ABSTRACT
Social media interventions addressing public health issues have proliferated at an unprecedented rate in the past decade. However, despite its nimble and flexible nature, social media has been applied to health issues in silos. By this, we mean that social media affordances have either been applied to addressing specific aspects of a health issue, or have focused on addressing one issue at a time, such as infectious diseases. Given the apparent commonalities in the technological characteristics of social media for health interventions, applying the same features to a distinct set of health issues leads to reinventing the wheel and, more important, redundancy in technological deliverables. This paper addresses this issue by proposing the general architecture of Health Suite, an integrative common platform built on a plug-and-play model for health-related social media solutions. We present summary findings from formative research studies that informed our idea, offer a detailed description of Health Suite and its various modules, and demonstrate how Health Suite’s modules have been adapted for designing a social media-based dengue prevention intervention in Colombo, Sri Lanka. The paper culminates with a brief discussion of challenges and future directions for this e-health architecture.

KEYWORDS
Health; social media; mobile; platform; e-health; architecture

1. INTRODUCTION
Despite being slow starters, health care practitioners have caught up to speed in terms of adopting social media technologies (PriceWaterhouseCoopers, 2012). The past decade (2004-2014) has witnessed an unprecedented proliferation of social media innovations that have aimed to strengthen different aspects of the public health ecosystem. These aspects include promoting healthy behaviors, encouraging public participation in health, and bolstering the delivery of health systems. However, we notice a number of commonalities in the functions and features offered by health-related social media systems or applications. This implies that while innovations might be flourishing, they are also reinventing the wheel. In this paper, we address this problem by proposing the conceptual framework for an integrated platform that can serve the needs of multiple health-related social media interventions.

This concept paper commences with a discussion of critical gaps in existing social media for health approaches. We then describe our research environment, and present summary findings from our needs assessment studies that form the basis for our integrated architectural framework. We then present our solution, Health Suite, its components and instantiate its relevance for dengue prevention and management in Sri Lanka. This paper culminates with a brief discussion of potential applications of hSuite, and plans for future expansion to allow for greater functional inclusiveness.

2. RELATED WORKS
The potential of social media to transform future healthcare is evidenced by the fact that 53% of smartphone users gather health information of their phones and at least 1/5th have at least one health app on their phone (Fox and Duggan, 2012). The implications of social media innovations are most directly felt by two groups of stakeholders in the public health ecosystem: the general public and public health authorities. The general
public can now share health-related messages with those in their social network, receive tailored health messages on their smartphones, and report disease incidents as and when they happen using channels like Twitter (McNab, 2009, Korda and Itani, 2013). Health authorities can now establish direct communication with the general public during health outbreaks, disseminate health educational messages, collect real-time health information through surveys and also use social media to communicate between their various departments (Thackeray et al., 2012, Burnett et al., 2013). While the range of functionalities listed above might seem like disparate interventions, social media technologies allow us to integrate them, modularize them, and offer them on a common platform.

Despite this capability, we see that social media innovations have been applied to health issues in silos. By this, we mean that social media systems have either been applied to addressing specific aspects of a health issue (for instance, promoting behavioral change for diabetes prevention through a mobile application), or have focused on addressing one issue at a time, such as infectious diseases (for examples, see: Greene et al., 2011, Cavallo et al., 2012, Culotta, 2010). While integrated social media platforms with modularized structures have been developed in the field of education (Bogdanov et al., 2012, Siemens et al., 2011), and in a functionally narrower format in personal healthcare (Chira et al., 2010), we have yet to see integrated solutions of a holistic nature in the area of public health. In this context, the term “holistic” implies a platform that can accommodate various functionalities required that strengthen three main areas of public health – epidemiological surveillance, health education and social support – and offer them in a modularized, customizable manner for the end user. From a technological standpoint, we recognize extensive commonalities in the technological features of existing social media for health interventions. The problem we are trying to address is to create a solution that can help to avoid reinventing the wheel and reduce redundancy in technological deliverables.

2. BACKGROUND

The Center of Social Media Innovations for Communities (COSMIC) in Singapore is a $10 million research center with a mandate to develop social media innovations that address social problems affected the middle-of-pyramid (middle class) populations in South & Southeast Asia. This collaborative research initiative spans three universities: National University of Singapore, Nanyang Technological University (NTU) and the Indian Institute of Technology, Bombay (IIT-B). The aim is to draw upon the trans-disciplinary ideas of experts from fields as disparate as information science, human-computer interaction, health communication and industrial design, to generate holistic, sustainable social media solutions to the problems we investigate. COSMIC-NTU focuses specifically on creating and testing social media solutions that address public health issues in the region, and comprises three trans-disciplinary cohorts of researchers investigating vector-borne disease outbreaks (e.g. dengue/malaria), infectious diseases (e.g. tuberculosis) and elderly care.

3. NEEDS ASSESSMENT

Consistent with the principles of user-centered design, the hSuite was informed by a series of needs assessment studies conducted to assess the core needs pertaining to each of the three areas. These studies, starting 2012, were conducted in communities across India, Singapore and Sri Lanka among groups of health inspectors, public health and medical experts, health journalists, disease survivors, and the elderly. Methodologies used included small and large-scale surveys, in-depth interviews and interview based surveys. Findings from these studies led us to identify specific social media functionalities that could help to address their needs. We present these functionalities in the form of three buckets:

1 Research papers reporting findings from these needs assessment studies are either in preparation or under review, and hence cannot be cited here. The three buckets reported in this paper are based on a summary of findings provided by each of the research cohorts within COSMIC.
3.1 Alerts

A critical component of preventive health and disease treatment is to pre-empt the occurrence of undesired health-related behaviors. These include accumulating stagnant water in pots (at an individual level) or the failure of allocating health systems resources strategically to prevent a disease outbreak (at a health systems level). Alerts, delivered in simple and innovative formats, can draw attention to or remind an individual or organization about a potential health threat, and enable the public and health agencies undertake preventive action in advance. Given the wide geographical areas that the health system stakeholders in our needs assessment were covering, we found that the visual power of social mapping systems and predictive algorithms can be used to disseminate geographically targeted alerts and further enhance the utility of this feature. On the other hand, the elderly need the facility of alerts to communicate urgent health-related messages or incidents, such as a fall, to their caregivers at the earliest time-point after the incident.

3.2 Care

In public health, the concept of “care” spans from provision of, and ensuring adherence to, medication regimen, to enabling social support systems for those afflicted by disease and disease-related stigma. Social media affordances can address these needs by providing features such as timely reminders that enhance medication adherence or vaccine uptake. Similarly, social media can act as a communication channel between patients and caregivers, thereby creating a virtual environment of social support. For instance, caregivers can send messages of positive reinforcement to patients using messaging platforms like Facebook and Twitter, while patients can reciprocate by sending messages about their health status. These features are especially useful in cases where the elderly are located away from their kith and kin, and physical caregiving by immediate family members becomes problematic.

3.3 Health Education

Consistent with emerging scholarship in this area, our needs assessment studies revealed the strong potential for social media as a channel for disseminating persuasive health-related messages. The participatory, multi-modal nature of social media facilitates two kinds of health messaging – static and dynamic. Static health communication involves the provision of persuasive health messages in the form of an educational module in a mobile application. Dynamic health communication refers to messaging that is tailored to health-related reports that patients can report to health authorities, agencies or providers. The participatory nature of social media further allows the opportunity to rapidly share health messages with members of one’s social network, using popular platforms such as Facebook and Twitter.

4. PROPOSED SOLUTION: HEALTH SUITE

Given the crosscutting nature of needs, and the ability of the above-described functionalities to address more than one health problem, we decided to create a common social media platform that would serve as a suite for a number of health-related applications. This platform is called the Health Suite (or hSuite). The following section provides a generic description of the initial architecture, together with descriptions of some modules within the three main layers of applications. These modules are subsequently utilized to demonstrate how they are employed and integrated to support a dengue prevention application. hSuite has been conceived as a flexible and inclusive concept and so, we foresee a number of functionalities and features that can be incorporated into the architecture as we continue to identify the needs of more health issues than the ones presently under investigation.

The overall architecture of hSuite is organized in the form of three main layers, each of which is comprised of a set of components and serves distinct functions. Underlying all the layers is a database that comprises data fields that are either common or, distinguishable to, each of the three projects with the capacity to accommodate more. A diagrammatic representation of hSuite is provided in Figure 1.
4.1 Base Layer

The base layer performs the administrative functions for the entire system and communicates with the database. This layer comprises four sub-components. First, the login manager manages authentication and supports authorization as well. Users can login to healthcare applications using social media credentials or alternately use the system login. Second, the log manager tracks every action by every user of the system and saves each action in the database. In addition, the log manager supports and enables the retrieval of the history of all actions by user, the timestamp or by task. Third, the user manager assigns each user to a specific group in a manner that each user is only allowed to access the roles assigned to that particular group. Lastly, the security manager is created for the purposes of managing data security by allowing encryption and decryption of data.

4.2 Application Layer

The business layer houses all the modules that can be used as features in different healthcare applications. The current version of hSuite comprises six modules but is flexible to accommodate more modules in the future. The geo-visualization wrapper allows the display of geospatial data in a Google map as graphical objects by generating hotspots or information maps. This module is useful for health authorities and the general public as it helps to disseminate geographically specific information (such as incidence of new cases during an infectious disease outbreak) in an easy-to-interpret visual format. The social media wrapper supports communication between healthcare applications and popular social media platforms such as
Facebook and Twitter. For instance, the elderly can use status messages or Twitter feeds to update their members of their social support system about their physical or mental health condition, or adherence to medication regimens.

The multimedia module manages unnecessary media files in the system and is executed as a service to clean the memory and disk space of the system. The survey module is a useful data collection tool that supports the administration of different types of surveys that can be conducted either one-off or on a recurrent basis. This module can be used by any of the project teams to conduct theoretically driven survey research, longitudinal studies of usage effects on health outcomes, and usability studies related to seeking feedback about the system on an ongoing basis. The messaging module manages all SMS communication through a GSM modem that facilitates the communication of the system over a mobile network. The time and schedule module is used for scheduling specific jobs defined by the user, and triggers actions based on pre-defined rules.

4.3 Presentation Layer

The presentation layer, essentially the front end of the suite, comprises of the mobile client, web client, services and hardware devices. The mobile client, the web client and services are specific to each project, and are designed by incorporating empirical study findings that evaluate user preferences in terms of ease-of-use, usefulness, and self-perceptions about their own ability to use the system.

In summary, we postulate that while the Health Suite is generally framed as a social media suite, its affordances are not restricted to popular social media platforms like Facebook and Twitter. Instead, the purpose is to offer a complete set of functionalities (including modules like multimedia and surveys) that can optimize the power of core social media features to generate creative, holistic solutions to public health problems.

5. Instantiation: Utilizing Health Suite Modules for Dengue Prevention in Sri Lanka

Individual modules from hSuite can be adapted and integrated into a new sub-system that provides solutions for specific health applications. In this section, we demonstrate how three components from hSuite have been integrated to develop an innovative socially mediated system, called Mo-Buzz, for dengue prevention in Sri Lanka. [For a more detailed elucidation of this intervention see (Lwin et al., 2014) and for a technological description of the system see Fernando et al. (2013)].

5.1 Mo-Buzz: A Socially Mediated System for Dengue Prevention & Management

5.1.1 Problem Description

Dengue, a mosquito-borne infectious disease caused by the bite of the female *Aedes Aegypti* mosquito, affects more than 50 million people globally, and specifically populations in the South and Southeast Asian regions. The island country of Sri Lanka faces an especially severe dengue burden with more 70,000 cases in 2012 and dengue-related mortality on the rise from 2009 to date (Tam et al., 2013).

The principal barriers to preventing dengue in Sri Lanka lie in three main problems: a) dengue-related surveillance is undertaken using outmoded paper-based mechanisms which cause delays in reporting and responding to dengue cases, b) during outbreak season, epidemiological surveillance and monitoring is undertaken in a reactive manner as a result of which neither the health authorities nor the general public are sufficiently prepared, and c) health education pertaining to dengue is undertaken using traditional modes of health messaging such as pamphlets, which are neither interactive nor persuasive. Having recognized these gaps in dengue prevention in Sri Lanka, our endeavor was to create a social media solution that could be easily integrated into the workflow of public health inspectors in Sri Lanka, and enable to overcome these barriers while providing quality dengue prevention services to the communities in Colombo. Our innovation
called Mo-Buzz integrates the following three components from hSuite to bolster dengue prevention and management in Sri Lanka.

5.1.2 Predictive Surveillance (hSuite Module – Geovisualization Wrapper)

The purpose is to develop a color-coded early warning system that displays dengue hotspots by generating predictive maps made available to both health authorities and the public on mobile devices (see Figure 2). Raw weather-related information such as rain, temperature and humidity is processed using predictive disease modeling. These models are fed into an automated system which generates predictive maps of dengue hotspots, using the Health Suite’s Hotspot Generator. As more data become available, either through the public health agencies or through crowdsourcing, we 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 prospect of having such a component is the short-term forecasts in infection and at-risk patterns that can be generated by the simulations.

Figure 2: Dengue outbreak predictions disseminated through hotspot maps

Figure 3: Citizens can report breeding sites through geo-tagged forms such as this

Figure 4: Health education messages on different aspects of dengue
5.1.3 Civic Engagement (hSuite Modules: Information Map, Messaging, Log Manager)

This component provides the cutting-edge addition to existing epidemiological efforts (see Figure 3). The key idea here is to activate 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 smartphones in image, text or video formats. These geo-tagged inputs are automatically reflected in the hotspot maps and can be accessed by health authorities for responding to citizen concerns as well as 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 Mo-Buzz system captures geo-spatial coordinates, time and date, and phone number of the contributor.

5.1.4 Health Communication (hSuite Module – Messaging, Login Manager)

The repository of outbreak information based on weather and citizen data is used to disseminate health messages to both, individuals and communities (see Figure 4). At the individual level, citizens receive tailored messages based on their input to the system. For instance, a citizen reporting malarial symptoms to Mo-Buzz can instantly receive a complete information guide on dengue symptoms, and cues to various preventive actions. At the community level, the system automatically sends health education messages to communities/zones that are highlighted on the maps as possible hotspots. Public health surveillance efforts are thus used to generate and deliver health communication messages. At a fundamental level, the system acts as a catalyst between the citizen and the public health system where the contributions of each stand to benefit the other. Overall, the intention is to use Mo-Buzz 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.

Messages can be alerts, reminders or any useful information generated by the system or authorized users. Personalized messaging is used to disseminate messages to end users according to the message settings. Users can select various options in the message registration process which uses by the messaging system. Messaging system uses both push and pull techniques according to the selected options. The proposed system always attempts to avoid messages broadcasting. Instead, it pushes messages to users based on their location, messages priority and other settings of messages and users. Also, client application can pull the messages according its options and user settings. These massages are sending to email boxes, to devices through Google cloud or as SMSs.

6. EVALUATION

Moving forward, the research team plans to evaluate Health Suite at two specific levels, in addition to the standard technical evaluation: conceptual and applied. At the conceptual level, the evaluation strategy will mainly assess breadth, depth and flexibility. Breadth can be assessed by the range and type of health issues for which the platform can provide holistic technological support. Depth can be examined in terms of the range of prevention aspects of specific health issues for which the platform can help to generate interventions. Flexibility can be examined in terms of its ability to support more modules or functionalities in an integrative manner.

Applied evaluation pertains to the efficaciousness and effectiveness of hSuite in responding to the needs of specific problem domains like Mo-Buzz for Dengue. This evaluation involves a critical assessment of specific implementation parameters, such as the time and human resource required to adapt it to dengue prevention, the level of adaptation required, and the technical robustness of the system in supporting a real-time intervention. Also useful and necessary will be studies of user acceptance of different modules being used for a Mo-Buzz like intervention and qualitative and quantitative assessments of constructs like usefulness, ease-of-use and future preferences.
7. DISCUSSION & CONCLUSION

In the context of recent developments in eHealth and mHealth, the hSuite provides an exemplar of a common platform built on a plug-and-play model that can serve social media-based interventions for a range of healthcare issues. The strength of the system lies not only in its flexibility to accommodate newer modules/functionalities in the future, but also in its ability to reduce redundancies in system design and the time taken for developing new systems. Equally, the framework offers public health researchers and practitioners the opportunity to find new areas of relevance to existing functionalities/features. From an academic standpoint, this phenomenon creates new vistas for innovative health interventions, and advances the state of science in public health.

In terms of governance, the hSuite is envisaged to be an open access tool that will be provided to interested health authorities to use, adapt and manage. For example, Mo-Buzz (hSuite) is currently being customized, deployed and managed by the Colombo Municipal Council and Mobitel for dengue prevention and management. It has been tested and used by the Council’s public health inspectors for 6 months from December 2013 to May 2014. The public app is currently being tested with a target launch in late 2014. The hSuite architecture can serve both as a stand-alone system (e.g. Mo-Buzz for now) or a centralized meta-platform (e.g. Mo-Buzz and beyond) where other health related applications can be built and managed centrally by the authorities. In the latter, it becomes necessary to ensure data integrity and trustworthiness, and user privacy is protected when we consider other factors like sensitive patient-doctor communication, and medical record keeping.

Future versions of hSuite are expected to accommodate a larger suite of functionalities, with the possibility of revisions and refinements to the existing technology architecture. The challenge is to further engineer the flexibility of the system in a manner that protects it from being accessible to only a specific category of health issues (such as communicable diseases), and instead opens it up for relevance to multiple health areas. In doing so, we believe that our needs-based approach is an effective ground-up strategy for developing social media based health interventions, and ensures that future innovations are rooted in human realities.

ACKNOWLEDGEMENT

This research is supported by the National Research Foundation, Prime Minister's Office, Singapore under its International Research Centres in Singapore Funding Initiative and administered by the Interactive Digital Media Programme Office.

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