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Research Article

Estimation and Comparison of Immunization Coverage under Different Sampling Methods for Health Surveys

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Immunization currently averts an estimated 2-3 million deaths every year in all age groups. Hepatitis B is a major public health problem worldwide. In this study, the estimates of hepatitis B vaccine coverage are compared among three sampling plans namely, 30×30 sampling and 30×7 sampling method under cluster sampling and systematic random sampling schemes. The data has been taken from the survey "Comparison of Two Survey Methodologies to Estimate Total Vaccination Coverage" sponsored by Indian Council of Medical Research, New Delhi. It is observed that the estimations of proportions of this vaccination coverage are significantly not different at 5% level of probability. Both 30×30 sampling and 30×7 sampling will be preferred to systematic sampling in estimation of hepatitis B vaccine coverage for this study population because of quick estimation and lesser cost. The 30×7 cluster sampling is the most recommended method for such immunization coverage especially in a developing country.

1. Introduction

World Health Organization states that trends related to global vaccination coverage (global estimates for 2008) continue to be positive [1]. Immunization has been one of the greatest public health successes. As many emerging and reemerging diseases are now the significant contributor to childhood morbidity and mortality, hepatitis B is one of them [2]. Hepatitis B is a liver disease caused by the hepatitis B virus [3]. It is a disease with high prevalence, severe morbidity, and premature mortality. It is highly infectious and can spread rapidly in the population through asymptomatic carriers [4]. About 78% of global pool of hepatitis B virus infection is from the Asian countries, particularly the developing countries of Asia-Pacific region [5]. Medical and public health experts strongly support universal vaccination against the hepatitis B virus, but many parents still do not think that their children need to be vaccinated. The hepatitis B virus is 100 times more infectious than the HIV virus [6]. The carrier rate of hepatitis B in India is different in the different regions of the country. The overall carrier rate is often quoted as being 4.7% [7]. Thus, India is an intermediate to high endemicity country [4].

Since 1982, hepatitis B vaccine has been available to prevent hepatitis B virus infection [8]. Hepatitis B vaccine was given within 12 hours of birth, then at 6 weeks and at 14 weeks [9]. This is to be noted that the children of Assam in the North-East Region of India have consistently evidenced low rates for routine childhood immunizations. Lack of information among the parents was one of the major causes of dropout of vaccinations [10].

In the late 1980s, the World Health Organization (WHO) developed the Expanded Program on Immunization (EPI) survey methodology also known as a two-stage (30×30) cluster sampling (recommended by WHO), which has been widely used ever since to assess vaccination coverage. Immunization status of children was evaluated using WHO-30 cluster methodology [11–14]. In this study, the estimates of hepatitis B (at birth) vaccine coverage are compared by using two-stage cluster and systematic random sampling method. The main objective of the study is to make a comparative study of hepatitis B (at birth) vaccine coverage between (i) two-stage cluster (30×30) and systematic random sampling and (ii) two-stage cluster (30×7) and systematic random

sampling. Also costs of surveys of these three methodologies have been compared.

2. Methods

The data for this study has been taken from a survey (conducted in 2011) "Comparison of Two Survey Methodologies to Estimate Total Vaccination Coverage" sponsored by Indian Council of Medical Research (ICMR), New Delhi. The data has been collected during the period from January to October, 2011.

2.1. 30 × 30 Cluster Sampling Method. In this method, the population needs to be divided into a complete set of nonoverlapping subpopulations, usually defined by geographic or political boundaries. These subpopulations are called clusters. In the first stage, 30 of these clusters are sampled with probability proportionate to the size (PPS) of the population in the cluster. Sampling with probability proportionate to size allows the larger clusters to have a greater chance of being selected. The clusters are sampled without replacement. In the second stage of sampling, 30 subjects are selected within each cluster. Although the sampling unit is the individual subject, the sampling is conducted on the household level.

2.2. 30 × 7 Cluster Sampling Method. The 30 × 7 cluster sample was developed by WHO in 1978. The goal of this sampling design was to estimate immunization coverage within ±10 percentage points of the true proportion, with 95% confidence. It is also a two-stage cluster sampling where in the first stage 30 clusters are selected and thereafter in the second stage 7 units are selected within each cluster [15].

2.3. Systematic Random Sampling. Systematic sampling is a random method of sampling in which only the first unit is selected with the help of random numbers and the rest get selected automatically according to some predesigned pattern. If the population size $N = nk$, where n is the sample size and k is an integer, and a random number less than or equal to k be selected and every kth unit thereafter. This procedure is linear systematic sampling. When $N \neq nk$, then every kth unit should be included in a circular manner till the whole list is exhausted; which is known as circular systematic sampling.

The questionnaire has been developed to collect information of household details like type of family, source of drinking water, purification of drinking water, toilet facility in the household, fuel used for cooking, number of household members, number of eligible members (the children of age from 6 months to 5 years), number of earning members in the household, and approximate monthly household income; information of the eligible members regarding record of vaccine and place of vaccination is collected. The vaccination coverage of hepatitis B at birth is considered.

The survey is conducted in Guwahati, the capital city of Assam. To get the idea of geographical location of Guwahati city, the ward map of the city has been collected and a listing of its wards from Guwahati Municipal Corporation (GMC) gives a lot of idea about the proper location of different wards of the city. And the listing of its wards gives the information about the number of assesses per ward. The city is comprised of a total of 60 wards. Out of 60, 30 wards are selected where selections are being made with the help of random number table (Table 1).

With the two-stage (30 × 30) cluster sampling method in the first stage 30 wards are selected and in the second stage 30 units from each ward are selected. For the selection of second stage units, a selected ward is divided into numbers of blocks such that the sizes of blocks are more or less of equal size. Also they are divided in such a way that the sizes of blocks are sufficient to draw the required numbers of sample. Then, one block is selected randomly and from that selected block we have collected the required number of sampling units (here it is 30 numbers of sampling units). Then, to select these 30 units, only the first household is randomly selected in a centrally located area of the block. After the first household is visited, the surveyor moves to the "next" household, which is defined as the one whose front door is closest to the one just visited. Where there are bylane in a particular lane survey procedure is carried out in that place according to the serial household number in that bylane. This process continues until all 30 eligible subjects are found. The subjects are chosen by selecting a household and for more than one eligible subject (children from 6 months to 5 years of age) in a household all are selected. This resembles random permuted block where the position of each unit is equally likely.

After completing the 1st sampling method (i.e., two-stage (30 × 30) cluster sampling) in a ward, 2nd sampling method (systematic random sampling) is carried out in same ward. In this sampling technique, a random number is selected from random number table on the basis of the number of households in a lane where the survey was carried out in case of two-stage (30 × 30) cluster sampling and this became the first sampling unit (household) of the systematic random sampling. After that, each household is selected at an interval of 10 households continuing the process until the 30 sampling units are not completed. Here, the interval of household is taken as 10 so that the interval is neither too small nor too large. If we take the interval too small, then we should get so many repetitions of the samples from two-stage (30 × 30) cluster sampling which results in the same sampling unit in the 2nd sampling method (systematic sampling) and if we take the interval too large, then there should not be any relation between the two methodologies as the larger interval will cover larger area and both of the sampling techniques should take different places.

3. Statistical Analysis

Here, we estimate hepatitis B (at birth) vaccine coverage, demographic characteristics, and other health outcomes under both sampling methods. Chi-square test has been used to compare the results obtained from the two sampling methodologies. Tests for equality of two population proportions and 95% confidence intervals have been used to compare estimates under the two methodologies for hepatitis B (at birth) vaccine coverage. The Z-statistic and 95% confidence interval for the difference of proportion are given as follows.

Table 1: Selected wards with area and total assesses.

Sl number	Ward number	Area	Total assesses
1	2	Jalukbari	1585
2	4	Near Pandu Colony Road	570
3	5	Gar Pandu	3094
4	9	Kamakhya Railway Station	44
5	11	Santipur	2768
6	12	Fatasil NC	5243
7	15	Udalbakra Grant	3450
8	17	Barsajai	1990
9	18	Bharalu	1971
10	24	TV Tower	2062
11	25	Ulubari	4185
12	26	Medical College Road	2655
13	33	Dighalipukhuri	1329
14	35	Chenikuthi	2950
15	36	Near Stadium	2721
16	37	Silpukhuri	2511
17	38	AIR	1723
18	40	Chandmari	1509
19	42	Opposite State Zoo	4027
20	43	Kachari Basti Road	3891
21	46	Guwahati Refinery	1330
22	47	Holy Child School	1125
23	48	Railway Colony	2397
24	50	State Zoo	2084
25	51	Hengerabari	5140
26	53	Sixmile	2073
27	54	Panjabari	2835
28	55	Beltola Bazar	2747
29	57	Rukminigaon	3855
30	59	Kahilipara	4664
31	60	Bhetapara	4674

Ward number 9 (Kamakhya Railway Station) is rejected as the ward list shows that the ward has only a total of 44 assesses.

The null hypothesis is

$H_0: P_1 = P_2$ (i.e., there is no significant difference between the proportions of the number of children undergoing hepatitis B (at birth) vaccine of two methodologies)

against the alternative

$H_1: P_1 \neq P_2$.

The test statistic is given by

$$Z = \frac{\widehat{p}_1 - \widehat{p}_2}{\sqrt{\widehat{p}\widehat{q}\left[(1/n_1) + (1/n_2)\right]}}, \quad \text{where } \widehat{p} = \frac{x_1 + x_2}{n_1 + n_2}, \tag{1}$$

where $\widehat{p}_1$ and $\widehat{p}_2$ are proportions of number of children undergoing hepatitis B (at birth) vaccine of cluster and systematic sampling, respectively. If $|Z| > 1.96$, we reject our null hypothesis.

The 95% confidence interval for $P_1 - P_2$ is given by

$$\begin{aligned}&\left(\widehat{p}_1 - \widehat{p}_2\right) - 1.96\sqrt{\frac{\widehat{p}_1\widehat{q}_1}{n_1} + \frac{\widehat{p}_2\widehat{q}_2}{n_2}}\\ &< P_1 - P_2 < \left(\widehat{p}_1 - \widehat{p}_2\right) + 1.96\sqrt{\frac{\widehat{p}_1\widehat{q}_1}{n_1} + \frac{\widehat{p}_2\widehat{q}_2}{n_2}}.\end{aligned} \tag{2}$$

4. Result and Discussion

Table 2 presenting the demographic and health practices of the respondents shows that under 30 × 30 sampling scheme

Table 2: The demographic and health practices of the respondents under the two sampling schemes (figures in %).

Sampling procedure	30 × 30		P value	30 × 7		P value
Variable	Cluster	Systematic		Cluster	Systematic	
Religion						
Hindu	87.2	91.1	0.02	87.6	84.8	0.66
Islam	11.1	7.3		10.5	13.3	
Others	1.7	1.6		1.9	1.9	
Caste						
General	75.0	71.6	0.18	72.9	75.2	0.84
SC	15.4	16.0		18.1	15.2	
ST	3.2	4.8		3.8	3.3	
OBC	6.3	7.7		5.2	6.2	
Source of drinking water						
Tap water	22.4	23.9	0.01	23.8	23.3	0.63
Tube well	5.8	3.9		5.7	4.8	
Well	51.1	56.0		45.7	51.4	
Others	20.7	16.2		24.8	20.5	
Purification of water						
Water filter	95.0	97.6	0.00	93.3	94.3	0.69
Others	5.0	2.4		6.7	5.7	
Toilet facility						
Sanitary latrine	93.8	95.9	0.04	94.3	92.9	0.55
Pit latrine	6.2	4.1		5.7	7.1	
Fuel used						
Kerosene	8.1	7.0	0.37	6.2	10.0	0.15
LPG	91.9	93.0		93.8	90.0	

there is a significant difference between two-stage cluster and systematic sampling in case of respondents religion (P = 0.02), source of drinking water (P = 0.01), purification of water (P = 0.00), and toilet facility (P = 0.04). On the other hand, there is no significant differences between two-stage cluster and systematic sampling under 30 × 7 sampling scheme.

The family related information of the respondents under the two sampling schemes (Table 3) shows that more than 90% are living in nuclear family; that is, people prefer to live in nuclear type of family rather than joint family. Family related information has not shown any significant differences between two-stage cluster and systematic sampling under both (30 × 30 and 30 × 7) sampling schemes except for the age of mother (P = 0.02) and the age of father (P = 0.00) under 30 × 30 sampling scheme.

Immunization related information of the respondents under the two sampling schemes (Table 4) shows that coverage of hepatitis B (at birth) vaccine is 58.4% and 55.8%, respectively, in 30 × 30 sampling scheme under cluster sampling and systematic sampling. On the other hand, it is 55.7% and 52.9% in 30 × 7 sampling scheme under two-stage cluster and systematic sampling, respectively.

From the result, it is clear that people prefer private health sector as nearly about 60% prefer private health sector.

Considering vaccination (hepatitis B at birth) of children by background characteristics of the respondents under the two sampling schemes (Table 5), it is observed that there is no significant difference between genders of children in both sampling schemes regarding their immunization of hepatitis B (at birth) vaccine. As the level of mother's education increases, the percentage of vaccination (hepatitis B at birth) coverage also increases.

Religion-wise, people belonging to others category (Christian, Jain) are 100% vaccinated whereas the remaining people are more or less 50% vaccinated against the vaccine (P = 0.01 under 30 × 30 sampling scheme). There is no such difference of estimates of hepatitis B (at birth) vaccine coverage under the two methodologies considering the category of the study population. It is seen that children belonging to higher income families are more vaccinated (more than 90%) and coverage of hepatitis B (at birth) vaccine in lower income families is very low (4.5–12% only).

Table 6 representing place of vaccination (hepatitis B at birth) of children by background characteristics of the respondents under the 30 × 30 sampling scheme shows that

Table 3: The family related information of the respondents under the two sampling schemes (figures in %).

Sampling procedure	30 × 30		P value	30 × 7		P value
Variable	Cluster	Systematic		Cluster	Systematic	
Type of family						
Nuclear	93.4	94.4	0.37	91.4	93.8	0.35
Joint	6.6	5.6		8.6	6.2	
Monthly household income						
Low	14.8	12.4	0.07	15.7	19.0	0.58
Middle	70.6	75.4		68.6	67.6	
High	14.7	12.2		15.7	13.3	
Age of father						
20–30	7.2	5.0	0.05	8.1	7.6	0.97
30–40	73.4	78.0		68.1	69.0	
40 and above	19.0	16.8		23.8	23.3	
Education of father						
No or primary education	3.1	1.4	0.00	3.3	4.8	0.43
High school	10.8	6.7		16.2	11.0	
Matriculate	8.3	9.6		5.7	7.6	
Intermediate	26.4	26.8		27.6	26.7	
Graduation	44.3	49.2		39.5	44.8	
Higher	7.0	6.3		7.6	5.2	
Occupation of father						
Govt. employee	20.2	21.0	0.69	22.9	18.6	0.72
Private sector employee	23.4	25.3		24.3	21.0	
Business	30.6	29.4		28.1	33.3	
Manual labour	10.1	8.2		10.5	11.9	
Driver	4.9	5.3		6.7	6.2	
Professional	10.8	10.6		7.6	9.0	
Age of mother						
15–25	8.8	5.8	0.02	10.0	11.4	0.64
25–35	79.5	84.1		75.7	77.1	
35 and above	11.5	10.0		14.3	11.4	
Education of mother						
No or primary education	6.2	4.0	0.16	6.7	6.2	0.40
High school	10.7	9.4		13.8	11.0	
Matriculate	12.2	10.9		10.0	15.7	
Intermediate	32.8	33.7		31.0	26.7	
Graduation	31.1	35.6		31.4	35.2	
Higher	6.0	5.9		7.1	5.2	
Occupation of mother						
Home maker	90.9	90.2	0.63	89.5	93.8	0.11
Employee	9.1	9.8		10.5	6.2	
Age of children						
6–24 months	26.8	24.0	0.16	21.9	23.3	0.40
24–48 months	35.4	34.0		37.1	31.0	
48–60 months	37.8	42.0		41.0	45.7	
Sex of the child						
Male	49.2	50.8	0.48	53.8	51.9	0.70
Female	50.9	49.1		46.2	48.1	

Table 4: Immunization related information of the respondents under the two sampling schemes (figures in %).

Sampling procedure	30 × 30		P value	30 × 7		P value
Variable	Cluster	Systematic		Cluster	Systematic	
Hepatitis B at birth						
Yes	58.4	55.8	0.27	55.7	52.9	0.56
No	41.6	44.2		44.3	47.1	
Place of vaccination						
Subdivisional civil hospital	22.2	22.3	0.46	19.5	23.3	0.25
Subcenters	18.2	20.9		22.9	20.5	
Private hospitals	28.6	26.5		31.9	24.8	
Private medical practitioner	31.1	30.3		25.7	31.4	

Table 5: Vaccination (hepatitis B at birth) of children by background characteristics of the respondents under the two sampling schemes (figures in %).

Sampling procedure	30 × 30		P value	30 × 7		P value
Background characteristics	Cluster	Systematic		Cluster	Systematic	
Sex of child						
Male	58.0	58.6	0.13	49.6	55.0	0.35
Female	58.7	52.5		62.9	50.5	
Mother's education						
No or primary education	1.8	0	0.33	7.1	0	0.28
High school	20.0	12.9		24.1	13.0	
Matriculate	27.5	23.5		19.0	24.2	
Intermediate	63.4	54.1		64.6	60.7	
Graduation	82.0	78.5		74.2	77.0	
Higher	92.6	92.3		93.3	81.0	
Religion						
Hindu	59.8	57.6	0.01	54.9	55.6	0.72
Islam	41.0	24.2		54.5	28.6	
Others	100.0	100.0		100.0	100.0	
Caste						
General	59.0	57.1	0.73	57.5	50.0	0.91
SC	56.1	53.8		44.7	59.4	
ST	55.2	44.2		62.5	85.7	
OBC	57.9	55.1		63.6	53.8	
Monthly household income						
Low	6.1	4.5	0.34	12.1	7.5	0.55
Middle	62.0	58.0		56.3	59.2	
High	93.2	94.4		97.0	85.7	

highly educated mothers prefer private health sector. Significant results are only in case of mother's education ($P = 0.00$), religion ($P = 0.01$), and monthly household income ($P = 0.01$) for subdivisional civil hospital under 30 × 30 sampling scheme.

Same result is seen in case of income of families as higher income families like to go to private health sector. Considering religion and caste of people, it is seen that more people prefer private health sectors. Compared with Table 7 representing place of vaccination (hepatitis B at birth) of children by background characteristics of the respondents under the 30 × 7 sampling scheme, it shows the same characteristics as Table 6.

Calculating estimates of proportion of number of children undergoing hepatitis B vaccine, it is seen that ward number 11 has the highest coverage (93% in two-stage (30 × 30)

Table 6: Place of vaccination (hepatitis B at birth) of children by background characteristics of the respondents under the 30 × 30 sampling scheme (figures in %).

Place of vaccination	Government health sector						Private health sector					
Background characteristics	Subdivisional civil hospital		*P* value	Subcenters		*P* value	Private hospital		*P* value	Private medical practitioner		*P* value
	Cluster	Systematic		Cluster	Systematic		Cluster	Systematic		Cluster	Systematic	
Sex of child												
Male	20.7	20.0	0.96	20.3	20.6	0.34	28.6	28.7	0.16	30.5	30.7	0.41
Female	23.8	24.9		15.9	21.3		28.7	24.0		31.7	29.8	
Mother's education												
No or primary education	39.3	22.9	0.00	46.4	57.1	0.72	1.8	0	0.60	12.5	20.0	0.09
High school	41.1	32.9		38.9	50.6		10.5	5.9		9.5	10.6	
Matriculate	36.7	23.5		34.9	52.0		9.2	14.3		19.3	10.2	
Intermediate	21.0	30.0		15.3	16.5		23.7	22.4		40.0	31.0	
Graduation	11.8	14.5		5.5	7.1		44.6	37.2		38.1	41.2	
Higher	3.7	5.8		1.9	1.9		68.5	57.7		25.9	34.6	
Religion												
Hindu	20.9	22.2	0.01	18.6	19.9	0.41	29.4	27.5	0.06	31.0	30.3	0.16
Islam	35.0	27.3		17.0	37.9		18.0	9.1		30.0	25.8	
Others	0	0		0	0		60.0	50.0		40.0	50.0	
Caste												
General	22.1	22.1	0.18	17.2	19.6	0.87	28.8	26.1	0.58	31.8	32.2	0.89
SC	22.3	18.9		21.6	28.0		26.6	25.9		29.5	27.3	
ST	6.9	18.6		37.9	32.6		31.0	25.6		24.1	23.3	
OBC	29.8	33.3		10.5	11.6		29.8	31.9		29.8	23.2	
Monthly household income												
Low	41.7	27.9	0.01	45.5	57.7	0.79	3.0	3.6	0.35	9.8	10.8	0.98
Middle	21.8	24.3		16.1	18.0		26.0	24.6		36.1	33.1	
High	4.5	3.7		0.8	1.9		66.7	62.0		28.0	32.4	

Table 7: Place of vaccination (hepatitis B at birth) of children by background characteristics of the respondents under the 30 × 7 sampling scheme (figures in %).

Place of vaccination	Government health sector						Private health sector					
Background characteristics	Subdivisional civil hospital		*P* value	Subcenters		*P* value	Private hospital		*P* value	Private medical practitioner		*P* value
	Cluster	Systematic		Cluster	Systematic		Cluster	Systematic		Cluster	Systematic	
Sex of child												
Male	18.6	21.1	0.69	30.1	21.1	0.09	28.3	24.8	0.65	23.0	33.0	0.49
Female	20.6	25.7		14.4	19.8		36.1	24.8		28.9	29.7	
Mother's education												
No or primary education	21.4	23.1	0.96	50.0	46.2	0.41	7.1	0	0.11	21.4	30.8	0.78
High school	27.6	34.8		48.3	47.8		17.2	4.3		6.9	13.0	
Matriculate	33.3	30.3		42.9	45.5		0	12.1		23.8	12.1	
Intermediate	18.5	30.4		16.9	8.9		29.2	23.2		35.4	37.5	
Graduation	15.2	12.2		10.6	8.1		45.5	37.8		28.8	41.9	
Higher	6.7	18.2		0	0		80.0	54.5		13.3	27.3	
Religion												
Hindu	21.2	22.5	0.05	21.7	20.8	0.72	32.1	25.8	0.90	25.0	30.9	0.94
Islam	9.1	32.1		36.4	21.4		22.7	10.7		31.8	35.7	
Others	0	0		0	0		75.0	75.0		25.0	25.0	
Caste												
General	17.6	24.7	0.20	22.9	20.9	0.95	34.6	21.5	0.39	24.8	32.9	0.59
SC	26.3	15.6		26.3	25.0		21.1	31.3		26.3	28.1	
ST	12.5	0		25.0	14.3		37.5	42.9		25.0	42.9	
OBC	27.3	35.8		9.1	7.7		27.3	38.5		36.4	15.4	
Monthly household income												
Low	24.2	27.5	0.24	51.5	52.5	0.22	9.1	5.0	0.50	15.2	15.0	0.99
Middle	22.9	24.6		21.5	14.8		26.4	24.6		29.2	35.9	
High	0	10.7		0	3.6		78.8	53.6		21.2	32.1	

Table 8: Estimates of proportion of number of children undergoing hepatitis B (at birth) vaccine and values of Z-statistic with confidence interval under 30 × 30 sampling scheme.

Sl number	Ward number	Cluster (p_1)	Systematic (p_2)	$\|Z\|$-value	CI
1	2	0.17	0.13	0.36	(−0.15, 0.21)
2	4	0.70	0.67	0.28	(−0.20, 0.27)
3	5	0.25	0.47	1.89	(−0.48, 0.01)
4	11	0.93	0.83	1.19	(−0.06, 0.26)
5	12	0.53	0.57	0.26	(−0.29, 0.22)
6	15	0.60	0.60	0.00	(−0.25, 0.25)
7	17	0.47	0.43	0.26	(−0.22, 0.29)
8	18	0.70	0.70	0.00	(−0.23, 0.23)
9	24	0.17	0.27	0.96	(−0.31, 0.11)
10	25	0.67	0.47	1.58	(−0.05, 0.45)
11	26	0.63	0.67	0.27	(−0.28, 0.21)
12	33	0.73	0.80	0.62	(−0.28, 0.15)
13	35	0.40	0.53	1.05	(−0.38, 0.12)
14	36	0.63	0.57	0.53	(−0.18, 0.31)
15	37	0.63	0.37	2.07**	(0.03, 0.51)
16	38	0.43	0.50	0.52	(−0.19, 0.32)
17	40	0.53	0.37	1.30	(−0.42, 0.08)
18	42	0.73	0.63	0.84	(−0.13, 0.33)
19	43	0.67	0.50	1.32	(−0.08, 0.41)
20	46	0.53	0.53	0.00	(−0.25, 0.25)
21	47	0.57	0.53	0.26	(−0.22, 0.29)
22	48	0.60	0.53	0.53	(−0.18, 0.32)
23	50	0.80	0.73	0.62	(−0.15, 0.28)
24	51	0.63	0.67	0.27	(−0.28, 0.21)
25	53	0.67	0.63	0.09	(−0.23, 0.25)
26	54	0.63	0.50	1.05	(−0.12, 0.38)
27	55	0.37	0.53	1.30	(−0.42, 0.08)
28	57	0.70	0.67	0.28	(−0.20, 0.27)
29	59	0.57	0.63	0.53	(−0.31, 0.18)
30	60	0.83	0.67	1.49	(−0.05, 0.38)
31	Combine	0.58	0.56	0.85	(−0.03, 0.07)

** Significant at 5% probability level.

cluster and 83% in systematic sampling). Ward number 2 shows the lowest coverage (17% in 30 × 30 cluster and 13% in systematic sampling).

Values of Z-statistic with confidence interval under 30 × 30 sampling scheme are given in Table 8. All Z-values are less than 1.96, except for ward number 37.

Again, estimates of proportion of number of children undergoing hepatitis B vaccine in case of 30 × 7 sampling are given in Table 9. It is seen that the highest coverage is 86% (ward number 11) and the lowest coverage is 0% in ward number 24. Values of Z-statistic with confidence interval under 30 × 7 sampling scheme show that except ward number 55 all other $|Z|$-values are less than 1.96.

Similarly, estimates of proportion of number of children undergoing hepatitis B vaccine (Table 10) in case of 30 × 30 cluster and 30 × 7 cluster sampling show that there is no significant difference between these two methodologies.

Comparison of larger systematic (30 × 30) and smaller systematic (30 × 7) sampling (Table 11) also shows the same result (only ward number 35 has a significant value).

5. Time and Cost Factor

To determine a better methodology, time and cost also play an important role. A comparison of time and cost factor between two-stage cluster and systematic sampling is given here. In case of 30 × 30 sampling scheme, it is seen that on average 148 households in each ward have been covered under cluster sampling and 459 households have been covered under systematic random sampling (Table 12). As the figure

Table 9: Estimates of proportion of number of children undergoing hepatitis B (at birth) vaccine and values of Z-statistic with confidence interval under 30×7 sampling scheme.

Sl number	Ward number	Cluster (p_1)	Systematic (p_2)	$\lvert Z \rvert$-value	CI
1	2	0.14	0.29	1.07	(−0.42, 0.12)
2	4	0.57	0.86	1.18	(−0.76, 0.19)
3	5	0.29	0.29	0.00	(−0.47, 0.47)
4	11	0.86	0.86	0.00	(−0.37, 0.37)
5	12	0.43	0.86	1.67	(−0.93, 0.07)
6	15	0.57	0.57	0.00	(−0.52, 0.52)
7	17	0.43	0.71	1.08	(−0.80, 0.23)
8	18	0.57	0.86	1.18	(−0.76, 0.19)
9	24	0.00	0.00	0.00	(0.00, 0.00)
10	25	0.71	0.29	1.60	(−0.10, 0.95)
11	26	0.57	0.57	0.00	(−0.52, 0.52)
12	33	0.86	0.86	0.00	(−0.37, 0.37)
13	35	0.71	0.43	1.11	(−0.22, 0.79)
14	36	0.71	0.71	0.00	(−0.47, 0.47)
15	37	0.71	0.43	1.08	(−0.23, 0.80)
16	38	0.57	0.43	0.53	(−0.38, 0.67)
17	40	0.71	0.43	1.08	(−0.23, 0.80)
18	42	0.86	0.57	1.18	(−0.19, 0.76)
19	43	0.57	0.43	0.53	(−0.38, 0.67)
20	46	0.57	0.57	0.00	(−0.52, 0.52)
21	47	0.57	0.14	1.67	(−0.07, 0.93)
22	48	0.71	0.43	1.08	(−0.23, 0.80)
23	50	0.57	0.57	0.00	(−0.52, 0.52)
24	51	0.43	0.71	1.08	(−0.80, 0.23)
25	53	0.43	0.71	1.08	(−0.80, 0.23)
26	54	0.43	0.57	0.53	(−0.67, 0.38)
27	55	0.43	0.14	2.09**	(0.02, 0.56)
28	57	0.71	0.86	0.65	(−0.57, 0.29)
29	59	0.57	0.57	0.00	(−0.52, 0.52)
30	60	0.86	0.86	0.00	(−0.37, 0.37)
31	Combine	0.56	0.53	0.11	(−0.49, 0.55)

** Significant at 5% probability level.

shows that more household has been covered in systematic random sampling so also the time required for collecting the data is also higher and it is near about three times (on the basis of average figure) that the time spent in case of two stage cluster sampling.

As the time required is more, the cost incurred is definitely high in case of systematic sampling. Again, in case of 30×7 sampling scheme, the number of households covered (on average) in each ward is 38 (in two-stage cluster sampling) while, in case of systematic random sampling, it is 114 numbers which is three times more than that of the figure of the two-stage cluster sampling. It means that on average the required time is three times more in systematic sampling than in two-stage cluster sampling so cost incurred is higher in systematic sampling. Thus, we can say that, in both sampling schemes, systematic sampling is more time-consuming than the two-stage cluster sampling and hence the cost is higher in systematic random sampling in compared to that of two stage cluster sampling.

6. Conclusion

It is found that there is no significant difference between the estimates of hepatitis B (at birth) vaccine coverage under the three methodologies in demographic and health practices, family related information, and immunization related information of the respondents of the study population. Mother's education plays an important role in case of vaccination

Table 10: Estimates of proportion of number of children undergoing hepatitis B (at birth) vaccine and values of Z-statistic with confidence interval for larger and smaller cluster sampling.

Sl number	Ward number	30×30 (p_1)	30×7 (p_2)	$\lvert Z \rvert$-value	CI
1	2	0.17	0.14	0.15	(−0.27, 0.17)
2	4	0.70	0.57	0.65	(−0.27, 0.33)
3	5	0.23	0.29	0.29	(−0.42, 0.14)
4	11	0.93	0.86	0.66	(−0.20, 0.22)
5	12	0.53	0.43	0.50	(−0.30, 0.31)
6	15	0.60	0.57	0.14	(−0.38, 0.24)
7	17	0.47	0.43	0.18	(−0.37, 0.25)
8	18	0.70	0.57	0.65	(−0.27, 0.33)
9	24	0.17	0.00	1.16	(0.03, 0.23)
10	25	0.67	0.71	0.24	(−0.42, 0.14)
11	26	0.63	0.57	0.30	(−0.34, 0.27)
12	33	0.73	0.86	0.69	(−0.43, 0.03)
13	35	0.40	0.71	1.50	(−0.69, −0.12)
14	36	0.63	0.71	0.40	(−0.46, 0.11)
15	37	0.63	0.71	0.40	(−0.46, 0.11)
16	38	0.43	0.57	0.66	(−0.55, 0.07)
17	40	0.53	0.71	0.87	(−0.56, 0.01)
18	42	0.73	0.86	0.69	(−0.43, 0.03)
19	43	0.67	0.57	0.48	(−0.31, 0.30)
20	46	0.53	0.57	0.18	(−0.45, 0.17)
21	47	0.57	0.57	0.02	(−0.41, 0.20)
22	48	0.60	0.71	0.56	(−0.49, 0.08)
23	50	0.80	0.57	1.27	(−0.16, 0.43)
24	51	0.63	0.43	0.99	(−0.20, 0.41)
25	53	0.67	0.43	1.17	(−0.17, 0.44)
26	54	0.63	0.43	0.99	(−0.20, 0.41)
27	55	0.37	0.00	1.91	(0.19, 0.45)
28	57	0.70	0.71	0.07	(−0.39, 0.18)
29	59	0.57	0.57	0.02	(−0.41, 0.20)
30	60	0.83	0.86	0.15	(−0.32, 0.12)
31	Combine	0.58	0.56	0.12	(−0.38, 0.23)

Table 11: Estimates of proportion of number of children undergoing hepatitis B (at birth) vaccine and values of Z-statistic with confidence interval for larger and smaller systematic sampling.

Sl number	Ward number	30×30 (p_1)	30×7 (p_2)	$\lvert Z \rvert$-value	CI
1	2	0.13	0.00	1.02	(0.01, 0.25)
2	4	0.67	0.86	0.99	(−0.50, 0.12)
3	5	0.47	0.29	0.87	(−0.20, 0.56)
4	11	0.83	0.86	0.15	(−0.32, 0.27)
5	12	0.57	0.86	1.43	(−0.60, 0.02)
6	15	0.60	0.57	0.14	(−0.38, 0.43)
7	17	0.43	0.71	1.34	(−0.66, 0.10)
8	18	0.70	0.86	0.84	(−0.46, 0.15)
9	24	0.27	0.00	1.54	(0.11, 0.42)
10	25	0.47	0.29	0.87	(−0.20, 0.56)
11	26	0.67	0.57	0.48	(−0.31, 0.50)
12	33	0.80	0.86	0.35	(−0.35, 0.24)
13	35	0.53	0.00	2.56**	(0.35, 0.71)
14	36	0.57	0.71	0.72	(−0.53, 0.23)
15	37	0.37	0.43	0.30	(−0.47, 0.34)
16	38	0.50	0.43	0.34	(−0.34, 0.48)
17	40	0.37	0.43	0.30	(−0.47, 0.34)
18	42	0.63	0.57	0.30	(−0.34, 0.47)
19	43	0.50	0.43	0.34	(−0.34, 0.48)
20	46	0.53	0.57	0.18	(−0.45, 0.37)
21	47	0.53	0.14	1.87	(0.08, 0.71)
22	48	0.53	0.43	0.50	(−0.30, 0.51)
23	50	0.73	0.57	0.84	(−0.24, 0.56)
24	51	0.67	0.71	0.24	(−0.42, 0.33)
25	53	0.63	0.71	0.40	(−0.46, 0.30)
26	54	0.50	0.57	0.34	(−0.48, 0.34)
27	55	0.53	0.14	1.87	(0.08, 0.71)
28	57	0.67	0.86	0.99	(−0.50, 0.12)
29	59	0.63	0.57	0.30	(−0.34, 0.47)
30	60	0.67	0.86	0.99	(−0.50, 0.12)
31	Combine	0.56	0.53	0.14	(−0.38, 0.44)

** Significant at 5% probability level.

coverage and selecting the place of vaccination. 30×7 sampling method failed to capture hepatitis B (at birth) vaccine coverage only in ward number 24. It is observed that both sampling schemes provide estimation of proportion of hepatitis B (at birth) vaccine coverage which is significantly not different at 5% level of probability indicating that it is insignificant and we have no evidence to reject the null hypothesis that there is no significant difference between the proportions of number of children undergoing hepatitis B (at birth) vaccine of two methodologies, namely, 30×30 cluster and systematic and 30×7 cluster and systematic sampling. On average, only 53–58% of children are vaccinated against hepatitis B. Coverage of hepatitis B (at birth) vaccine is moderate in this urban society of North-East India indicating poor child health scenario. It may be concluded that methodology-wise 30×7 sampling scheme (two-stage cluster sampling) will be preferred to 30×30 and systematic sampling because of quick estimation and lesser cost. But it

Table 12: Household covered in each ward under 30 × 30 and 30 × 7 sampling schemes.

Sl number	Ward number	Number of households covered			
		30 × 30		30 × 7	
		Cluster	Systematic	Cluster	Systematic
1	2	105	400	43	70
2	4	215	530	68	180
3	5	133	400	40	90
4	11	127	420	32	80
5	12	105	410	21	80
6	15	163	510	56	100
7	17	216	520	33	140
8	18	122	390	30	80
9	24	130	500	24	150
10	25	149	440	35	100
11	26	123	420	34	90
12	33	139	440	34	110
13	35	108	420	22	80
14	36	126	390	32	100
15	37	84	540	15	210
16	38	123	570	37	140
17	40	137	490	31	120
18	42	181	430	51	120
19	43	168	450	54	90
20	46	166	680	55	170
21	47	168	450	38	110
22	48	112	360	25	120
23	50	147	490	43	200
24	51	188	450	42	100
25	53	118	380	26	90
26	54	177	550	43	90
27	55	125	420	39	90
28	57	167	390	35	80
29	59	235	530	70	130
30	60	192	410	38	110
Total HH covered		4449	13780	1146	3420
Average HH covered		148	459	38	114

is also to be noted that 30 × 30 sampling scheme will be more reliable than 30 × 7 sampling scheme as the sample size is larger in case of 30 × 30 sampling scheme than the later one.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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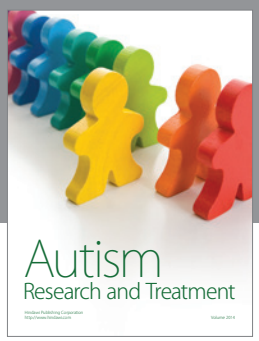

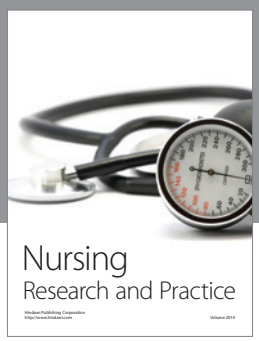

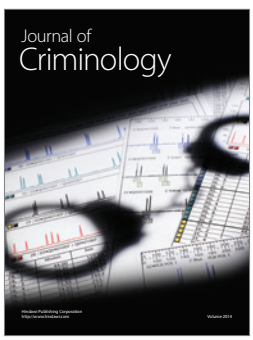

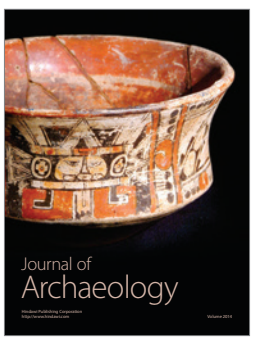

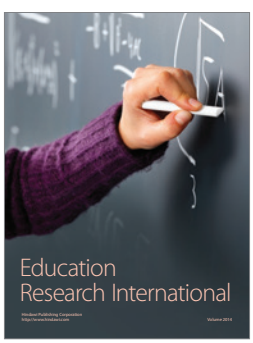

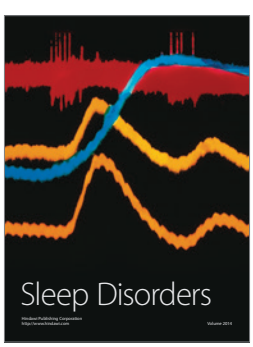

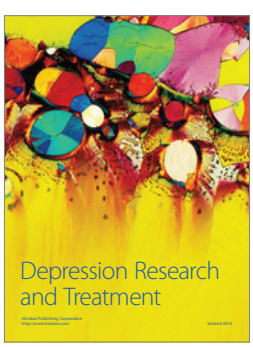

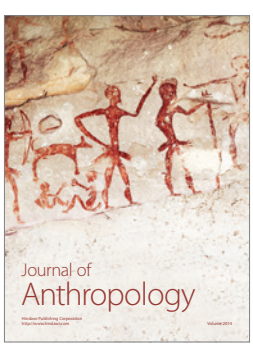

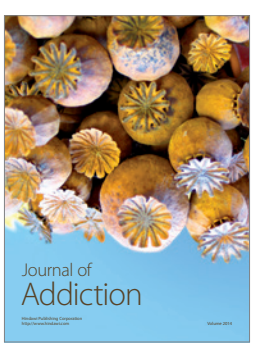

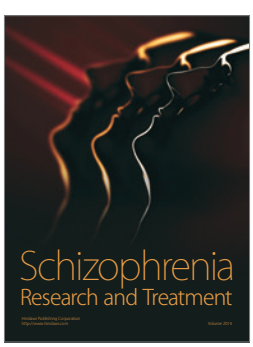

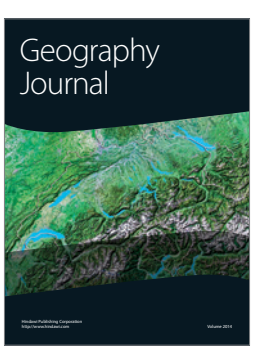

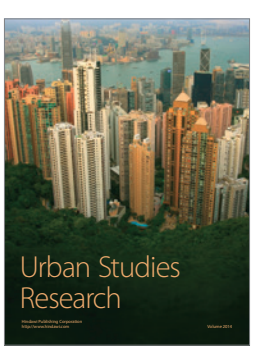

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