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Viewpoint

Geological hazards: From early warning systems to public health toolkits

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ABSTRACT

Extreme geological events, such as earthquakes, are a significant global concern and sometimes their consequences can be devastating. Geographic information plays a critical role in health protection regarding hazards, and there are a range of initiatives using geographic information to communicate risk as well as to support early warning systems operated by geologists. Nevertheless we consider there to remain shortfalls in translating information on extreme geological events into health protection tools, and suggest that social scientists have an important role to play in aiding the development of a new generation of toolkits aimed at public health practitioners. This viewpoint piece reviews the state of the art in this domain and proposes potential contributions different stakeholder groups, including social scientists, could bring to the development of new toolkits.

1. Geohazards and public health

Internet-based geospatial tools and information are playing an increasing role in monitoring, modelling and managing health risks posed by the natural environment. Much of these applications have been in the arena of infectious diseases (e.g. Moreno-Sanchez et al., 2006) reflecting their obvious priority in global health. An example is the U.S.–Mexico Border Environmental Health Initiative (http://borderhealth.cr.usgs.gov/projectindex.html) which provides decision support tools for public health officials, environmental managers and the general public.

However, there are other aspects of the natural environment which pose risks to human health. This includes geological risks from ongoing exposures to chemicals in rocks and soils, as well as atmospheric particulate exposures. Sudden geological events such as landslides, earthquakes and volcanic eruptions (collectively termed geohazards) and their derived hazards such as tsunamis, also pose risks. Internet-based, geographic information plays an important role across all aspects of geological risk mitigation and much of this can be demonstrably shown to have been translated into public health initiatives. For example, the World Health Organization Eastern Mediterranean Region Office E-atlas of environmental health hazards (http://www.who-eatlas.org/eastern-mediterranean/) was created to aid public health emergency preparedness and response.

Nevertheless as Horwell and Baxter (2006) note, there is much more that needs to be done in terms of linking earth sciences, epidemiological knowledge and medical preparedness. One should also add the social sciences into this network. In essence there are significant shortfalls in bridging the gap between geological knowledge and health protection. We contend that, in the case of geohazards, there is sometimes a lack of coordination between geologists, who operate early warning systems (EWS) and those responsible for health protection. An example of this was observed during the 2004 tsunami which affected the Indian Ocean countries following a major landslide event linked to tectonic activity. Such extreme events typically result in sanitation and waste disposal problems, as well as impacts caused by stricken power

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Table 1
Search terms for literature review.

Successful search terms	Unsuccessful search terms yielding irrelevant content
Earthquake + health	Geological + health
Earthquake + "public health"	Geological + "public health"
Volcanic + health	"Extreme geological events" + health
Volcanic + "public health"	"Extreme geological events" + "public health"
Tsunami + health	
Tsunami + "public health"	
Earthquake + GIS	
Volcanic + GIS	
Tsunami + GIS	
Earthquake + "remote sensing"	
Volcanic + "remote sensing"	
Tsunami + "remote sensing"	

generation which affects water pumping stations, leading to risk of secondary health-related problems including such as further toxic exposures and infectious disease outbreaks (Akbari et al., 2004; Ministry of the Environment Republic of Indonesia, 2005; Joint UNEP/OCHA Environment Unit, 2005a; Joint UNEP/OCHA Environment Unit, 2005b). There is the possibility of longer-term health impacts as well, for example, in the case of volcanic eruptions due to exposure to atmospheric particulates from ash deposition (Hansell et al., 2006; Horwell and Baxter, 2006; Horwell et al., 2013).

Public health usually functions in reactive mode regarding such extreme events and policies seldom plan for high risk, low probability scenarios. For example, the United Nations Global Assessment Report on Disaster Risk Reduction 2011 (ISDR, 2011) highlighted the lack of contingency plans for the Icelandic volcanic ash cloud that affected Europe in 2010, pointing out it was not unusual in that such eruptions occur every 20–40 years on average and that it is predictable that parts of Europe may be affected with north-northwesterly winds occurring 6% of the time; further the volcano had been in eruption for 4 weeks before the ash cloud reached UK airspace so there had been time to act. Health consequences of a future, large-scale Icelandic eruption may be severe in Europe: a risk assessment (Schmidt et al., 2011) of an eruption similar to that happening in 1783–84 suggested that it would cause approximately 142,000 additional deaths from cardiovascular and respiratory disease in Europe if a similar eruption were to occur today. This viewpoint piece reviews the state of the art in this domain and proposes potential contributions different stakeholder groups, including social scientists (such as sociologists, human geographers and social anthropologists), could bring to the development of new toolkits. In particular we examine the current state of affairs in institutional and technical frameworks pivotal to better integrating warning systems and public health tools for the ultimate purpose of better public health decision-making. To provide a foundation for the views expressed in this article a search for relevant literature and frameworks/initiatives using Thomson Reuters Web of Science and the National Center for Biotechnology Information Pubmed; the search terms employed in this study can be found in Table 1. This formal literature search was supplemented by domain literature knowledge from each of the co-authors.

2. Where are we now?

Much to date has relied solely on mapping of at-risk populations (e.g. El Abidine El Morjani et al., 2007; Peduzzi et al., 2005, 2009) and post-disaster on-the-ground mapping for relief response (MapAction, 2009). There is still nevertheless a shortfall in reliable, operational systems for identifying priority locations for public health investigations and resource allocation commensurate with on-the-ground circumstances which may be rapidly changing. Without the necessary institutional frameworks and collaborative technologies such operational systems for public health is a distant aspiration but nothing more.

This situation is starting to change with the emergence of the Group on Earth Observations (Patz, 2005) for developing coordinated data acquisition and surveillance. The group is working on a technical framework termed the Group on Earth Observation System of Systems (GEOSS), which aims to better integrate health-related needs as one of its nine societal benefit goals (Nativi, 2010). However, the current and planned work of GEOSS health stream includes no reference to geohazards and health together (geohazards vulnerability mapping is included but not linked to health). This may well suggest that the health practitioner community has not pushed this aspect of health protection to highlight the information toolkit gaps. This contrasts with the GEOSS programmes regarding not only infectious disease control, but also atmospheric and water pollution. National and even continent-wide spatial data infrastructures such as INSPIRE (http://inspire.jrc.ec.europa.eu/) now aid the dissemination of geographic information using centralised Internet portals.

Another promising avenue for change is the Open Geospatial Consortium (OGC, http://www.opengeospatial.org/) which has established a range of standard specifications for Web services that facilitate the exchange and processing of geospatial data (Granell et al., 2010; Reichardt, 2010). Though there have been open source GIS developments for more than 30 years, the specification and widespread use of OGC standards has led to rapid developments currently being witnessed in open source GIS including interoperability and the capacity to perform Google-based "mash-ups" (Anand et al., 2010; Leibovici et al., 2011; Pollino et al., 2012).

We suggest that the 'health and place' community could make more effort to push for such initiatives to better link with WHO GIS programmes, with existing earth sciences initiatives (Table 2) such as the United Nations Environment Programme (UNEP) Project of Risk Evaluation, Vulnerability, Information and Early Warning (PREVIEW) (Giuliani and Peduzzi, 2011). PREVIEW is a global, Internet-based portal underpinned by a spatial data infrastructure. Achieving synergies between WHO and UNEP could make regularly updated geohazards data feeding into existing health GIS toolkits for local users to utilise a reality and not just a distant aspiration. One example of an existing health GIS toolkit used by local-level users is the Small Area Health Statistics Unit (SAHSU) Rapid Inquiry Facility (RIF) (Beale et al., 2010). The RIF was initially designed as a menu-based tool for SAHSU staff with no specialist training in GIS or geographical data linkage techniques, to help them analyse routinely collected health data in relation to environmental exposures in the UK and has subsequently been adapted for use in several European countries, and within the US Centers for Disease Control and Prevention (CDC) environmental public health tracking programme. It is situated in a desktop GIS platform and draws on external health, population, exposure and risk modifier information (e.g. deprivation, age) to provide relative risks in relation to exposures, but could readily be modified for use in extreme event situations. Currently the RIF team are redeveloping the tool to better integrate commercial and open source technologies (http://www.sahsu.org/content/rapid-enquiry-facility). This redevelopment includes the inclusion of XML-based interfaces, theoretically enabling seamless access to near real-time datasets from Internet sources.