention (VBDP) in South Asia

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***Abstract*— Every year millions of people in south Asia and other tropical regions face the threat of vector-borne infectious diseases (VBD) such as Malaria and Dengue. Existing prevention strategies use principles of epidemiology and health communication separately, despite the fact that new technological capabilities may enable us to integrate the two disciplines. This paper describes an ongoing effort in Singapore that plans to integrate hotspot mapping, civic engagement and health communication to extend the boundaries of participatory epidemiology in VBD prevention. We chronicle the research that informed our approach, present the conceptual underpinnings from a participatory epidemiological lens, and describe the challenges and opportunities encountered. It is our hope that, when actualized, this trans-disciplinary model integrating insights from public health, communication and sociology will provide a holistic solution for policymakers and health prevention agencies tackling VBD threats in south Asia.**

Keywords- Malaria/Dengue; mHealth; Participatory epidemiology; social media

I. INTRODUCTION

Despite vastly improved medical and public health services, vector-borne diseases (VBDs) such as malaria and dengue present a serious challenge to public health authorities in many developing countries. In countries like India and Vietnam, malaria threatens the lives of no less than 1,322 million people in the south-east Asian (SEA) region [1]. In Singapore, Dengue remains a threat despite a steady drop in infections since 2005's dramatic outbreak of nearly 14,000 cases [2]. As public health authorities work towards solutions to efficiently manage the VBD scenario, it is remarkable that social media is used to a bare minimum in a region known for its technological prowess. For instance, in India, health authorities initiate preventive action (like fumigation) in a reactive manner after receiving on-the-ground information of incidences by their cadre of health personnel.

On the health education side, Indian health authorities use traditional media such as TV, radio, newspapers and pamphlets while the country continues to boast amongst the fastest rates of mobile phone adoption. In Singapore too, health authorities predominantly use traditional media although there have been recent attempts by the National Environmental Authority (NEA) to use digital media for hotspot mapping and health education through a collaboration with an initiative called X-Dengue [3]. The magnitude of the vector-borne disease burden in these regions demands the enhancement of existing reactive unilateral mechanisms with proactive, dynamic, and nimble solutions that are as useful to the general public as they are to health authorities.

We propose an emerging and virgin approach called participatory epidemiology (PE) that can guide future solutions to Malaria/Dengue prevention in Southeast Asia. We present a brief background and organizing principles of PE. Later, we present ongoing work in Singapore that is anchored in PE approaches to develop a tripartite interactive system called MoBuzz. We conclude by presenting challenges and future plans for implementation and scale-up.

II. ICTS & PARTICIPATORY EPIDEMIOLOGY FOR VBDPS

The use of information and communication technologies (ICTs) in public health has rapidly proliferated over the last two decades given the deep penetration of the internet and mobile phones in both developed and developing countries. The nature of use, however, has differed depending on the region and problem context. In developed countries such as the US, where the burden of chronic diseases such as obesity and cancer is high, ICTs have been used for designing and testing educational and behavioral interventions and delivering remote care through telemedicine [4].

At a systemic level, ICTs have been deployed in the design of health information management systems giving rise to the study of disciplines such as clinical informatics and patient informatics. Developing regions such as Africa and Asia are rife with infectious and communicable diseases, and issues related to maternal and child health. In these resource-limited settings, ICTs (mainly mobile phones) have been used largely for the purposes of data collection, surveillance and mobile-based telemedicine [5]. However, their application in behavioral and/or educational interventions has been largely limited. Interventions that straddle the individual, community and system levels are rare despite the numerous affordances of mobile phones and social media.

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Vector-borne infectious diseases present us an opportunity to creatively address this gap because of the nature of their transmission and the preventive strategies that are required for their management and control. Let us take the case of malaria. Malaria is a preventable, life-threatening disease caused by parasites (called Plasmodium) that are transmitted to people through bites of infected mosquitoes (called Anopheles). It is known that Anopheles mosquitoes usually bite at night, and transmission is closely related to climatic conditions such as rainfall, temperature, and humidity. Anopheles breeding sites can range from pots and vessels, small puddles of water to large construction sites. We also know that malarial symptoms, such as fever, headache, chills and vomiting, usually surface 10-15 days after the infective mosquito bite. The best treatment upon malarial diagnosis is Artimesinin-based Combination Therapy (ACT), although evidence of resistance have been reported. Such a scenario presents core needs for the two main stakeholder groups – public health authorities and the general public. Public health authorities need a system that:

a) empowers them with *a priori* outbreak information to facilitate early preparedness for preventive actions;
b) receives ongoing/dynamic information so as to monitor the disease spread in real-time; and
c) allows them to educate citizens, promote practice of preventive behaviors and, respond to specific informational requests from the general public.

The general public needs a system that:

a) alerts them about potential outbreaks in their area/vicinity;
b) allows them to interact with authorities and share information about any outbreak-related issue;
c) provides authentic information from authorities about what preventive actions to take; and
d) allows them to share information with members in their informal social networks.

At a basic level, PE denotes the use of local, on-ground intelligence to gather information and track the spread, causes, and effects of diseases. The PE concept was popularized by Catley and Mariner's work in East Africa where they employed qualitative community-based approaches to derive animal health status from local farmers [6]. However, the rapid proliferation of the internet and mobile phones has transformed the PE landscape in recent years. As is shown by initiatives such as FrontlineSMS and Ushahidi [7], disease surveillance, health monitoring, and information sharing can now be digitally integrated and used to link disparate stakeholders such as health authorities, health providers and the general public. Chunara *et al*. [8] tested an online initiative where respondents reported their experiences with malaria, and concluded that "micro-monitoring and online reporting are a rapid way to solicit malaria, and potentially other public health information". The Program for Monitoring Emerging Diseases [9] provides an online reporting system and rapid information dissemination related to infectious disease outbreaks. In this sense, participatory epidemiology also denotes employing participatory methods – those nestled in, and involving communities – to collect epidemiological data. The other key principle includes the use of participatory mapping techniques in order to inform prevention activities.

III. MoBuzz – Extending the PE Concept

We propose that the conceptual capabilities of PE can be extended to provide holistic preventive solutions for Malaria/Dengue if mobile phones and social media were to be integrated into the conceptual matrix. We propose MoBuzz, an integrated mobile and desktop-based health risk communication system that is built upon PE principles. MoBuzz extends its reach to provide an interface between citizens and health authorities, and customized health messages to enhance preventive behaviors and health awareness. Our system comprises three main components: predictive surveillance; civic engagement and health communication. Our preventive e-health system provides support for disease prevention among health individuals. We demonstrate how data aggregation and visualization technologies can be used for population health reporting.

A. *Predictive Surveillance*

Let us take Singapore as an example of a city plagued by Dengue. The intention is to develop a color-coded early warning system that displays Dengue hotspots by generating predictive maps (Fig. 2) made available to both health authorities and the public on mobile devices. Raw weather-related information such as rain, temperature and humidity is processed using predictive disease modeling that feeds into an automated system which generates predictive maps of Dengue hotspots.What distinguishes this project from other similar crowd sourcing and crowd informatics platforms is the integration of a disease modeling and simulation component. Here, we build a hierarchy of spatio-temporal epidemic models.

Figure 1. Prototype display of Dengue hotspots in Singapore

In the simplest of these models, we have a human population density that is averaged over time but not space, and a dynamic mosquito population, i.e. mosquitoes move around in the spatial grid. Susceptible humans ($S(x, y, t)$) can be infected by infected mosquitoes ($i(x, y, t)$), while susceptible mosquitoes ($s(x, y, t)$) can then be infected by infected humans ($I(x, y, t)$). Humans who recover from the infection ($R(x, y, t)$) then become immune to further infection. Infected mosquitoes do not recover, and die at the same rate as uninfected mosquitoes. These are replaced by new mosquitoes that are susceptible. In our simulations, we can control how fast the mosquitoes move, how easy it is for mosquitoes to infect humans, and how easy it is for humans to infect mosquitoes. We then measure the spatial extent of infected mosquitoes. This defines the human population that is *at risk* of infection, which provides more policy-relevant information than the actual incidences of infected humans. As more data become available, either through public health agencies or crowd sourcing, we will refine the epidemic model to incorporate influences from meteorological factors like temperature and rainfall, as well as anthropogenic factors like changes in demographics and land use. For policy makers and crowd sensing participants, the most attractive prospects of having such a component are the short-term forecasts in infection and at-risk patterns that can be generated.

B. Civic Engagement

This component provides the cutting-edge addition to existing PE efforts. The key idea here is to encourage the general public to contribute to surveillance efforts in the event of disease outbreaks. In this instance, citizens can report breeding sites, mosquito bites, and Dengue symptoms using their smart phones in image (Fig. 3), text (Fig. 4) or video formats. These inputs are automatically reflected in the hotspot maps and can be accessed by health authorities for responding to citizen concerns and for initiating preventive actions in specific communities. The process is facilitated rapidly because of two reasons: a) mobile phone-based inputs from citizens are geo-tagged; and b) the MoBuzz system captures geo-spatial coordinates, time and date, and phone number of the contributor.

C. Dynamic Health Communication & Alerts

The repository of outbreak information based on weather and citizen data is used to disseminate health messages to both individuals and communities. At the individual level, citizens receive tailored messages based on their input to the system. For instance, a citizen reporting malarial symptoms to MoBuzz will instantly receive a complete information guide on Dengue symptoms, and cues to various preventive actions. At the community level, the system will automatically send health education messages to communities/zones (Fig. 5) that are highlighted on the maps as possible hotspots. Public health surveillance efforts are

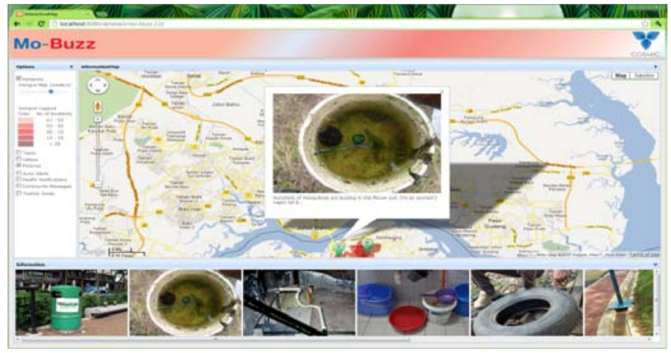

Figure 2.Citizens images of breeding sites reflected on maps

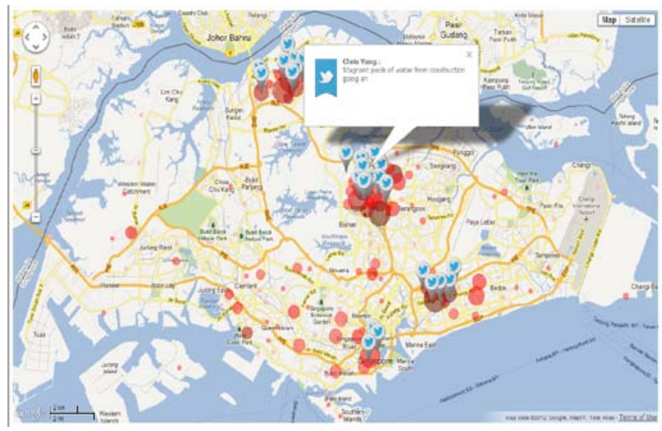

Figure 3.Risk information sent by citizens through Twitter feeds are displayed on the maps

Figure 4.MoBuzz issues automated alerts and health messages using website and mobile apps

thus used to generate and deliver health communication messages. Fundamentally, the system acts as a link between the citizen and the public health system where the contributions of each benefit the other. Overall, the intention is to use MoBuzz for efficient and effective risk prevention and outbreak management. In addition to communication modules, the system is capable of sending alerts to citizens living in areas identified as potential hotspots.

D. Scenario

Fig. 5 shows a possible scenario for the use of MoBuzz. The meteorological department (from left) feeds weather data to the system that is used to generate hotspot maps. Concurrently, a vigilant citizen, John reports a possible breeding site by sending a picture to MoBuzz. In response, the system sends him preventive information that he can send to his family/friends that can further disseminate it to

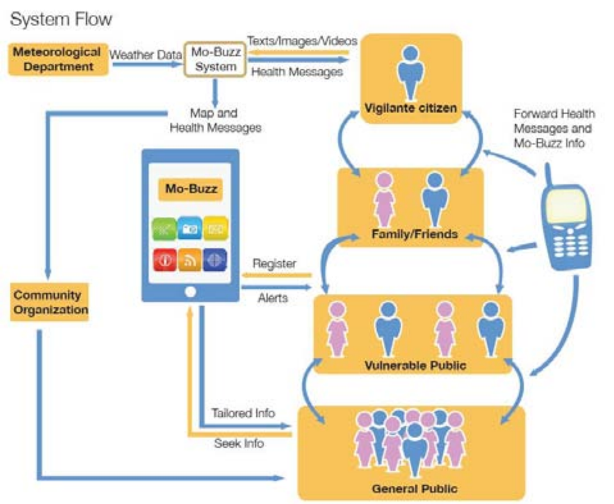

Figure 5.System flow depicting interaction between stakeholders and system

other actors in their social network. The messages contain information about the MoBuzz website/mobile app. This activates the vulnerable actors to register on the MoBuzz website (or download the app), allowing them to receive future alerts automatically. The information continues to go viral as the vulnerable individuals continue to send it to other members in their respective social networks. These individuals follow a similar protocol for registration and can potentially request MoBuzz for specific kinds of information based on their issues of concern. In the meantime, the dynamic maps displayed on the website and available on the mobile app can be used by community organizations and civic agencies to strategize preventive efforts. The innovation in MoBuzz lies in integrating the disparate fields of epidemiology, civic engagement and health communication using social media.

E. Content Validation

One of the major challenges of a technology-driven participatory health system enterprise is validating the quality of informational inputs from citizens. Our validation process is consistent in keeping with the core idea of using participatory media and crowd sourcing technologies. We use people (individuals and health systems personnel) as validation experts. For instance, when MoBuzz receives a breeding site alert from Zone X, the system will send a validation request to all its registered users and health personnel in that zone. These individuals can visit the site and use mobile-based reporting to revert to MoBuzz on the authenticity of this input.

IV. CONCLUSION & FUTURE WORK

One of the key questions we encountered in the process of conceptual ideation and prototype design was: how do we get people to participate? In response, we propose an incentive-based system that offers, say, 5-minutes of free talk time for inputs and an equal number for validation. Such incentives will involve a partnership with multiple stakeholders including telecom companies, civic agencies and health authorities. We recognize that offering an easy-to-use, simple and attractive interface design will add to the adoption and usability MoBuzz and its various affordances. Moving forward, we plan to test the three main components among various audience groups using experimental techniques and assess their responses to the system in terms of media, messaging, design and interface. We are working with collaborators in Sri Lanka and Malaysia to scale-up and test our system. We propose that our system can be replicated to address gaps in the prevention and management of a number of infectious disease outbreaks such as SARS and H1N1. Conceptually, our idea broadens the current understanding of participatory epidemiology and highlights future opportunities for epidemiologists and health communication experts to integrate their expertise.

REFERENCES

[1] World Health Organization. (2012, October 16). *Malaria: Disease Burden in SEA Region*. Available: http://www.searo.who.int/en/Section10/Section21/Section340_4018.htm

[2] B. K. Koh, L. C. Ng, Y. Kita, C. S. Tang, L. W. Ang, K. Y. Wong, L. James, and K. T. Goh, "The 2005 dengue epidemic in Singapore: epidemiology, prevention and control," *Annals of the Academy of Medicine, Singapore*, vol. 37, pp. 538-45, Jul 2008.

[3] http://www.x-dengue.com.

[4] A. G. Ekeland, A. Bowes, and S. Flottorp, "Effectiveness of telemedicine: A systematic review of reviews," *International Journal of Medical Informatics*, vol. 79, pp. 736-771, 2010.

[5] P. N. Mechael, "The Case for mHealth in Developing Countries," *Innovations: Technology, Governance, Globalization*, vol. 4, pp. 103-118, 2009/01/01 2009.

[6] A. Catley, "Use of participatory epidemiology to compare the clinical veterinary knowledge of pastoralists and veterinarians in East Africa," *Tropical Animal Health and Production*, vol. 38, pp. 171-184, 2006/04/01 2006.

[7] C. C. Freifeld, R. Chunara, S. R. Mekaru, E. H. Chan, T. Kass-Hout, A. Ayala Iacucci, and J. S. Brownstein, "Participatory Epidemiology: Use of Mobile Phones for Community-Based Health Reporting," *PLoS Med*, vol. 7, p. e1000376, 2010.

[8] R. Chunara, V. Chhaya, S. Bane, S. R. Mekaru, E. H. Chan, C. C. Freifeld, and J. S. Brownstein, "Online reporting for malaria surveillance using micro-monetary incentives, in urban India 2010-2011," *Malaria journal*, vol. 11, p. 43, 2012.

[9] http://www.promedmail.org.