Geovisualization of Disease Data to Improve Healthcare in Rural India

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Abstract

Rural India faces a lack of adequate healthcare facilities and doctors, contributing to a high disease burden. There is the possibility of utilizing mobile phones for disease management and monitoring with the widespread adoption of mobile phones throughout the developing world, including rural India. This paper proposes a geovisualization that uses health data recorded by mobile phone to identify hot spots and patients at risk. End-users will be able to view the locations with high prevalence rates of disease and make decisions about health resource allocation from it.

Background and Relevance

Rural India faces significantly less healthcare in terms of access, quality, and outcomes than the urban centres of that country. This is reflected in the higher morbidity and infant mortality rates and lower life expectancy for the rural population (Patil, Somasundaram, & Goyal, 2002). Easily diagnosed, preventable, and treatable diseases such as; Malaria, Tuberculosis, and Flu are some of the most common cause for deaths in neglected areas (Singh et al., 2011). The high disease burden can be attributed to the limited number of trained medical staff, poor access to healthcare facilities, and distance to and costs incurred for seeking medical treatment (Agarwal & Lau, 2010; Patnaik, Brunskill, & Thies, 2009). It is within this context that innovative approaches to healthcare must be investigated for increasing efficiency and efficacy for rural communities.

With the expansion of mobile phone coverage and user adoption in developing countries, particularly in rural areas, the opportunity for using mobile phones as a health tool (m-health) has been made possible. Déglise, Suggs, & Odermatt (2012) identify four types of intervention which mobile phones are currently being used for in developing countries; prevention, disease surveillance, disease management, and patient compliance. Such interventions rely on the widespread availability of mobile phones, data storage, and transmission capabilities including location information and providing quick and cheap forms of direct communication (Chhabra, 2013; Ramachandran et al., 2010). M-health initiatives currently being developed and tested make use of short message service (SMS), calling, and mobile phone based applications to record health information. Examples include; monitoring adherence to antiretroviral therapy (Haberer et al., 2010), monitoring the risk of diabetes (Agarwal & Lau, 2010), and delivering sexually transmitted infection prevention information (Swendeman & Rotheram-Borus, 2010). Providing health information by phone calls and SMS to rural populations is a cost-effective and efficient mechanism for disseminating critical health information where other public health literacy methods like print or television advertisements might not be accessible for rural populations (Lefebvre, 2009). Furthermore, reporting health information to healthcare workers via mobile phone can eliminate the need for costly and timely travel to health clinics and can be used by healthcare professionals who might be located elsewhere to suggest treatment to specific patients who are most at risk.

By combining the use of mobile phones to record health data with disease prediction algorithms that do not require direct doctor to patient interaction, such as the World Health Organization's (WHO) scoring system for leptospirosis (Faine, 1982), health ministries and non-governmental organizations can monitor the outbreak of particular disease as the data is collected and updated. Singh et al. (2011) evaluated the leptospirosis scoring diagnostic tool with 90% accuracy where healthcare workers record variables such as patient temperature, presence of jaundice, and age etc. Such an application in practice could eliminate barriers for disease management and intervention from timely delays by using paper records and missing cases due to inaccessibility to doctors as well as increasing the number of patients being screened contributing to more accurate disease monitoring. Furthermore, such a system does not require the presence of a nurse to record the data, instead a community health worker with basic training can successfully carry out the data collection with high accuracy as demonstrated by (Patnaik et al., 2009). The recorded data can then be used to identify clusters of disease (Kulldorff & Nagarwalla, 1995) and be used to direct medical resources such as medicine and medical personnel. It can also be used to create awareness for vulnerable populations through the use of SMS and calling to alert people residing in hot spots of their risk of contracting a communicable disease.

It is within this context that a geovisualization is proposed to map patients, perform spatial statistical analysis of disease cases, and identify hotspots where resources must be directed to. The proposed geovisualization will be web-based and could be accessible to doctors, health ministries, non-governmental organizations, and other actors who have a stake in disease monitoring. This paper will provide an overview of the required data and methods to be used in designing and utilizing the geovisualization. It will also report on the predicted results and conclusions from deploying it in rural India.

Methods and Data

This project will utilize health data recorded by healthcare workers with mobile phones in rural India. Data will be collected using a form that captures the variables used in the scoring system for leptospirosis detection (Faine, 1982). This form can be adapted to local conditions or for different diseases requiring different inputs, for example, cardiovascular disease (CVD) with the CVD risk prediction approach developed by (Gaziano et al, 2008). Additional information pertaining to the individual patient will be acquired including a unique identifier, contact information, the latitude and longitude of their home address, and the street and village in which they live. The healthcare workers recording the data will be provided training about data collection and input to ensure the highest level of accuracy for data input.

Once the data is collected and the form is submitted as an SMS, it will be added to a central database through FrontlineSMS. FrontlineSMS can send and receive SMS from mobile phones onto an internet enabled computer. The SMS data can then be exported to a database. The database will feed the patient data into a script that geocodes their home location into a dynamic KML network link along with each patient's health data (Google-based). This KML network link will be read through the Google Maps API in a HTML page for the end-users. As the data is updated for each patient the KML network link will subsequently be updated reflecting any changes in the data. The script will also be used to calculate the risk of disease based on the WHO's leptospirosis algorithm using the recorded health data. The points on the map representing the patients will be colour coded to indicate their risk of disease.

A separate script will be written to identify the presence of spatial disease clusters. This script will use the maximum likelihood ratio to test for clustering proposed by (Kulldorff & Nagarwalla, 1995). Population data required for the spatial statistics will be used from the 2011 census of India (Chandramouli & Office of the Registrar General & Census Commissioner, 2011). The script will create a KML network link layer displaying the location of any detected clusters. This KML network link will also be fed into the Google Maps API overlaying with the patient data.

Results

The proposed system will be able to visualize the location of patients, their risk of disease, and the location of disease clusters. End-users will be doctors, epidemiologists, and public health officials from health ministries or non-governmental organizations. End-users will make decisions about resource allocation based on the location of disease clusters. Furthermore, healthcare workers will be able to identify patients with high risk of disease and provide SMS, phone calls, or home visits to address their health risks as is required.

There are several potential issues that could complicate the results of the geovisualization and in turn affect the way the tool is used. Privacy concerns might dissuade patients from providing exact home addresses, contact information, or even participating in the monitoring. The healthcare workers who input the data will need to be trained and tested such that they understand the proper data structure and how to measure the health indicators. Language and educational levels of the workers may influence this potential problem. Furthermore, if the data that is being collected is not accurate, or representative of the population (due to patients opting out), any conclusions about the presence or absence of disease cluster must be carefully examined.

Conclusions

The disease burden in rural India is high because of low access to adequate health facilities and low number of healthcare professionals, especially doctors. The ubiquity of mobile phones can provide innovative health interventions increasing the efficiency and effectiveness of healthcare in rural areas (Chhabra, 2013). The proposed system uses healthcare workers in rural areas to record health data with a mobile phone. This data is uploaded to a database through SMS. The data is then presented in a geovisualization for end-users. The geovisualization shows the location of patients, their risk of disease and the presence of disease clusters. The geovisualization is updated as the data is collected to reduce any delay in intervention. Such a system will help the decision making process when deciding where valuable and scarce health resources should be directed. It also allows for direct and immediate communication between healthcare workers and patients through SMS and phone calls based on their health data to recommend, for example, seeing a doctor. This geovisualization has the potential to improve the delivery of healthcare in rural India reducing the disease burden.

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