Title:

A field trial of a survey method for estimating the coverage of selective feeding programs

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Abstract

Objective

To test a survey method applicable to estimating the coverage of selective feeding programs in humanitarian emergencies.

Methods

The trial survey used a stratified design with strata defined using the *centric systematic area sample* method. Thirty 100 km^2 quadrats were sampled. Communities located closest to the centre of each quadrat were sampled using a *case-finding* approach.

Findings

The method proved simple and rapid to implement and allowed overall and per-quadrat coverage to be estimated. Overall coverage was 20.0% (95% C.I. = 13.8%, 26.3%). Per-quadrat coverage ranged between zero (in nine quadrats) and fifty percent (in one quadrat). Coverage was highest in quadrats closest to therapeutic feeding centres and in quadrats containing major roads leading to the towns in which therapeutic feeding centres were located.

Conclusion

The method should be used, in preference to EPI-derived survey methods, for estimating the coverage of selective feeding programs. It should also be considered when evaluating the coverage of other selective entry programs or when coverage is likely to be spatially inhomogeneous.

Introduction

Program coverage is assuming greater importance as an indicator for monitoring and evaluating humanitarian interventions. In 2003 specific coverage indicators for selective feeding programs were included in the SPHERE project's humanitarian guidelines for the first time [1]. The focus on coverage has called into question the appropriateness of traditional therapeutic feeding centre (TFC) based interventions [2, 3] but the absence of suitable methods for estimating the coverage of selective feeding programs is hindering progress towards the acceptance of alternatives to TFC based interventions. At present, an adaptation of the WHO Expanded Programme on Immunisation (EPI) coverage survey method [4, 5, 6, 7] is recommend for assessing the coverage of selective feeding programs [8]. This is a two-stage cluster sampling approach which begins by dividing a population into *clusters* for which population estimates are available. A subset of clusters is selected in the first sampling stage. The probability of a particular cluster being selected is proportional to the size of the population in that cluster. Clusters with large populations are more likely to be selected than clusters with small populations. This sampling procedure, called *probability proportional to size* (PPS), helps to ensure that individuals in the program area have an equal chance of being sampled when a quota sample is taken in the second stage of the survey [9]. In recognition of the difficulties of drawing a random sample in many developing countries [10], the EPI method uses a non-random sampling method in the second stage. The most commonly used second stage sampling method is a proximity technique. The first household to be sampled is chosen by selecting a random direction from the centre of the cluster, counting the houses along that route, and picking one at random. Subsequent households are sampled by their physical proximity to the previously sampled household. Sampling continues until a fixed sample size as been collected. Sampling is simple and requires neither mapping nor enumeration of households. It is, consequently, both quicker and cheaper than using simple random sampling in the second stage of the survey [11]. The EPI method does, however, have problems. The PPS process should result in a self-weighted sample but it cannot be relied upon to do so if estimates of cluster population sizes are inaccurate [12]. In addition, PPS locates the bulk of data-collection in the most populous communities. This may leave areas of low population density unsampled (i.e. those areas consisting of communities likely to be distant from health facilities, feeding centres, and distribution points). This may cause surveys to evaluate coverage as being adequate even when coverage is poor or non-existent in areas outside of urban centres [13]. With the exception of the first child, none of the observations in the within-cluster sample are selected using an equal probability selection method. This,

together with the fact that the within-cluster sample size is usually too small to estimate coverage in any cluster with reasonable precision, means that the EPI method can return only a single estimate of coverage, even when coverage is spatially inhomogeneous. This is an important limitation since identifying areas with poor coverage is an essential step towards improving program coverage and, hence, program impact.

Despite these problems, an adaptation of the EPI method is frequently used to estimate the coverage of selective feeding programs. The currently accepted method is to use a two-stage cluster sampled survey to estimate the prevalence of acute undernutrition in the program area [8]. Coverage is assessed either *directly* or *indirectly*. Coverage is estimated *directly* using formula 1 [8]. This approach introduces a further problem. The sample size used in these surveys is usually 900 children collected in thirty clusters [8]. This sample size allows the *prevalence* of acute undernutrition (i.e. wasting) to be estimated with reasonable precision, but the sample size available to estimate *coverage* depends on the prevalence of acute undernutrition found by the survey. When the aim of the survey is to estimate the coverage of a feeding program for *severe* acute undernutrition, the sample size will usually be too small to estimate coverage with reasonable precision. The *effective sample size* is further reduced by the *design effect* introduced by cluster and proximity sampling [12] which is likely to be considerable if coverage is spatially inhomogeneous [12] (i.e. if coverage is high in some communities but low in others). Formula 1 includes children who may not be eligible for entry into the program on the day of the survey (i.e. children in the recovery phase whose weight-for-height is above the program's entry criteria or no longer exhibit nutritional oedema). These children, now in recovery, were *recently* severely undernourished. Formula 1 is, therefore, an estimator of *recent period* coverage. This can be thought of as analogous to *period prevalence* estimates derived from (e.g.) 14-day recall. An alternative (*point*) estimator is the ratio of cases receiving treatment found in the sample to the total number of cases requiring treatment found in the sample (formula 2). The use of this estimator is subject to the same sample size constraints as formula 1. An *indirect* method is also used [8]. In this, a two-stage cluster sampled survey is used to estimate the prevalence of acute undernutrition in the program area. Coverage is estimated using formula 3. The denominator of this formula is subject to considerable uncertainty. The population estimate is usually derived from census data. In complex emergencies certain factors may lead to census data not being accurate (e.g. political manipulation, the absence of a functioning civil society, population displacement, and poor security). Population estimates are often corrected by the application of estimates of population growth which can seldom account for

displacement, migration, or high mortality in the target population. Survey sample sizes are usually too small to estimate the prevalence of *severe* acute undernutrition with useful precision. This results in prevalence estimates with confidence intervals that are wide relative to the magnitude of the estimate, leading to similarly imprecise estimates of program coverage.

Thus, when applied to the problem of assessing the coverage of selective feeding programs, the EPI method has important limitations. This paper presents a trial of an alternative method aimed at addressing these shortcomings.

Methods

Trial Location

The trial survey aimed to estimate the coverage of a centre-based therapeutic feeding program for the treatment of severe acute undernutrition in the Mchinji district of Malawi. This district had been subject to prolonged food shortages resulting from erratic rainfall between 2000 and 2002, reduced agricultural inputs, the sale of a large proportion of the strategic grain reserve, and the reluctance of donors to release funds following allegations of fund misuse by the Government of Malawi. The prevalence of acute undernutrition reached 12.5% in March 2002. Semi-quantitative food security assessments performed in October 2001, April 2002 and August 2002 predicted ongoing food shortages. A range of nutritional interventions were started in March 2002 including a therapeutic feeding program consisting of three therapeutic feeding centres of which two were based at government health facilities and one at a 'mission' hospital run by the Christian Health Association of Malawi. At the time of the survey reported here (March 2003) the prevalence of acute undernutrition in the district was returning to acceptable levels and was estimated as being 2.9% in December 2002 [25].

Survey Design

The trial survey used a stratified design with strata defined using the *centric systematic area sample* method [14, 15, 16, 17]. This method involves dividing the survey area into non-overlapping squares of equal area (*quadrats*) and sampling the community or communities located closest to the centre of each quadrat. A 1:50,000 scale map of the district was available from the 1998 Malawi national census. A ten-by-ten kilometre grid was overlaid onto this map. The positioning of the grid was chosen to maximise the area covered by the survey. All quadrats with more than half of their area inside the district were sampled. Thirty 100 km^2 quadrats were sampled. The selected quadrats covered approximately 3000 km^2 (89.4%) of the 3356 km^2 total land area of Mchinji district. Areas not covered by the survey were at the periphery of the district where less than 50% of the quadrat area fell within the district boundaries. Communities located closest to the centre of each quadrat were then sampled using a *case-finding* approach. The number of communities sampled from each quadrat was determined by the number of communities in that quadrat which could be sampled by a survey team in a single day. This varied between quadrats (see Table 1) and depended on the size of each community (in terms of

both population and physical extent) and the distances between communities. Once sampling started in a community, it continued until no further cases could be found. No communities were partially sampled. The location of the centre of each quadrat was identified by reference to the map. A list of communities to be sampled from each quadrat was made prior to the survey team visiting the quadrat. The order of this list (which was also the order in which the communities were sampled) was determined by the proximity of each community to the centre of the quadrat, with the community closest to the centre of the quadrat being sampled first.

Case-finding

For the within-community samples, a case-finding approach was adopted. Four methods were investigated. These were:

1. Screening of all children in a single community at a central location in their home community.

2. Screening of all children living in multiple communities at a central location outside of their home community.

3. Screening of children in a single community identified by their mothers as sick, thin, or oedematous at a central location in their home community.

4. *Investigative case-finding*: Screening, in their homes, of children identified as thin, sick, or oedematous by the community health worker. Additional children were also identified by mothers in each of the screened households. When survey teams were directed to an empty house, attempts were made to locate the occupants. In most cases, the mothers and children were close to home and were called by neighbours. If mothers and children could not be located immediately, houses were re-visited at the end of the day.

Children reported as being in a therapeutic feeding centre on the day of the survey were visited and examined at the therapeutic feeding centre. For each method, village of residence, name, sex, age, weight, height, and the presence or absence of bilateral pitting oedema were recorded for each child. Examination of this data showed that each method identified the same children. The fourth method was considerably more efficient than the other methods, allowing a survey team to screen up to six communities in one day, and was adopted as the case-finding method for the trial survey.

Case-definitions

Cases were defined as children aged between six months and five years with ≤ 70% of the weight-for-height median of the NCHS reference population [18] or bilateral pitting oedema. This was also the entry criteria used for the therapeutic feeding program. Receipt of treatment was ascertained by the child's presence in a therapeutic feeding centre or by documentary evidence (i.e. possession of a program card or identity bracelet).

Program Coverage

Coverage in each quadrat was estimated as the ratio of cases receiving treatment found in the sample to the total number of cases found in the sample (formula 2). Overall coverage was estimated by treating each quadrat as a stratum in a stratified sample [9] with sample weights derived from the population of the communities sampled in each quadrat.

Data handling

Data were entered, checked, and cleaned using EpiInfo v6.04d [19] and analysed using the *R* Language for Data Analysis and Graphics [20]. The spatial distribution of coverage was investigated by estimating coverage in each quadrat and plotting the data using histograms and mesh maps.

Results

The survey method proved simple and rapid to implement. Data collection took three survey teams ten days to complete. Data from the trial survey are shown in Table 1. Overall coverage was 20.0% (95% C.I. = 13.8%, 26.3%). The distribution of per-quadrat coverage is shown in Figure 1. Coverage ranged between zero (in nine quadrats) and fifty percent (in one quadrat). The spatial distribution of per-quadrat coverage is shown in Figure 2. The length of the sides of the filled squares reflect the level of coverage found in each quadrat. The small open squares indicate quadrats with zero coverage. The legend shows examples of what the size of the square would be if estimated coverage were 100%, 50%, or 25% as well as showing the symbol used to indicate zero coverage. The filled squares are continuously variable in size between zero and one-hundred percent. The crosses mark the approximate locations of the three therapeutic feeding centres. Dotted lines are used to indicate the approximate locations of major roads. Coverage was highest in quadrats closest to the therapeutic feeding centres and in quadrats containing major roads leading to the towns in which the therapeutic feeding centres were located.

Discussion

Centric systematic area sampling is widely used in ecology to ascertain the spatial distribution of abundance of plant and animal species over wide areas, and in human geography to investigate point phenomena such as the distribution of specific types of retail businesses [14, 15, 16, 17]. Its principal advantages are reported to be simplicity of use in the field [17], the ability to sample evenly across a wide area [17], simplicity of data handling [21], and the addition of a spatial dimension to survey data [15, 17]. In practice, the method proved simple to use in the field although this may not be the case if useful maps are not available. Even spatial sampling is virtually guaranteed by the use of a sampling grid and is only likely to be compromised when factors such as poor security prevents some quadrats from being sampled. The terrain of the trial survey location made it feasible to define quadrats by overlaying a simple grid onto a map of the program area. More difficult terrains (e.g. program areas divided by impassable rivers, gorges, or military fronts) may require more imaginative quadrat location strategies. Entry and management of data was considerably quicker than for a two-stage cluster sampled survey since data analysis procedures require only summary data for each quadrat. Data handling procedures are simple enough to be performed by hand or using a standard spreadsheet package. The use of case-finding, as opposed to probability sampling, in the second stage provides an *exhaustive* sample. The case finding approach is likely to identify all, or nearly all, cases in sampled communities. This allows per-quadrat coverage to be calculated precisely and meaningful comparisons of per-quadrat coverage to be made. The ability to calculate per-quadrat coverage allows a spatial assessment of coverage, providing information useful for program management: In the trial location the survey results would cause action to be taken to address the zero coverage in the south-west corner of the program area. In different contexts it may be necessary to develop and test alternative case-finding procedures in order to ensure exhaustive within-community samples. Centric systematic area sampling may also be used for estimating the coverage of less restrictive programs (e.g. supplementary feeding programs) where investigative case-finding procedures may provide a less exhaustive sample than proved possible in the trial survey. This lack of exhaustiveness may be addressed by using other case-finding methods such as door-to-door screening. This would not impact upon survey costs since estimating the coverage of less restrictive programs (i.e. programs treating relatively common conditions) would require that only a single community be sampled from each quadrat. The exhaustiveness of case-finding procedures can be estimated using *capture-recapture* methods [22, 23, 24]. Estimating the exhaustiveness of the case-finding procedure and using this estimate to correct for under-reporting would enable the method

to yield estimates of both prevalence and coverage from a single survey. The trial survey estimated the prevalence of severe acute undernutrition as 1.59% (95% CI = 1.34%, 1.88%), calculated as the ratio of the number of cases found in the sample to the total population under five years in the sampled communities and assuming an exhaustive case-finding procedure. This estimate was broadly in line with that reported by a recent nutrition survey of the same population [25].

There are potential problems with the proposed survey method. The centric systematic area sampling method, like any systematic sampling method, can produce biased estimates if there is periodic variation in coverage and the sampling locations tend to coincide with this periodicity [26]. This is difficult to control against without prior knowledge of the periodic variation, although simple checks, such as ensuring that sampling locations are not (e.g.) all in valleys or all on hilltops and adjusting the grid position accordingly, should help to minimise this problem. The trial survey used a proximity method to select the centrally located communities to be sampled in each quadrat. A more rigorous sampling procedure such as selecting communities at random in each quadrat or using a finer grid and selecting a single central community from each quadrat could be adopted but this would increase the cost of surveys and is likely to yield little increase in accuracy [21]. The proposed survey method assumes homogeneity of coverage within quadrats. The area of each quadrat is, however, considerably smaller than the program area (approximately one-thirtieth of the program area in the case of the trial survey) making this assumption more plausible than that of homogeneity over an entire program area. Census population estimates of the sampled communities were used to derive sample weights. It has already been noted that census data may be unreliable in some emergency contexts. The method is, however, likely to be robust to such unreliability and, when accurate population estimates are not available, data may be analysed as arising from a simple random sample [21]. Alternatively, sample weights derived from rapid eye estimates or proxies of population such as roof counts may be used without introducing significant error [9]. The ability of the case-finding method to return an exhaustive sample cannot be assumed. A poor case-finding method might systematically exclude (e.g.) children of minority groups or children in households on periphery of sampled communities leading to a bias in coverage estimates. The case-finding method should, therefore, be tested against the results of (e.g.) door-to-door screening exercises using capture-recapture methods [22, 23, 24] prior to use in surveys.

An advantage of the proposed method is that it is likely to sample considerably more communities than would usually be sampled in an EPI-derived survey. The trial survey sampled 151 communities

compared to the maximum of 30 communities usually sampled in EPI-derived surveys. It should be noted that the PPS procedure often causes more than one cluster to be sampled from larger communities causing many EPI-derived surveys to sample fewer than the usual maximum of thirty communities. Table 2 compares the results of the trial survey with the results of a survey of Mchinji district using an EPI-derived method undertaken in December 2002 [25]. The trial survey method screened more children from more communities and found more cases in more communities than the EPI-derived method, resulting in a more precise estimate of program coverage. The trial method was able to identify areas of low or zero coverage whereas the EPI-derived method was limited to providing a single district-wide estimate.

The trial survey took longer to complete than the EPI-derived survey. This is because one survey team took one day to sample one quadrat whereas a survey team can usually sample two clusters per day in an EPI-derived survey. The proposed survey method could, however, be as efficient as EPI-derived methods in higher prevalence situations and in less compact survey areas. Importantly, active case-finding is central to both successful program implementation and the proposed survey method. This means that the estimation of coverage could be integrated with program outreach. This would allow continued estimation of coverage and prevalence as part of routine program activity, removing the need for expensive and repeated cross-sectional surveys.

The method used to calculate coverage in the trial survey returned a *point* coverage estimate (i.e. from formula 2) but a *recent period* coverage estimate (i.e. from formula 1) may be calculated if required.

The survey method presented here addresses the shortcomings of EPI-derived methods as applied to the problem of estimating coverage in selective feeding programs. The results indicate that the method should be used, in preference to EPI-derived survey methods, for estimating the coverage of selective feeding programs. It should also be considered when evaluating the coverage of other selective entry programs or when coverage is likely to be spatially inhomogeneous.

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$$\frac{\text{number of respondents attending the feeding program}}{\text{number of cases not attending the feeding program} + \text{number of respondents attending the feeding program}} \times 100$$

Formula 1

$$\frac{\text{number of cases attending the feeding program}}{\text{total number of cases}} \times 100$$

Formula 2

$$\frac{\text{number of recipients attending the feeding program}}{\text{estimated prevalence of severe acute undernutrition} \times \text{estimated population}} \times 100$$

Formula 3

Table 1 : Data from the trial survey

Quadrat*		Communities Visited	Population < 5 years**	Children Screened	Cases Found	Cases Covered	Cover (%)
x	*y*						
3	7	6	433	55	7	2	28.6%
4	5	5	362	46	4	0	0.0%
4	6	5	233	43	4	1	25.0%
4	7	6	346	53	3	1	33.3%
4	8	5	186	53	3	1	33.3%
4	9	4	246	39	5	1	20.0%
5	3	5	256	36	3	0	0.0%
5	4	6	270	53	2	0	0.0%
5	5	5	175	52	3	0	0.0%
5	6	3	138	37	3	1	0.0%
5	7	5	268	48	5	2	40.0%
5	8	6	301	57	2	0	0.0%
5	9	4	274	36	4	1	25.0%
5	10	6	351	52	5	0	0.0%
6	4	5	358	51	5	2	0.0%
6	5	3	391	29	8	1	12.5%
6	6	4	276	35	6	0	0.0%
6	7	6	366	49	6	1	16.7%
6	8	4	189	38	3	1	33.3%
6	9	5	385	51	5	1	20.0%
6	10	5	173	46	6	2	33.3%
7	4	6	237	53	5	1	20.0%
7	5	5	227	48	3	1	33.3%
7	6	5	262	47	4	0	0.0%
7	7	5	287	48	6	3	50.0%
7	8	6	268	55	4	0	0.0%
8	3	6	380	50	8	2	25.0%
8	4	6	345	57	5	2	40.0%
8	6	3	345	37	6	1	16.7%
8	7	6	231	49	3	1	33.3%

* Specified as west to east (*x*) and south to north (*y*) co-ordinates in the sampling grid
** Census estimates of the under-five population in the visited communities

Figure 1 : Distribution of coverage in 30 quadrats

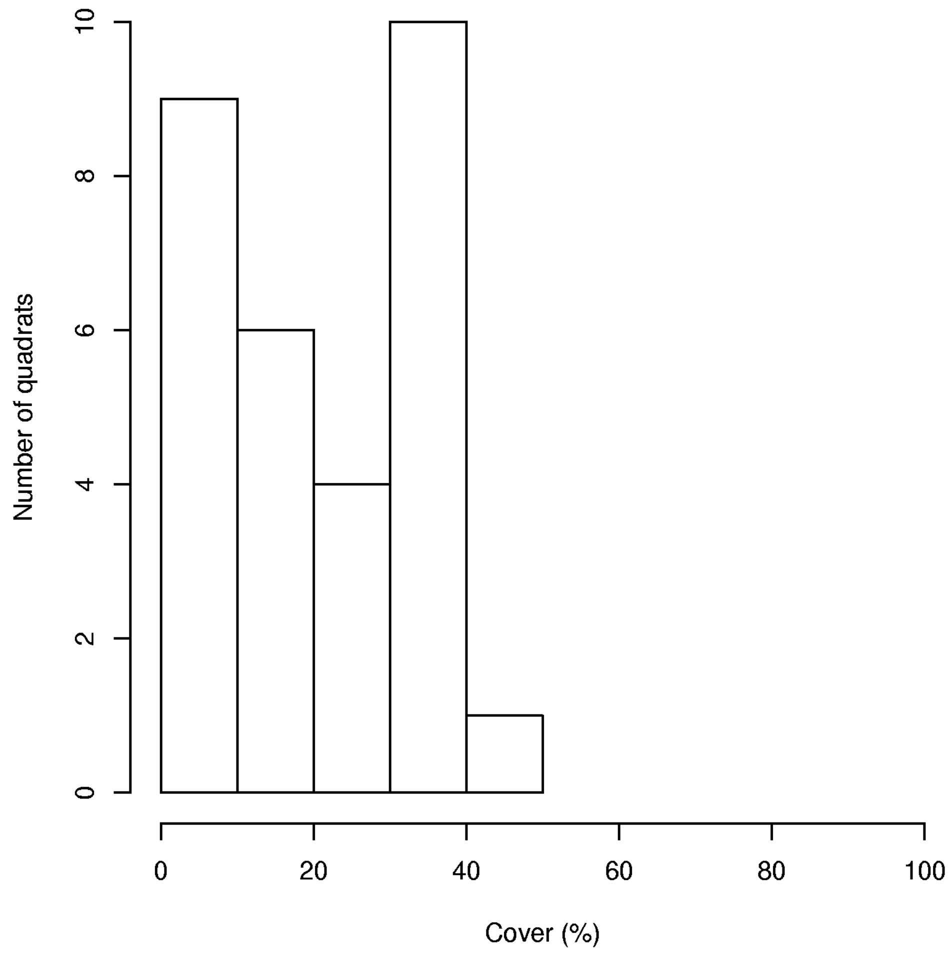

Figure 2 : Spatial distribution of coverage in 30 quadrats

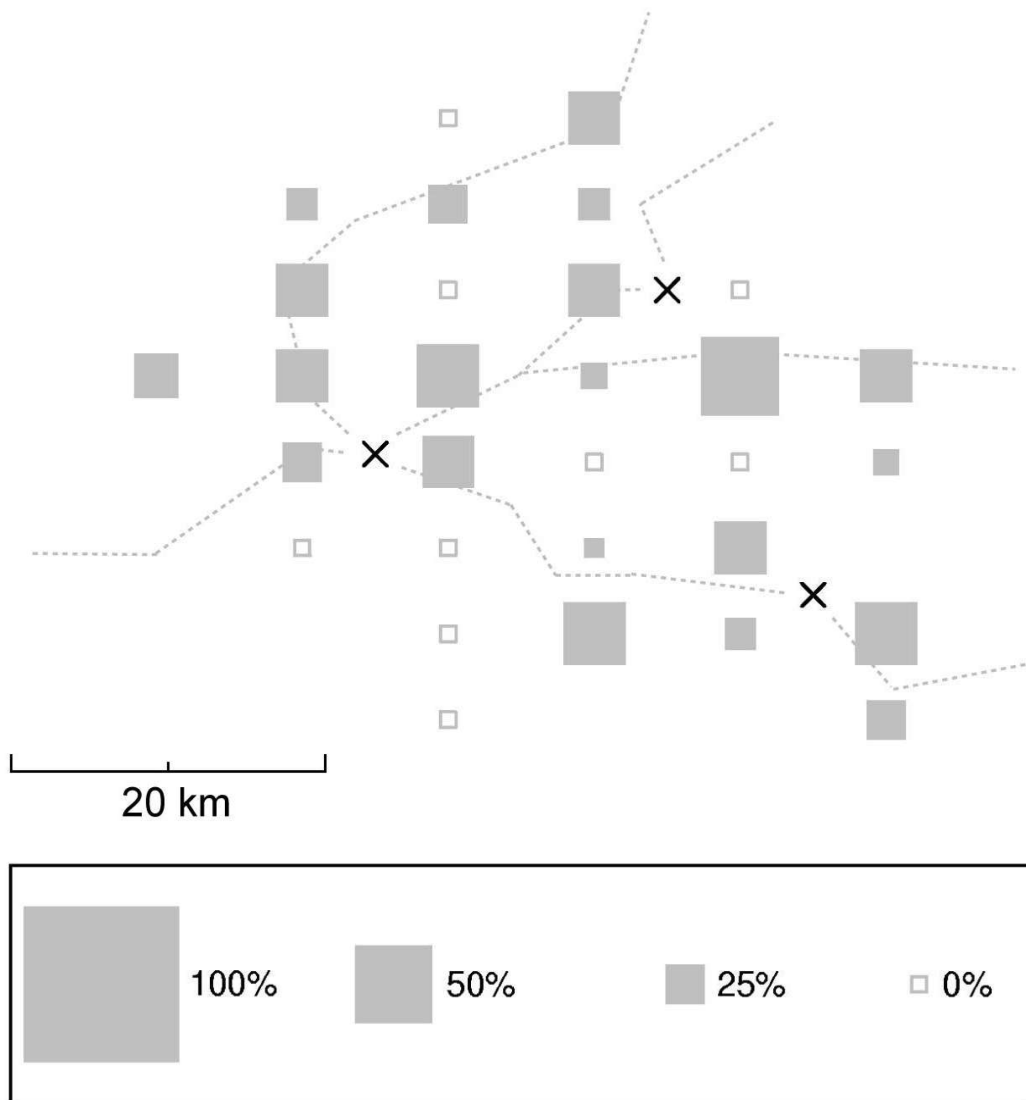

Table 2 : Methods, sample sizes, and results for two different surveys

	EPI-derived survey	Trial survey
Design	Cluster	Stratified
First-stage sampling	PPS	Centric systematic area
Second stage sampling	Proximity	Exhaustive (case-finding)
Clusters / quadrats sampled	30	30
Communities sampled	30	151
Usable clusters / quadrats*	7	30
Children screened	1025	1403
Staff required (person-days)**	81	123
Cases found	10	136
Cases covered	1	29
Cover (%)	10.0%	20.0%
95% confidence interval	0.2%, 44.5%	13.8%, 26.3%
Prevalence (%)	0.98%	1.59%
95% confidence interval	0.47%, 1.79%	1.34%, 1.88%

* The number of clusters / quadrats in which one or more cases were found
** Includes training, supervision, survey days, data-entry, and data analysis but excludes testing and evaluation of case-finding methods for the trial survey

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