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Rapid Assessment of Prevalence of Cataract Blindness at District Level

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Aim. To find an optimal cluster size and number of clusters for a reasonable estimate of the prevalence of cataract blindness in people aged ⩾50 years in 19 rural districts of a state in India.

Materials. Cluster sampling methodology was used in 19 rural districts of Karnataka State, India. In each district, 15 clusters were randomly selected and 90 people aged ⩾50 years were examined in each cluster. As a result the visual acuity and lens status of a total of 22 218 people were assessed.

Methods. For each district, the design effect for cluster size ranging from 20 to 90 was calculated and the optimal cluster size and the required number of clusters to achieve an accuracy of 1% errors and 80% confidence was assessed.

Results. The age and gender adjusted prevalence of cataract blindness varied from 1.58% to 7.24%, which justifies district level surveys. The design effect is nearly 1.5 for clusters of sizes 30 and 40. With an average prevalence of 4.93% with 1% error and 80% confidence level, the optimal number of clusters is 37 and 28 for a cluster size of 30 and 40 respectively and the average sample size for a district around 1100.

Conclusions. Rapid assessments for cataract blindness in those aged ⩾50 years can be conducted at district level in India with existing resources and at affordable costs. These provide reliable data, essential for effective monitoring and planning. Other parameters, for instance, surgical coverage can also be assessed. The availability of standardized software for data entry and analysis and strict adherence to survey procedures is essential.

Keywords: cataract blindness; rapid assessment; cluster sampling; prevalence, India

In most developing countries, age-related cataract remains the single major cause of blindness. India, like many other countries in South East Asia, is undergoing major demographic changes with reducing birth rates and rapidly increasing life expectancy.[1] This, combined with limited capacity to cover the increased demand for cataract surgical services, leads to a sharp increase in blindness from age-related cataract.

National surveys were undertaken in 1971 and in 1986 to assess the magnitude and causes of blindness in India.[2,3] However, such national surveys are complicated, lengthy and expensive exercises. The sample size was large since it is determined by the disorder with the lowest prevalence. The results became only available many years after the survey was conducted, thereby losing much of their validity as planning tools to facilitate adequate allocation of health resources. Furthermore, the results of these surveys are valid for the country as a whole and for major states, but not for individual districts.

In India, a district has, on average, a population of 2 million and is the nucleus for implementation of health programmes, including the blindness control programme. District Blindness Control Societies prepare annual action plans to augment eye care services in their districts.[4] To estimate the need for services, extrapolations are generally made from State level data. However, due to large variations in socioeconomic conditions, in age and sex composition of the population, available resources for surgical services and possible risk factors, the prevalence and causes of blindness are likely to vary considerably between districts.

National surveys are major exercises and usually not conducted regularly. Resources at district level in India are adequate to conduct a limited survey using a simple, standardized methodology.

The specific aim of the rapid assessment presented in this article is to provide estimates of the prevalence of cataract blindness in the population aged ⩾50 years. District level surveys for cataract blindness, repeated every 4–5 years, could indicate trends in prevalence and

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TABLE 1 *Prevalence of cataract blindness in India in different age groups in the year 1986*

Age group (years)	Population	Prevalence VA[a] <3/60	Estimated cases VA <3/60
40–49	70 949 093	0.31%	221 650
50–59	48 825 182	1.95%	952 239
60–69	29 752 845	5.94%	1 767 599
70+	13 732 083	9.39%	1 289 941
Total 40+	163 259 203	2.59%	4 231 429
Total 50+	92 310 110	4.34%	4 009 779

[a] Visual acuity.
Source: ref. 3.

coverage and thereby facilitate effective monitoring and planning at district level. This prevalence is an indicator of the disease burden and of the service load. The article focuses on the methodological aspects. We investigate clusters of various sizes in 19 rural districts of Karnataka State of India and try to find the optimal cluster size and number of clusters for providing adequate estimates of the magnitude of blindness due to cataract.

For the purpose of this assessment, blindness due to cataract is defined as obvious lenticular opacity combined with a visual acuity (VA) <3/60 with the available correction. A person is called blind due to cataract if both eyes meet these criteria. This is consistent with the international definition for blindness given by the WHO.[5] In India, blindness is defined as a visual acuity <6/60 with the available correction.

MATERIALS

Karnataka is a state in the south-west of India, with 19 rural and one urban district (Bangalore). The total population in 1995 was estimated at 45 million (extrapolation from 1991 census data).

In 1986, the prevalence of cataract blindness (VA <3/60) in Karnataka was 0.53% and for India as a whole 0.59% (Table 1). Karnataka is therefore an 'average' state as far as blindness is concerned,[3] and with an annual number of cataract operations in 1995 of around 2700 per million population, it compares well with the all-India level of 2500 cataract operations per million in 1995.[6]

The National Survey of Blindness in 1986 indicated that of all those blind due to cataract and aged ⩾40 years, 5.2% were 40–49 years old and the remaining 94.8% were ⩾50 years. The prevalence of cataract blindness in the population of ⩾40 years was 2.59%; in the population >50 years of age 4.34%. Therefore it was decided to take the sample from the population ⩾50 years.

Assuming the prevalence of cataract blindness in those aged ⩾50 years in Karnataka had increased since 1986, it was estimated at 4.3% in 1995 when the present survey was done. Taking into account a 20% sampling error the sample size was calculated as 913 for an 80% confidence level. Allowing a design effect in the range of 1.5 due to cluster sampling, it was decided to survey a minimum of 1350 eligible people in each district. This took into account that the estimated prevalence of 4.3% was probably on the lower side. The logistics required to organize such surveys in 19 districts was also an important consideration. For a field survey of this magnitude, the cost and the precision have to be balanced.

For practical and logistic reasons, a sampling design of 15 clusters and a cluster size of 90 was selected. Such a large cluster size allowed us to investigate the adequacy of smaller sizes. In each district, three survey teams were constituted, each consisting of a trained Paramedical Ophthalmic Assistant (PMOA), a field supervisor and the local health worker. The PMOA were given a one-day training course, at the end of which an assessment was made on the inter-observer variation. Since the clinical examination was limited to the examination of the lens (normal; obvious opacity; aphakia) and the visual acuity, the inter-observer agreement was near perfect, as has been reported by other studies.[7]

As a sampling frame, data from the 1991 census was used. This lists, for each district, the villages, towns and cities and their populations. We prepared a list with cumulative total of the population. By dividing the total population of all the areas in a district by the number of clusters, in this case 15, the sampling interval was obtained. By choosing a random number between 0 and the sampling interval, the first area and the starting point for the systematic sampling was determined. The remaining 14 areas were identified by adding the sampling interval to the chosen random number. If the community in the area was too small to provide the required 90 people aged ⩾50 years, the investigators moved to the area next on the census list to complete the required number.

By following this procedure, areas are selected with probability proportional to size. This procedure is well known to be self-weighting. Within each area, 90 people aged ⩾50 years were selected by the cluster method, following the procedure recommended for rapid assessments.[8]

A total of 26 084 eligible people were listed in all 19 rural districts of Karnataka State. The urban district

TABLE 2 *Proportion of response and prevalence rate of cataract blindness in different districts*

District	Listed	Examined	Response rate (%)	Prevalence rate (%)
Bangalore–rural	1351	1339	99.1%	4.33%
Belgaum	1370	1344	98.1%	3.79%
Bellary	1371	1293	94.3%	6.00%
Bidar	1381	1090	78.9%	4.17%
Bijapur	1391	1307	94.0%	6.56%
Chickmagalur	1378	1055	76.6%	3.37%
Chitradurga	1369	1218	89.0%	5.97%
Dakshin Kannada	1377	975	70.8%	4.59%
Dharwad	1391	1147	82.5%	5.15%
Gulbarga	1379	1046	75.9%	5.37%
Hassan	1371	1321	96.4%	2.74%
Kodagu	1370	991	72.3%	1.58%
Kolar	1358	1270	93.5%	5.70%
Mandya	1364	1263	92.6%	4.65%
Mysore	1371	1027	74.9%	4.05%
Raichur	1381	1335	96.7%	5.58%
Shimoga	1361	1036	76.1%	4.12%
Tumkur	1373	1113	81.1%	7.24%
Uttar Kannada	1377	1048	76.1%	4.00%
Total	26 084	22 218	85.2%	4.93%

TABLE 3 *Visual status non-responders as reported by relatives and neighbours versus those who could be examined*

Non-responders			People examined		
Believed not blind	3291	85.1%	Not blind	18 019	81.1%
Believed one eye blind	55	1.4%	One eye blind	1096	4.9%
Believed both eyes blind	339	8.8%	Both eyes blind	1652	7.4%
Believed one eye operated	115	3.0%	One eye operated	884	4.0%
Believed both eyes operated	66	1.7%	Both eyes operated	567	2.6%
Total	3866	100.0%	Total	22 218	100.0%

of Bangalore was not included, since a survey in a large city requires a different approach. No subgrouping by age or gender was used. Non-response was quite high due to the non-availability of some people, despite repeated visits and some people did not want to be examined. A total of 22 218 people aged ⩾50 years (85.2%) were examined. Response by district is given in Table 2.

For those who could not be examined, an anecdotal visual status was obtained through interview of members of the same household or nearest neighbours. The results are shown in Table 3.

It seems that the distribution of blindness and aphakia among the non-responders differs little from the general population and may not have created a bias in the survey.

Three survey teams, completing one cluster of 90 people in a day, meant that all 15 clusters could be finished in 5 days, with a few extra days to revisit the non-responders. The costs per district ranged between Indian Rupees 35 000 and 50 000 (US$1000–1450).

METHODS

The precision of an estimate made through a cluster random sampling survey depends upon the size of the sample and the amount of clustering, the item under examination and how this is distributed in the population. When the item is evenly distributed, the sample can be small and still provide good accuracy; with a wide variation in distribution a much larger sample will

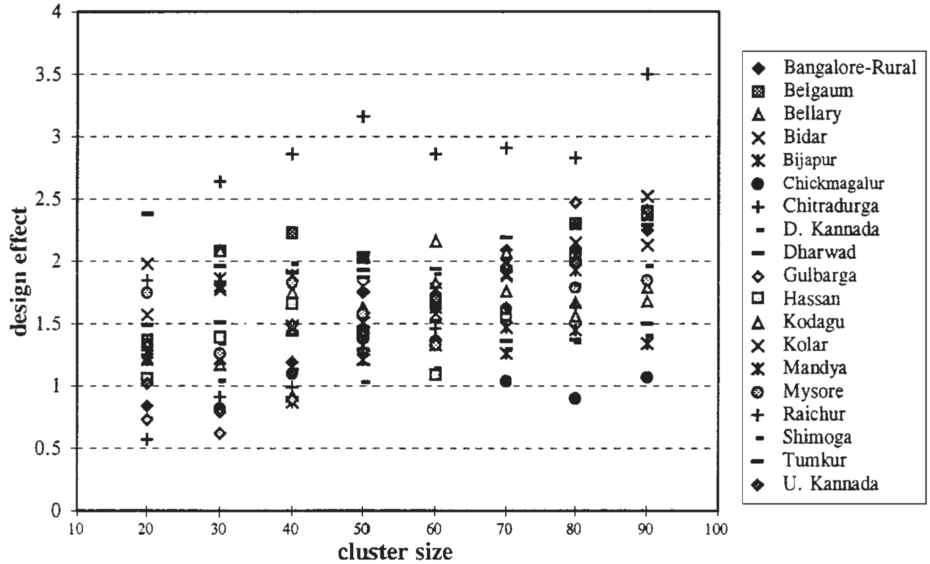

FIGURE 1 *Design effect by different cluster sizes in different districts*

be required. The level of variation in the distribution is expressed in the design effect: the inflation in accuracy of the estimate when a specific design of selection is followed, compared with simple random sampling.

The survey data were analysed for the design effect for various sizes of clusters. Even though clusters of size 90 were studied, it was also possible to investigate the performance of clusters of smaller sizes. The number of the blind amongst the first 20, the first 30, the first 40, etc., up to a maximum of first 90 people listed in each cluster was tabulated. Clusters of size 10 were not considered as that could erode the cost and speed advantages of the cluster sampling procedure.

The formula used to compute the design effect is as follows:[9]

$$\text{Design effect} = V_1(p) / V_2(p),$$

$$\text{where } V_1(p) = \left[\frac{c^2}{(\Sigma bi)^2} \times \frac{\Sigma yi^2 - 2p\Sigma ibiyi + p^2\, \Sigma ib^2 i}{c(c-1)} \right]$$

yi = number of cataract blind people in the i-th cluster,
bi = number of people examined in the i-th cluster,
pi = yi/bi,
c = number of clusters (= 15 in our case),
and $V_2(p) = (pq/n)$; $p = \Sigma yi/\Sigma bi$, $q = 1-p$, $n = \Sigma ibi$.

Note that $V_1(p)$ is the variance of p for the cluster sampling used by us and $V_2(p)$ is the variance for simple random sampling. For all different cluster sizes in each district, the design effect was calculated from the survey data. These values were plotted in Figure 1.

The number of clusters, c, required to get an estimate of prevalence within a specified precision can be calculated by the formula:[9]

$$c = \frac{pqD}{bs^2}, \quad \text{where}$$

s = (error allowed either way)/z,
z = standard normal deviate, corresponding to the desired level of confidence
D = design effect
p = prevalence obtained
q = 1–p
b = size of the cluster
c = number of clusters

Allowing an error of 1% and a confidence level of 80%, the number of clusters required to achieve this level of accuracy was calculated for different cluster sizes in each district. The values thus obtained are given in Table 4.

RESULTS

The results in terms of prevalence of bilateral cataract blindness in each district in Karnataka are given in the

TABLE 4 *Number of clusters for different cluster sizes*

District	Cluster size							
	20	30	40	50	60	70	80	90
Bangalore–rural	29	34	21	28	23	24	22	20
Belgaum	22	35	29	24	19	14	18	17
Bellary	90	50	27	37	34	27	22	21
Bidar	65	43	25	22	19	19	19	16
Bijapur	68	49	25	29	26	21	21	17
Chickmagalur	28	12	10	12	9	6	4	5
Chitradurga	69	71	54	51	39	39	35	38
Dakshin Kannada	31	26	22	13	13	13	12	12
Dharwad	82	38	46	42	30	30	26	23
Gulbarga	32	20	20	25	28	30	30	27
Hassan	23	16	13	9	6	9	12	12
Kodagu	20	21	12	7	9	8	6	5
Kolar	123	62	35	34	28	25	24	27
Mandya	60	54	40	32	23	16	19	20
Mysore	68	35	36	26	20	20	20	18
Raichur	26	28	30	33	29	26	22	30
Shimoga	44	33	39	27	23	20	16	17
Tumkur	58	56	34	40	29	22	20	19
Uttar Kannada	23	14	20	17	19	17	16	17
Range	20–123	12–71	10–55	7–67	6–48	6–39	4–45	5–38
Average	50.6	36.7	28.3	26.7	22.4	20.3	19.2	19.0
Total sample size	1011.6	1101	1133	1337	1345	1422	1533	1710

[a] In the body of the Table are the number of clusters.

last column of Table 2. The wide variation between the districts, ranging from 1.74% to 7.5%, justifies the need to undertake district level surveys. This variation indicates that it is not appropriate to use state level values for planning or monitoring at the district level.

The design effect for different cluster size in all districts were plotted in a graph (Figure 1). The values showed a uniform pattern for all but two districts. Examination of the data revealed that two clusters in Raichur district and one cluster in Uttar Kannada district had far more cataract blind persons than the remaining clusters in these and other districts. We had a total of 285 clusters (19 districts with 15 clusters each), but those three clusters differed so strongly that this could only be attributed to observer's error. These three were removed from the calculations and the survey will be repeated there.

Figure 1 shows that the average design effect is generally low at 1.2 for a cluster size of 20, around 1.5 for a cluster of size 30 to 40 and increasing further with larger clusters. Cluster size 20 was not considered since the number of clusters would be high and cause operational constraints. A cluster size of 30 or 40 sampling units seems most appropriate for the Indian situation, based on statistical considerations as well as on operational feasibility. However, the number of clusters can be determined entirely on statistical considerations, i.e. to achieve the specified precision with the desired probability.

The number of clusters required for different cluster sizes (error 1% and confidence 80%) are indicated in Table 4. Even though there are wide variations between districts because of the different values of the design effect and the different prevalence rates, an average still seems to be a representative value. This works out to nearly 37 clusters for cluster size 30, or 28 for cluster size 40.

The total sample size and the average number of clusters corresponding to various sizes of clusters are plotted in Figure 2. As is expected, the number of clusters declines and total sample increases as the cluster size increases. The decline is sharp up to the size 40 after which the gradient is small. The total sample size increases too steeply when the cluster size goes up from 40 to 50. These can be considered as indications of the adequacy of size 40 for which the design effect is nearly as low as for size 30.

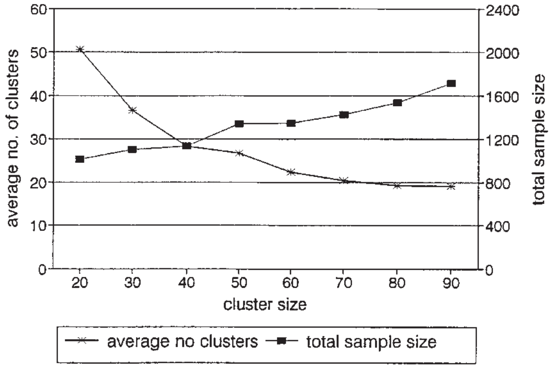

FIGURE 2 *Total sample size and average number of clusters for various sizes of clusters*

DISCUSSION

The district level assessments of the prevalence of cataract blindness in those aged ⩾50 years presented here are not a replacement for national blindness surveys. They focus only on one cause of blindness and a small portion of the population. However, in most developing countries, and certainly in India, blindness due to cataract is by far the major cause of blindness and requires most of the eye care resources.

In order to facilitate adequate monitoring and efficient management of eye care services at district level, regular assessments of the prevalence of cataract blindness are essential. This survey shows that such assessments can be carried out confidently by a paramedical ophthalmic assistant after a one-day training session. Strict adherence to survey procedures monitored by trained supervisors is essential. Three clusters had to be removed from our analysis, due to unusual results attributed to poor supervision. The variation in prevalence of cataract blindness justifies district level surveys.

Examination of the design effect of clusters of various sizes indicates that a size of 30 or 40 may be optimal. For a maximum error of 1% on either side of the estimate of prevalence of bilateral cataract blindness with a confidence level of 80%, the average number of clusters required is 37 and 28 respectively. Thus, it is recommended that a 37×30 or 28×40 cluster random sampling may be tried in other areas as a rapid assessment methodology to estimate the prevalence of bilateral cataract blindness at district level.

In the Indian situation, 37×30 cluster sampling may be preferable from the operational point of view, since experience from the field suggests that one team can cover two such clusters in one day if the travelling time between the clusters is one hour or less. Since the clusters are within the same district, it may be possible to group the clusters in such a way that two clusters can be covered on the same day by one team. In other situations, a 28×40 strategy may be preferable.

The implications of this design on logistics, time and costs have to be explored and analysed. To facilitate data entry and analysis at district level, a standard software package is required. Such a package is under development.

It may be useful to repeat this cluster sampling survey in districts with a higher, as well as in districts with a lower, prevalence of cataract blindness and analyse the design effect, optimal cluster size and number of clusters.

It is possible to obtain other indicators, for instance, prevalence of aphakia and cataract surgical coverage from the survey data. Detailed analysis is required to calculate the accuracy of the estimates for these indicators.

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