Feasibility of using global system for mobile communication (GSM)-based tracking for vaccinators to improve oral poliomyelitis vaccine campaign coverage in rural Pakistan

Subhash Chandira,⇑, Vijay Kumar Dharmaa, Danya Arif Siddiqia, Aamir Javed Khan

a Interactive Research and Development, Karachi, Pakistan
b Harvard Medical School Center for Global Health Delivery–Dubai, UAE

ABSTRACT

Despite multiple rounds of immunization campaigns, it has not been possible to achieve optimum immunization coverage for poliovirus in Pakistan. Supplementary activities to improve coverage of immunization, such as door-to-door campaigns are constrained by several factors including inaccurate hand-drawn maps and a lack of means to objectively monitor field teams in real time, resulting in suboptimal vaccine coverage during campaigns. Global System for Mobile Communications (GSM) - based tracking of mobile subscriber identity modules (SIMs) of vaccinators provides a low-cost solution to identify missed areas and ensure effective immunization coverage. We conducted a pilot study to investigate the feasibility of using GSM technology to track vaccinators through observing indicators including acceptability, ease of implementation, costs and scalability as well as the likelihood of ownership by District Health Officials. The real-time location of the field teams was displayed on a GSM tracking web dashboard accessible by supervisors and managers for effective monitoring of workforce attendance including ‘time in-time out’, and discerning if all target areas - specifically remote and high-risk locations - had been reached. Direct access to this information by supervisors eliminated the possibility of data fudging and inaccurate reporting by workers regarding their mobility. The tracking cost per vaccinator was USD 0.26/month. Our study shows that GSM-based tracking is potentially a cost-efficient approach, results in better monitoring and accountability, is scalable and provides the potential for improved geographic coverage of health services.

1. Background

The World Health Assembly resolved to eradicate poliomyelitis (polio) in 1998. With continued efforts, the number of positive polio cases declined from 350,000 in 1988 to 74 in 2015. Currently, the only remaining countries with endemic wild poliovirus (WPV) are Pakistan, Nigeria and Afghanistan and unless transmission of the disease is interrupted in these countries, the world remains at risk of a resurgence of polio.

The optimal immunization coverage (minimal immunization coverage required to achieve herd immunity, varies between 80 and 95% by vaccine antigen) is necessary to realize the full potential of vaccines [1]. In Pakistan, there is sub-optimal coverage of routine immunization by the Expanded Program for Immunization (EPI) services [2,3]. According to the Pakistan Demographic and Household Survey (PDHS 2012−13 [4]), a little over half (54%) of children aged 12–23 months were fully vaccinated with BCG, measles, and three doses of DPT and polio while 85% have received the recommended 3 doses of Oral Polio Vaccine (OPV). However this is below the recommendations of the polio eradication strategy to maintain a consistently high level (90% and above) of Oral Polio Vaccine (OPV) coverage among children under one year of age [5], also referred to as the ‘bedrock for polio eradication’ [6]. In light of low coverage of routine immunization [7], supplementary immunization activities (SIAs) consisting of door-to-door administration of the oral polio vaccine (OPV) to children under five years of age have been a cornerstone of polio eradication efforts. While Pakistan is getting closer to achieving polio eradication with the number of positive polio cases declining from 89 in 2009 to 20 in 2016 [2,3,8], several barriers to eradication remain (Fig. 1). Micro-planning which is the cornerstone of the four pillars of polio eradication remains inadequate; Vaccinators rely on hand-drawn maps to demarcate priority-areas and identify target

⇑ Corresponding author at: Interactive Research and Development, 4th Floor, Woodcraft Building, Plot 3 & 3-A, Sector 47, Korangi Creek Road, Karachi-74900, Pakistan.
E-mail address: Subhash.chandir@irdresearch.org (S. Chandir).
households. These hand-drawn maps are time-consuming to prepare and often do not take new settlements or those on the boundaries of adjacent areas into account. As a result, households may repeatedly be missed during SIAs, and since identification of missed households relies upon reports provided by field staff, there is no precise way of assessing which households remain unreached. Furthermore, optimal coverage may not be reached as there is a lack of objective and real-time monitoring of field teams involved in SIAs. Experts in the field of polio eradication agreed that major factors affecting the polio eradication program in Pakistan were poor preparation during the pre-campaign phase including substandard micro-planning and poor campaign monitoring and reporting [9]. These constraints are not unique to Pakistan only. In a survey study conducted in Sudan and Zambia, frontline health workers pointed that key factors to improve coverage during supplementary vaccination campaigns for polio and measles included better mapping (Sudan n = 26, 65.4%); supervision (Sudan n = 26, 53.8%) and good planning (Zambia n = 22, 31.8%) [10].

The rapid and vast proliferation of mobile technology has revolutionized the interaction of health systems. The widespread penetration of mobile phones provides expanded access to new technologies including Global Information System (GIS), and online mapping tools (e.g. Google Maps). These technologies can be leveraged for more detailed maps and satellite images for demarcation and identification of priority areas during routine and large-scale mass immunization activities [11]. Additionally, combined with tracking services, these technologies can provide a powerful tool for monitoring field-workers and undertaking assessments of missed areas during SIAs [12].

Previous studies have utilized geospatial data combined with tracking services to improve the efficacy of immunization campaigns. The decrease of WPV cases in Nigeria from 122 to 0 between 2012 and 2015 was associated with the use of tracking and mapping interventions [12], however polio resurgence with 4 WPV cases in 2016 highlights the need for further improvements in SIAs to prevent future instances of resurgence of wild poliovirus in the country [2,13]. Global Positioning System (GPS) tracking of vaccination teams led to improved micro-planning and nearly real-time monitoring of team performance in Nigeria, improved coverage of vaccination and a consequent reduction in the number of WPV cases in GIS accessible states [14,15]. However, location based tracking utilizing GIS technology is cost-prohibitive, especially in a developing country context.

The Global System for Mobile communication (GSM) is a widely available digital cellular technology used for transmitting mobile voice and data services. The mobile phone is continuously connected with a cellular tower or station. The GSM positioning utilizes a combination of the telecommunication network-based services, active cellular phones in the vicinity and triangulation network infrastructure including cellular ID, which is the unique identifier of the nearest signal tower the phone is communicating with Wang et al. [16]. The accuracy of GSM based positioning is on average between 50 and 100 meter, depending on cell tower density. Urban areas have a higher density of cell towers, and therefore the accuracy is greater [17]. GSM does not require the use of specialized equipment, and any individual with a GSM cellular phone and SIM from the same telecom provider can be tracked [18,19]. In comparison to GPS tracking, GIS is a low cost and readily scalable option.

Pakistan is one of the world’s fastest growing markets for telecommunications [20], which currently has over 133 million cell-phone subscribers with a mobile market penetration of approximately 76% [21], and costs of cellular phones continue to fall. Therefore, Global System for Mobile Communications (GSM) may be a potential tool for tracking vaccinators in vaccine coverage studies.

We piloted the use of Global System for Mobile Communications (GSM) based GIS tracking for vaccinators within a polio supplementary immunization campaign to assess the acceptability, demand, and implementation of GIS tracking. Additionally, we aimed to create a cost projection for a district-wide implementation of the intervention based on costs incurred during the pilot.

2. Methods

GSM tracking is commercially available in Pakistan through all mobile network operators’ (MNOs) and complies with the Pakistan Telecommunication Authority guidelines. There is no additional hardware requirement for GSM-based tracking. Additionally, the MNOs application programming interfaces (API), based on simple Object Access Protocol (SOAP), can easily be integrated with other software. The system relies on existing ~47,000 cellular phone towers across the country which has 92% land coverage [21].
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