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AN EVALUATION STUDY OF IMMUNIZATION COVERAGE IN CATCHMENT AREAS OF RURAL HEALTH TRAINING CENTRE WITH GEOGRAPHIC INFORMATION SYSTEM

Community Medicine

Varsha Kadam*	Senior Resident, Dept of Community Medicine. *Corresponding Author
D.H.Rao	Asso. Professor, Dept of Community Medicine.
Seema Bansode Gokhe	Prof & Head, Dept of Community Medicine.

ABSTRACT

Background: Immunization is one of the most successful and cost-effective public health interventions of the 21st century preventing 2–3 million deaths from common childhood illnesses including diphtheria, pertussis, tetanus, and measles per year. Despite this, 22.6 million children are still not reached by routine immunization services. As GIS is now an integral component of EPI management and is used to plan and evaluate immunization activities. More specifically, GIS in EPI is used to visually display and compare immunization coverage data among districts, regions, and countries (thematic maps) and to track changes in disease location (dot density maps). **Methodology:** In this cross sectional study, Geographic Information System along with Lot Quality Assurance Sampling Technique survey was used to evaluate immunization coverage of catchment areas attached to Rural Health Training Centres with total sample of 250 children. Study was conducted for 9 months amongst 12- 24 months age group of children. A pretested & pre-defined semi structured questionnaire was used for data collection to conduct interview of children's mothers in their vernacular languages after taking their consent to participate in this study. **Results:** Immunization coverage at RHTC was 94%. Multinomial logistic regression analysis showed the associations of immunization coverage with sociodemographic & other relevant factors at 95% CI. Birth order (OR 2.49, 0.26- 23.4), type of family (OR 1.01, 0.79- 1.27), mothers education (OR 1.36, 0.45- 4.06) & fathers occupation (OR 2.20, 0.70- 6.9) were significantly associated with full immunization coverage. While factors related with inadequate immunization were mothers occupation (OR 1.07, 0.32- 3.54) & fathers education (OR 1.01, 0.36- 2.84) . Spatial mapping done of all 25 lots of UHTC areas with full immunization coverage & with 'inadequate immunization' coverage with their geographic location. **Conclusion:** GIS technology helped to estimate the proportions of children having access to immunization service and proportions of children who complete the immunization schedule. It will precisely indicate the variations in coverage levels with specific geographic areas.

KEYWORDS

Immunization coverage, GIS technology, LQAS method.

INTRODUCTION

Immunization is one of the major public health interventions for the protection of children from life-threatening conditions, which are preventable. The concerted global effort to use immunization as a public health strategy began when the World Health Organization (WHO) launched the Expanded Programme on Immunization (EPI) in 1974, following the successful global smallpox eradication programme. Immunization is one of the most successful and cost-effective public health interventions of the 21st century preventing 2–3 million deaths from common childhood illnesses including diphtheria, pertussis, tetanus, and measles per year (Mahapatra T, 2017). Despite this, 22.6 million children are still not reached by routine immunization services (Mavimbe JC et al, 2005) According to NFHS survey 5(2019-2021) , Immunization coverage of India was 76.4% & of Maharashtra was 73.5% only.

Current performance is far below as stated by Global Vaccine Action Plan 2011–2020 the goal of reaching greater than 90% for all vaccines in the RI schedule by 2020 (WHO GAVI 2011-2020; 1-44). In 2002, the World Health Organization, the United Nations Children's Fund, and other partner organizations such as GAVI, the Vaccine Alliance, developed the 'Reaching Every District' (RED) guide to improve immunization program performance and reduce inequities in countries with low immunization coverage (Feldstein LR et al,2017; Peck M et al, 2017). Since its development, the RED strategies have been implemented in several African and Asian countries to a varying degree, resulting in increased immunization coverage (WHO, GVAP 2011-2020;1-44; Peck M et al, 2017). The RED strategies encourage and guide countries to develop microplans at the district and health facility level in order to estimate resource needs and formulate action plans based on available data to increase immunization coverage (Ali D et al, 2019).

The effectiveness and efficiency of RED microplans largely depend on detailed knowledge of the local situation; accurate population estimates; and maps showing the location of health facilities, villages, and other points of interest. The microplanning approach helps the district with determining the resources needed, including vaccine requirements, human resource allocation, service delivery strategies, and supervision (Ali D et al, 2019). However, outdated population estimates and limited information on the distances between health facilities and communities make it difficult to make evidence based decisions. There is a growing interest in applying geographical information systems (GIS) to the immunization field (Gammino VM et al, 2014; Barau I et al, 2014).

To evaluate immunization coverage in small health areas LQAS technique is most suitable for continuous programme monitoring as part of supervisory activities and can be designed to classify health areas simply as 'acceptable' or 'unacceptable' rather than to determine the precise level of coverage for the area (Hoshaw-Woodard, 2001).

One of the main concerns in country like India is the validity of the data collection and documentation of the information. The advent of new technology has revolutionized ways in which information on problems of health is collected and disseminated (Krishna, 2017) The spread of Geographic Information Systems (GIS) – a set of tools to capture, store, transform, analyse, and display spatial data –has improved spatial analysis of health related services and population health. GIS to supplement existing monitoring and evaluation efforts in supported areas to better target district-wide health system strengthening interventions (Schuurman N et al, 2010; McLafferty SL, 2003; Tanser FC & Sueur D, 2002; Munyaneza F et al, 2014).

Recent applications of GIS to support immunization programs include identifying and reaching previously unreached populations with vaccinations, remotely monitoring the performance of vaccination teams in the field and exploring the effects of vaccine strategy delivery mechanisms on coverage rates (Gammino VM et al, 2014; Barau I et al, 2014; Utazi CE et al, 2019). The GIS microplanning methods for accurate population estimates and use of maps as a programmatic platform go beyond RI and hold potential for other public health programs and primary health care interventions including those related to reproductive, maternal, newborn and child health (Ali D et al, 2019). Therefore, understanding the geographic determinants in making health programming decisions may support the improvement of service availability, access, utilization and outcomes for betterment of health system.

METHODOLOGY

The study was conducted in the catchment areas of Rural Health centre attached to a tertiary teaching medical institution. Permission was taken from in- charge of centre to conduct this study. The overall population was 72,123 in Rural Health Training Centre. There were 29 subunits in RHTC, we have selected 25 lots randomly as per convenience of ASHA from these subunits as decided by LQAS method. We have excluded 4 subunits in RHTC because they were not satisfying inclusion criteria & lot sample size. Those who have fulfilled inclusion criteria were interviewed using a pretested, semi-structured questionnaire.

Study Design: Cross-sectional study
Study Location: The field practice areas of Rural Health Centre attached to a tertiary teaching medical institution.
Study Duration: The current study was conducted for 9 months from January 2020 to March 2020 and from September 2020 to February 2021.

Sample size: 250 children.

Sample size calculation:
(Ministry of Health & Family Welfare Booklet 2011)

1. Selection of Lots : Can select maximum number of Lot i.e. 25 Hence, 25 lots were selected to study Urban Health Training Centres.
2. Level of confidence level and Accuracy : At 95% confidence level and 6% desired level of accuracy sample size would be 267.
3. Calculation of target population : Target population would be 3% of total population.

- Total population (RHTC): 72123 ; Target population: 2164 for RHTC

4. Sampling fraction = Total sample size/target population = 267/ 2164*100=12%

- Here sampling fraction coming more than 10% hence its showing large sample size for that we have to revise sample size by following formula
- Revised sample size = Total sample size/1+sampling fraction= 267/1.12=238 , its sampling fraction coming within limit of sampling fraction i.e. 10%

5. Calculation of sample size in each lot : Total sample size/ no. of lots = 238/25=10
6. Sample size would be 250

Sampling method: Lot Quality Assurance sampling method

Subjects: Children of 12-24 months

Procedure methodology:
Spatial mapping using a GPS receiver and GIS: A handheld GPS receiver (Garmin GPS 72H) was switched on in front of the household of subject. A GPS receiver displayed the information regarding elevation, time, and receiver's current location, i.e., latitude and longitude in terms of degrees and minutes (North .o.' and East .o.'). These values was recorded in the standard questionnaire. On entering the GPS coordinates in a computer with GIS software, the households of study subjects was spatially mapped. The data was analyzed using MS excel(Krishna, 2017).

Fig.1 Garmin GPS handheld device with label

Fig.2 While doing data collection in RHTC area along with ASHA

Steps For Data Collection Using Gps Handheld Devise:

- **At the beginning of GPS data collection…**

Step 1- Clearing out any existing waypoints and set to correct data display formats.
Step 2 - Set the information about study subject ,waypoint name in GPS handheld device.
Step 3- Log out of GPS handheld device.

- **After data collection…**
- Ensured that GPS data were collected for each lot.
- Exported data from GPS handheld device.

1) Sample Gps Data Collection Form:

- **Gps-receiver Number**
- **Lot Number**
- **Waypoint Name**

Latitude . ° N/s

(in decimal degrees)

Longitude . ° E/w

(in decimal degrees)

- **Elevation (meters)**

1) Transferring GPS coordinates from GPS handheld device to waypoints:

I. The serial cable or USB cable specific to the GPS handheld device was used to connect that device with laptop/desktop.
II. GPS coordinates for the sampled households from GPS handled device transferred to QGIS software to store them as waypoints. These Waypoints used for mapping of areas using GIS software.
III. A computer with a serial or USB port and the following programs installed:

1. QGIS software
2. Microsoft Excel
3. The listing data for the sampled households including the latitude/longitude coordinates (waypoints).

- Lot Quality Assurance Sampling (LQAS) is the most appropriate evaluation method in this context as it has been used successfully in past evaluations of vaccination coverage (Dubray et al., 2006; Tawfik et al, 2001). LQAS provides both a city wide estimate and estimates for geographic subunits. The limitation of the method is that a specific estimate for each subunit cannot be evaluated, but they are classified as having 'acceptable' or 'unacceptable' vaccination coverage based on upper (>85%) and lower cut-offs (<70%) defined for the specific survey (Hoshaw Woodard 2001).
- The areas were divided into 25 non-overlapping Lots based on administrative neighbourhoods with well known boundaries. In one lot sample size was taken according to target population of that area. A lower threshold of 70% vaccination coverage below which a lot was considered to have 'unacceptable' vaccination coverage and an upper threshold of 85% above which a lot was considered to have 'acceptable' vaccination coverage.
- To select households within each of the 25 lots, a systematic sampling planning done.

1. List of all households in wards were taken from the centre.
2. Household in each lot randomly selected and from this point moved to next house until we get desired sample size in one lot.
3. Only one target child and one mother selected for survey. If they didn't fill inclusion criteria moved to next house.
4. If more than one child of same mother found then target randomly selected from them.

Inclusion Criteria:

1. Children receiving routine immunization & fall in age group of 12-24 months.
2. Having immunization card with them or record with health care worker.

Exclusion Criteria:
1.Not having immunization record

Statistical Analysis:
Data was analyzed using SPSS version 22 & MS Excel. Chi square test & multinomial logistic regression test applied to see association between variables & immunization coverage. Mapping done with the help of QGIS software.

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RESULTS

A total of 250 children were included in study belonging to 12-24 months of age. Out of 250 children, 132 (52.8%) were males & 118 (47.2%) were females from Rural Health Training Centre.

Table 1. Immunization coverage of study subjects at RHTC Area:

	RHTC Area
CI (completely immunised)	235 (94%)
PI (Partially immunised)	15 (6%)

Table 1 shows distribution of immunization coverage at RHTC area. Complete Immunization coverage at RHTC was 94%.

Table 2. Immunisation coverage of each vaccine at RHTC Area

Vaccine name	Coverage at RHTC
BCG	100%
OPV0	234 (93.6%)
Hep B	203 (81.2%)
OPV1/PV1/IPV1	100%
OPV2/PV2	100%
OPV3/PV3/IPV2	249 (99.6%)
MR1/Vit A1	246 (98.4%)
DPT1/OPVB/MMR/Vit A2	149(out of 170)-87.6%

Fig.3 Bar diagram showing Immunization coverage for each vaccine at RHTC Area

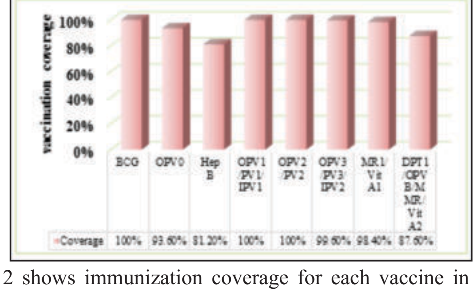

Table 2 shows immunization coverage for each vaccine in RHTC areas. Coverage for OPV1/PV1/IPV1, OPV2/PV2 & OPV3/PV3/IPV2 was 100%, 100% & 99.6% respectively. Coverage for DPT1/OPVB/MMR/VitA2 was 87.6%. Immunization coverage was lower for OPV0 Hep B (81.2%), DPT1/OPVB/MMR/Vit A (87.6%) in RHTC area as compared to other vaccines.

Table 3. Association of variables with immunization coverage at RHTC Area

Sr No	Variable	CI	PI	P value	
1.	**Gender**	M	123	112	0.37 (Non-significant)
		F	9	6	
2.	**Age**	<1 year	57	4	0.46 (Non-significant)
		>1 year	178	11	
3.	**Types of family**	Nuclear family	74	7	0.17 (Non-significant)
		Joint family	161	8	
4.	**Mothers education**	Primary	139	12	0.277 (Non-significant)
		Secondary	62	2	
		Graduation	34	1	
5.	**Mothers occupation**	Housewife	192	11	0.09 (Non-significant)
		In service	19	0	
		Others	24	4	
6.	**Fathers education**	Primary	137	12	0.22 (Non-significant)
		Secondary	50	1	
		Graduation	48	2	
7.	**Fathers occupation**	Labourer	128	11	0.14 (Non-significant)
		In service	31	0	
		Others	99	4	
8.	**Birth order**	1	110	5	0.02 (Significant)
		2	97	5	
		3	21	5	
		>3	6	0	

Table 3 shows association between variables &immunization coverage. There was no association seen in gender, age, mothers education & fathers education except birth order where P value was <0.05.

Table 4. Multinomial logistic regression analysis for the associations of immunization coverage with sociodemographic & other relevant factors: at 95% CI, df-1.

VARIABLE	RHTC	
	Full Immunization	**Inadequate Immunization**
	Odds ratio(95% CI)	**Odds ratio(95% CI)**
1.Birth order (first to sixth)	2.49 (0.26- 23.4) **(Significant)**	0.40 (0.04- 3.75)
2.Type of family (NF & Joint Family)	1.01 (0.79- 1.27) **(Significant)**	0.98 (0.78- 1.25)
3.Mothers education (primary to postgraduation)	1.36 (0.45- 4.06) **(Significant)**	0.73 (0.24- 2.18)
4.Mothers occupation (Housewife/others/Inservice)	0.93 (0.28- 3.09)	1.07 (0.32- 3.54) **(Significant)**
5.Fathers education (primary to postgraduation)	0.98 (0.35- 2.77)	1.01 (0.36- 2.84) **(Significant)**
6.Fathers occupation (labourer/others/In service)	2.20 (0.70- 6.9) **(Significant)**	0.45 (0.14- 1.42)

In the above table no.4, shows Multinomial logistic regression analysis for the associations of immunization coverage with socio demographic & other relevant factors at 95% CI. Birth order (OR 2.49, 0.26- 23.4), type of family (OR 1.01, 0.79- 1.27), mothers education (OR 1.36, 0.45- 4.06) & fathers occupation (OR 2.20, 0.70- 6.9) were significantly associated with full immunization coverage. While factors related with inadequate immunization were mothers occupation (OR 1.07, 0.32- 3.54) & fathers education (OR 1.01, 0.36- 2.84) .

Table 5. Immunization coverage of Lots in UHTC area

IMMUISATION COVERAGE	RHTC
>85% (Acceptable lots)	Vasind-1 (100%) Vasind -2 (100%) Asangaon (100%) Awale (100%) Shei (100%) Bhatsai (100%) Ambivali (100%) Shere (100%) Pali (100%) Dahagaon (100%) Khativali (100%) Madh (100%) Amerje (100%) Kajalivihir (100%) Shubhvastu (90%) Chandroti (90%) Sawroli (90%) Sane (90%) Katbav (90%) Sarmal (90%) Masvane (90%)
71-85%	Karale (80%) Mahuli (80%) Walshet (80%) Mamnoli (80%)

As shown in table 5, 21 lots were acceptable in UHTC area as per LQAS criteria (>85% immunization coverage).

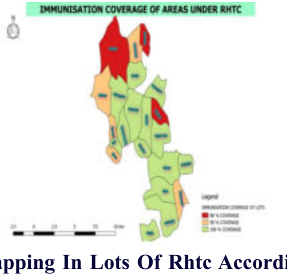

Fig. 4 Spatial Mapping In Lots Of Rhtc According Toacceptabi litycriteria Of Lqas Method

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Spatial mapping of vaccination coverage was done with QGIS software on a computer. [Figure 4] describes the spatial map of the study area and 25 lots surveyed. Red & pink color represents lots with inadequate immunization coverage. Light green color represents lots with full immunization coverage. Lots with pink & light green color were acceptable lots having >85% immunization coverage.

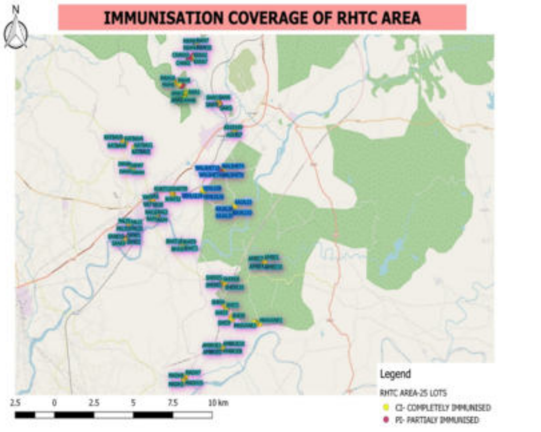

Fig. 5 Spatial Mapping In All Lots Of Rhtc Accordingto Immu nization Coverage Of Area

Spatial mapping of vaccination coverage was done with QGIS software on a computer. [Figure 5] describes the spatial map of the study area and 25 lots surveyed. Yellow color represents fully immunized children & pink color represents partially immunized children.

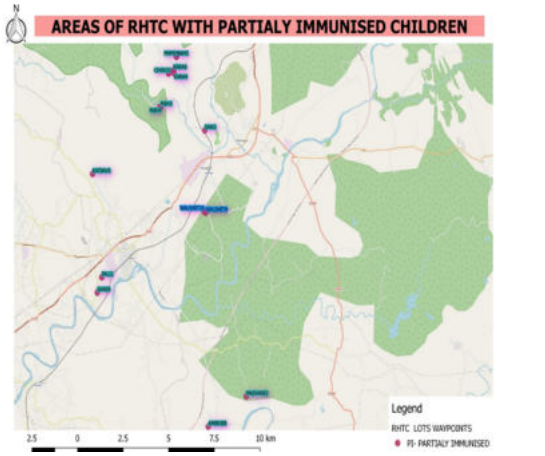

Fig. 6 Spatial Mapping In Inadequate Immunization Areas Of Rhtc

Spatial mapping of vaccination coverage was done with QGIS software on a computer. [Figure 6] describes the spatial map of the study area and 25 lots surveyed. Pink color represents partially immunized children.

Example Of Maps For Individual Lot Of Rhtc Area:

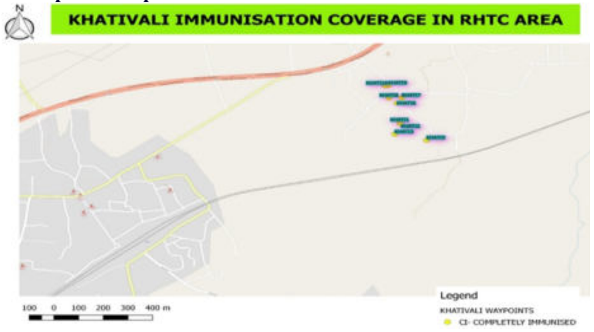

Fig. 7 Spatial Mapping In Khativali According To Immunization Coverage Of Area

Fig. 8 Spatial Mapping In Mahuli According To Immunization Coverage Of Area

DISCUSSION

A cross sectional study was conducted titled ' An evaluation study of immunization coverage of catchment areas belonging to Health Training Centres attached to tertiary teaching medical Institution by Geographic Information System. Lots quality assurance sampling method was used for data collection. A total of 250 children by LQAS method were included in the present study belonging to 12-24 months age.

Similar age group children were included in a study conducted by **Assefa Desalew et al (2020)** in Ethiopia & a study conductedby **K Punith, K Lalitha et al (2008)** at Mathikere Urban Health Centre, Bangalore which includes children aged 12 months to 23 months with desired sample size. However, a study conducted by **Andrew Clark, Colin Sanderson (2009)** in UK which includes children aged 6 weeks to 36 months. In most of the studies children aged 12 months to 23 months were included.

In this study Immunization coverage at RHTC was 94% as shown in table 1. Immunization coverage for rural was 76.8% according to **NFHS-5 (2019-2021). Xinyi Zhang et al (2018)** observed full vaccination coverage in rural children were 81.5% & in a study conducted by **Yu Hu, Ying Wang (2019) et al** found full vaccination coverage was 94% in rural areas. In a study conducted by **Mohammad Hardhantyo et al (2020)** in Indonesia had observed incompletely immunized children in urban area were 54.7%.

Coverage for OPV1/PV1/IPV1, OPV2/PV2 & OPV3/PV3/IPV2 was 100%, 100% & 99.6% respectively. Coverage for DPT1/OPVB/MMR/VitA2 was 87.6%. Immunization coverage was lower for OPV0 Hep B (81.2%), DPT1/OPVB/MMR/Vit A (87.6%) in RHTC area as compared to other vaccines. Immunization coverage was lower for OPV0 (62.5%), Hep B (59.2%), DPT1/OPVB/MMR/Vit A (74.8%) as compared to other vaccines in UHTC area. These values supported by **NFHS-5 (2019-2021)** in which immunization coverage for BCG, OPV, Pentavalent & MR vaccine at urban level was 95.2%, 80.5%, 83.9% & 87.9% respectively.

A study conducted by **Abadi Girmay et al (2019)** in Ethiopia observed that vaccination coverage of BCG, OPV1/OPV2/ OPV3, Pentavalent1/Pentavalent2/Pentavalent3, MR was 90%, 91.5%/ 85.3%/78.9%, 90%/84%/77.9% , 80.5% respectively. Similar immunization coverage observed in a conducted by **Bhuwan Sharma et al (2014)** in urban slums of Mumbai for BCG, OPV0, OPV1/OPV2/OPV3,DPT1/DPT2/DPT3, HepB1/HepB2/HepB3, MR was 97.1%, 89.5%, 96.7%/96.2%/93.8%, 96.7%/95.7%/92.9%, 95.2%/91.4%/88.1%, 87.6% respectively. In both the studies highest coverage seen for BCG & lowest for MR vaccine.

Main common reason for 'inadequate immunization' was child sickness (4.4%) followed by mother was not knowing date/day of vaccination(1.6%). A study conducted by **Bhuwan Sharma et al (2014)** in urban slums of Mumbai observed the main reason for noncompliance was given as child's illness at the time of scheduled vaccination followed by lack of knowledge regarding importance of immunization & **C.M. Singh et al (2019)** in Bihar India observed the most common reason for incomplete immunization was unavailability of child on the day of vaccination followed by sickness of the child.

As shown in table 4 multinomial logistic regression analysis done to see the associations of immunization coverage with sociodemographic & other relevant factors at 95% CI. Birth order (OR 2.49, 0.26- 23.4), type of family (OR 1.01, 0.79- 1.27), mothers education (OR 1.36, 0.45- 4.06) & fathers occupation (OR 2.20, 0.70- 6.9) were significantly associated with full immunization coverage. While factors related with inadequate immunization were mothers occupation (OR 1.07, 0.32- 3.54) & fathers education (OR 1.01, 0.36-2.84) .

These findings supported by a study conducted by **Abadi Girmay et al (2019)** that having antenatal care visit (AOR=2.75, 95%CI: 1.52-5.0), higher level of maternal education (AOR=2.39, 95%CI: 1.06-5.36), mothers' good knowledge on immunization (AOR=3.70, 95%CI: 2.37-5.79), short distance to health facility (AOR=2.65, 95%CI: 1.61-4.36), and being born in health institutions (AOR=2.58, 95%CI: 1.66-3.99) had increased the odds of full immunization coverage while having five and more family size reduced the odds of children's vaccine uptake (AOR=0.62, 95%CI: 0.38-0.99). Similar findings seen in a study conducted by **Anonh Xeuatvongsa et al (2017)** have observed factors relating to family characteristics such as maternal/paternal ethnicity (maternal ethnicity: OR 0.31, 95% CI: 0.18–0.53, paternal ethnicity: OR 0.32, 95%CI: 0.19–0.54), maternal/paternal occupation (maternal occupation: OR 2.60, 95%CI: 1.57–4.33, paternal occupation: OR 2.05, 95% CI: 1.26–3.33), and maternal/paternal education (maternal education: OR 1.66, 95% CI: 1.05–2.61, paternal education: OR 2.16, 95% CI: 1.34–3.48) were associated with full vaccination of the children.

In the present study as shown in table 5, 21 lots were acceptable in UHTC area as per LQAS criteria (>85% immunization coverage).From this study found out that LQAS sampling method is convenient method to find out immunization coverage of subunits, small pockets of any area so that we can work on that particular area to improvise immunization coverage by finding out factors responsible for inadequate immunization in that area.

A study conducted by **K Punith, K Lalitha et al (2008)** & **Singh J, Jain DC, et al (1996)** in India found that lot quality assurance sampling is better in evaluating primary immunization than cluster. Considering time & resources allocation lot quality assurance sampling method can be used as a tool to identify the problematic subareas. Similar findings seen in a study conducted by **K.P. Alberti, JP Guthman (2008)** in Paris concluded that LQAS method provides both citywide estimate and estimates for geographic subunits. They are classified as having acceptable/unacceptable vaccination coverage based on upper and lower cut off defined for the specific survey (Hoshaw-Woodard, 2001). In this study they have followed a lower threshold of 70% vaccination coverage below which a lot was considered to have 'unacceptable' vaccination coverage and an upper threshold of 85% above which a lot was considered to have 'acceptable' vaccination coverage.

Spatial mapping done with use of GIS software in this study. figure no 5 & 6 shows spatial mapping of all 25 lots of RHTC area with full immunization coverage & with 'inadequate immunization' coverage respectively. A study conducted by **NR Ramesh Mashti et al (2017)** in India concluded that spatial map describes the topography of the village and surrounding areas, latitude, and connectivity by road.

The spatial mapping describes the distance of households located in the village from the primary health care provider and also distance to the nearest healthcare provider, i.e., sub-center/PHC & **Mahapatra T. et al (2017)** in India also concluded that GIS technology will help to estimate what proportions of children have access to immunnisation service and what proportions of children complete the immunization schedule. It will precisely indicate the variations in coverage levels with specific geographic areas. A study conducted by **Disha Ali et al (2019)** in Nigeria also concluded that traditional microplanning relies on census figures to project target populations and on community estimates of distances, while GIS microplanning uses satellite imagery to estimate target populations and spatial analyses to estimate distances.

CONCLUSIONS

GIS technology helped to visualize all areas with 'fully immunized children' & 'partially immunized children' with their geographic locations. It will help to estimate the proportions of children having access to immunization service and proportions of children who complete the immunization schedule. It will precisely indicate the variations in coverage levels with specific geographic areas. New vaccines are being introduced into the national immunization schedule in developing countries covering a different range of age groups. The efficient planning and implementation of more complex immunization programs demands high quality information & that will be possible with new GIS technology.

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