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Commentary

Mapping of cholera cases using satellite based recording systems to investigate the outbreak

Global positioning system (GPS) is a satellite navigation system which delivers specially coded satellite signals that can be communicated in a GPS receiver, allowing the receiver to compute position, velocity and time of the object. GPS technology contained the space segment, control segment and the user segment. The most essential part of GPS system, the GPS receiver and user communities are present in user segment. GPS receiver acquires signals and converts the radio signals into position, velocity and time estimates[1]. Google Earth is not a geographic information system (GIS) with the extensive analytical capacities, but it is much easier than those high performance analytical software packages.

In the mid-19th century, John Snow mapped cases of cholera in Soho, London, and traced the source of the outbreak to a contaminated water pump[2]. He was the pioneer of cholera mapping. After that GIS and GPS systems were incorporated in the mapping techniques. Detection of cholera transmission risk system in Sabah, Malaysia, using GIS, satellite remote sensing (RS) and GPS was an example of usage of advanced technology in cholera control[3]. GPS system was also useful for detection of drainage networks on cholera outbreaks in Lusaka, Zambia[4]. Use of GPS system was an astounding event, which helped to conclude that insufficient coverage of drainage networks was an elevated risk of cholera outbreaks in Zambia[4]. GPS system was also used widely to map the disastrous cholera outbreak in Haiti in the year 2010[5]. Mapping of cholera-epidemic prone areas and the predisposing factors of cholera in Ilala district, Tanzania, was done using GPS and GIS system[6]. GPS and Google Earth system can easily record and store the waypoints that can help to navigate directly to the desired location. Thus, affected areas which require attention, can be located easily.

Cholera is still a considerable health burden in several geographical areas, reflecting poor maintenance of hygiene related infrastructure and difficulties in implementation of control measures in developing countries[7]. The devastating cholera outbreak during 2010 in Haiti, placed this ancient scourge at the forefront of the global public health agenda[8]. This severe, dehydrating diarrhoeal disease is triggered by the Gram-negative bacterium *Vibrio cholerae.* Till date, *V. cholerae* has more than 200 established serogroups and among them only O1 and O139 can cause pandemic and epidemic cholera. The clinical O1 strains can further be subdivided into two serotypes Ogawa and Inaba[9]. In recent years, novel pathogenic variants of *V. cholerae* O1 have been emerged and disseminated throughout the world[10-12]. This indicates a cryptic change in the genome of *V. cholerae*, which subsequently modified the epidemiology of cholera[13]. Ramesh Masthi and colleagues[14] in this issue described *V. cholerae* O1 Ogawa as a causative agent in the cholera outbreak in a village near Bengaluru, India during June 2013 which was spread through the contaminated water. They used GPS technology to gather information on this outbreak. Recent advances in GPS technology allowed scientist to accurately track the spread of an outbreak by measuring the accurate distribution of morbidity, mortality, and location of household of cases. Based on these technologies to capture the detailed information regarding the cholera outbreak, house-to-house survey was performed by the investigators. They used hand held GPS receiver to record the diarrhoea cases and subsequently these data were mapped with the help of Google Earth software. According to the signals received from the GPS receiver it was depicted that the cholera outbreak in this village was prevalent from 8th to 18th June 2013 with age distribution of cases ranged from 5 months to 93 yr. Epidemic peak was observed on the third and

fourth day of the outbreak with an attack rate of 6.9 per cent and case fatality rate of 3.7 per cent[14]. Stool sample microscopy using "hanging drop" revealed "darting motility" resembling *Vibrio cholerae*. But this result does not confirm the presence of *V. cholerae* O1. Further, arresting of darting motility by adding *V. cholerae* O1 antiserum would have been the definite test for *V. cholerae* O1, which was not performed in this study.

Google Earth can represent the earth as a three dimensional globe and thus provides detailed information regarding roads, populated places, geographic attributes water bodies, *etc*. GPS coordinates and Google Earth helped to generate spot map using satellite, which indicated the clustering of cases around the suspected water sources in the village[14]. With this clustering analysis the authors identified that the pipelines of the bore wells which was the only source of drinking water got damaged. With the help of Google Earth aerial view, prime suspected area in the village was identified and necessary actions were taken. Not only that the spatial distribution of cases accumulated with the aid of coordination of GPS tracking and Google Earth mapping, but also the locations of the household and routes from the Primary Health Centre in the outbreak area were recorded and made available. Google earth was successfully used to understand the cholera epidemic affecting Guinea-Bissau in 2008 focusing on the geographical spread to guide prevention and control activities executing the cluster analysis[15]. Just as John Snow's groundbreaking cholera maps of the nineteenth century displayed that poor sanitation leading to contaminated water was spreading disease[2], this study, which combined accurate mapping with the latest GPS technology, further emphasized the importance of improving the quality of water supplies and infrastructure for sanitation to seriously tackle diseases such as cholera.

These technologies have the potentiality to act as an early warning system for cholera in many developing countries, especially during the start of an outbreak. Once a cholera outbreak has been confirmed, large-scale rapid preventive measures, including mass vaccinations, promotion of protective behaviours related to food and water handling, improvement of hygiene and sanitation and ensuring that a sufficient supply of materials for cholera treatment, such as oral rehydration salts and antibiotics, could be mobilized to minimize morbidity and mortality so that it cannot progress into an epidemic. Wider use of GPS and GIS system to tackle cholera outbreaks was reported from several countries in 21st century[3-6]. This study further highlighted that GPS technology, combined with the Google Earth system was a useful tool to augment our understanding of preventive measure of the outbreak by providing the location of the households and an insight as to how people interact with the environment which in turn indicated contaminated bore wells as the main source of cholera outbreak. For now, however, it is safe to say that the quest for using GPS and Google Earth for disease control has just begun but it can definitely be used as a better mapping tool. Finally, the spread of disease especially infectious disease, is inevitably spatial and infection travels from individual to individual following a network of contacts within a population through local or global transmission[16]. Wider use of these modern technologies is ideally suited for infectious disease surveillance and control as resources are usually limited when responding to outbreaks, and knowledge about where to orient interventions is crucial. In conclusion, available tools for spatial analysis should be incorporated into the prevailing surveillance systems in order to improve planning, preparedness and management of cholera epidemics.

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References

1. Maddison R, Ni Mhurchu C. Global positioning system: a new opportunity in physical activity measurement. *Int J Behav Nutr Phys Act* 2009; *6* : 73.
2. Paneth N. Assessing the contributions of John Snow to epidemiology: 150 years after removal of the broad street pump handle. *Epidemiology* 2004; *15* : 514-6.
3. Abdul Rasam AR, Noor AM, Ahmad N, Ghazali R. MyGeoHealth: *GIS-based cholera transmission risk system in Sabah, Malaysia*. In: IEEE 7th International Colloquiumon, Signal processing and its applications (CSPA); 2011. p. 474-9. Available from: *http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5759925&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5759925,* accessed on November 12, 2015.
4. Sasaki S, Suzuki H, Fujino Y, Kimura Y, Cheelo M. Impact of drainage networks on cholera outbreaks in Lusaka, Zambia. *Am J Public Health* 2009; *99* : 1982-7.

5. Shah S. Mapping cholera: A Tale of 2 Cities Scientific American [Interactive]; 2014. Available from: *http://www.scientificamerican.com/article/mapping-cholera-tale-of-2-cities/*, accessed on November 12, 2015.
6. Mayala BK, Mboera LE, Gwacha F. Mapping of cholera risks using geographical information system in Ilala district, Tanzania. *J Health Res Bull* 2003; *5* : 8-12.
7. Mukhopadhyay AK, Takeda Y, Nair GB. Cholera outbreaks in the El Tor biotype era and the impact of the new El Tor variants. *Curr Top Microbiol Immunol* 2014; *379* : 17-47.
8. Piarroux R, Barrais R, Faucher B, Haus R, Piarroux M, Gaudart J, *et al*. Understanding the cholera epidemic, Haiti. *Emerg Infect Dis* 2011; *17* : 1161-8.
9. Raychoudhuri A, Mukhopadhyay AK, Ramamurthy T, Nandy RK, Takeda Y, Nair GB. Biotyping of *Vibrio cholerae* O1: Time to redefine the scheme. *Indian J Med Res* 2008; *128* : 695-8.
10. Raychoudhuri A, Patra T, Ghosh K, Ramamurthy T, Nandy RK, Takeda Y, *et al*. Classical ctxB in *Vibrio cholerae* O1, Kolkata, India. *Emerg Infect Dis* 2009; *15* : 131-2.
11. Naha A, Pazhani GP, Ganguly M, Ghosh S, Ramamurthy T, Nandy RK, *et al*. Development and evaluation of a PCR assay for tracking the emergence and dissemination of Haitian variant ctxB in *Vibrio cholerae* O1 strains isolated from Kolkata, India. *J Clin Microbiol* 2012; *50* : 1733-6.
12. Naha A, Chowdhury G, Ghosh-Banerjee J, Senoh M, Takahashi T, Ley B, *et al*. Molecular characterization of high-level-cholera-toxin-producing El Tor variant *Vibrio cholerae* strains in the Zanzibar Archipelago of Tanzania. *J Clin Microbiol* 2013; *51* : 1040-5.
13. Ghosh P, Naha A, Pazhani GP, Ramamurthy T, Mukhopadhyay AK. Genetic traits of *Vibrio cholerae* O1 Haitian isolates that are absent in contemporary strains from Kolkata, India. *PLoS One* 2014; *9* : e112973.
14. Ramesh Masthi NR, Madhusudan M, Puthussery YP. Global positioning system & Google Earth in the investigation of an outbreak of cholera in a village of Bengaluru, Urban district, Karnataka. *Indian J Med Res* 2015; *142* : 533-7.
15. Luquero FJ, Banga CN, Remartínez D, Palma PP, Baron E, Grais RF, *et al*. Cholera epidemic in Guinea-Bissau (2008): the importance of "place". *PLoS One* 2011; *6* : e19005.
16. Holmes EE. Basic epidemiological concepts in a spatial context. In: Tilman D, Kareiva P, editors. *Spatial ecology*: *The role of space in population dynamics and interspecific interactions*. Princeton, NJ: Princeton University Press; 1997. p. 111-36.