GeoWeb and Web 2.0: New tools for public health

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Advances in health and medicine have resulted in great benefits for public health in high-income countries. Many low and middle-income countries (LMIC), however, have not enjoyed the same advancements. As such, new strategies are required to support health innovations to benefit these countries [1]. The use of information and communication technologies and the collection of public health data have been highlighted as two key drivers for improving global public health.

Many LMIC are unable to engage in public health data collection as a result of financial and technical barriers. This study addresses these barriers within the context of global health priorities by assessing the possibility for simple and affordable web technologies to support the development of public health surveillance systems which are suitable for low-resource environments.

The potential for novel web technologies to contribute to public health surveillance was demonstrated through an injury data collection and analysis pilot study conducted in Cape Town, South Africa. The findings of this study illustrate the potential value of web-based applications for enabling low-cost injury data collection and analysis in low-resource settings.

Injury burden and surveillance in LMIC

Injuries are a huge public health burden globally. For children in particular, and also adults of working age, injury is one of the leading causes of death in nearly every country in the world, whether high, medium, or low income [2]. Injury is however, a much more pressing and acute problem in low-resource settings including the world's low and middle-income countries. The burden of injury rests disproportionately in LMIC, as 90% of the world's 5-million annual injury-related deaths occur in these countries [3, 4]. Unfortunately, this huge burden of injury is also mirrored by a large burden of high-profile communicable diseases, such as HIV/AIDS, tuberculosis, and malaria [5]. Thus, attention to the injury burden is often overlooked by stakeholders in these settings, including governments, and donor and funding agencies that wish to see their funds connected with high-profile disease eradication efforts. Furthermore, injury is also responsible for a huge economic burden because it is the working-aged members of a family that are typically killed, and those that live impose a great financial burden on their families and friends [6].

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 [7]. Injury surveillance systems are well established in high-income countries, however they are rare in LMIC. As a result, data are unavailable which means injury prevention efforts cannot be rationally planned [3]. The hospital-based trauma registry model is ubiquitous in the developed world. This model allows for hospitals to collect patient data for their own purposes, which can then be further aggregated to populate regional injury surveillance systems. These systems are designed to collect data for analysis of the epidemiology of injury. In addition they can be used for many other purposes including quality of care improvement, examining outcomes from injuries sustained, analysis of trauma system functioning, and for resource allocation purposes. Information regarding patterns of injuries, demographic characteristics...
of patients, and areas where injuries occur would greatly contribute to injury prevention in LMIC [3]. Also, LMIC could also benefit from the additional purposes of surveillance systems, including for improving the quality of patient care and better allocation of resources.

Geographic information systems (GIS) can play a crucial role in understanding the burden of injury [8, 9]. GIS is useful for many injury surveillance and prevention tasks [8], including, uncovering the determinants of injury through analysis of its social and environmental correlates [e.g. 10], allocating personnel and financial resources, and identifying suitable locations for injury prevention and safety programmes [11]. GIS technologies range from sophisticated licensed desktop software to free, lightweight, web-based applications.

**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. Although Web 2.0 is most famous for the shift in the web's usability and interactivity, another great hallmark of this "new generation Web" – though thus far less heralded – is the paradigm shift in technology [12]. 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 shift is the success of the "Web office" (or Office 2.0) productivity software suites which are freely available and accessible anywhere through a web browser [13].

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" [14]. These new technologies are bringing Web 2.0 approaches to GIS, which is helping to "democratise" this once exclusive domain [15, 16]. 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 [17]. 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 as a test case. All aspects of data input, analysis, and visualisation were undertaken using Web 2.0 and GeoWeb technologies.

**Methods**

A pilot study was conducted at Groote Schuur Hospital, a large publicly-funded hospital in Cape Town, South Africa (a middle income country). A needs assessment uncovered an urgent need for a streamlined hospital-based trauma registry that could be used for epidemiological analysis and administration purposes. A current system in place at the hospital was not utilised 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. The pilot project was conducted over one month during which approximately 800 patients were recorded.

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 [18], 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; this was accomplished without the need for advanced computer skills or programming using the Forms feature available in Google Docs. During the needs assessment phase, the hospital described a desire to have simple data analysis tools for in-house data exploration and visualisation. Free and easy-to-use GeoWeb applications were demonstrated for these purposes in place of complex and costly desktop GIS.

**Results**

**Data collection and management**

In total 785 patients were recorded in the month long pilot study. Two researchers conducted the data capture;
this required assembling the data from various sources and recording it on a one-page paper form, one for each patient. Halfway through the study, doctors and the clinical staff who would eventually be charged with form completion began to assist with completion of the forms as part of their routine patient documentation. These staff were provided training and assistance in order for them to become familiar with the data, where it could be abstracted from, and the purposes of its completion. One person spent between one and three hours each day entering between 20 and 50 patient records into the trauma database, which was housed online in a Google Docs Spreadsheet. Fig. 1 shows the Google Docs Form, which facilitated streamlined data input through the ability for the data fields to be entered in the same order as on the paper form using dropdown menus, checkboxes, and text fields.

Data exploration and visualisation

A data processing, exploration, and visualisation 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 website (www.mapalist.com) – which is designed to work directly with Google Docs Spreadsheets – was used for data georeferencing. Its simple user-friendly interface is organised as a set of steps that the user proceeds through in order to geocode and visualise 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 website, or restricted to private viewing. There are also options to export results as Keyhole Markup Language (KML) files, and to automatically update the map if new data are added to the Google Docs Spreadsheet. An injury hotspot map created in Mapalist is shown in Fig. 2.

The free version of Google Earth [19] was used to develop an injury data spatial visualisation tool. Interactive visualisations were created to examine injury patterns in Cape Town suburbs (see Fig. 3). Mapalist was used to geocode the injury data (injuries by suburb) and create KML files, which could then be opened in Google Earth to explore the spatial distribution of injury in Cape Town interactively at multiple scales. The visualisation was created by exporting the geocoded results from Mapalist as Google Earth (KML) files.

Fig. 3: Google Earth visualisation of injuries by suburb. In this visualisation the map user can explore the spatial distribution of injury in Cape Town interactively at multiple scales. The visualisation was created by exporting the geocoded results from Mapalist as Google Earth (KML) files.

Discussion

A pilot study was conducted at a 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 visualisation solutions for low-resource settings. In addition, the pilot study demonstrated the potential for simple, web-based spatial analysis to highlight patterns of injuries. These achievements are notable as many health organisations in LMIC are unlikely to have access to licensed geospatial software or data analysis and visualisation tools, nor the expertise to operate them. The database was simple to set up and operate using Google Docs, including the data entry form and the spreadsheet. Mapalist was the better georeferencing website for the purposes of this study, as it is designed to work specifically with Google Spreadsheets which made the process more streamlined. Additionally, in comparison with the BatchGeocode tools, more visualisation options and data query functionality were available. Recent studies have used Google Earth for public health activities in low-resource settings [e.g. 20, 21, 22], however most examples used licensed proprietary software in addition to Google Earth. In this study, all tools were chosen explicitly because they had no licensing fees, were simple to use, and required no programming or sophisticated computer skills. For organisations with financial constraints or who have no expertise in traditional GIS, Google Earth may be an appropriate platform for data visualisation.

This article is primarily focused on the technological aspects of Web 2.0, however, another powerful characteristic of the new web is its ability to advance sharing and collaboration [23, 24].
Through the collaboration functions built in to many of these technologies, there is the potential for bridging the gap between researcher and stakeholder, including policy-makers and citizens [25]. Google Docs Spreadsheets are accessible and editable anytime, at any web-enabled computer, providing the user is provided access. The georeferencing websites similarly promote sharing and collaboration. For example, Mapalist has an advanced user-account system where users can view, edit, and update all of their maps in an easy-to-use interface. Maps can be privately or publicly viewable; if maps are restricted from public viewing, an email link can be sent to collaborators for viewing on a different computer.

The Google Earth platform also fosters collaboration and data sharing; KML files of data in Google Earth can be shared via email for viewing on any computer that has the software installed. The potential for these systems to allow for swift collaboration and sharing may be one of the most promising aspects of the web technologies for use in public health surveillance in any setting, irrespective of the level of resources at hand.

Web 2.0 technologies — due to their simplicity and lack of cost (or low cost) — will enable organisations in LMIC to develop data collection, analysis, and visualisation capabilities from within. This study presents a preliminary step in the development of a framework for resource-poor organisations to engage in authentic grassroots public health surveillance without the need for outside expertise. Future research will need to focus on issues such 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. Also, as high-level geospatial analysis is not possible with GeoWeb applications, it will also be necessary to assess the utility of the technology’s visualisation, 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 who are not familiar with geospatial or epidemiological concepts.

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References


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