

Sample Design

ICAN

International Common Assessment of Numeracy



LEARNigeria®



Sample design of ICAN 2019¹

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¹ Sampling and statistical guidance for ICAN was provided by Dr Wilima Wadhwa (at ASER Centre, India). This note is based on sampling notes authored by Dr Wilima Wadhwa in previous editions of the Annual Status of Education Report (ASER) in India.

ICAN stands for the International Common Assessment of Numeracy. Designed by the People's Action for Learning (PAL) Network, ICAN was implemented in 13 countries across Africa, Asia, and the Americas with children in the age-group of 5-16. The assessment was carried out in the sampled households in rural communities.

Introduction

In ICAN 2019, the survey coverage was limited to a rural sample and the scale of the survey was limited to one district² (sub-state/regional/provincial unit) in each participating country. In each surveyed district, ICAN employed a two-stage sample design, with a random sample of rural communities³ drawn in the first stage and households randomly selected from each of the sampled rural communities in the second stage. This sampling strategy generated estimates representative for the selected district.⁴ Since the survey was limited to only one district per country, ICAN 2019 data cannot be used as a proxy for national estimates or to compare countries. Rather, this exercise aimed to demonstrate proof of concept in two ways:

- To demonstrate the feasibility of using a common assessment framework and set of tools across very different country contexts; and
- To highlight the ways in which ICAN can be used to generate estimates that respond to important questions confronting countries in the Global South.

The development and implementation of the sampling plan was a collaborative exercise involving the leaders from PAL members in participating countries, Project Management Team (PMT) members and the PAL Network Secretariat. The PMTs built consensus on the target age group, selected the district to be surveyed, obtained the official sampling frame of all rural communities in the selected district, worked with local sampling experts to do the sampling, and kept track of rural communities surveyed and the use of replacement rural communities, if any. PMTs used a series of sampling formats to document the completion of each of these tasks.

Target population

Unlike school-based assessments and consistent with the citizen-led assessment (CLA) approach of assessing all children regardless of schooling status, ICAN defines its target population by age rather than class (see Table 1). Across all districts covered in ICAN 2019, all children in the age group of 5-16 years in sampled households were surveyed. This age range takes into account a number of different but interrelated factors, including the prescribed age of entry to and completion of primary school in participating countries, the reality of large proportions of overage children in primary classes in Global South countries, and the fact that many older children are not able to handle foundational tasks despite several years of schooling. By conducting the assessment in sampled households, ICAN 2019

² For ease of communication, 'District' in this note refers to a sub-state/regional/provincial unit, which is known by different names in different countries. For instance, this unit is called a Local Government Area in Nigeria, a District in India, a Department in Senegal, a sub-county in Kenya, and so on.

³ Rural communities are called by different names in different countries. For instance, these units are called Villages in India and Pakistan; Enumeration Areas in Kenya, Uganda, Tanzania, Mozambique; District in Senegal, and so on. For ease of communication, this note refers to all of these stage 1 units as 'rural communities'.

⁴ Surveyed districts in participating countries are: Arusha Rural (Tanzania), Betul (India), Ikorodu (Nigeria), Jhenaidah (Bangladesh), Larde (Mozambique), Makwanpur (Nepal), Matagalpa (Nicaragua), Mubende (Uganda), Mwala (Kenya), Ségou (Mali), Tivaouane (Senegal), Toba Tek Singh (Pakistan) and Xalapa Rural (Mexico).

represented all children in the target population in the surveyed districts, including those who may not regularly attend officially recognised schools.

Table 1: ICAN participating countries: Education systems and target-population in the existing PAL Network CLAs*

Region	Country	Education system	Prescribed age of entry to Class 1	Age at the end of primary classes	Age-group surveyed in existing CLA?	Age-group assessed in existing CLA?
Eastern and Southern Africa	Kenya	Primary classes: 1 to 8 Secondary classes: 1 to 4	6 years	13 years	4-16 years	6-16 years
	Mozambique	Primary classes: 1 to 7 Secondary classes: 1 to 5	6 Years	12 years	7-16 years	7-16 years
	Tanzania	Primary classes: 1 to 7 Secondary classes: 1 to 6	6 Years	12 years	6 months-16 years	6-16 years
	Uganda	Primary classes: 1 to 7 Secondary classes: 1 to 6	6 Years	12 years	6-16 years	6-16 years
West Africa	Mali	Primary classes: 1 to 9 Secondary classes: 1 to 3	6 years	14 years	6-14 years	6-14 years
	Nigeria	Primary classes: 1 to 6 Secondary classes: 1 to 6	6 years	11 years	3-15 years	5-15 years
	Senegal	Primary classes: 1 to 6 Secondary classes: 1 to 7	7 years	12 years	9-16 years	9-16 years
America	Mexico	Primary classes: 6 years Secondary classes: 6 years	6 years	11 years	7-17 years	7-17 years
	Nicaragua	Primary classes: 6 years Secondary classes: 5 years	6 years	11 years	N/A	N/A
South Asia	Bangladesh	Primary classes: 1 to 5 Secondary classes: 6 to 12	6 years	10 years	N/A	N/A
	India	Primary classes: 1 to 8 Secondary classes: 9 to 12	6 years	13 years	3-16 years	5-16 years
	Nepal	Primary classes: 1 to 8 Secondary classes: 9 to 12	5 years	12 years	5-16 years	5-16 years
	Pakistan	Primary classes: 1 to 5 Elementary classes: 6 to 8 Secondary classes: 9 to 10 Higher Secondary classes: 11 to 12	5 years	10 years	3-16 years	5-16 years

Note: *Based on information reported by PMTs.

Sampling precision

Since ICAN 2019 estimates were to be generated at the district level, the minimum sample size calculations were done at the district level. The sample size was determined by the following considerations:

- Incidence of what is being measured in the population: Some of the participating countries did have estimates of foundational learning outcomes at the district level but for other countries these estimates were not available.
- Confidence level of estimates: The standard used is 95%.
- Precision required on either side of the true value: The standard degree of accuracy most surveys employ is between 5% and 10%. An absolute precision of 5% along with a 95% confidence level implies that the estimates generated by the survey will be within 5 percentage points of the true values with a 95% probability. The precision can also be specified in relative terms — a relative precision of 5% means that the estimates will be within 5% of the true value. Relative precision requires higher sample sizes.

Sample size

Sample size calculations can be done in various ways, depending on what assumptions are made about the underlying population. With a 50% incidence, 95% confidence level, and 5% absolute precision, the minimum sample size required in each stratum is 384.⁵ This derivation assumes that the population proportion is normally distributed. A sample size of 384 would imply a relative precision of 10%. The sample size would increase to 1600 for a relative precision of 5%.⁶ Note that all the sample size calculations require estimates of the incidence in the population. For ICAN, only some participating countries can get an estimate of the incidence from previous rounds of assessments. Even this incidence varies across different indicators — so incidence of numeracy ability is different from incidence of dropouts. In addition, more observations are needed to measure things that are not binary. Given these considerations, sample size of 1200 households in each district was finalised for ICAN 2019.⁷

Since ICAN has a two-stage sample design, the district level sample size of 1200 households was allocated to the two stages of sampling. In each district, 60 rural communities were randomly sampled in the first stage. In the second stage, 20 households were randomly selected in each of the 60 sampled rural communities from the first stage.⁸

⁵ The sample size with absolute precision is given by $\frac{z^2 p q}{d^2}$ where z is the standard normal deviate corresponding to 95% probability (=1.96), p is the incidence in the population (0.5), $q=(1-p)$ and d is the degree of precision required (0.05).

⁶ The sample size with relative precision is given by $\frac{z^2 q}{r^2 p}$ where z is the standard normal deviate corresponding to 95% probability (=1.96), p is the incidence in the population (0.5), $q=(1-p)$ and r is the degree of relative precision required (0.1).

⁷ Sample size calculations assume simple random sampling. However, simple random sampling is unlikely to be the method of choice in an actual field survey. Therefore, often a “design effect” is added to the sample size.

⁸ This allocation of the total sample size to the different sampling stages is often based on logistical and cost considerations. For instance, a sample size of 1200 households per district could have been allocated into 80 rural communities per district and 15 households per rural community; or 40 rural communities per district and 30 households per rural community. The first allocation would yield higher precision but cost more. Precision increases with a larger number of first-stage units since that reduces the adverse effect of a large intra-cluster correlation; however, cost also increases with a larger number of first-

Stratification

Often household surveys are stratified on various parameters of interest. The reason for stratification is to get enough observations on entities that have the characteristic that is being studied. ICAN 2019 stratified the sample by population in the first stage. No stratification was possible at the second stage. In order to stratify on households with children in the target age group of 5-16 age group, in the second stage, the population of such households in the sampled rural communities were required, which was not possible without a complete house listing exercise.

Selection of survey district

Step 1: Selection of district in the country

Since ICAN 2019 was implemented in only one district in each country it was important to ensure that the district was selected with care. While the districts were not selected completely randomly, care was taken to not choose districts that were anomalous in terms of their numeracy learning outcomes.

For member countries where more than one language is spoken, the first criteria to select the district for ICAN was to identify districts where language selected for the assessment is spoken predominantly. For example, since PAL Network member in India selected Hindi as the language for ICAN, then as the first criteria, only those districts were considered for selection where Hindi is spoken predominantly. Table 2 below summarises the language selected by the PAL Network members for ICAN.

Table 2: Languages selected for ICAN 2019

Region	Country	Language selected
Eastern and Southern Africa	Kenya	English, Kamba
	Mozambique	Portuguese
	Tanzania	Kiswahili
	Uganda	English
West Africa	Mali	French
	Nigeria	English
	Senegal	Wolof
Central America	Mexico	Spanish
	Nicaragua	Spanish
South Asia	Bangladesh	Bangla
	India	Hindi
	Nepal	Nepali
	Pakistan	Urdu

Once the participating countries shortlisted districts based on language selected for ICAN and the language pre-dominantly spoken in the district, there were three possible scenarios for district selection.

stage units, since that entails travelling to more rural communities (the marginal cost of surveying additional households in a given rural community is negligible). Therefore, there is a trade-off between precision and cost.

Table 3: Scenarios for district selection in ICAN 2019

	CASE 1: Citizen-led national assessment program available with estimates representative at the district level	CASE 2: (Other) National level learning assessment program available with estimates representative and available at the district level	CASE 3: No learning data available at national and/or district level
Step 1.1	Match district average of numeracy levels for respective primary classes (combined) (% children who can do at least subtraction) with the national average for the latest cycle of the assessment	Match district average of numeracy levels for respective primary classes (combined) with the national average for the latest cycle of the assessment If data for all combined primary classes are not available, then look for estimates for classes 2, 3 or 4 If data for numeracy is not available then use the assessment results that are available for all primary classes combined or for classes 2, 3 or 4	Speak to at least two local statistical experts within the Ministry of Education or Statistics/or other institutes of national recognition
Step 1.2	List down all districts where the district average falls within +/- 10 percent points of the national average	List down all districts where this district average falls within +/- 10 percent points of the national average	List down all districts where learning are expected to be more or less like the national level by looking at education and other development indicators
Step 1.3	If more than one such districts exist, then select the district where survey partners and field enumerators can easily be recruited		
Countries which followed the case	India, Kenya, Mali, Pakistan Senegal, Tanzania, Uganda		Bangladesh, Mexico, Mozambique, Nepal, Nicaragua, Nigeria,

Two-stage clustered sample design

Step 2: Sampling of rural communities (in the first stage)

In each selected district, rural communities were sampled using the Probability Proportional to Size (PPS) sampling method. This method allowed rural communities with larger populations to have a higher chance of being selected in the sample. It is most useful when the first stage sampling units vary considerably in size, because it ensures that households in larger rural communities have the same probability of getting into the sample as those in smaller rural communities, and vice-versa.

One of the most important sampling tasks for the PMTs was to obtain the official sampling frame of rural communities for the selected district. The sampling frame is a list of all rural communities in the district that have households, and is the list from which the rural communities were sampled.

A suitable rural community measure of size (MOS) was a critical aspect of the sampling plan, because the size of a rural community determines its probability of selection. The most appropriate rural community MOS was an up-to-date count of the number of households. For this purpose, it was mandatory to use the sampling frames from the latest round of Census for which data was available. The rural community sampling frame is usually a spreadsheet containing a single entry for each rural community. This entry includes a unique identification number and location identifiers to locate the rural community (if appropriate given the country's privacy laws), and at least the rural community MOS, that is, the number of households.

Step 3: Sampling of households (in the second stage)

Even though the purpose of ICAN is to estimate learning levels among children, the household was chosen as the sampling unit in the second stage. The decision to sample households in the second stage is based on the absence of a house list that creates problems when a survey is to be representative at multiple levels of aggregation.⁹ In such a survey, estimates have to be weighted with appropriate weights to account for different underlying population sizes - a more populous district or state will have a higher weight in the national estimate compared to a less populous state. The calculation of these weights requires the underlying population proportion of the target group of interest. So, if the household were the unit of sampling then number of households in the rural community would be required to calculate the weights. On the other hand, if children were the unit of sampling, the total number of such children in the rural community would be required to calculate the weights. A houselisting of the rural community would provide not only the frame for sampling these children, but also the total number of children in the rural community. ICAN resolved this problem by sampling households. Household weights are easy to calculate since in most cases sampling frames provides the rural community population of households.

Therefore, the sampling strategy of ICAN provides a representative sample of the household population of the district under consideration. Note that ICAN does not sample children, because of

⁹ Though ICAN 2019 was carried out in only one district/sub-state region in each country it is intended to be scaled up to be representative at larger levels in future editions.

the difficulties of doing a houselisting; instead all children in target age-group of 5-16 years are surveyed in the sampled households. It is for this reason, that even households with no children in the target age group count as part of the sample.

In each sampled rural community, 20 households were surveyed. Borrowing from their existing CLA programs, participating countries followed two methods of randomly sampling households in the rural community:

Method 1: rural community mapping and the 5th household rule

The process followed by the field enumerators is described below:

1. Walk around the rural community and make a map and divide the rural community into four parts. In case of rural community with more than four sections/hamlets, randomly sample any four sections/hamlets.
2. In each part go to a central location and use the fifth household rule starting from the left to sample households. Continue this procedure until you have administered the survey in 5 households in each of the four sections of the rural community.

Method 2: household listing and systematic random sampling using the nth rule

The process followed by the field enumerators is described below:

1. Walk around the rural community and make a map and/or confirm the boundary of the rural community.
2. List down all the households in the rural community on a houselisting format.
3. Randomly sample 20 households using the nth rule. Divide the total number of households in the rural community by 20 to get the nth number that will be used to select the households. Randomly sample the first household from the houselisting format and add the nth number to select the second household and so on.
4. Continue this procedure until 20 households are sampled for survey

Method 1 was followed by countries in America and South Asia and Mali in West Africa. Method 2 was followed by countries in Eastern and Southern Africa and Nigeria and Senegal in West Africa. Following either of these random sampling methods of selecting household does not affect comparability of results across the districts.

Replacements and exclusion

ICAN is designed to get reliable estimates of children's foundational numeracy levels. For representation, one key principle of sampling is equal probability sampling. For this, the availability of a latest and reliable sampling frame, for each stage of sampling, is crucial. However, in some cases, political, organisational or operational factors make complete coverage difficult to attain. Thus, in some rare situations, certain groups of rural communities, households and children may have to be excluded or have to be replaced.

Rural community level replacements: Although it was expected that very few sampled rural communities will have to be replaced, PMTs were permitted to replace rural communities in the following circumstances:

1. If the community had been converted to an urban municipality and hence was no longer a part of the target rural population;¹⁰
2. Inaccessible due to natural disasters, like floods, etc.
3. Safety concerns due to insurgency problems

To handle this issue, 10 replacement rural communities were drawn as an independent sample from the same district using the process described above.

Household Level Replacements: During the data collection sampled households could be replaced due to the following reasons:

1. Household was locked and no information could be collected from the household
2. Household respondents did not want to participate in the assessment

In these cases, the immediate next household was sampled for the survey.

Child Level Exclusions: During the data collection children in the target age-group could be excluded due to the following reasons:

1. Children who were not available in the rural community during data collection¹¹
2. Children who have physical/intellectual disabilities such that they could not participate in the ICAN assessment. Children with functional disabilities who were able to participate in the survey were included in the assessment.

¹⁰ This can happen due to an outdated sampling frame of rural communities.

¹¹ Data collection was carried out over two days in each rural community. One of the days was mandatorily a day when the school is closed (usually a Sunday or any other holiday).