Web technologies for public health surveillance in low and middle-income countries

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1. Introduction

Advances in public health and medicine in recent years have vastly improved health outcomes such as life expectancy and infant mortality, however, these gains have largely been confined to high-income countries (Laxminarayan et al. 2006). As such, new strategies are required to support health innovations to benefit the world's low and middle- income countries (LMIC) (Gardner et al. 2007). Current priorities for global health include improved collection of public health data and expanded use of information and communication technologies. Barriers including severely restricted finances and a lack of trained personnel have traditionally meant that many LMICs could not engage in public health data collection. This study addresses these barriers within the context of global health priorities by assessing the possibility for no-cost, easy-to-use Web technologies to support the development of public health surveillance systems suitable for low-resource environments. The promise of these technologies was demonstrated through an injury data collection and spatial analysis pilot study conducted in Cape Town, South Africa. Results indicate the potential value of Web-based applications to permit low cost injury data collection and analysis in the world's poorest countries. Moreover, the project highlights the possibilities for an emerging collection of Web-based technologies to facilitate authentic self-organization for disenfranchised groups.

1.1 Injury Burden and Surveillance in LMIC

The burden of injury rests disproportionately in LMIC. Of the 5 million global annual deaths attributed to injury, 90% occur in LMIC (Hofman et al. 2005; Peden et al. 2002).

Public health surveillance involves the systematic collection, analysis and interpretation of data and the dissemination of information to those who need to know in order that action may be taken (World Health Organization 2008). Injury surveillance systems are well-established in high-income countries, but very rare in LMIC. As a result, no data are available which means injury prevention efforts cannot be planned (Hofman et al. 2005).

Geographic Information Systems (GIS) are useful for many injury surveillance and prevention tasks (Cusimano et al. 2007), including, uncovering the determinants of injury through analysis of its social and environmental correlates (e.g. Yiannakoulias et al. 2003), allocating personnel and financial resources, and identifying suitable locations for injury prevention and safety programmes (Schuurman et al. 2009).

1.2 Web 2.0 and the Geospatial Web

A fundamental shift in the World Wide Web, termed Web 2.0 (or, the Social Web, the Read/Write Web, etc.), is allowing for much greater participation and interaction among Web users. Another great hallmark of this 'new generation Web' – though thus far less heralded - is the paradigm shift in technology (Murugesan 2007). The ability to use the Internet as a platform for services and applications has resulted in the increasing use of no-cost Web-based applications in place of licensed proprietary software. A prime example of this technology is the ‘Web office’ (or Office 2.0) productivity software suites which are freely available and accessible anywhere through a Web browser (Gambadauro & Magos 2008).

The geospatial Web (or GeoWeb) refers to the “global collection of general services and data that support the use of geographic data in a range of domain applications” (Lake & Farley 2007, p. 15). These new technologies are bringing Web 2.0 approaches to GIS, which is helping to ‘democratize’ this once exclusive domain (Boulos & Burden 2007; Goodchild 2008). Geospatial Web technologies range from the now ubiquitous virtual globes, to user-contributed street maps, and Web-based geocoding services.

The unique technologies of Web 2.0 and the GeoWeb may be particularly well-suited to public health surveillance in LMIC, where lack of finances and trained personnel have traditionally acted as barriers to information and technology uptake (al-Shobakky & Imsdahl 2007). The purpose of this study was to demonstrate the capability of these new Web technologies to be used for public health surveillance in low-resource settings, using an injury surveillance pilot project in Cape Town, South Africa as a test case. All aspects of data input, analysis, and visualization were undertaken using Web 2.0 and GeoWeb technologies.

2. Methods

A pilot study was conducted at Groote Schuur Hospital, a large publicly-funded hospital in Cape Town. A needs assessment uncovered an urgent need for a streamlined injury surveillance system that could be used for epidemiological analysis and administration purposes. A current system in place at the hospital was not utilized because the data collection protocols, the computer database, and the data analysis tools were all deemed too complex and time-consuming for use by staff at the busy trauma unit.

A simplified paper form was developed to collect data on various aspects of injured patients, including demographic details, and injury type. Also, spatial information was recorded, including the patient’s home location, and the location where the injury was sustained. Using Google Docs (Google 2008a), the free Web-based office suite, we developed and tested a streamlined and readily modifiable trauma data entry and management system. An easy-to-use online data entry form was created to mimic the paper hardcopy form; this required no programming or advanced computer skills. The pilot project was conducted over one month during which approximately 800 patients were recorded.

During the needs assessment phase, the hospital described a desire to have simple data analysis tools for in-house data exploration and visualization. Free and easy-to-use GeoWeb applications were demonstrated for these purposes in place of complex and costly desktop GIS.

3. Results

3.1 Data Collection and Management

One person spent between one and three hours entering between 20 and 50 patient records daily into the trauma database, housed online in a Google Docs Spreadsheet. Figure 1 shows the Google Docs Form that was created to allow for easy data input through the ability for the data fields to be entered in the same order as on the paper form.

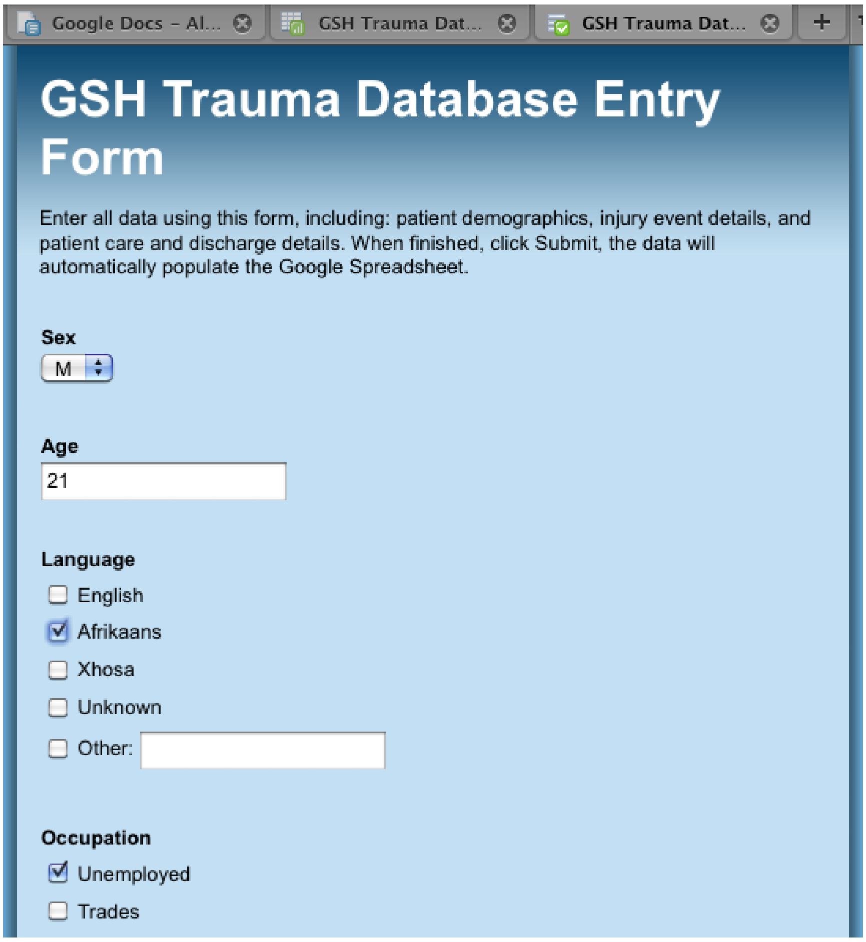

Figure 1. Google Docs data entry form: A simple online form was created for entering the injury data into a Google Spreadsheet database. The Form creation utility allows for the design of a data entry system without the need for programming or advanced computer skills. Once completed, the form is submitted and the record automatically populates the spreadsheet.

3.2 Data Exploration and Visualization

A data processing, exploration, and visualization system was developed as a demonstration of the potential for free and simple Web technologies to be used for injury surveillance in low-resource settings. The Mapalist geocoding Web site (www.mapalist.com) - which is designed to work directly with Google Spreadsheets - was used for data georeferencing. Its simple user-friendly interface is organized as a set of steps that the user proceeds through in order to complete the geocoding, visualize the data, and save the output. At the final step, the user sets the save parameters for the map, including the name, and whether it can be viewed by the public on the Mapalist's Web site, or restricted to private viewing. There are also options to export results as KML files, and to automatically update the map if new data is added to the Google Spreadsheet. An injury hotspot map created in Mapalist is shown in Figure 2.

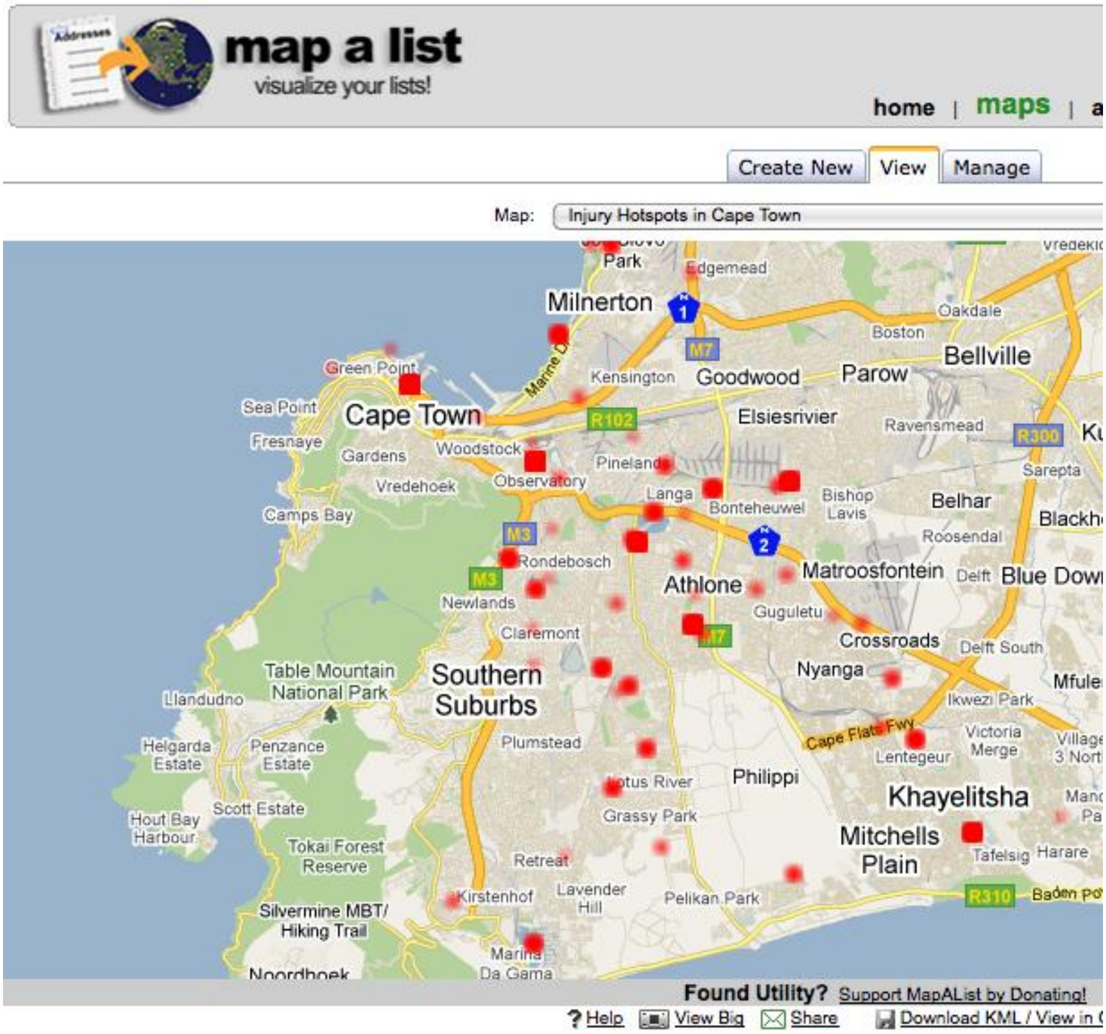

Figure 2. Mapalist injury concentration (hotspot) map. A simple hotspot map can be made using the Mapalist georeferencing system. Although the options for hotspot mapping are rudimentary, this is a valuable and distinctive feature of the Mapalist system, as GeoWeb applications generally do not have the capability of visualizing concentrations without API modification. Also of great utility is the option to set the map to update automatically if new data points are added to the linked Google Spreadsheet.

The free version of Google Earth (Google 2008b) was used to develop an injury data spatial visualization tool. Interactive visualizations were created to examine injury patterns in Cape Town neighbourhoods (Figure 3). KML files for the visualizations were created using Mapalist, which could then be opened in Google Earth to allow for exploration and visualization of the spatial data at multiple scales.

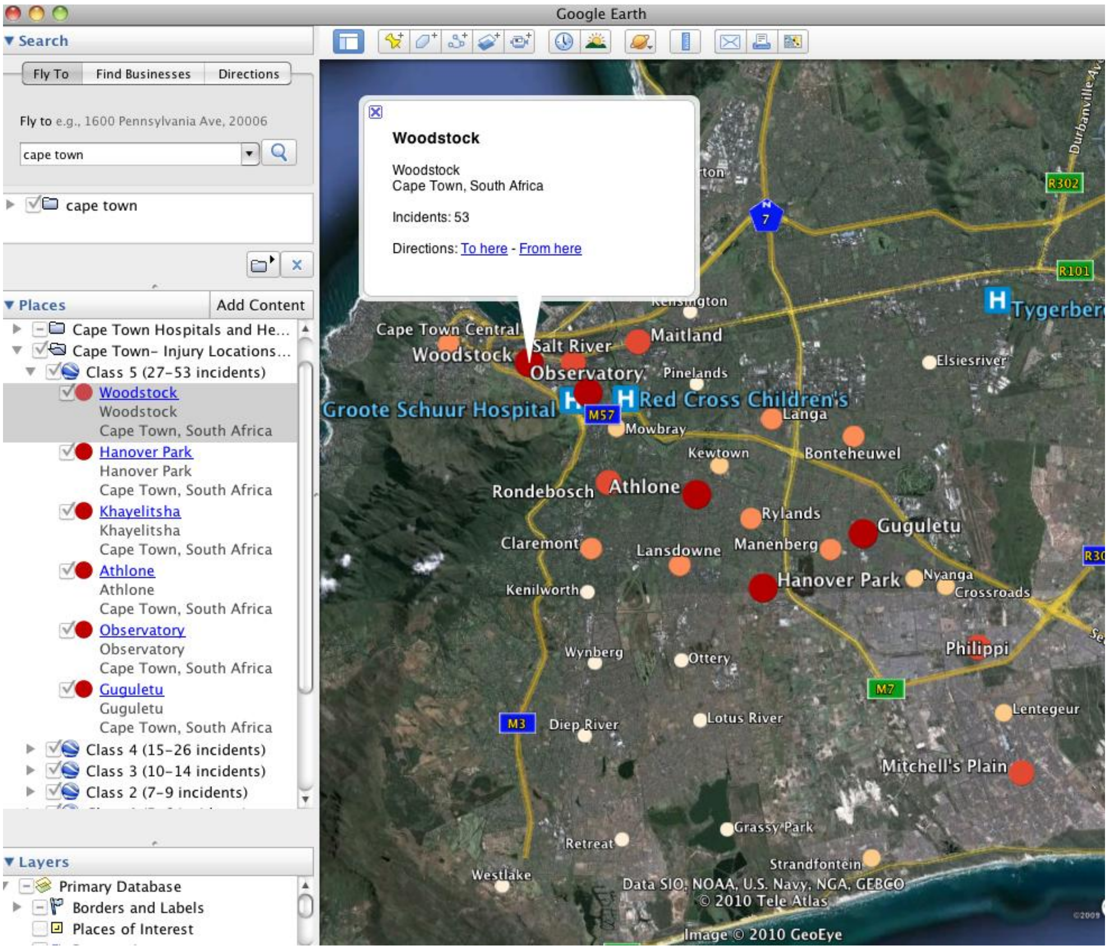

Figure 3. Google Earth visualization of injuries by neighbourhood. In this visualization the map user can explore the spatial distribution of injury in Cape Town interactively at multiple scales. Incidents were aggregated to the suburb (neighbourhood) level. The visualization was created by exporting the geocoded results from Mapalist as Google Earth (KML) files.

3.3 User Evaluations

Informal user-evaluations were conducted to assess whether the data collection and analysis system would be useful for the trauma unit, and if the system could be operated and utilized without the need for outside expertise. User-evaluations of the paper form were positive, with clinical staff suggesting that they were easy to complete and were less time-consuming than the current system's two-page form. An informal user-test of the Google Docs Form and Spreadsheets with a member of staff who held data entry duties was positive. In comparison with the previous database system, the data entry and management system developed in this study was deemed to be much simpler to use and the records could be entered into the database more rapidly. Staff at the unit were able to visually explore the data and recognize spatial patterns of injury using the Google Earth and Mapalist visualizations.

4. Discussion

A pilot study was conducted at a low-resource hospital in Cape Town using Web technologies to highlight a simple and affordable injury surveillance alternative. The technologies successfully demonstrated in this study represent simple and affordable data management and visualization solutions for low-resource settings. In addition, the pilot demonstrated the potential for simple, web-based spatial analysis to highlight concentration of injuries. These achievements are notable as most organizations in LMIC are unlikely to have access to licensed geospatial software or data analysis and visualization tools, nor the expertise to operate them. The low-cost and simplicity of Web 2.0 and GeoWeb technologies present a great opportunity for improving public health in LMIC – vastly easier and streamlined data collection is in itself a great contribution. What may ultimately prove to be more exciting though, is the ability for organizations in LMIC to develop data collection, analysis, and visualization capabilities from within using these technologies. This may help to address the 'elephant in the room' for participatory and community GIS – the fact that many projects lack genuine grassroots self-organization and problem definition (Elwood et al. 2009; Ramsey 2009).

This study is a preliminary step in the development of a framework for resource-poor organizations to engage in authentic grassroots public health surveillance without the need for outside expertise. Future research will need to focus on such issues as usability, utility, and sustainability. For example, a formal user-test will be required to assess the feasibility of in-house development and operation of the system. As high-level geospatial analysis is not possible with GeoWeb applications, it will also be necessary to assess the utility of the technology's visualization, and data exploration capabilities. In addition, the potential limitations of this study will have to be examined more fully. These include the issue of poor Web access in some countries, issues of data security with Web technology, and the potential for incorrect display of data by users without knowledge of geospatial or epidemiological concepts.

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