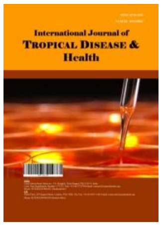

International Journal of TROPICAL DISEASE & Health

40(3): 1-9, 2019; Article no.IJTDH.54251
ISSN: 2278–1005, NLM ID: 101632866

Spatial Mapping of Measles-Rubella Campaign in a Rural Area near Bengaluru, Karnataka, India

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Authors' contributions

This work was carried out in collaboration between both authors. Authors NRRM and AJ contributed to the study design, data collection, statistical analysis, protocol writing, literature search and first draft. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJTDH/2019/v40i330227
Editor(s):
(1) Dr. Arthur V. M. Kwena, Associate Professor, Department of Medical Biochemistry, Ag. Dean School of Medicine, College of Health Sciences, Moi University, Kenya.
Reviewers:
(1) Karen Soares Trinta, Brazil.
(2) Mandadapu. S. V. K. V. Prasad, Jawaharlal Nehru Technological University, India.
(3) Martin Potgieter, University of Limpopo, South Africa.
Complete Peer review History: http://www.sdiarticle4.com/review-history/54251

Original Research Article

Received 24 November 2019
Accepted 28 January 2020
Published 04 February 2020

ABSTRACT

Immunization is an important public health intervention. The Measles-Rubella (MR) campaign was launched during 2017 in India for the elimination of measles. This study explored vaccination coverage and spatial mapping using QGIS and Google Earth Pro. WHO-EPI 30 clusters sampling technique for evaluation of vaccination coverage was performed in villages within the rural area of a Medical College near Bengaluru. Seven children aged 2-15 years were surveyed per cluster, resulting in 210 children. Smartphones having GPS/Garmin GPS72H (handheld GPS receiver) were used for noting coordinates. Subsequently all these coordinates were plotted for spatial mapping of vaccination coverage. The geospatial characteristics of the households surveyed were described using spatial mapping. Results indicate that 87.6% were immunized with MR Vaccine under the campaign, but 12.4% remained unimmunized, the reasons given being absence, ignorance, or refusal because of rumours concerning side-effects. The Measles-Rubella campaign coverage was found to be satisfactory. In addition the spatial mapping is a useful tool for measurement of coverage of a vaccination campaign. There was no clustering of unimmunized subjects observed on spatial mapping.

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Keywords: Geographic information systems; Measles-Rubella vaccine; vaccination coverage.

1. INTRODUCTION

Immunization is one of the major public health interventions for the protection of children from preventable life-threatening conditions. Vaccines have saved the lives of many millions of children in the world, and are one of the most important interventions in public health [1]. Global data for measles reported an increase by 300% in the first three months of 2019, compared with the same period in 2018. Spikes in the number of cases have occurred where high overall vaccination coverage exists such as the United States of America, Israel, Thailand, and Tunisia, with the disease spreading rapidly among clusters of unvaccinated people. Many countries are experiencing measles outbreaks with a sustained global rise in numbers of cases [2].

The Government of India launched the Expanded Programme of Immunization (EPI) in 1978 and the Universal Immunization Programme (UIP) in 1985 with six vaccines, namely; BCG, Oral Polio, Diptheria, Pertusis, Tetanus (DPT) and Measles [3]. The objective of the programme was to vaccinate at least 85% of all infants fully within one year [4]. Over the years, the incidence of the vaccine preventable diseases has declined [5].

The World Health Organization Organisation(WHO)as indicated in the Coverage Evaluation Survey of 2009 in India by UNICEF [6] recommends this method be undertaken for estimating immunization coverage among infants, a technique, which has been found to be very useful by public health administrators in low-income countries as it is rapid, operationally convenient and cost effective [6]. One of the main concerns in a country such as India is the validity of data collection and the documentation of information. The advent of new technology has, however, revolutionized ways in which information on problems of health is collected and disseminated. Geographic Information System (GIS), Global Positioning System (GPS) and Google Earth™ are modern tools available that can be used to measure health events through spatial mapping [7]. GIS has been used extensively for mapping of diseases in the last two decades. For example, GPS data was used to study the geographical distribution of HIV infected patients and to implement the rollout of treatment as prevention in an efficient manner [8]. GPS was used for spatial mapping the distribution of malaria vector mosquitoes and also for risk mapping in analyzing the past and present trends inmonitoring and evaluation of malaria [9].

GPS provides much needed contextual information [10], and explores potential associations of environmental factors on the disease [11]. Google Earth Pro™ [12] is a free software that can be downloaded onto a computer or to any compatible gadgets such as smart phones and tablets [13].

Following the success of the polio programme, the Government of India launched the Measles-Rubella (MR) campaign in February 2017 in selected states (Goa, Karnataka, Lakshadweep, Puducherry and Tamil Nadu) for children aged 9 months to15 years and later introduced it into the routine immunization programme in these states [14]. The goal of the campaign is to accelerate population immunity, and so reduce deaths from measles and disability from the congenital rubella syndrome [14].

However, the introduction of MR vaccine under the campaign was not a smooth affair as there were rumours about complications/ deaths due to vaccines and refusal for vaccination [15]. Hence, the MR campaign vaccination coverage was presumed to be low. Thus this study set out to scientifically assess the coverage of MR Vaccine under the campaign in the study area, and to spatial map the -MR campaign using QGIS [16] and Google Earth Pro™ in a rural area near Bengaluru, Karnataka, India. The results will be of value as MR campaign coverage has not been mapped. Spatial mapping using GIS may provide additional information on the vaccination coverage and the information gathered may help planners to identify gaps for better implementation of the program.

2. MATERIALS AND METHODS

Our exploratory cross-sectional study was undertaken in villages within the rural field practice area of a Medical college near Bengaluru, Karnataka, India during March 2018. The study subjects were children aged 2 to15 years. The WHO standard EPI 30 cluster sampling technique was used [17] and seven children per cluster were surveyed for assessing vaccine coverage. Fifty nine villages in the area were line listed along with their cumulative population, summed at 70243. A sampling interval was calculated by dividing the total cumulative population by 30 (clusters). The first was selected by a random number using a currency note, and the remaining clusters were selected by adding the sampling interval. Selection of the street, household and direction of survey was random. Subsequently households were surveyed in a continuous series till seven children (2-15 years) were found in each cluster. The survey was conducted using a pretested, semi-structured questionnaire. Socio-demographic details of all family members, immunization under the MR campaign, and reasons for not immunizing the child were recorded. Modified BG Prasad's Classification was used to classify subjects based on the socio-economic profile. Subjects who were given the vaccine during the campaign and had a MR vaccination card available were considered to be immunized. A vaccination coverage of <50% was considered poor, 50-80% average, and 80-90% satisfactory and > 90% good. Data were collected by the authors with the support of field staff Subjects needed to be 2-15 years old, have been resident in the area for a minimum of 6 months, and accompanied by informed consent given by the responsible adult respondent. Severely ill or immunocompromised children were excluded.

A handheld GPS receiver (Garmin GPS 72H) or smartphones having GPS was switched on in front of the household of subject. The GPS information page displayed information regarding the GPS receiver's current location (*i.e.* latitude and longitude in terms of degrees and minutes). The co-ordinates were recorded in the standard questionnaire On entering GPS coordinates (obtained during the household survey) in a computer with Google Earth Pro^{TM} (free software installed), spatial maps with location of households were displayed. Similarly, QGIS (free open source GIS application version 2.18.24) was downloaded [16]. The shp. files (revenue maps) of villages in the study area were downloaded and were used to map the clusters spatially under study [18].

Ethical clearance was obtained from by the KIMS Institutional Ethics Committee Ref No.: KIMS/IEC/D-07/2017. Confidentiality of study participants and data was ensured. Data were entered in Microsoft Excel [19] and R studio (Version 1.1.463P) and R commander statistical package [20] was used for analysis. Descriptive statistics such as median and percentage were calculated. Univariate analysis was applied to look for associations between immunization status and other variables such as gender, mother's education and age, father's occupation, and family socio-economic status.

3. RESULTS

A total of 210 subjects, of whom 106 (50.5%) were girls, were surveyed. Their median age with interquartile range was 3 (2,6) years (Table 1).Socio-economic profile, , indicated 20(9.5%) in Class I, 79(37.6%) in Class II, 86(40.9%) in Class III, 24(11.5%) in Class IV and 1 (0.5%) in Class V [19]. A majority 150(71.4%) belonged to nuclear, 8(3.8%) to joint and 52(24.8%) to three generation families.

A total of 184 (87.6%; 95% CI [82.4% - 91.8%]) were immunized with MR Vaccine during the campaign (Table 1). Reasons for the 26 remaining unimmunized were absence at the time of vaccination 19, (73.1%), ignorance 5, (19.2%) and refusal 2, (7.7%).The geospatial characteristics of the households surveyed are presented in Fig. 1.

A revenue, or cadastral, map (Fig. 2a) shows the boundaries of sub-divisions of land, land ownership, jurisdiction and composition of village government. A thematic map focuses on a specific theme such as climate, population density or health issues in contrast to general maps (that sow geological and geographical characteristics together). Our thematic map (Fig. 2a) required, as minimum requirements, installation of QGIS software, shp. files of the area and GPS household coordinates in our Excel sheet. In Fig. 2b the 30 clusters under study were depicted using Google Earth Pro^{TM} as drop pins. By zooming in, details of each 30 clusters could be scrutinized.

All immunized and unimmunized subjects can be depicted using QGIS Spatial map (Fig. 3a), where the analysis of data for larger areas is comparatively easier than by Google Earth Pro, which gives a satellite view (Fig. 3b). It was observed that unimmunized subjects were uniformly distributed across the study area and not clustered in one area.

Association between immunization status and gender, mother's education and age, father's occupation, and family socio-economic status was measured by univariate analysis; no significant association was observed.

Table 1. Immunisation status according to the sex of the study subjects (n=210)

Immunization status	Sex		Total
	Male	**Female**	
Immunized	91(87.5)	93(87.7)	184 (87.6%)
Unimmunized	**13(12.5)**	13(12.3)	26 (12.4%)
Total	**104(100.0)**	**106(100.0)**	**210(100.0)**

Figures in parenthesis indicate percentages

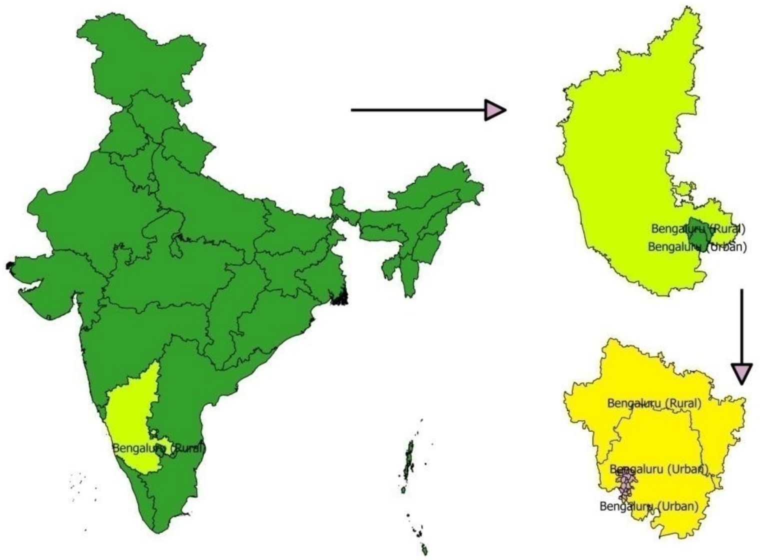

Fig. 1. QGIS spatial map indicating location of the state, district and study area

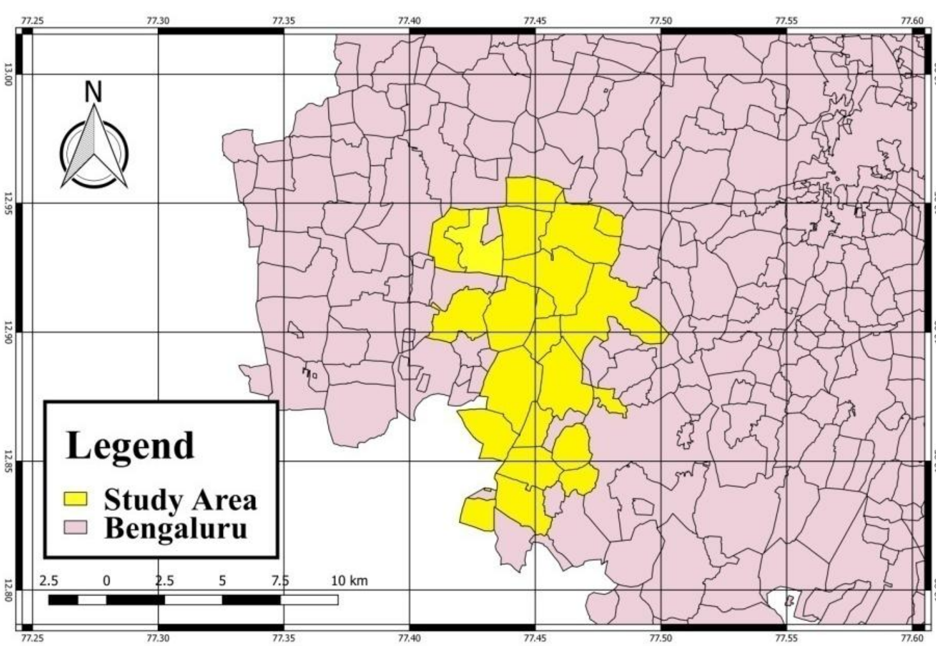

Fig. 2a. QGIS revenue map of the study area as a thematic layer

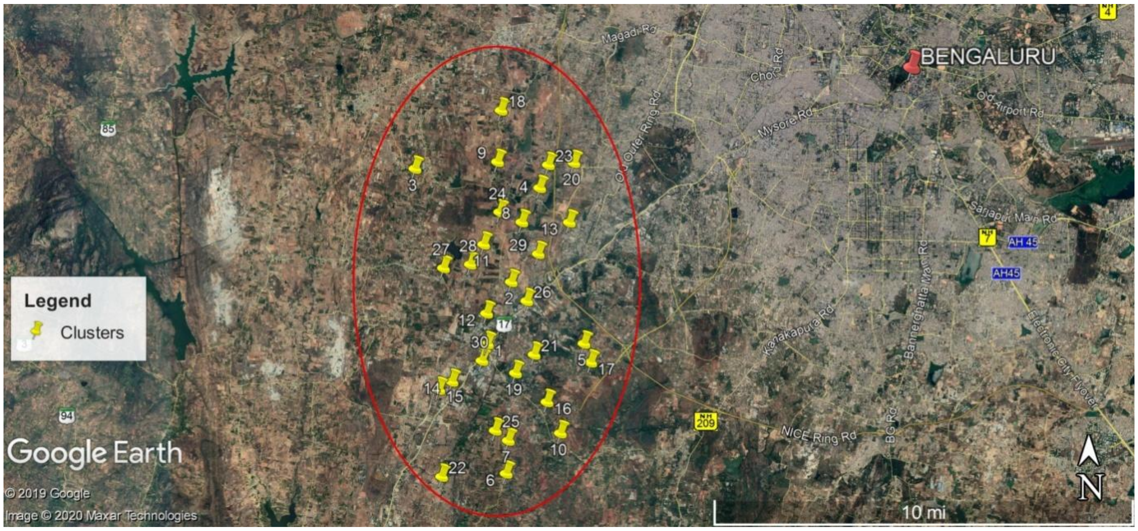

Fig. 2b. Thirty clusters under study depicted using Google Earth Pro™ as drop pins

4. DISCUSSION

In Karnataka state, the coverage of Measles Rubella campaign was 86.4% in Mysore [21] which was similar to the observations of the present study and 97% in Udupi [22]. The possible reason for higher coverage in Udupi can be due to the fact that the immunization coverage and literacy levels in Udupi is higher and additionally the study was conducted one month after the campaign hence the recall bias would be low. Measles Rubella campaign Campaign coverage from other states in India showed 60% coverage in Jharkhand [23] and 80.2% in Tamil Nadu [24]. Measles Rubella campaign coverage from other countries like Bangladesh was 90% [25], Kenya 93% [26] and Haiti 91% [27], which is little higher than the present study findings.

The main reasons for unvaccinated children were rumours and fear of adverse event following vaccination, lack of faith in immunization, unawareness about the campaign and the location for vaccination booth in studies from different settings (Mysore, Udupi, Jharkhand, Tamil Nadu, Bangladesh and Haiti). [21,22,23,24,25,26] which is similar to the observation in the present study. Factors such as child's school attendance, mother's education, education of caregivers, household wealth and religion were significantly associated with the vaccination status of the child in studies from different settings (Tamil Nadu, Bangladesh, Kenya and Haiti) [24,25,26,27]. No such association was observed in the present study.

The initial fear of refusal for MR vaccines based on media outputs [28] was found to be untrue as majority of the subjects were vaccinated. The Government Health Departments used appropriate electronic and print media to minimize the fear associated with the campaign [29].

Emerging free softwares provide access to satellite imagery and simple editing tools (e.g. Google Earth™) to complement existing geographic information system (GIS) software for accurate measurement of measles rubella campaigns. This allows the cross checking of data by independent monitors. The grass route level workers of the government like the ASHA and Anganwadi workers in the villages have been provided Tablets. They are being trained in data entry. The tablets when connected to the net have in built GPS. In a country like India with its large population and wide variation in the health care delivery systems across the states, empowering the grass root workers will help in easier and accurate measurement and storage of health events.

In a study conducted by Khan J et al. GIS spatial mapping was used to depict the vaccine specific prevalence and clustering across India [30]. Two cities in Mexico (Chetumal and Merida) were colour-coded to show presence of dengue cases and the data layers were successfully imported in a format known as shapefile into a GIS software [31]. We have similarly in the present study colour coded the vaccination coverage in the study area and able to differentiate high coverage areas from low coverage areas, etc.

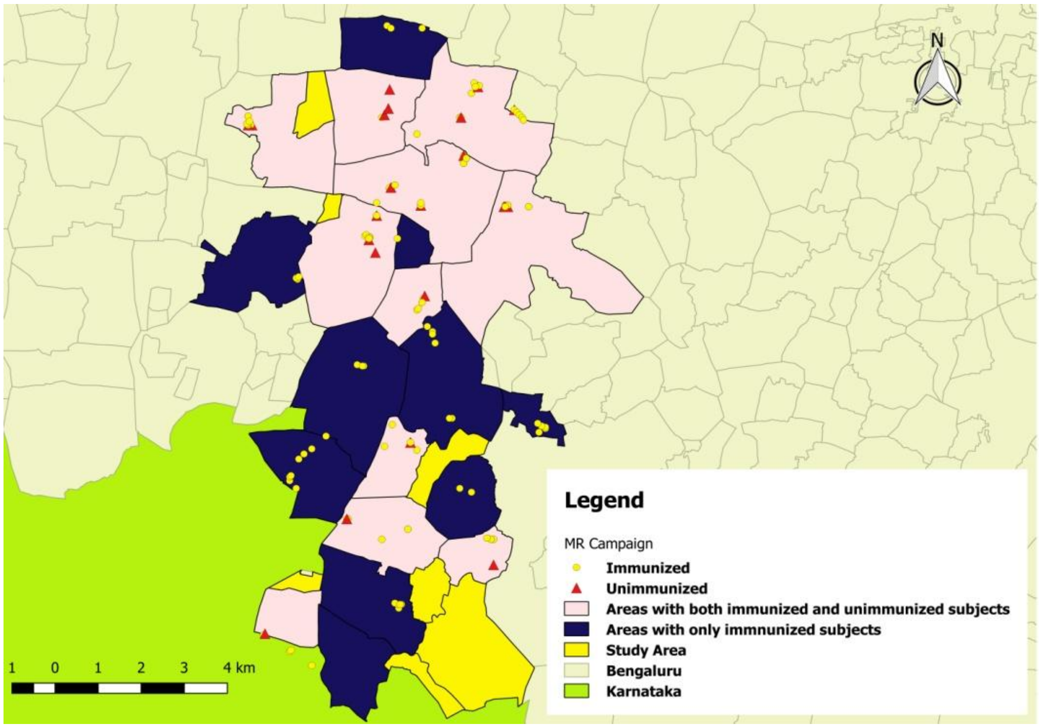

Fig. 3a. QGIS spatial map depicting MR Campaign coverage

Fig. 3b.Cluster with both immunized and unimmunized subjects using Google Earth Pro map

The campaign is an important step towards reducing measles and rubella morbidity and mortality in the country, and also outlines the country's efforts to its commitment to eliminate measles and control rubella & congenital rubella syndrome by 2020. It is recommended that efforts are taken to improve the routine immunization coverage of the MR Vaccine and supplementary immunization campaigns be conducted to bridge the gap and reach the status of elimination. However if the campaign is not reaching the intended target then the possibility of cases of Measles and Rubella occurring are very high and halt the progression of the elimination strategy.

5. CONCLUSION

Measles-Rubella campaign coverage though good was not at the expected level of ninety five percent according to the current global target of 95% at the national level as well as state-district. QGIS and Google Earth Pro were found to be useful in spatial mapping the vaccination coverage. Clustering of partially or unimmunized subjects was not observed through QGIS mapping.

Supplementary immunization activities can help achieve the goal of 95% coverage for Measles Rubella vaccine to reach elimination. Health education is of utmost importance to increase awareness regarding the importance of vaccines and curb rumors regarding their ill effects. GPS, QGIS and Google Earth Pro can be used to create maps for microplanning and track vaccination teams to enhance coverage, supervision, and accountability.

6. LIMITATIONS

A child was considered vaccinated, based on the availability of the MR card. There may have been instances where the child was vaccinated but the MR card not available or the MR card given to a child not actually vaccinated. Moreover, recording of GPS coordinates may vary between instruments but remains within an accepted level of accuracy.

CONSENT

Informed and written consent was obtained from the responsible adult respondents of subjects, usually the mother.

ETHICAL APPROVAL

Ethical clearance was obtained from by the KIMS Institutional Ethics Committee Ref No.: KIMS/IEC/D-07/2017. Confidentiality of study participants and data was ensured.

ACKNOWLEDGEMENT

We would like to thank all the PHC Medical Officers, Anganwadi workers, ASHAs and ANMs in the study field area for their co-operation during the conduct of the study. We express our sincere gratitude to all the study subjects and their parents/guardians for their participation and co-operation in the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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[Last Accessed 2020 Jan 25]

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/54251