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Research Paper

# Geo-spatial reporting for monitoring of household immunization coverage through mobile phones: Findings from a feasibility study

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ABSTRACT

*Background:* The addition of Global Positioning System (GPS) to a mobile phone makes it a very powerful tool for surveillance and monitoring coverage of health programs. This technology enables transfer of data directly into computer applications and cross-references to Geographic Information Systems (GIS) maps, which enhances assessment of coverage and trends.

*Objective:* Utilization of these systems in low and middle income countries is currently limited, particularly for immunization coverage assessments and polio vaccination campaigns. We piloted the use of this system and discussed its potential to improve the efficiency of field-based health providers and health managers for monitoring of the immunization program.

*Methods:* Using "30 × 7" WHO sampling technique, a survey of children less than five years of age was conducted in random clusters of Karachi, Pakistan in three high risk towns where a polio case was detected in 2011. Center point of the cluster was calculated by the application on the mobile. Data and location coordinates were collected through a mobile phone. This data was linked with an automated mHealth based monitoring system for monitoring of Supplementary Immunization Activities (SIAs) in Karachi. After each SIA, a visual report was generated according to the coordinates collected from the survey.

*Result:* A total of 3535 participants consented to answer to a baseline survey. We found that the mobile phones incorporated with GIS maps can improve efficiency of health providers through real-time reporting and replacing paper based questionnaire for collection of data at household level. Visual maps generated from the data and geospatial analysis can also give a better assessment of the immunization coverage and polio vaccination campaigns.

*Conclusion:* The study supports a model system in resource constrained settings that allows routine capture of individual level data through GPS enabled mobile phone providing actionable information and geospatial maps to local public health managers, policy makers and study staff monitoring immunization coverage.

## 1. Background

The exponential boom in the telecommunication industry across the globe has enabled better and advanced initiatives linking the concept of healthcare with the use of mobile phone applications. Mobile phone technology has aided in making data collection processes easier and accurate [1]. It has also enabled direct digital data entry into mobile phone application at the point of data collection allowing the ability to enter, review and analyze data in real-time [2]. Recent studies have indicated the effective use of mobile phones as a means of locating target populations, assessing issues pertinent to health care facilities and expanding health literacy among local communities, especially in low income countries [3]. Further the introduction of Global Positioning System (GPS) during data collection in mobile phones and cross-referencing it to Geographic Information Systems (GIS) maps has been a valuable development. This cost-effective measure in public health care settings has enabled obtaining clear presentation of data of the participant's environment. This in turn, promises a better assessment approach of trends and correlations to allow improvement in the planning, monitoring and surveillance of public health programs in developing countries [4–6].

Childhood immunization is a cornerstone in reducing morbidity and

*Abbreviations:* GPS, Global Positioning System; GIS, Geographic Information System; SIA, Supplementary Immunization Activity; EPI, Expanded Program on Immunization; ERB, Ethical Review Board; GSM, Global System for Mobile; USB, Universal Serial Bus; WHO, World Health Organization

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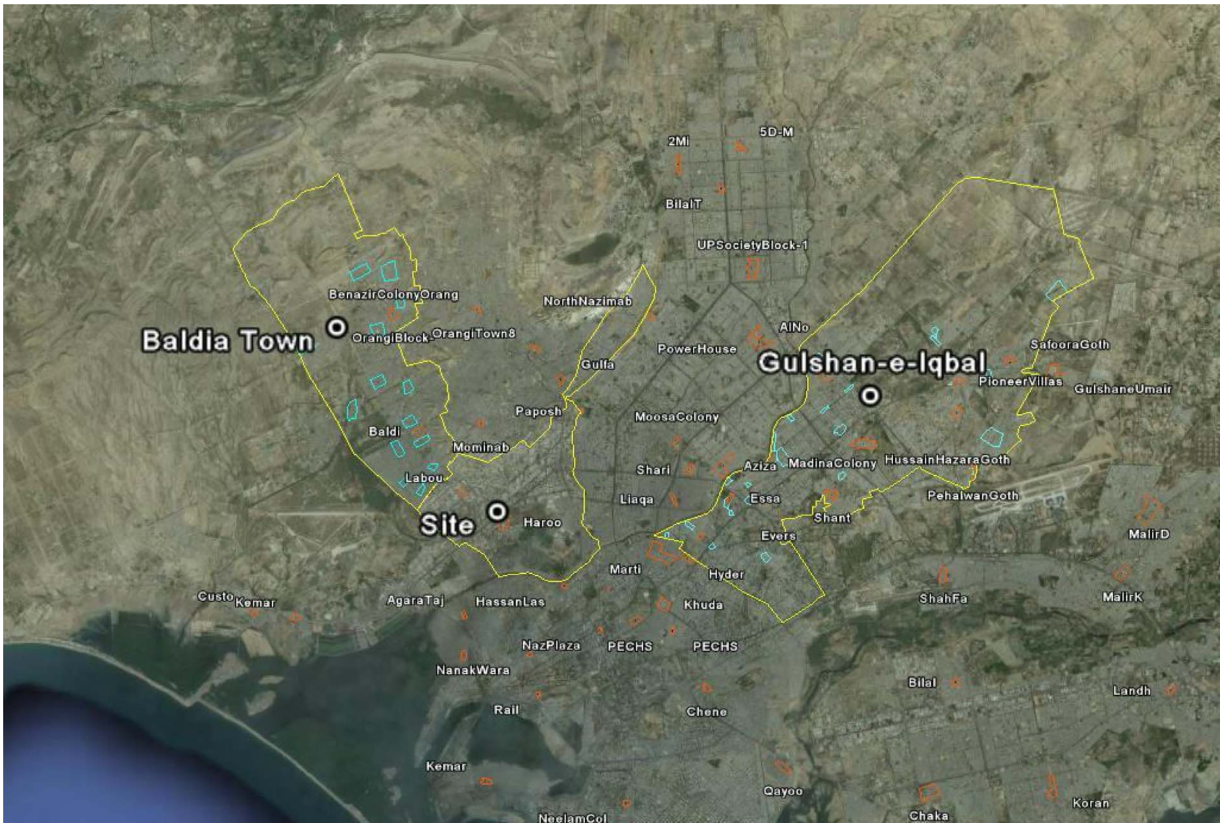


**Fig. 1.** Google Earth Maps identifying all clusters with names in the entire Karachi and three high risk towns-Baldia, Gulshan-e-Iqbal- Site.

mortality among children under five. Globally, various programs have been initiated to immunize each child against vaccine-preventable diseases along with setting up targets and evaluating goals periodically. Countries with endemic vaccine-preventable illnesses such as India, Nigeria and Mozambique have employed GIS technology to monitor and improve coverage rates setting up examples for other developing countries. Despite these technologies being increasingly used to evaluate the distribution of health services, inability to operate GPS devices indoor, complexity of stand-alone GIS software, and infrastructure required for linking GIS maps with the paper or electronic data and collecting of coordinates due to safety conducts or local bye in are still some of the hindrances for use of these tools in resource constrained settings [7–9].

Unfortunately, routine immunization coverage in Pakistan is still below the desired level due to multiple challenges faced by the country's Expanded Program of Immunization (EPI), leading to thousands of deaths from vaccine-preventable childhood illnesses [10]. Pakistan is among the three remaining endemic countries besides Afghanistan and Nigeria reporting Polio positive cases and struggling with interruption of poliovirus transmission [11]. Also, the country experiences multiple measles outbreaks, resulting in large numbers of morbidity and mortality among affected children [12]. A number of factors influence low immunization coverage in Pakistan among which inaccurate vaccine coverage estimates and lack in accountability at the district level are major concerns.

The government of Pakistan in collaboration with international agencies is working on introducing different strategies to improve the immunization coverage as well as strengthening monitoring approach in the field during Supplementary Immunization Activities (SIA) [10,13]. Stringent monitoring of immunization activities at the field and household level plays an essential role in boasting immunization coverage. However, in Pakistan, immunization activities are greatly affected by poor access to remote communities, accountability of the vaccinators, variable sociopolitical circumstances and poor governance at the district levels [14].

In order to ensure accountability and overcome these challenges, better monitoring tools and strategies are needed to determine coverage during each immunization campaign and Polio supplementary immunization campaigns. Pakistan is a developing country, currently possessing a strong network of mobile connectivity with around 140.5 million subscribers covering all socioeconomic strata [15]. Since 2014, an escalating trend has also been observed in the acceptance of smart phones as compared to feature phones in Pakistan. With increase uptake of mobile phone technology, mobile health or mHealth based interventions can be planned and implemented to improve immunization coverage and access to primitive groups in the community via short messaging service (SMS) and voice call based interventions [16].

In this study, we lay out a foundation for using geospatial map to monitor and visualize immunization coverage at the household and town level using mobile phone to collect location coordinates and baseline survey close to real time. Further we compared these maps obtained through a mHealth based and conventional lot quality assurance system (LQAS) monitoring system to evaluate polio supplementary immunization coverage at a household level. In this paper, we have described the process and discussed the potential of this strategy to improve the efficiency of field-based health providers and health managers for implementation and monitoring of the program.

## 2. Methods

### 2.1. Study site

This study was conducted in Karachi. It is among the world's largest cosmopolitan cities with an estimate 21 million people [17,18]. Being the financial and commercial hub of Pakistan, there is an annual 5% population rise in Karachi [19].