SINGLE, DOUBLE AND MULTIPLE SAMPLING PLANS: POISSON DISTRIBUTION

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Abstract

Systematic and standardized approach for monitoring and evaluating disease control programs is needed. The conventional sample survey methods are expensive, time consuming and need a great deal of resources. Lot Quality Assurance Sampling (LQAS) technique, originally a quality control tool in an industry, which was tried successfully for monitoring and evaluating immunization programs, leprosy, tuberculosis, sleeping sickness etc., control programs. Literature review suggests that all, except three, studies employing LQAS survey methodology used single sampling plan and normal approximation method to compute sample size. Hence, there is a need to develop formulae to obtain nomograms on sample sizes as ready reckoner when the variable of interest follows Poisson distribution. The methods for sample size calculation using LQAS methodology under single/double, multiple sampling plans are provided separately for Poisson distribution with/without considering the Power are developed. Pragmatic solutions for the sample size and the corresponding acceptable number 'd' are obtained for different sampling plans such as single, double and multiple sampling plans.

Keywords: Lot Quality Assurance Sampling, sample Size, monitoring and evaluating disease control programs, Poisson distribution.

1. INTRODUCTION

The conventional sample survey methods to monitor the disease control programs are expensive, time consuming and need a great deal of resources. Therefore, there is a need for rapid assessment procedures, for future planning. Lot Quality Assurance Sampling (LQAS) technique which has been tried successfully for monitoring and evaluating immunization programs, leprosy, tuberculosis, sleeping sickness etc., control programs. The required sample size will depend upon the underlying assumptions and the investigator's requirements of Type I error and Power. There are also other important considerations such as cost, time-frame, feasibility and losses due to non-response that must be taken into account, when deciding finally on the size of the study. The criteria for choosing a combination of sample size and critical value depends on the health planner's concern about controlling both, the chance of concluding that a community has low disease prevalence when in fact it is low. It also depends on various distributional assumptions of the variable of interest and the choice of a single or two-stage sampling plan. For our study Poisson distribution is considered as variable of Interest.

Thus choice of sample size (n) and critical value (d) depends upon the following parameters specified by the health administrator.

N = lot size (i.e., target population in the community)

P_0 = Upper threshold proportion of people with a specified disease beyond which intervention is deemed necessary.

P_a = Lower threshold proportion of people with a specified disease below which health administrators have determined it to be more economical to continue surveillance while focusing intervention resources on more needy communities

α = Type I error

β = Type II error

In LQAS, the aim is to calculate values of n and d that limit the chance of making a type I error to some specified level of α, usually α is set at 5%

In single sample plan without Power for given values of N, P_0, d* and α the sample size n is calculated, such that

$$P\left(d \le d^* / N, P_0\right) = 1-\alpha \quad \text{---------- (a)}$$

For given values of N, P_0, P_a, d*,α,β the sample size n is determined with Power such that in a single sample plan

$$P\left(d \le d^* / N, P_0\right) = 1-\alpha \quad \text{---------- (b)}$$

$$P\left(d \le d^* / N, Pa\right) = \beta \quad \text{---------- (c)}$$

An important aspect of these calculations, in either case, is the probability distribution of the variable of interest, used in making choices that are sensitive to the probability parameters stated by the researches, such as the α and β levels.

1.1. Data Source

The source of data was from a large cross-sectional survey on leprosy conducted by National Institute of Epidemiology of ICMR (Indian Council Of Medical Research) in Tamil Nadu. The main objective of the first study was to examine the validity of LQAS by using real life data from an initially highly leprosy endemic state, for leprosy distribution and for the design effect (enhancing factor for the sample size) if two-stage cluster sample survey is employed. The survey was conducted from 6th January 2001 to 30th March 2001. Information on age, sex and residential status of every member in the household was collected from the head of the household or any senior member of the family through a structured questionnaire. It was decided to complete the survey for the entire sample to generate data on leprosy distribution. Leprosy inspectors screened all the resident members of the household that were present at the time of the first and repeated visits for clinical examination for leprosy. A case of leprosy is defined as an individual who has manifestations of leprosy and who needs treatment. Supervisory staff confirmed the diagnosis of the cases. All the cases were classified by their types, i.e. single skin lesion

(SSL), paucibacillary (PB) or multibacillary (MB). A case was defined as PB if he / she had five or less number of skin lesions, with not more than one nerve lesion, and all the slit skin smears were negative for acid fast bacilli (AFB). A person was considered as an MB case if he or she had more than five skin lesions or more than one nerve lesion or the individual's skin smear was positive for AFB. Leprosy patients with single patch receiving single dose treatment are not considered for prevalence, but, if put on 6 months PB MDT, they are considered in prevalence. New cases were those who were diagnosed for the first time through the present survey. Old case is defined as one who is already diagnosed and is under treatment. Directorate of Medical and Rural Health Services of Tamil Nadu and National Institute of Epidemiology, Chennai were involved to monitor the quality of data.

Five to six experienced paramedical staff members as teams were formed to cover a given district. Each team consisted of one health educator, three to four leprosy inspectors and one laboratory technician from the state government. Laboratory technicians were involved in collecting slit-skin smears. Medical officers from the Directorate of Public Health, Tamil Nadu and National Institute of Epidemiology, Chennai were involved to monitor the quality of clinical examination.

During the survey 62,157 persons were enumerated and 56,469 (90.8%) were examined. The coverage for clinical examination in each district was above 90%. The coverage was similar for both rural and urban areas. In all, 96 (83 new and 13 old) cases were detected. Of the 96 cases, 31 belonged to SSL type, 48 belonged to PB type and the remaining 17 cases were diagnosed as MB type. The number of PB and MB cases varied between 3 and 13 among the districts. There were 46 cases in the rural areas and 50 cases in the urban areas. In all these cases the skin smears were negative for AFB.

1.2. Review of literature

Ordinarily, LQAS provides a binary classification system. A finer classification system might be provided by applying alternative sampling plans to data already collected and classified as coming from low-prevalence communities by previously applied sampling plans. This approach started by collecting data with a sampling plan designed to identify very high prevalence communities. A second sampling plan designed to identify moderately high-prevalence communities was then applied to the data from communities not classified as "very high prevalence" by the previous sampling plan. This process continued until all communities had been classified. To test this procedure, data were analysed by applying the sampling plan specified above (maximum sample size 50 and 14 allowed defects) to identify communities with prevalence >30%. A second sampling plan to identify communities with prevalence >20% (maximum sample size 50 and nine allowed defects) was then applied to the data from communities not classified as "high prevalence" by the first sampling plan. Communities identified as high prevalence by the first sampling plan were classified as "high prevalence", communities identified as high prevalence by the second sampling plan as "medium prevalence", and the remaining communities as "low prevalence". The agreement between actual prevalence classes and the classifications made with the two sampling plans was calculated.

Murthy, et .al. (2001), examined whether the health administration in Tamil Nadu state, India could use lot quality assurance sampling (LQAS) for identifying high prevalence areas for leprosy to initiate necessary corrective measures. The null hypothesis was that leprosy prevalence in the selected district was at or above 10 per 10,000 and the alternative hypothesis was that it was at or below 5 per 10,000. The sample size required to be examined at 5% level of significance was determined to be 25,500 individuals with 17 as an acceptable maximum number of cases (critical value). Two-stage cluster sample design was adopted.

Gupte and Murthy in their article on 'Lot Quality Assurance Sampling (LQAS) For Monitoring Leprosy Elimination Program' considered various situations and strategies

through simulations. For this purpose, a hypothetical computerized population of 10 million persons was created. This population mimics the actual population in terms of the empirical information on rural /urban distributions and the distribution of households by size for the state of Tamil Nadu, India. Various levels with respect to leprosy prevalence are created using this population. For experiment I, two separate populations are used with prevalence levels at 0.1 per 10,000 and 1 per 10,000. Similarly, separate populations are used with prevalence levels at 3 and 1 per 10,000 for experiment II; 5 and 1 per 10,000 for experiment III; and 10 and 5 per 10,000 for experiment. The distribution of the number of cases in the population was demonstrated to follow the Poisson process. Thus, samples sizes and corresponding critical values were computed using Poisson approximation.

The authors employed prevalence of leprosy as the variable of interest for monitoring the Leprosy elimination program. The authors rightly employed Poisson approximation method to compute the sample size and to carryout LQAS surveys. Besides, they employed two stage cluster sampling procedure rather than conventional single sampling plan to assess the disease control programs. The authors, accordingly, modified the sample size needed for the survey.

Valadez, et. al.(2004), in their Tripreport, Dominican RepublicWashingtonDC: WorldBank,Global HIV/AIDSProgram mentioned that the Lot Quality Assurance Sampling (LQAS) method was used, with education districts representing supervision areas. Twenty-seven members of the national technical team of State Secretariat of Education (SEE) and Presidential Council on HIV/AIDS (COPRESIDA) were trained in the LQAS methodology.

World Health Organization(2004b) assessedneonatal tetanus elimination in Eritrea. The total population of the 5 sub-zones was estimated at 2,60,000. Given that the double-sample LQA-CS design (n_1 = 1000, n_2 = 2000; d_1 = 0, d_2 = 3) suggested for use in evaluating NT elimination was initially designed for larger populations, it was decided to modify the design for the Eritrea survey. The design selected was a single sample design (n = 1300; d = 1). This design has similar probabilities of classifying the smaller population surveyed in Eritrea as “pass” or “fail” to that of the double-sample plan when testing larger populations.

Gupte, et .al. (2004), considered the reported prevalence in Tamil Nadu, an endemic state in India, as 4 per 10,000 because state leprosy authorities anticipated certain level of under estimation in the prevalence. They expected the leprosy prevalence in the state to be about 7 per 10,000. The Null Hypothesis to be examined was thus, whether the prevalence of leprosy in the state was at or below 7 per 10,000. Sample size that they provided for was adequate to conclude that the prevalence levels could be between 4 and 7 per 10,000 for the state. Details of the design are available from their earlier work.

The sample size, assuming Poisson approximation, with 5% level of significance and Power of 90% required to test the Hypothesis, was determined as 53,000 people. Allowing 20% as the margin of non-response, a sample of 64,000 people in the state was considered sufficient. The maximum allowable number of leprosy cases (d, critical value) in this sample was 25.

Application of lot sampling of sputum AFB smears for the assessment of microscopy centres by *Selvakumar N*, et al, in 2005 reported that 20 smears per month per MC were selected systematically; 1547 slides from DMCs and 726 from AMCs were checked respectively, by STLSs at the DTC and by RL laboratory technicians. Discrepancies were resolved by referee.

2. Illustration of computing the sample size for the variable of interest follows Poisson Distribution

Suppose, one wants to examine whether the health administrator in a state of India could use lot quality assurance sampling (LQAS) for identifying high prevalence areas for leprosy for initiating necessary corrective measures. The

null hypothesis was that leprosy prevalence in the selected district was at or above ten per 10,000. The prevalence in this situation is very much low. In this context, the variable of interest i.e. leprosy prevalence in the community follows Poisson distribution. The Poisson distribution is the statistical distribution that describes the probability of a particular configuration of rare outcomes when the total number of trials is infinite. If P denotes the probability of observing the characteristic, then the chance that there will be exactly 'd' individuals with the event in a sample of size 'n' is given by the following expression

$$P_r\left(d \le d^*\right) = \sum_{d=0}^{d^*} \frac{e^{-m} m^d}{d!} \quad ,$$

where $m = np_o$.n = 1000 and $P_0 = 0.001$, the sample size is computed

d*	0	1	2	3	4	5	6	7
$P_r(d \le d^*)$,	0.3679	0.3679	0.1839	0.0613	0.0153	0.0031	0.0005	0.00007

Suppose we are interested in detecting communities with $P \ge 0.001$ and wish to limit the chance of a Type I error to $\alpha = 0.05$. We need to specify d* in order to calculate n. Assume that we want to conclude that the community has $P < 0.001$ if 1 or fewer people in our sample prove to be defective. Therefore, we set d* = 1. Sample size is calculated by solving the formula for n. This involves tedious calculations with iterations. Then the required sample size will be 355. On the other hand, the sample size required under normal approximation will be 4480 much larger than required value. Similarly, the Poisson distribution is used for sample size determination for varying d*. The results are presented in Table 2.1.

Comparable results are presented for $\alpha = 0.01$ in Table 2.2.

2.1 Illustration of computing the sample size with Power

Suppose we want to examine whether a state of India has reached leprosy elimination stage or not. The Null Hypothesis to be examined is thus, whether the prevalence of leprosy in the state is at or below P_0 per 10,000 with 95% level of confidence. Alternatively, the prevalence in the state should be above P_0 but below P_a. We would like to have 90% Power to ensure that the state having prevalence below P_a and at or above P_0 should not be wrongly classified as high prevalence area.

The Null and alternative Hypotheses and the spread of the distributions of the variable are used to compute the required sample size. The expected number of people 'n' required and the number of leprosy cases (critical value) 'd' are obtained using the exact Poisson probability distribution and by solving the following two equations through iterations:

$$P(d \le d^*) = \sum_{d=0}^{d^*} \frac{e^{-np_o} m^d}{d!} = \boldsymbol{\alpha}$$

Where $m = np_0$

$$P(d > d^*) = \sum_{d=0}^{d^*} \frac{e^{-n\,p_a} m^d}{d!} = \boldsymbol{\beta}$$

Where $m = np_a$

2.1.1. Numerical Example

The following four experiments with possible prevalence levels nearer to the target of leprosy elimination are considered for examination and verification. Situation I considers prevalence levels at base level as 0.1 per 10,000 and alternatively at 1 per 10,000. Similarly, Situation II considers prevalence levels at 3 for baseline and alternatively at 1 per 10,000. Situation III considers prevalence levels at 5 for baseline and alternatively at 1 per 10,000 and 10 at baseline and alternatively 5 per 10,000 for situation IV. Situation I is considered to investigate whether the prevalence in the population lies at or above 1 per 10,000 (and alternativce hypothesis set at 0.1 per 10,000). Situation II is considered to detect whether the leprosy prevalence in the population is at or above 3 per 10,000 populations (with alternative

hypothesis set at 1 per 10,000 populations). Situation III is to examine whether the leprosy prevalence in the population is at or above 5 per 10,000 populations (with alternative hypothesis set at 1 per 10,000 populations). Situation IV is to investigate whether the leprosy prevalence in the population is at or above 10 per 10,000 populations (with alternative hypothesis set at 5 per population).

	Prevalence per 10000			
	Situation I	Situation II	Situation III	Situation IV
Base	≤1	≥3	≥5	≥10
Altern	<0.1	<1	<1	<5
Sampl	48300	3940	15500	25500
Critica	1	6	3	17

Suppose, we are interested to investigate whether the prevalence in the population lies at or above 1 per 1000 i.e. $P_0 \geq 0.001$ (and alternative hypothesis set at 5 per 10,000 i.e $P_a = 0.0005$). Then, the sample size 'n' required at 95% level of confidence and 90% Power is 24,305 people and the critical value (acceptable number of cases) 'd' is 16 (see Table). The Table 2.3 provides sample sizes when level of confidence is 95% and Power 90% for various values of P_o and P_a. Sample sizes are computed for confidence level of 99% and 80% Power and presented in Table 2.4

2.2. Illustration for double sampling

Let health administrator be interested in investigating whether the prevalence in a given population lies at or above 1 per 1000 i.e. $P_0 \geq 0.001$ (and alternative hypothesis set at 5 per 10,000 i.e. $P_a = 0.0005$). Then, the sample size 'n' required at 95% level of confidence and 90% Power is 24,305 people and the critical value (acceptable number of cases) d is 16 (see Table).

As against usually considered in the earlier situations, we have chosen here, the value of n_1 as 25% of n_1+n_2 and d_2^* is calculated as follows: $n_1 = 6077$. This value of n_1 is substituted in the equation

$$P(d \leq d^*) = \sum_{d=0}^{d^*} \frac{e^{-np_o} m^d}{d!} = \alpha.$$

Where $m = np_0$

It may be observed that that d_1^* is computed as 2 using $\alpha = 0.05$, reflecting our desire to accept an endemic state has reached leprosy elimination stage under H_o (see Table 2.5). Sample sizes and critical values under double sampling plan for $\alpha = 0.01$and 0.05; and $\beta = 0.10$ and 0.20 are presented in Tables 2.5 and 2.6.

2.3. Computation of Multiple Sampling Sample Size

We consider the same example as considered earlier. However, we adopt here the multiple sampling plan. Let us assume that the health administrator is interested in examining whether the prevalence in a given population lies at or above 1 per 1000 i.e. $P_0 \geq 0.001$ (with an alternative hypothesis set at 5 per 10.000 i.e $P_a = 0.0005$). As shown earlier in chapter III the sample size 'n', required at 95% level of confidence at 90% Power is 24,305 people and the critical value (acceptable number of cases) 'd' is 16 (see Table 2.7).

For illustration, we considered a multiple sampling plan with three stages. We have taken here also, the value of n_1 as $(1/3)^{rd}$of $n_1+n_2+n_3$ and d_1^* is calculated as follows: $n_1 = 8102$. This value of n_1 is substituted in the equation

$$P(d \leq d^*) = \sum_{d=0}^{d^*} \frac{e^{-np_o} m^d}{d!} = \alpha$$ (Where m $= np_0$) to compute d_1^*. It may be observed that that d_1^* is computed as 4 using $\alpha = 0.05$, reflecting our desire to accept an endemic state has reached leprosy elimination stage under H_0 (See Table 2.7). Sample sizes and the acceptable number of leprosy cases (critical value) under multiple sampling plan for $\alpha = 0.01$ and 0.05; and $\beta = 0.10$ and 0.20 are presented in Tables 2.7 and 2.8.

TABLE 2.1 VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH NO POWER CONSIDERATION FOR $\alpha = 0.05$

P_0	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.0075	0.008	0.009	0.01
d*=0	52	26	18	13	11	9	8	7	7	6	6
d*=1	355	178	119	89	71	60	51	48	45	40	36
d*=2	818	409	273	205	164	137	117	109	103	91	82
d*=3	1366	683	456	342	274	228	196	183	171	152	137
d*=4	1970	985	657	493	394	329	282	263	247	219	197
d*=5	2613	1307	871	653	523	436	374	349	327	291	262

TABLE 2.2 VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH NO POWER CONSIDERATION FORα = 0.01

P_0	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.0075	0.008	0.009	0.01
d*=0	10	5	4	3	2	2	2	2	2	1	1
d*=1	149	75	50	38	30	25	22	20	19	17	15
d*=2	436	218	146	109	88	73	63	59	55	49	44
d*=3	823	412	275	206	165	138	118	110	103	92	83
d*=4	1278	639	426	320	256	213	183	171	160	142	128
d*=5	1784	892	595	446	357	298	255	238	223	199	179

TABLE 2.1 (A) VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH NO POWERCONSIDERATION FOR $\alpha = 0.05$

P_0	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
d*=0	513	257	171	129	103	86	74	65	57
d*=1	3553	1777	1185	889	711	593	508	445	395
d*=2	8177	4089	2726	2045	1636	1363	1169	1023	909
d*=3	13668	6832	4555	3416	2733	2278	1952	1708	1519
d*=4	19701	9851	6568	4926	3941	3284	2815	2463	2189
d*=5	26130	13065	8710	6533	5226	4355	3733	3266	2904

TABLE 2.2 (A) VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH NO POWER CONSIDERATION FOR $\alpha = 0.01$

P_0	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009
d*=0	100	50	34	25	20	17	15	13	12
d*=1	1485	743	495	372	297	248	213	186	165
d*=2	4360	2180	1454	1090	872	727	623	545	485
d*=3	8231	4116	2745	2058	1647	1372	1176	1029	915
d*=4	12788	6394	4263	3197	2558	2131	1827	1599	1421
d*=5	17849	8926	5951	4463	3570	2975	2550	2231	1984

TABLE 2.3 VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α = 0.05 AND β = 0.10

P_0 = 0.001

Pa	n	d
0.0001	4745	1
0.0002	7760	3
0.0003	10514	5
0.0004	15708	9
0.0005	24305	16
0.0006	41845	31
0.0007	79907	65
0.0008	192000	169
0.0009	812098	765

P_0 = 0.002

Pa	n	d
0.0002	2375	1
0.0004	3885	3
0.0006	5256	5
0.0008	7853	9
0.0010	12151	16
0.0012	20919	31
0.0014	40505	66
0.0016	96547	170
0.0018	406042	765

P_0 = 0.003

Pa	n	d
0.0003	1582	1
0.0006	2585	3
0.0009	3505	5
0.0012	5235	9
0.0015	8102	16
0.0018	13947	31
0.0021	27003	66
0.0024	64355	170
0.0027	270700	765

P_0 = 0.004

Pa	n	d
0.0004	1186	1
0.0008	1940	3
0.0012	2629	5
0.0016	3927	9
0.0020	6076	16
0.0024	10460	31
0.0028	20253	66
0.0032	48268	170
0.0036	203543	767

P_0 = 0.005

Pa	n	d
0.0005	949	1
0.0010	1551	3
0.0015	2103	5
0.0020	3142	9
0.0025	4861	16
0.0030	8369	31
0.0035	15982	65
0.0040	38613	170
0.0045	161800	762

P_0 = 0.006

Pa	n	d
0.0006	791	1
0.0012	1293	3
0.0018	1753	5
0.0024	2618	9
0.0030	4051	16
0.0036	6973	31
0.0042	13318	65
0.0048	32000	169
0.0054	134662	761

$P_0 = 0.007$

Pa	n	d
0.0007	678	1
0.0014	1108	3
0.0021	1502	5
0.0028	2244	9
0.0035	3472	16
0.0042	6141	32
0.0049	11573	66
0.0056	27581	170
0.0063	115718	763

$P_0 = 0.008$

Pa	n	d
0.0008	593	1
0.0016	970	3
0.0024	1315	5
0.0032	1963	9
0.0040	3038	16
0.0048	5230	31
0.0056	10127	66
0.0064	24133	170
0.0072	101897	767

$P_0 = 0.009$

Pa	n	d
0.0009	528	1
0.0018	862	3
0.0027	1168	5
0.0036	1745	9
0.0045	2700	16
0.0054	4649	31
0.0063	9001	66
0.0072	21452	170
0.0081	90575	768

$P_0 = 0.01$

Pa	n	d
0.001	475	1
0.002	776	3
0.003	1052	5
0.004	1571	9
0.005	2430	16
0.006	4184	31
0.007	8101	66
0.008	19306	170
0.009	81517	768

TABLE 2.3 (A) VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR $\alpha = 0.05$ AND $\beta = 0.20$

$P_0 = 0.001$

Pa	n	d
0.0001	2914	0
0.0002	4700	1
0.0003	7754	3
0.0004	11843	6
0.0005	18208	11
0.0006	30242	21
0.0007	58818	46
0.0008	139644	120
0.0009	590170	550

$P_0 = 0.002$

Pa	n	d
0.0002	1455	0
0.0004	2372	1
0.0006	3877	3
0.0008	5922	6
0.0010	9104	11
0.0012	15120	21
0.0014	29409	46
0.0016	69822	120
0.0018	295085	550

P_0 = 0.003

Pa	n	d
0.0003	970	0
0.0006	1581	1
0.0009	2585	3
0.0012	3948	6
0.0015	6069	11
0.0018	10080	21
0.0021	19606	46
0.0024	46548	120
0.0027	196724	550

P_0 = 0.004

Pa	n	d
0.0004	729	0
0.0008	1186	1
0.0012	1939	3
0.0016	2961	6
0.0020	4552	11
0.0024	7560	21
0.0028	14705	46
0.0032	34911	120
0.0036	147543	550

P_0 = 0.005

Pa	n	d
0.0005	587	0
0.0010	949	1
0.0015	1551	3
0.0020	2369	6
0.0025	3642	11
0.0030	6048	21
0.0035	11763	46
0.0040	27929	120
0.0045	118034	550

P_0 = 0.006

Pa	n	d
0.0006	484	0
0.0012	791	1
0.0018	1293	3
0.0024	1974	6
0.0030	3035	11
0.0036	5040	21
0.0042	9802	46
0.0048	23275	120
0.0054	98365	550

P_0 = 0.007

Pa	n	d
0.0007	416	0
0.0014	678	1
0.0021	1108	3
0.0028	1692	6
0.0035	2602	11
0.0042	4320	21
0.0049	8403	46
0.0056	19949	120
0.0063	84310	550

P_0 = 0.008

Pa	n	d
0.0008	364	0
0.0016	593	1
0.0024	970	3
0.0032	1481	6
0.0040	2276	11
0.0048	3780	21
0.0056	7352	46
0.0064	17456	120
0.0072	73772	550

$P_0 = 0.009$

Pa	n	d
0.0009	324	0
0.0018	525	1
0.0027	862	3
0.0036	1316	6
0.0045	2023	11
0.0054	3360	21
0.0063	6536	46
0.0072	15516	120
0.0081	65575	550

$P_0 = 0.01$

Pa	n	d
0.001	292	0
0.002	470	1
0.003	776	3
0.004	1185	6
0.005	1821	11
0.006	3024	21
0.007	5882	46
0.008	13965	120
0.009	59020	550

TABLE 2.4.VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR $\alpha = 0.01$ AND $\beta = 0.10$

$P_0 = 0.001$

Pa	n	d
0.0001	6636	1
0.0002	10045	3
0.0003	16000	7
0.0004	24138	13
0.0005	38077	24
0.0006	65570	47
0.0007	123605	98
0.0008	294685	255
0.0009	1231390	1150

$P_0 = 0.002$

Pa	n	d
0.0002	3320	1
0.0004	5023	3
0.0006	8000	7
0.0008	12070	13
0.0010	19039	24
0.0012	32786	47
0.0014	61806	98
0.0016	147344	255
0.0018	615690	1150

$P_0 = 0.003$

Pa	n	d
0.0003	2213	1
0.0006	3348	3
0.0009	5334	7
0.0012	8047	13
0.0015	12693	24
0.0018	21857	47
0.0021	41202	98
0.0024	98229	255
0.0027	410465	1150

$P_0 = 0.004$

Pa	n	d
0.0004	1660	1
0.0008	2512	3
0.0012	4000	7
0.0016	6035	13
0.0020	9520	24
0.0024	16393	47
0.0028	30902	98
0.0032	73973	255
0.0036	307849	1150

$P_0 = 0.005$

Pa	n	d
0.0005	1328	1
0.0010	2009	3
0.0015	3200	7
0.0020	4828	13
0.0025	7616	24
0.0030	13115	47
0.0035	24722	98
0.0040	58937	255
0.0045	246280	1150

$P_0 = 0.006$

Pa	n	d
0.0006	1107	1
0.0012	1675	3
0.0018	2667	7
0.0024	4024	13
0.0030	6347	24
0.0036	10929	47
0.0042	20601	98
0.0048	49115	255
0.0054	205235	1150

$P_0 = 0.007$

Pa	n	d
0.0007	949	1
0.0014	1435	3
0.0021	2286	7
0.0028	3449	13
0.0035	5440	24
0.0042	9368	47
0.0049	17658	98
0.0056	42098	255
0.0063	175915	1150

$P_0 = 0.008$

Pa	n	d
0.0008	830	1
0.0016	1256	3
0.0024	2000	7
0.0032	3018	13
0.0040	4760	24
0.0048	8197	47
0.0056	15451	98
0.0064	36836	255
0.0072	153924	1150

$P_0 = 0.009$

Pa	n	d
0.0009	738	1
0.0018	1117	3
0.0027	1778	7
0.0036	2683	13
0.0045	4231	24
0.0054	7286	47
0.0063	13734	98
0.0072	32743	255
0.0081	136822	1150

$P_0 = 0.01$

Pa	n	d
0.001	664	1
0.002	1005	3
0.003	1600	7
0.004	2414	13
0.005	3808	24
0.006	6557	47
0.007	12361	98
0.008	29469	255
0.009	123140	1150

TABLE 2.4. (A) VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER SINGLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α= 0.01 AND β = 0.20

P_0 = 0.001

Pa	n	d
0.0001	-	-
0.0002	8407	2
0.0003	13110	5
0.0004	18784	9
0.0005	30581	18
0.0006	50213	34
0.0007	96600	74
0.0008	228950	194
0.0009	960880	889

P_0 = 0.002

Pa	n	d
0.0002	-	-
0.0004	4203	2
0.0006	6555	5
0.0008	9392	9
0.0010	15291	18
0.0012	25108	34
0.0014	48302	74
0.0016	114475	194
0.0018	480440	889

P_0 = 0.003

Pa	n	d
0.0003	-	-
0.0006	2802	2
0.0009	4370	5
0.0012	6261	9
0.0015	10194	18
0.0018	16738	34
0.0021	32202	74
0.0024	76318	194
0.0027	320290	889

P_0 = 0.004

Pa	n	d
0.0004	-	-
0.0008	2102	2
0.0012	3278	5
0.0016	4696	9
0.0020	7646	18
0.0024	12554	34
0.0028	24151	74
0.0032	57240	194
0.0036	240220	889

P_0 = 0.005

Pa	n	d
0.0005	-	-
0.0010	1682	2
0.0015	2622	5
0.0020	3757	9
0.0025	6117	18
0.0030	10043	34
0.0035	19321	74
0.0040	45790	194
0.0045	192174	889

P_0 = 0.006

Pa	n	d
0.0006	-	-
0.0012	1401	2
0.0018	2185	5
0.0024	3131	9
0.0030	5097	18
0.0036	8369	34
0.0042	16101	74
0.0048	38160	194
0.0054	160145	889

$P_0 = 0.007$

Pa	n	d
0.0007	-	-
0.0014	1201	2
0.0021	1873	5
0.0028	2684	9
0.0035	4369	18
0.0042	7174	34
0.0049	13801	74
0.0056	32707	194
0.0063	137267	889

$P_0 = 0.008$

Pa	n	d
0.0008	-	-
0.0016	1051	2
0.0024	1639	5
0.0032	2348	9
0.0040	3823	18
0.0048	6277	34
0.0056	12076	74
0.0064	28619	194
0.0072	120110	889

$P_0 = 0.009$

Pa	n	d
0.0009	-	-
0.0018	934	2
0.0027	1457	5
0.0036	2087	9
0.0045	3398	18
0.0054	5580	34
0.0063	10734	74
0.0072	25439	194
0.0081	106763	889

$P_0 = 0.01$

Pa	n	d
0.001	-	-
0.002	841	2
0.003	1311	5
0.004	1879	9
0.005	3059	18
0.006	5022	34
0.007	9661	74
0.008	22895	194
0.009	96088	889

TABLE 2.5 VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER DOUBLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α = 0.05 AND β= 0.10

P_0=0.001

Pa	n_1+n_2	d_2	n_1	d_1
0.0001	4745	1	1187	0
0.0002	7760	3	1940	0
0.0003	10514	5	2629	0
0.0004	15708	9	3927	1
0.0005	24305	16	6077	2
0.0006	41845	31	10462	5
0.0007	79907	65	19977	13
0.0008	192000	169	48000	37
0.0009	812098	765	203025	179

P_0=0.002

Pa	n_1+n_2	d_2	n_1	d_1
0.0002	2375	1	594	0
0.0004	**3885**	**3**	972	0
0.0006	5256	5	1314	0
0.0008	7853	9	1964	1
0.001	12151	16	3038	2
0.0012	20919	31	5230	5
0.0014	40505	66	10127	13
0.0016	96547	170	24137	37
0.0018	406042	765	101511	179

P_0=0.003

Pa	n_1+n_2	d_2	n_1	d_1
0.0003	1582	1	396	0
0.0006	2585	3	647	0
0.0009	3505	5	877	0
0.0012	5235	9	1309	1
0.0015	8102	16	2026	2
0.0018	13947	31	3487	5
0.0021	27003	66	6751	13
0.0024	64355	170	16089	37
0.0027	270700	765	67675	179

P_0=0.004

Pa	n_1+n_2	d_2	n_1	d_1
0.0004	1186	1	297	0
0.0008	1940	3	485	0
0.0012	2629	5	658	0
0.0016	3927	9	982	1
0.0020	6076	16	1519	2
0.0024	10460	31	2615	5
0.0028	20253	66	5064	13
0.0032	48268	170	12067	37
0.0036	203022	765	50756	179

P_0=0.005

Pa	n_1+n_2	d_2	n_1	d_1
0.0005	949	1	238	0
0.0010	1551	3	388	0
0.0015	2103	5	526	0
0.0020	3142	9	786	1
0.0025	4861	16	1216	2
0.0030	8369	31	2093	5
0.0035	16203	66	4051	13
0.0040	38613	170	9654	37
0.0045	162417	765	40605	179

P_0=0.006

Pa	n_1+n_2	d_2	n_1	d_1
0.0006	791	1	198	0
0.0012	1293	3	324	0
0.0018	1753	5	439	0
0.0024	2618	9	655	1
0.0030	4051	16	1013	2
0.0036	6973	31	1744	5
0.0042	13502	66	3376	13
0.0048	32177	170	8045	37
0.0054	135350	765	33838	179

P_0=0.007

Pa	n_1+n_2	d_2	n_1	d_1
0.0007	678	1	170	0
0.0014	1108	3	277	0
0.0021	1502	5	376	0
0.0028	2244	9	561	1
0.0035	3472	16	868	2
0.0042	5977	31	1495	5
0.0049	11573	66	2894	13
0.0056	27581	170	6896	37
0.0063	116013	765	29004	179

P_0=0.008

Pa	n_1+n_2	d_2	n_1	d_1
0.0008	593	1	149	0
0.0016	970	3	243	0
0.0024	1315	5	329	0
0.0032	1963	9	491	1
0.0040	3038	16	760	2
0.0048	5230	31	1308	5
0.0056	10127	66	2532	13
0.0064	24133	170	6034	37
0.0072	101511	765	25378	179

P_0=0.009

Pa	n_1+n_2	d_2	n_1	d_1
0.0009	528	1	132	0
0.0018	862	3	216	0
0.0027	1168	5	292	0
0.0036	1745	9	437	1
0.0045	2700	16	675	2
0.0054	4649	31	1163	5
0.0063	9001	66	2251	13
0.0072	21452	170	5363	37
0.0081	90232	765	22558	179

P_0=0.01

Pa	n_1+n_2	d_2	n_1	d_1
0.001	475	1	119	0
0.002	776	3	194	0
0.003	1052	5	263	0
0.004	1571	9	393	1
0.005	2430	16	608	2
0.006	4184	31	1046	5
0.007	8101	66	2026	13
0.008	19306	170	4827	37
0.009	81208	765	20302	179

TABLE 2.5 (A) VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER DOUBLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α= 0.05AND β = 0.20

P_0=0.001

Pa	n_1+n_2	d_2	n_1	d_1
0.0001	2914	0	729	0
0.0002	4700	1	1175	0
0.0003	7754	3	1939	0
0.0004	11843	6	2961	0
0.0005	18208	11	4552	1
0.0006	30242	21	7561	3
0.0007	58818	46	14705	9
0.0008	139644	120	34911	25
0.0009	590170	550	147543	127

P_0=0.002

Pa	n_1+n_2	d_2	n_1	d_1
0.0002	1455	0	364	0
0.0004	2372	1	593	0
0.0006	**3877**	**3**	970	0
0.0008	5922	6	1481	0
0.001	9104	11	2276	1
0.0012	15120	21	3780	3
0.0014	29409	46	7353	9
0.0016	69822	120	17456	25
0.0018	295085	550	73772	127

P_0=0.003

Pa	n_1+n_2	d_2	n_1	d_1
0.0003	970	0	243	0
0.0006	1581	1	396	0
0.0009	2585	3	647	0
0.0012	3948	6	987	0
0.0015	6069	11	1518	1
0.0018	10080	21	2520	3
0.0021	19606	46	4902	9
0.0024	46548	120	11637	25
0.0027	196724	550	49181	127

P_0=0.004

Pa	n_1+n_2	d_2	n_1	d_1
0.0004	1186	1	297	0
0.0008	1940	3	485	0
0.0012	2629	5	658	0
0.0016	3927	9	982	1
0.002	6076	16	1519	2
0.0024	10460	31	2615	5
0.0028	20253	66	5064	13
0.0032	48268	170	12067	37
0.0036	203022	765	50756	179

P_0=0.005

Pa	n_1+n_2	d_2	n_1	d_1
0.0005	587	0	147	0
0.001	949	1	238	0
0.0015	1551	3	388	0
0.002	2369	6	593	0
0.0025	3642	11	911	1
0.003	6048	21	1512	3
0.0035	11763	46	2941	9
0.004	27929	120	6983	25
0.0045	118034	550	29509	127

P_0=0.006

Pa	n_1+n_2	d_2	n_1	d_1
0.0006	484	0	121	0
0.0012	791	1	198	0
0.0018	1293	3	324	0
0.0024	1974	6	494	0
0.003	3035	11	759	1
0.0036	5040	21	1260	3
0.0042	9802	46	2451	9
0.0048	23275	120	5819	25
0.0054	98365	550	24592	127

P_0=0.007

Pa	n_1+n_2	d_2	n_1	d_1
0.0007	416	0	104	0
0.0014	678	1	170	0
0.0021	1108	3	277	0
0.0028	1692	6	423	0
0.0035	2602	11	651	1
0.0042	4320	21	1080	3
0.0049	8403	46	2101	9
0.0056	19949	120	4988	25
0.0063	84310	550	21078	127

P_0=0.008

Pa	n_1+n_2	d_2	n_1	d_1
0.0008	364	0	91	0
0.0016	593	1	149	0
0.0024	970	3	243	0
0.0032	1481	6	371	0
0.004	2276	11	569	1
0.0048	3780	21	945	3
0.0056	7352	46	1838	9
0.0064	17456	120	4364	25
0.0072	73772	550	18443	127

P_0=0.009

Pa	n_1+n_2	d_2	n_1	d_1
0.0009	324	0	81	0
0.0018	525	1	132	0
0.0027	862	3	216	0
0.0036	1316	6	329	0
0.0045	2023	11	506	1
0.0054	3360	21	840	3
0.0063	6536	46	1634	9
0.0072	15516	120	3879	25
0.0081	65575	550	16394	127

P_0=0.01

Pa	n_1+n_2	d_2	n_1	d_1
0.001	292	0	73	0
0.002	470	1	118	0
0.003	776	3	194	0
0.004	1185	6	297	0
0.005	1821	11	456	1
0.006	3024	21	756	3
0.007	5882	46	1471	9
0.008	13965	120	3492	25
0.009	59020	550	14755	127

TABLE 2.6 VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER DOUBLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α = 0.01AND β = 0.10

P_0=0.001

Pa	n_1+n_2	d_2	n_1	d_1
0.0001	6636	1	1659	0
0.0002	10045	3	2512	0
0.0003	16000	7	4000	0
0.0004	24138	13	6035	1
0.0005	38077	24	9520	3
0.0006	65570	47	16393	7
0.0007	123605	98	30902	18
0.0008	294685	255	73672	54
0.0009	1231390	1150	307848	267

P_0=0.002

Pa	n_1+n_2	d_2	n_1	d_1
0.0002	3320	1	830	0
0.0004	5023	3	1256	0
0.0006	8000	7	2000	0
0.0008	12070	13	3018	1
0.001	19039	24	4760	3
0.0012	32786	47	8197	7
0.0014	61806	98	15452	18
0.0016	147344	255	36836	54
0.0018	615696	1150	153924	267

P_0=0.003

Pa	n_1+n_2	d_2	n_1	d_1
0.0003	2213	1	554	0
0.0006	3348	3	837	0
0.0009	5334	7	1334	0
0.0012	8047	13	2012	1
0.0015	12693	24	3174	3
0.0018	21857	47	5465	7
0.0021	41202	98	10301	18
0.0024	98229	255	24558	54
0.0027	410465	1150	102617	267

P_0=0.004

Pa	n_1+n_2	d_2	n_1	d_1
0.0004	1660	1	415	0
0.0008	2512	3	628	0
0.0012	4000	7	1000	0
0.0016	6035	13	1509	1
0.002	9520	24	2380	3
0.0024	16393	47	4099	7
0.0028	30902	98	7726	18
0.0032	73673	255	18419	54
0.0036	307849	1150	76963	267

P_0=0.005

Pa	n_1+n_2	d_2	n_1	d_1
0.0005	1328	1	332	0
0.001	2009	3	503	0
0.0015	3200	7	800	0
0.002	4828	13	1207	1
0.0025	7616	24	1904	3
0.003	13115	47	3279	7
0.0035	24722	98	6181	18
0.004	58937	255	14735	54
0.0045	246280	1150	61570	267

P_0=0.006

Pa	n_1+n_2	d_2	n_1	d_1
0.0006	1107	1	277	0
0.0012	1675	3	419	0
0.0018	2667	7	667	0
0.0024	4024	13	1006	1
0.003	6347	24	1587	3
0.0036	10929	47	2733	7
0.0042	20601	98	5151	18
0.0048	49115	255	12279	54
0.0054	205235	1150	51309	267

P_0=0.007

Pa	n_1+n_2	d_2	n_1	d_1
0.0007	949	1	238	0
0.0014	1435	3	359	0
0.0021	2286	7	572	0
0.0028	3449	13	863	1
0.0035	5440	24	1360	3
0.0042	9368	47	2342	7
0.0049	17658	98	4415	18
0.0056	42098	255	10525	54
0.0063	175915	1150	43979	267

P_0=0.008

Pa	n_1+n_2	d_2	n_1	d_1
0.0008	830	1	208	0
0.0016	1256	3	314	0
0.0024	2000	7	500	0
0.0032	3018	13	755	1
0.004	4760	24	1190	3
0.0048	8197	47	2050	7
0.0056	15451	98	3863	18
0.0064	36836	255	9209	54
0.0072	153924	1150	38481	267

P_0=0.009

Pa	n_1+n_2	d_2	n_1	d_1
0.0009	738	1	185	0
0.0018	1117	3	280	0
0.0027	1778	7	445	0
0.0036	2683	13	671	1
0.0045	4231	24	1058	3
0.0054	7286	47	1822	7
0.0063	13734	98	3434	18
0.0072	32743	255	8186	54
0.0081	136822	1150	34206	267

P_0=0.01

Pa	n_1+n_2	d_2	n_1	d_1
0.001	664	1	166	0
0.002	1005	3	252	0
0.003	1600	7	400	0
0.004	2414	13	604	1
0.005	3808	24	952	3
0.006	6557	47	1640	7
0.007	12361	98	3091	18
0.008	29469	255	7368	54
0.009	123140	1150	30785	267

TABLE 2.6 (A) VARIABLE OF INTEREST FOLLOWS POISSON DISTRIBUTION UNDER DOUBLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α= 0.01AND β= 0.20

P_0=0.001

Pa	n_1+n_2	d_2	n_1	d_1
0.0001	4600	0	1150	0
0.0002	8407	2	2102	0
0.0003	13110	5	3278	0
0.0004	18784	9	4696	0
0.0005	30581	18	7646	2
0.0006	50213	34	12554	5
0.0007	96600	74	24150	13
0.0008	228950	194	57238	40
0.0009	960880	889	240220	204

P_0=0.002

Pa	n_1+n_2	d_2	n_1	d_1
0.0002	-	-	-	-
0.0004	4203	2	1051	0
0.0006	6555	5	1639	0
0.0008	9392	9	2348	0
0.001	15291	18	3823	2
0.0012	25108	34	6277	5
0.0014	48302	74	12076	13
0.0016	114475	194	28619	40
0.0018	480440	889	120110	204

P_0=0.003

Pa	n_1+n_2	d_2	n_1	d_1
0.0003	-	-	-	-
0.0006	2802	2	701	0
0.0009	4370	5	1093	0
0.0012	6261	9	1566	0
0.0015	10194	18	2549	2
0.0018	16738	34	4185	5
0.0021	32202	74	8051	13
0.0024	76318	194	19080	40
0.0027	320290	889	80073	204

P_0=0.004

Pa	n_1+n_2	d_2	n_1	d_1
0.0004	-	-	-	-
0.0008	2102	2	526	0
0.0012	3278	5	820	0
0.0016	4696	9	1174	0
0.002	7646	18	1912	2
0.0024	12554	34	3139	5
0.0028	24151	74	6038	13
0.0032	57240	194	14310	40
0.0036	240220	889	60055	204

P_0=0.005

Pa	n_1+n_2	d_2	n_1	d_1
0.0005	-	-	-	-
0.001	1682	2	421	0
0.0015	2622	5	656	0
0.002	3757	9	940	0
0.0025	6117	18	1530	2
0.003	10043	34	2511	5
0.0035	19321	74	4831	13
0.004	45790	194	11448	40
0.0045	192174	889	48044	204

P_0=0.006

Pa	n_1+n_2	d_2	n_1	d_1
0.0006	--	-	-	-
0.0012	1401	2	351	0
0.0018	2185	5	547	0
0.0024	3131	9	783	0
0.003	5097	18	1275	2
0.0036	8369	34	2093	5
0.0042	16101	74	4026	13
0.0048	38160	194	9540	40
0.0054	160145	889	40037	204

P_0=0.007

Pa	n_1+n_2	d_2	n_1	d_1
0.0007	-	-	-	-
0.0014	1201	2	301	0
0.0021	1873	5	469	0
0.0028	2684	9	671	0
0.0035	4369	18	1093	2
0.0042	7174	34	1794	5
0.0049	13801	74	3451	13
0.0056	32707	194	8177	40
0.0063	137267	889	34317	204

P_0=0.008

Pa	n_1+n_2	d_2	n_1	d_1
0.0008	-	-	-	-
0.0016	1051	2	263	0
0.0024	1639	5	410	0
0.0032	2348	9	587	0
0.004	3823	18	956	2
0.0048	6277	34	1570	5
0.0056	12076	74	3019	13
0.0064	28619	194	7155	40
0.0072	120110	889	30028	204

P_0=0.009

Pa	n_1+n_2	d_2	n_1	d_1
0.0009	-	-	-	-
0.0018	934	2	234	0
0.0027	1457	5	365	0
0.0036	2087	9	522	0
0.0045	3398	18	850	2
0.0054	5580	34	1395	5
0.0063	10734	74	2684	13
0.0072	25439	194	6360	40
0.0081	106763	889	26691	204

P_0=0.01

Pa	n_1+n_2	d_2	n_1	d_1
0.001	-	-	-	-
0.002	841	2	211	0
0.003	1311	5	328	0
0.004	1879	9	470	0
0.005	3059	18	765	2
0.006	5022	34	1256	5
0.007	9661	74	2416	13
0.008	22895	194	5724	40
0.009	96088	889	24022	204

TABLE 2.7VARIABLE OF INTEREST FOLLOWS POISSION DISTRIBUTION UNDER MULTIPLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α= 0.05 AND β = 0.10

P_0=0.001

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0001	4745	1	3164	0	1582	0
0.0002	7760	3	5174	2	2587	0
0.0003	10514	5	7010	3	3505	1
0.0004	15708	9	10472	5	5236	2
0.0005	24305	16	16204	10	8102	4
0.0006	41845	31	27897	19	13949	8
0.0007	79907	65	53272	41	26636	18
0.0008	192000	169	128000	109	64000	51
0.0009	812098	765	541399	502	270700	243

P_0=0.002

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0002	2375	1	1584	0	792	0
0.0004	**3885**	**3**	2590	2	1295	0
0.0006	5256	5	3504	3	1752	1
0.0008	7853	9	5236	5	2618	2
0.001	12151	16	8101	10	4051	4
0.0012	20919	31	13946	19	6973	7
0.0014	40505	66	27004	42	13502	19
0.0016	96547	170	64365	110	32183	51
0.0018	406042	765	270695	502	135348	243

P_0=0.003

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0003	1582	1	1055	0	528	0
0.0006	2585	3	1724	2	862	0
0.0009	3505	5	2337	3	1169	1
0.0012	5235	9	3490	5	1745	2
0.0015	8102	16	5402	10	2701	4
0.0018	13947	31	9298	19	4649	8
0.0021	27003	66	18002	42	9001	19
0.0024	64355	170	42904	110	21452	51
0.0027	270700	765	180467	502	90234	243

P_0=0.004

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0004	1186	1	791	0	396	0
0.0008	1940	3	1294	2	647	0
0.0012	2629	5	1753	3	877	1
0.0016	3927	9	2618	5	1309	2
0.002	6076	16	4051	10	2026	4
0.0024	10460	31	6974	19	3487	8
0.0028	20253	66	13502	42	6751	19
0.0032	48268	170	32179	110	16090	51
0.0036	203022	765	135348	502	67674	243

P_0=0.005

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0005	949	1	633	0	317	0
0.001	1551	3	1034	2	517	0
0.0015	2103	5	1402	3	701	1
0.002	3142	9	2095	5	1048	2
0.0025	4861	16	3241	10	1621	4
0.003	8369	31	5580	19	2790	8
0.0035	16203	66	10802	42	5401	19
0.004	38613	170	25742	110	12871	51
0.0045	162417	765	108278	502	54139	243

P_0=0.006

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0006	791	1	528	0	264	0
0.0012	1293	3	862	2	431	0
0.0018	1753	5	1169	3	585	1
0.0024	2618	9	1746	5	873	2
0.003	4051	16	2701	10	1351	4
0.0036	6973	31	4649	19	2325	8
0.0042	13502	66	9002	42	4501	19
0.0048	32177	170	21452	110	10726	51
0.0054	135350	765	90234	502	45117	243

P_0=0.007

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0007	678	1	452	0	226	0
0.0014	1108	3	739	2	370	0
0.0021	1502	5	1002	3	501	1
0.0028	2244	9	1496	5	748	2
0.0035	3472	16	2315	10	1158	4
0.0042	5977	31	3985	19	1993	8
0.0049	11573	66	7716	42	3858	19
0.0056	27581	170	18388	110	9194	51
0.0063	116013	765	77342	502	38671	243

P_0=0.008

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0008	593	1	396	0	198	0
0.0016	970	3	647	2	324	0
0.0024	1315	5	877	3	439	1
0.0032	1963	9	1309	5	655	2
0.004	3038	16	2026	10	1013	4
0.0048	5230	31	3487	19	1744	8
0.0056	10127	66	6752	42	3376	19
0.0064	24133	170	16089	110	8045	51
0.0072	101511	765	67674	502	33837	243

P_0=0.009

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0009	528	1	352	0	176	0
0.0018	862	3	575	2	288	0
0.0027	1168	5	779	3	390	1
0.0036	1745	9	1164	5	582	2
0.0045	2700	16	1800	10	900	4
0.0054	4649	31	3100	19	1550	8
0.0063	9001	66	6001	42	3001	19
0.0072	21452	170	14302	110	7151	51
0.0081	90232	765	60155	502	30078	243

P_0=0.01

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.001	475	1	317	0	159	0
0.002	776	3	518	2	259	0
0.003	1052	5	702	3	351	1
0.004	1571	9	1048	5	524	2
0.005	2430	16	1620	10	810	4
0.006	4184	31	2790	19	1395	8
0.007	8101	66	5401	42	2701	19
0.008	19306	170	12871	110	6436	51
0.009	81208	765	54139	502	27070	243

TABLE 2.7 (A) VARIABLE OF INTEREST FOLLOWS POISSION DISTRIBUTION UNDER MULTIPLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α = 0.05 AND β = 0.20

P_0=0.001

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0001	2914	0	1943	0	972	0
0.0002	4700	1	3134	0	1567	0
0.0003	7754	3	5170	2	2585	0
0.0004	11843	6	7896	3	3948	1
0.0005	18208	11	12139	7	6070	2
0.0006	30242	21	20162	13	10081	5
0.0007	58818	46	39212	29	19606	12
0.0008	139644	120	93096	77	46548	35
0.0009	590170	550	393447	360	196724	173

P_0=0.002

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0002	1455	0	970	0	485	0
0.0004	2372	1	1582	0	791	0
0.0006	**3877**	**3**	2585	2	1293	0
0.0008	5922	6	3948	3	1974	1
0.001	9104	11	6070	7	3035	2
0.0012	15120	21	10080	13	5040	5
0.0014	29409	46	19606	29	9803	12
0.0016	69822	120	46548	77	23274	35
0.0018	295085	550	196724	360	98362	173

P_0=0.003

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0003	970	0	647	0	324	0
0.0006	1581	1	1054	0	527	0
0.0009	2585	3	1724	2	862	0
0.0012	3948	6	2632	3	1316	1
0.0015	6069	11	4046	7	2023	2
0.0018	10080	21	6720	13	3360	5
0.0021	19606	46	13071	29	6536	12
0.0024	46548	120	31032	77	15516	35
0.0027	196724	550	131150	360	65575	173

P_0=0.004

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0004	729	0	486	0	243	0
0.0008	1186	1	791	0	396	0
0.0012	1939	3	1293	2	647	0
0.0016	2961	6	1974	3	987	1
0.002	4552	11	3035	7	1518	2
0.0024	7560	21	5040	13	2520	5
0.0028	14705	46	9804	29	4902	12
0.0032	34911	120	23274	77	11637	35
0.0036	147543	550	98362	360	49181	173

P_0=0.005

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0005	587	0	392	0	196	0
0.001	949	1	633	0	317	0
0.0015	1551	3	1034	2	517	0
0.002	2369	6	1580	3	790	1
0.0025	3642	11	2428	7	1214	2
0.003	6048	21	4032	13	2016	5
0.0035	11763	46	7842	29	3921	12
0.004	27929	120	18620	77	9310	35
0.0045	118034	550	78690	360	39345	173

P_0=0.006

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0006	484	0	323	0	162	0
0.0012	791	1	528	0	264	0
0.0018	1293	3	862	2	431	0
0.0024	1974	6	1316	3	658	1
0.003	3035	11	2024	7	1012	2
0.0036	5040	21	3360	13	1680	5
0.0042	9802	46	6535	29	3268	12
0.0048	23275	120	15517	77	7759	35
0.0054	98365	550	65577	360	32789	173

P_0=0.007

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0007	416	0	278	0	139	0
0.0014	678	1	452	0	226	0
0.0021	1108	3	739	2	370	0
0.0028	1692	6	1128	3	564	1
0.0035	2602	11	1735	7	868	2
0.0042	4320	21	2880	13	1440	5
0.0049	8403	46	5602	29	2801	12
0.0056	19949	120	13300	77	6650	35
0.0063	84310	550	56207	360	28104	173

P_0=0.008

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0008	364	0	243	0	122	0
0.0016	593	1	396	0	198	0
0.0024	970	3	647	2	324	0
0.0032	1481	6	988	3	494	1
0.004	2276	11	1518	7	759	2
0.0048	3780	21	2520	13	1260	5
0.0056	7352	46	4902	29	2451	12
0.0064	17456	120	11638	77	5819	35
0.0072	73772	550	49182	360	24591	173

P_0=0.009

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0009	324	0	216	0	108	0
0.0018	525	1	350	0	175	0
0.0027	862	3	575	2	288	0
0.0036	1316	6	878	3	439	1
0.0045	2023	11	1349	7	675	2
0.0054	3360	21	2240	13	1120	5
0.0063	6536	46	4358	29	2179	12
0.0072	15516	120	10344	77	5172	35
0.0081	65575	550	43717	360	21859	173

P_0=0.01

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.001	292	0	195	0	98	0
0.002	470	1	314	0	157	0
0.003	776	3	518	2	259	0
0.004	1185	6	790	3	395	1
0.005	1821	11	1214	7	607	2
0.006	3024	21	2016	13	1008	5
0.007	5882	46	3922	29	1961	12
0.008	13965	120	9310	77	4655	35
0.009	59020	550	39347	360	19674	173

TABLE 2.8VARIABLE OF INTEREST FOLLOWS POISSION DISTRIBUTION UNDER MULTIPLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α = 0.01 AND β= 0.10

P_0=0.001

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0001	6636	1	4424	0	2212	0
0.0002	10045	3	6697	1	3349	0
0.0003	16000	7	10667	3	5334	1
0.0004	24138	13	16092	7	8046	2
0.0005	38077	24	25385	14	12693	5
0.0006	65570	47	43714	28	21857	11
0.0007	123605	98	82404	61	41202	26
0.0008	294685	255	196457	164	98229	75
0.0009	1231390	1150	820927	754	410464	363

P_0=0.002

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0002	3320	1	2214	0	1107	0
0.0004	5023	3	3349	1	1675	0
0.0006	8000	7	5334	3	2667	1
0.0008	12070	13	8047	7	4024	2
0.001	19039	24	12693	14	6347	5
0.0012	32786	47	21858	28	10929	11
0.014	61806	98	41204	61	20602	26
0.0016	147344	255	98230	164	49115	75
0.0018	615696	1150	410464	754	205232	363

P_0=0.003

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0003	2213	1	1476	0	738	0
0.0006	3348	3	2232	1	1116	0
0.0009	5334	7	3556	3	1778	1
0.0012	8047	13	5365	7	2683	2
0.0015	12693	24	8462	14	4231	5
0.0018	21857	47	14572	28	7286	11
0.0021	41202	98	27468	61	13734	26
0.0024	98229	255	65486	164	32743	75
0.0027	410465	1150	273644	754	136822	363

P_0=0.004

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0004	1660	1	1107	0	554	0
0.0008	2512	3	1675	1	838	0
0.0012	4000	7	2667	3	1334	1
0.0016	6035	13	4024	7	2012	2
0.002	9520	24	6347	14	3174	5
0.0024	16393	47	10929	28	5465	11
0.0028	30902	98	20602	61	10301	26
0.0032	73673	255	49116	164	24558	75
0.0036	307849	1150	205233	754	102617	363

P_0=0.005

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0005	1328	1	886	0	443	0
0.001	2009	3	1340	1	670	0
0.0015	3200	7	2134	3	1067	1
0.002	4828	13	3219	7	1610	2
0.0025	7616	24	5078	14	2539	5
0.003	13115	47	8744	28	4372	11
0.0035	24722	98	16482	61	8241	26
0.004	58937	255	39292	164	19646	75
0.0045	246280	1150	164187	754	82094	363

P_0=0.006

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0006	1107	1	738	0	369	0
0.0012	1675	3	1117	1	559	0
0.0018	2667	7	1778	3	889	1
0.0024	4024	13	2683	7	1342	2
0.003	6347	24	4232	14	2116	5
0.0036	10929	47	7286	28	3643	11
0.0042	20601	98	13734	61	6867	26
0.0048	49115	255	32744	164	16372	75
0.0054	205235	1150	136824	754	68412	363

P_0=0.007

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.007	949	1	633	0	317	0
0.0014	1435	3	957	1	479	0
0.0021	2286	7	1524	3	762	1
0.0028	3449	13	2300	7	1150	2
0.0035	5440	24	3627	14	1814	5
0.0042	9368	47	6246	28	3123	11
0.0049	17658	98	11772	61	5886	26
0.0054	42098	255	28066	164	14033	75
0.0063	175915	1150	117277	754	58639	363

P_0=0.008

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0008	830	1	554	0	277	0
0.0016	1256	3	838	1	419	0
0.0024	2000	7	1334	3	667	1
0.0032	3018	13	2012	7	1006	2
0.004	4760	24	3174	14	1587	5
0.0048	8197	47	5465	28	2733	11
0.0056	15451	98	10301	61	5151	26
0.0064	36836	255	24558	164	12279	75
0.0072	153924	1150	102616	754	51308	363

P_0=0.009

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0009	738	1	492	0	246	0
0.0018	1117	3	745	1	373	0
0.0027	1778	7	1186	3	593	1
0.0036	2683	13	1789	7	895	2
0.0045	4231	24	2821	14	1411	5
0.0054	7286	47	4858	28	2429	11
0.0063	13734	98	9156	61	4578	26
0.0072	32743	255	21829	164	10915	75
0.0081	136822	1150	91215	754	45608	363

P_0=0.01

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.001	664	1	443	0	222	0
0.002	1005	3	670	1	335	0
0.003	1600	7	1067	3	534	1
0.004	2414	13	1610	7	805	2
0.005	3808	24	2539	14	1270	5
0.006	6557	47	4372	28	2186	11
0.007	12361	98	8241	61	4121	26
0.008	29469	255	19646	164	9823	75
0.009	123140	1150	82094	754	41047	363

TABLE 2.8 (A) VARIABLE OF INTEREST FOLLOWS POISSION DISTRIBUTION UNDER MULTIPLE SAMPLING PLAN WITH POWER CONSIDERATION SAMPLE SIZES AND CRITICAL VALUES FOR α = 0.01 AND β = 0.20

P_0=0.001

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0002	8407	2	5605	1	2803	0
0.0003	13110	5	8740	2	4370	0
0.0004	18784	9	12523	5	6262	1
0.0005	30581	18	20388	10	10194	3
0.0006	50213	34	33476	20	16738	7
0.0007	96600	74	64400	46	32200	19
0.0008	228950	194	152634	124	76317	56
0.0009	960880	889	640587	581	320294	278

P_0=0.002

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0004	4203	2	2802	1	1401	0
0.0006	6555	5	4370	2	2185	0
0.0008	9392	9	6262	5	3131	1
0.001	15291	18	10194	10	5097	3
0.0012	25108	34	16739	20	8370	7
0.0014	48302	74	32202	46	16101	19
0.0016	114475	194	76317	124	38159	56
0.0018	480440	889	320294	581	160147	278

P_0=0.003

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0006	2802	2	1868	1	934	0
0.0009	4370	5	2914	2	1457	0
0.0012	6261	9	4174	5	2087	1
0.0015	10194	18	6796	10	3398	3
0.0018	16738	34	11159	20	5580	7
0.0021	32202	74	21468	46	10734	19
0.0024	76318	194	50879	124	25440	56
0.0027	320290	889	213527	581	106764	278

P_0=0.004

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0008	2102	2	1402	1	701	0
0.0012	3278	5	2186	2	1093	0
0.0016	4696	9	3131	5	1566	1
0.002	7646	18	5098	10	2549	3
0.0024	12554	34	8370	20	4185	7
0.0028	24151	74	16101	46	8051	19
0.0032	57240	194	38160	124	19080	56
0.0036	240220	889	160147	581	80074	278

P_0=0.005

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.001	1682	2	1122	1	561	0
0.0015	2622	5	1748	2	874	0
0.002	3757	9	2505	5	1253	1
0.0025	6117	18	4078	10	2039	3
0.003	10043	34	6696	20	3348	7
0.0035	19321	74	12881	46	6441	19
0.004	45790	194	30527	124	15264	56
0.0045	192174	889	128116	581	64058	278

P_0=0.006

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0012	1401	2	934	1	467	0
0.0018	2185	5	1457	2	729	0
0.0024	3131	9	2088	5	1044	1
0.003	5097	18	3398	10	1699	3
0.0036	8369	34	5580	20	2790	7
0.0042	16101	74	10734	46	5367	19
0.0048	38160	194	25440	124	12720	56
0.0054	160145	889	106764	581	53382	278

P_0=0.007

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0014	1201	2	801	1	401	0
0.0021	1873	5	1249	2	625	0
0.0028	2684	9	1790	5	895	1
0.0035	4369	18	2913	10	1457	3
0.0042	7174	34	4783	20	2392	7
0.0049	13801	74	9201	46	4601	19
0.0054	32707	194	21805	124	10903	56
0.0063	137267	889	91512	581	45756	278

P_0=0.008

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0016	1051	2	701	1	351	0
0.0024	1639	5	1093	2	547	0
0.0032	2348	9	1566	5	783	1
0.004	3823	18	2549	10	1275	3
0.0048	6277	34	4185	20	2093	7
0.0056	12076	74	8051	46	4026	19
0.0064	28619	194	19080	124	9540	56
0.0072	120110	889	80074	581	40037	278

P_0=0.009

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.0018	934	2	623	1	312	0
0.0027	1457	5	972	2	486	0
0.0036	2087	9	1392	5	696	1
0.0045	3398	18	2266	10	1133	3
0.0054	5580	34	3720	20	1860	7
0.0063	10734	74	7156	46	3578	19
0.0072	25439	194	16960	124	8480	56
0.0081	106763	889	71176	581	35588	278

P_0=0.01

Pa	$n_1+n_2+n_3$	d_3	n_1+n_2	d_2	n_1	d_1
0.002	841	2	561	1	281	0
0.003	1311	5	874	2	437	0
0.004	1879	9	1253	5	627	1
0.005	3059	18	2040	10	1020	3
0.006	5022	34	3348	20	1674	7
0.007	9661	74	6441	46	3221	19
0.008	22895	194	15264	124	7632	56
0.009	96088	889	64059	581	32030	278

3. Summary, Implications and conclusions

When diseases such as smallpox, leprosy, Polio have reached elimination stage, monitoring them through routine resources is difficult. In other words, prevalence of leprosy/ small pox/Polio in different geographical areas can be called very low or rare in the statistical sense; World Health Organization (WHO) defined elimination of leprosy as prevalence. There can be no universal answer to "How large should the sample size be?" Sample size depends upon the aims, nature and scope of the study and on the expected result and all these need to be considered at the beginning of the study. The required sample size also depends upon the investigator's requirements of Type I error, Power, cost, time-frame, feasibility and losses due to non-response. To estimate prevalence of leprosy of 1 case per 10,000 populations with a precision of ± 10% through a conventional survey, one needs 3.8 million people in the sample. In contrast, LQAS technique requires much smaller sample size. Here, the variable of interest, viz. number of leprosy cases follows Poisson distribution. The sample size should, accordingly be computed.

For this purpose, a number of studies conducted so far based on LQAS were reviewed. Review of the literature, till date, suggests that there are several researchers who tried the LQAS method to evaluate preventive services or to estimate disease incidence or to assess disease control programme. These studies are either published in the scientific literature or available with WHO as of 2003. A total of 811 LQAS health surveys, conducted from 1984 through 2006, were identified. One hundred and sixty (160) were conducted between 1984 and 1999. There was more than four-fold increase (650) in the number surveys conducted during 2000 - 2008. These surveys provide experience from countries belonging to African, American, European, South-East Asia, and Western Pacific Regions. Of the 811 LQAS surveys, 147 were conducted in an urban area, 564 took place in a predominantly rural province, region or district, 62 urban & rural and 37 surveys covered the entire country. The size of the total population in the sampling frame ranged from 900 to 1.2 billion persons. Lots were defined as health centre (or sub centre) catchment areas, townships, villages within a single district, zones or wards of a city, or districts within a province. The number of lots per study ranged from 2 to 870. Of the 811 surveys, 54 had < 10 lots, 612 had 10-19 lots, 67 had 20-29 lots, 47 had 30-99 and 30 had more than 100 lots. The total sample size ranged from 70 to 48,300 in a simulation study for monitoring leprosy elimination programme. LQAS surveys have been used to measure immunization coverage. This is because the LQAS method overcomes several limitations of the WHO recommended 30-cluster survey method. For a given level of precision, an LQAS immunization coverage survey requires about half the size of a WHO recommended 30-cluster survey. It was noticed that in all studies, except two or three adopted single sampling plans and normal approximation as suggested in their paper by Lemeshow& Taber to whatever the distribution of the variable of interest followed.

The present work gives a brief account and application of LQAS methodology for monitoring and assessing disease control programmes and suggests appropriate methodologies on the derivation of sample sizes and critical values when the variable/characteristic of interest follows hyper geometric, binomial or Poisson distribution when LQAS is adopted with

single, double, multiple and sequential sampling plans.

References

[1] *Abt K.,* "Poisson Sequential Sampling modified towards maximal safety in adverse event monitoring", *Biometrica Journal, 1998, Vol 40 (1), : 21-41.*

[2] *Chapman, Douglas G.,* "Inverse, Multiple and sequential sample censuses", *Biometrics 8 : 286-306.*

[3] *Claudio F Lanata,* "An evaluation of LQAS to Monitor and Improve Immunization Coverage", *International Journal of Epidemiology, 196(4):1086-1090.*

[4] *Cochran W.G.,* "Sampling Techniques" *3rd edition, Wiley, New York (1977).*

[5] *DhuirenGhish, Andrew Vogt,* "Rectification of sample size in Bernoulli and Poisson sampling", *Proceedings of SRMS, American Statistical Association.*

[6] *Dodge H F ,Romig H.G.,* "Sampling Inspection Tables", *John Wiley & Sons, 1959.*

[7] *Douglas C Montegomery,* "Introduction to Statistical Quality Control", *3rd edition, John wiley& Sons Inc.*

[8] *Gupte MD, Murthy BN,* "Application of LQAS for leprosy elimination monitoring – examination of some critical factors", *International Journal of Epidemiology, 2004, Apr;33(2):349-50.*

[9] *Gupte MD, Murthy BN,* "LQAS for monitoring leprosy elimination programme", *International Journal of Leprosy 1999; Vol 67 (2): 143-149.*

[10] *Gupte MD, Murthy BN, et.al.* "Application of lot quality assurance sampling for leprosy elimination monitoring- examination of some critical factors", *International Journal of Epidemiology 2004:33:344-348.*

[11] *Lemeshow S, Stroth G,* "Quality assurance sampling for evaluating health parameters in developing countries", *Survey Methodology, 15 (1): 71-81 (1989).*

[12] *Lemeshow S, Taber S,* "LQAS; Single and Double Sampling Plans", *World Health Statistics Quart 1991:44:115-132 [Medline].*

[13] *Leslie Kish,* "Statistical design for research", *John Wiley & Sons, 1987.*

[14] *Murhty B.N., Subbiah M.,* "LQAS for monitoring leprosy elimination in an endemic district in Tamil Nadu", *Indian Journal of Leprosy Vol 73 (2) 2001: 111-119.*

[15] *Murthy B.N., Radhakrishna S, et. al.,* "LQAS for monitoring immunization coverage in Madras city", *Indian Pediatrics, Vol. 36 (1999): 555-559.*

[16] *Murthy M.N.,* "Sampling theory and Methods", *Statistical Publishing Society, 1967.*

[17] *N. Selvakumar, E.Prabakaran, Murthy B.N., et. al., "Application of lot sampling in AFB smears for the microscopic centres", Int J of T.B and Lung Disease. Vol 9, 2005: 306-309.*

[18] *Ramesh Rao T.R., Muthy B.N., Sathakathulla A.A.,* "Application of lot quality assurance smpling for monitoring-examination of some critical factors", *Paper presented in the ICM Satellite International Conference, Sambalpur University Odissa Sep 2010.*

[19] *Robertson SE, Anker M Roison AJ, et .al.,* "The lot quality technique : A global review of applications in the assessment of health services and disease surveillance", *World health Stat Quart 50: 199-209.*

[20] *Russell V Lenth,* "Some practical guidelines for effective sample–size determination", *The American Statistician (2001): 187-193.*

[21] *Sathakathulla A.A, Murhty B.N, Ramesh Rao T.R.,* "Sample size determination in the application of lot quality assurance sampling for monitoring disease control programmes", *Paper presented in the ICM Satellite International Conference, Sambalpur University Odissa Sep 2010.*

[22] *Selvakumar N, Murthy B.N., et.al.,* "LQAS of Sputum Acid-Fast Bacillus Smear for Assesssing Sputum Smear Microscopy Centres", *Journal of Clinical Microbiology, Vol 43 (2) Feb 2005: 913-915.*

[23] Selvakumar N, Murthy BN, Prabhakarn E., et.al., "Application of LQAS of Sputum AFB smears for the assessment of microscopy centres", *Indian Journal of Teberc Lung Dis., Vol 9 (3) : 306-309.*

[24] *Weekly Epidemiological record No.* ***24, 2004, 79:221–228.***

[25] *Sathakathulla A A , Murthy B N "Single, Double and Multiple Sampling Plans*: Binomial Distribution" Paper Accepted for Publication RRST- 2012.