World Health Organization

Meeting Report

(16 June 2017)

Meeting to share lessons learnt from the roll-out of the 2015 WHO Vaccination Coverage Cluster Survey Reference Manual and to set an operational research agenda around vaccination coverage surveys

Dates: 18-21 April 2017

Location: World Health Organization Headquarters, Geneva, Switzerland

Online repository: All meeting materials, including presentations and additional files are available in a shared Dropbox. The link is: http://bit.ly/WHO-vax-survey-mtg

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Glossary

AMP: Agence de Medecine Preventive

CAPI: Computer Assisted Personal Interviewing

CDC: United States Centers for Disease Control and Prevention

CI: Confidence Interval

DHS: Demographic and Health Surveys

EPI: Expanded Programme on Immunization

FBS: Federal Bureau of Statistics

GIS: Geographic Information System

GPS: Geographic Positioning System

HBR: Home-Based Records

HPV: Human Papilloma Virus

HQ: Headquarters

IVAC: International Vaccine Access Center

KAP: Knowledge Attitudes and Practices

LQAS: Lot Quality Assurance Sampling

MDA: Mass drug administration

MICS: Multiple Indicator Cluster Surveys

MOH: Ministry of Health

MOU: Memorandum of Understanding

NICS: National Immunization Coverage Survey (in Nigeria)

NIPS: National Institute of Population Sciences

NRD: Neglected Topical Diseases

NSO: National Statistical Office

OCV: Oral Cholera Vaccine

ODK: Open Data Kit

PAHO: Pan American Health Organization

PC: Preventive Chemotherapy

PSS: Probability Sampling with Segmentation

RI: Routine Immunization

SAGE: WHO's Strategic Advisory Group of Experts on Immunization

SIA: Supplementary Immunization Activity

SMART: Standardized Monitoring and Assessment of Relief and Transitions

VCQI: Vaccination Coverage Quality Indicators

WHO: World Health Organization

Background

Since the early 1990s, the World Health Organization (WHO) has provided guidance to Member States, partner agencies and institutions on methods for measuring vaccination coverage through surveys. With the goal of improving survey precision, accuracy, and overall quality, an extensive review and revision of coverage survey methods and materials resulted in the release, in 2015, of the working draft of the WHO Vaccination Coverage Cluster Survey Reference Manual (Survey Reference Manual).

Countries have started using guidance included in the 2015 Survey Reference Manual for routine immunization (RI) and tetanus surveys, as well as surveys following supplementary immunization activities (SIA) and several training activities have taken place. While rolling-out the 2015 Survey Reference Manual and working with countries to promote an increased use of survey coverage estimates and other data, it has become apparent that there is enormous variation in survey design, quality of survey implementation and reporting, as well as around the analytical uses of surveys, i.e., obtaining and using vaccination indicators beyond coverage estimates. Similarly, it is clear that more needs to be done to bridge knowledge gaps around methodological issues that may affect the accuracy of survey-based vaccination coverage estimates, particularly in the current context of the Expanded Programme on Immunization (EPI), with the addition of many new vaccines and the broadening of ages targeted for vaccination.

Important experience has been gained, along with best practices and lessons learned. It is expected that consolidating this information will allow WHO to finalize the Survey Reference Manual for official publication by the end of 2017, along with accompanying material such as practical summary guides, templates, tools to calculate sample size and tools to facilitate survey analysis.

To this end, WHO convened a meeting from 18 to 21 April 2017 at the WHO headquarters in Geneva, Switzerland. The meeting brought together EPI managers from countries that have recently implemented vaccination coverage surveys using one or more of the elements recommended in the Survey Reference Manual, along with survey experts, statisticians, partners, representatives from WHO regional offices and headquarters, and technical assistance providers. The agenda is in Annex A and the full list of participants is available in Annex B of this report.

Meeting Objectives

1. To share experiences and lessons learned from the implementation of surveys following the 2015 draft WHO Vaccination Coverage Cluster Survey Reference Manual in order to inform finalization of the Survey Reference Manual, and a suite of accompanying tools

2. To define an operational research agenda around vaccination coverage surveys

Meeting Action Points[1]

WHO (as a facilitator or lead)

- Finalize and publish the revised 2015 Vaccination Coverage Cluster Survey Reference Manual taking into account the steps listed in Annex C.
- Provide guidance to ensure countries have a good rationale for doing a survey, and that those without sufficient rationale are discouraged.
- Continue strengthening collaborations between the Expanded Programme on Immunization (EPI), the Demographic and Health Surveys (DHS), the UNICEF Multiple Indicator Cluster Survey (MICS), and the Standardized Monitoring and Assessment of Relief and Transitions (SMART) teams.
- Lead conversations and reflection on how to translate data into knowledge for decision making, including discussing early on how the coverage survey will be analyzed and used.
- Develop or identify methods/tools for collecting rapid assessment (or for estimation/validation) useful vaccination coverage at the district and local levels, that would be more practical and affordable than doing surveys in all districts.
- Consider providing further guidance on oversampling selected areas or populations as needed for decision making, rather than all or no district level strata.
- Create a set of quality criteria that can be used to grade survey results to better inform the users on potential limitations or survey quality issues.
- Document/compile case studies of what went right and wrong when implementing vaccination coverage surveys, mainly when using the 2015 WHO Survey Manual.
- Document/compile budget and sample information from surveys to demonstrate budget/ sample size trade-offs and drivers of costs in different settings.
- Develop standard questions on household and demographic characteristics, as well as barriers and reasons for non-vaccination or knowledge of the immunization services (see below, under operational research) noting that these contents will still need to be adapted and tested in each country.
- Examine how to ensure health facility visits are worth the effort (e.g. when should they be done? can you collect other info besides vaccination status during the same visit?).
- Develop a minimum standard template for EPI survey reports to standardize critical outputs - Tables could mirror DHS and MICS standards to allow for easy comparability.
- Define a set of additional survey analysis (beyond coverage) and how to best standardize them.
- Work with immunization programs so they can identify their needs for additional/secondary survey analyses.
- Describe and explain what are the differences between the DHS, MICS and EPI methodologies, including details in indicator calculation, and in the way results are presented.
- Compile an exhaustive list of possible sources of bias in vaccination coverage surveys, which countries can use as a checklist of issues to discuss in their report limitations or strengths sections.
- Develop guides/toolkits to help interpret results and highlight actions to be taken based on the survey findings.
- Explore using online tools to support survey planning and analysis, including existing tools that explore analysis of disparities such as WHO's annual equity analysis and UNICEF Equist.

[1] These actions points are subject to small modifications based on the results of the survey to be sent to the meeting participants, as well as to those invited but unable to attend.

- Improve standards and technology for sharing datasets and documentation.

Country Immunization programmes

- Designate an individual or working group to engage closely with DHS/MICS on the vaccination components of their surveys, from planning to report writing and result dissemination. This individual or group can advise on the formulation of vaccination questions, training of supervisors and enumerators, pilot testing and fieldwork protocols to maximize the quality of vaccination data collection, in order to increase the credibility of results for the EPI manager and reduce the need for parallel EPI surveys.
- When an EPI survey is needed, consider coupling the EPI survey to MICS or DHS, when feasible and appropriate
- Take the lead in defining the EPI needs that can be addressed via a vaccination coverage survey. Actively participate in a Vaccination Coverage Survey design (including expected tables and graphs), piloting, training, facilitation of field visits and access to registers in health facilities, and report writing and dissemination with all stakeholders. The latter also applies to engaging with the team leading a DHS, MICS and any other survey collecting vaccination data
- Take provisions to make Immunization coverage survey reports and datasets available to the global community.

Donors and partners

- Promote collaboration between EPI and DHS, MICS and other household surveys that include immunization indicators.
- Consider measures to prevent EPI coverage surveys in countries with a recent or upcoming MICS or DHS survey, unless specific questions or reasons warrant the implementation of an EPI survey. When an EPI survey is needed, consider coupling the EPI survey to MICS or DHS as appropriate.
- Ensure that non-technical staff dealing with countries better understand the role of surveys, vis-à-vis other available tools to answer specific questions.
- Encourage immunization programs to identify their needs for secondary survey analyses.

DHS, MICS, SMART for nutrition surveys, other household surveys that collect immunization data

- Communicate potential survey plans as early as possible to WHO and country EPI programmes. This will facilitate coordination and collaboration, and allow EPI to account for DHS, MICS and other household surveys in their annual and multi-year planning.

Proposed operational research topics

- **Sampling**
  - Use of gridded data and other computer-assisted approaches for sampling.
  - Studies to quantify who (e.g., nomadic populations, persons with set houses in urban areas) is missing from sampling frames and develop methodologies to improve the sampling frames' coverage.
- **Recall**
  - Study the extent and impact of recall response bias, especially in low and middle income countries.
  - Studies seeking to understand factors influencing poor recall in different contexts. This could be done by first identifying statistically significant characteristics (from persons being interviewed and from interviewers) associated with poor recall that could then guide a qualitative or mixed methods study.

- **Survey design and instruments**
  - Extent and impact of survey tools and interviewers in recall response bias, especially in low and middle income countries.
  - How to formulate questions about vaccine coverage, particularly in the case of recall, including use of visual cues?
  - Defining a standard set of Knowledge, Attitudes and Practices (KAP) questions that could be added to surveys, based on proper social science methodologies.
- **Data collection**
  - Test the accuracy of data entry using different electronic collection formats and platforms; develop evidence-based recommendations for interfaces and for data entry protocol (e.g., enter the dates and take one or more clear photos; after data entry have a partner read the dates from the card out loud while you review them on the screen).
  - Study the role of publicizing the survey in the selected clusters ahead of time increase the number of cards available.
  - Improve recommendations on taking photos during data collection and how to better use them.
- **Analysis/use**
  - Develop small-area estimation methods as a possible alternative to estimating district and other local levels vaccination coverage.
  - Study statistical adjustment approaches for survey-based vaccination coverage estimates, particularly to address possible bias due to recall (based on respondent characteristics, length since vaccination to recall, etc).
  - Test interventions to promote use of data for evidence-driven decision making.

Summary of the meeting sessions

Topic 1: Context for vaccination coverage surveys and the Survey Reference Manual

Day 1 focused on the current state and role of vaccination coverage surveys, and the context and motivation for the revised Survey Reference Manual.

1.1) Setting the stage – Why we assess vaccination coverage

Dr. Jean Marie Okwo-Bele and Ms. Marta Gacic-Dobo of WHO presented a vision of how vaccination coverage surveys fit into the evolving immunization landscape. Global immunization coverage is estimated to have remained relatively stable in the mid 80%s for the past 5 years. WHO's Strategic Advisory Group of Experts (SAGE) on immunization, Gavi, the Vaccine Alliance and other global immunization stakeholders have named insufficient quality and use of data as a key challenge impeding the success of immunization programmes. Surveys are a potentially important complement to administrative data, particularly when administrative systems are weak. They also can answer questions that administrative data systems are usually unable to provide, particularly related to coverage disparities.

Meeting participants discussed how to increase the usefulness of coverage surveys for programmatic needs and decision-making. Surveys often reflect something that happened 2-3 years prior, which mainly serves to monitor trends overtime and coverage disparities. However, surveys are unlikely to inform what EPI programme managers need to inform their activities on a day-to-day basis, i.e., mainly managerial and operational decisions. Thus surveys and administrative systems are complementary. This is also a consideration regarding whether coverage surveys should be representative at the national, regional, or district level. Countries stated that they would prefer having results that align with the country's administrative and decision-making levels, which are typically districts. Conducting a high-quality probability-based survey at the district level may not be necessary, financially viable, or operationally manageable. To address issues at district level, participants highlighted the need to develop or identify practical tools that could be used to complement administrative data to guide decision-making at the local level. These issues were revisited throughout the week.

Participants also suggested that establishing clear objectives and strategies for how the survey results will be used up-front would improve survey utilization and a better understanding of surveys strengths and limitations, as currently the question of use often comes up late in the process. Finally, it was noted that survey work is increasingly contracted out to consultants or other third parties like National Statistical Offices (NSOs) or research institutions, which may reduce country ownership and the use of survey results, and that these types of collaborations are an area that need further discussions to ensure both impartial and quality survey implementation, as well as EPI ownership and capacity improvement.

1.2) Updated survey guidance

WHO presented an introduction to the 2015 Survey Reference Manual, which includes enhanced guidance for five main areas: (1) Defining survey scope and objectives; (2) Using probability sampling and weighted analysis; (3) Improving vaccination ascertainment; (4) Providing explicit steps to minimize bias and bolster quality; and (5) Recommending comprehensive reports that are compelling and explicit about survey quality.

Discussion elaborated on the factors leading to these revisions. In the past, a simple 30x7 EPI survey design (i.e., 30 clusters of 7 children each, assuming 50% coverage, +/- 10% precision and a design effect of 2) was developed because the EPI schedule was much simpler; coverage levels were low and an idea of the ball-park of

coverage was considered sufficient; and all statistical calculations were done by hand. However, given the complexities of the EPI in the 21st century; the need for more accuracy and precision with increasing coverage levels; the emphasis on accountability and transparency; and the widespread computational power and evolved statistical capacities in countries, it is now appropriate to move past the 30x7 design (which uses quota sampling and selection of households by the surveyor teams) towards a more statistically valid and higher quality survey design. The 2015 draft Survey Reference Manual uses current standards of household survey methodologies that can produce better estimates of true population coverage figures.

It was highlighted that although the 2015 draft Survey Reference Manual may be perceived as "new" by the EPI community, the survey-related concepts within it are very well established in the broader survey community (e.g., probability-based sampling, pre-selection of households & weighted analyses). Additionally, the Manual reinforces topics related to data quality that were described in earlier survey manuals but are often subject to shortcuts and inadequate attention during survey fieldwork. Still, the updated manual may be perceived as proposing a more expensive and challenging methodology compared to what was done in the past. Nevertheless, the higher cost is a consequence of ensuring high quality and independent surveys that will result in credible results that serve as the basis for programme decisions.

Vaccination coverage surveys usually include additional questions around caregiver attitudes, mainly reasons for under-vaccination. UNICEF presented on this topic, and shared their experience with a Knowledge, Attitudes and Practices (KAP) study conducted in Uganda in partnership with the Harvard School of Public Health. One key lesson was the importance of interviewing people who *are not* using vaccination services (to understand why not), as well as those who *are* using immunization services (to understand what motivates them). This point was reinforced by PATH's experience with Human Papilloma Virus (HPV) vaccine demonstration projects. Additionally, meeting participants emphasized that KAP data requires a) a careful framing of questions, often requiring an initial stage of qualitative research, b) good rapport between the interviewer and the child's caregiver, as honest answers require the caregiver to trust the interviewer, and c) adaptive analysis that may require more decisions on the part of the analyst than is usually the case with vaccination coverage indicators.

Participants discussed whether KAP questions should be routinely included in vaccination coverage surveys. Some countries stated it would be useful, given that their quantitative coverage results identify the same problem areas each year, but they are not sure how to improve coverage. However, others felt it was premature to include KAP questions in the standard survey because they are not yet validated, require more complex training and interpretation to be quality and useful, and come with an added cost. It should be noted that in an observational survey it is very difficult to distinguish cause and effect, thus identifying factors associated with being or not being vaccinated does not show whether those factors are the cause or the result of having attended a vaccination session (e.g. parents who go regularly to get their child vaccinated are exposed to more health education thus know more about vaccination than parents who do not take their child; which is cause and which is effect?). As a next step, it was suggested to establish a KAP working group to discuss whether setting defining a potential items to be included, and methods for question formulation and training that promote quality responses is something to be added to the Survey Manual.

1.3) DHS, MICS, EPI, and other surveys

An analysis was presented that explored patterns in coverage estimates from EPI surveys, Demographic and Health Surveys (DHS) and UNICEF's Multiple Indicator Cluster Surveys (MICS) conducted in the same country within 1 year of each-other (see figures in annex D).

This review showed some examples of wide discrepancies with EPI surveys usually finding more cards and higher coverage than DHS/MICS. Other examples showed reasonably close agreement between the two surveys conducted close in time. There was no consensus on why differences exist. Based on the information available in survey reports, coverage indicator definitions are largely similar. It is always possible there are differences in exclusion criteria and how missing values and "don't know" values are treated and are not well documented; however, given the gross differences observed in some instances, such coding differences are unlikely to explain away all of the difference. It is possible that multi-indicator surveys like DHS/MICS may give less emphasis and field team energy to obtaining all immunization cards than the vaccine-focused EPI surveys; another potential factor could the bias introduced by different sampling methods and field data collection protocols, with the earlier EPI method biased toward higher coverage results, or a combination of factors.

The many instances of EPI surveys conducted very close in time to DHS or MICS raised questions about survey planning and how to make EPI, DHS and MICS surveys complementary rather than duplicative. There was agreement that more coordination was needed between EPI, DHS and MICS to improve overall efficiency. While it is true that EPI programmes may be unaware of a planned DHS/MICS, or they may not have full confidence in the results if they are not engaged in the planning, design, fine-tuning of immunization questions (particularly those to elicit recall), training, field implementation, and analysis, it is important that EPI programmes be proactive in scoping out such information on other surveys and becoming appropriately engaged. Additionally, in the case that a DHS survey does not contain all of the detailed information needed to guide managerial EPI decisions, there is a need to provide better practical guidance around when a targeted or rapid EPI survey is justified. These issues were revisited on the final day, during a session on coordination and collaboration.

There were a series of presentations on different coverage survey approaches. DHS discussed their public data policy, adapting standardized materials to each country, the use of Computer Assisted Personal Interviewing (CAPI) and photography of cards and registries (including limitations of using tablets for taking photographs). They also communicated that DHS surveys are typically representative at the national, urban/rural, and provincial/regional-level, but not at the district-level. Standardized Monitoring and Assessment of Relief and Transitions (SMART) discussed their emphasis on guiding survey content based on relevance for programmatic decision-making. It was also mentioned that nutrition surveys, including those done as part of the SMART collaboration, often include immunization indicators. The Yemen Social Protection Survey highlighted challenges their survey had faced, many of which stemmed from cultural factors, but how they were able to overcome difficulties and obtain immunization data in various rounds with improving card availability in each. A polio representative discussed their lot quality assurance sampling (LQAS) approach[2] following polio vaccination rounds, which is used to assess whether areas should be revaccinated, and how they collate LQAS with other sources of information such as surveillance data. A UNICEF representative shared how MICS data will now be available much more quickly in the form of a report more oriented towards the tabulated data than the narrative content. UNICEF also discussed the balance between rigor, cost and time, specifically as related to sampling methods, household listing and the addition of KAP questions. Like DHS, MICS makes all datasets and final reports systematically available, and participants thought WHO should encourage countries to do the same for EPI surveys and provide a platform to this effect.

[2] LQAS is a design/interpretation method, not a sampling method. An a priori defined decision rule for pass/fail is explicitly linked to a specific sample size. The need to have a specific sample size requires quota sampling. Quota sampling can be achieved through convenience sampling, simple random sampling (SRS) with replacement (or 100% response if lucky), or cluster sampling followed by convenience or SRS (both with replacement). Validity of inference depends on proper sampling methods, and analyses that account for the sampling design. Reports on the use of LQAS should include details on the sampling design, response rate and replacement protocols.

Nigeria presented on their experience combining an EPI coverage survey (Nigeria National Immunization Coverage Surveys (NICS)) and MICS survey in 2016. They did this by supplementing the MICS sample with additional enumeration areas to achieve the desired precision for state-level estimates. The key lessons learned were that proper planning and organization are key to such an endeavor, including government ownership, and strong training and monitoring (including harmonization of monitoring guidelines). The effort was also made easier using CAPI.

1.4) Literature reviews

Two literature reviews were presented on characteristics and potential biases of vaccine coverage surveys. The first review, conducted in 2009, aimed to describe the advantages and disadvantages of methods used to estimate routine immunization coverage, as well as inequalities in vaccine access as reported in the literature. It concluded that there is no 'ideal' survey method, but that it should be selected based on the desired timeliness and precision, balanced with capacity and resources. It also stressed that for surveys to be relevant, findings must be used for decision making, which is often not the case – a theme that echoed throughout this meeting eight years after the 2009 literature review. In terms of study quality, it found that many studies did not meet, or did not report on, quality criteria for important study characteristics such as inclusion criteria. It found that age, socio-economic factors and location were some of the main dimensions of inequitable access, while ethnicity, religion and ecology typically did not show disparities.

The second review, which is currently underway, described the wide array of methodological factors that have been studied as potentially biasing coverage estimates. It found that most studies focused on the topics of sampling and recall bias, whereas there were relatively few studies on the bias potentially introduced by factors such as collection procedures, training, and question wording. This review will ultimately summarize the current evidence on survey methodological factors, and help identify gaps that should be addressed in an operational research agenda.

One of the articles included in the reference material, though not presented in this session, reviews limitations of vaccination coverage surveys and proposes potential strategies to reduce biases of vaccine coverage surveys (Cutts et al., PLoS 2013)

Topic 2: Sampling

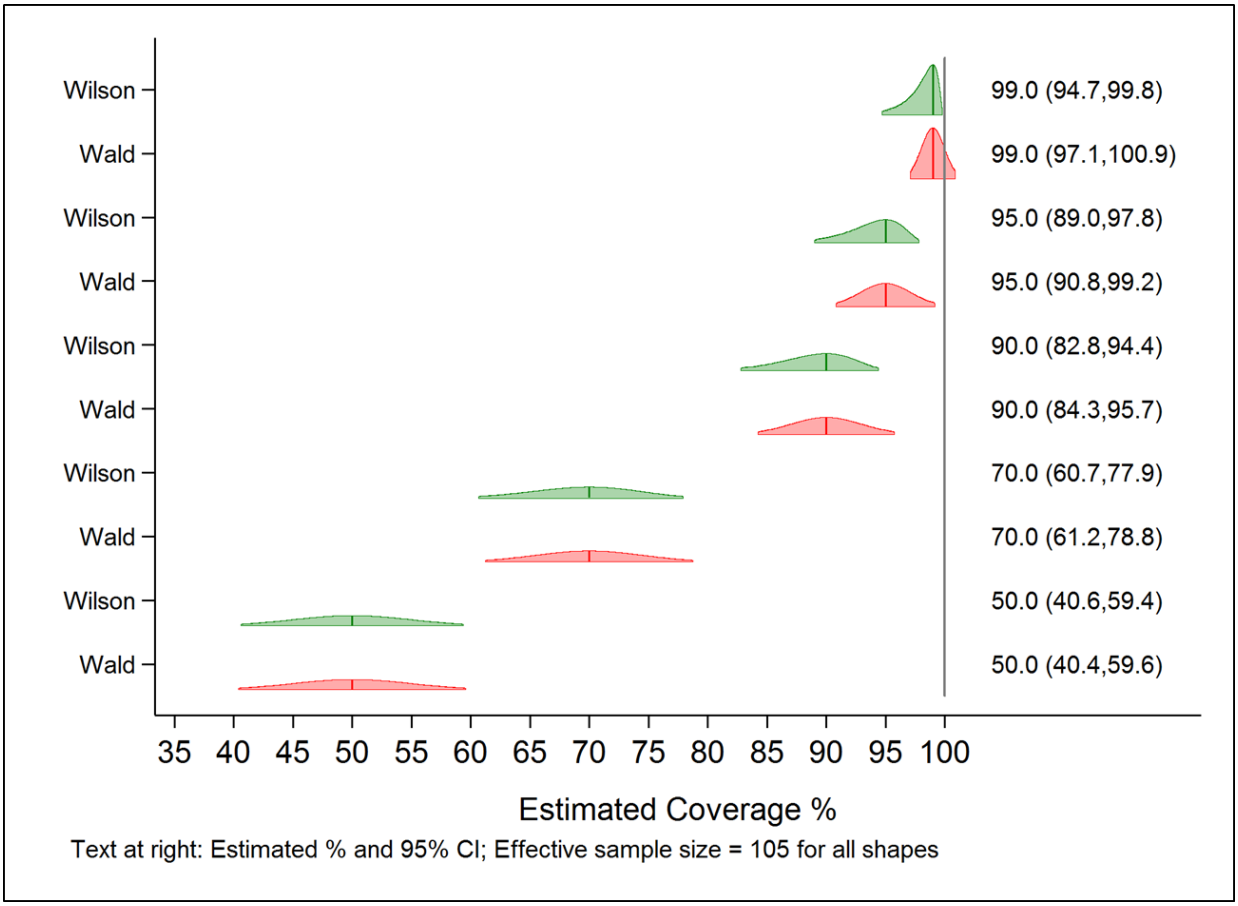
Day 2 focused on the revised guidance around sampling, and specifically the use of probability sampling.

2.1) Overview of probability sampling

The day began by defining shared language around key sampling terms. "Accurate" means lack of bias, thus accuracy would be the measure of bias. "Precise" means having a meaningful confidence interval (CI), thus precision would be the measure of the meaningfulness of the CI. Having narrow enough CI to inform the primary decision(s) for which the data are needed is to be considered when planning for the survey precision. "Probability sampling" means every eligible person has a known probability of being randomly selected in the survey; this is the basis of calculating meaningful CIs. Note that the known probability of selection needs to be strictly positive (non-zero) to eliminate selection bias.

It was also highlighted that the 2015 draft Survey Reference Manual, recommended that confidence intervals (CIs) for proportions be asymmetric when sample sizes are small or moderate. Therefore, it recommends not using the traditional sample size formula that assumes a symmetric Wald interval. The formulae for asymmetric

intervals are usually wider than Wald and have one arm (the one that points toward 50%) that is much longer than the corresponding arm of the Wald interval. Slide 23 in the presentation, pasted below, illustrates this point.



As a result, even if the design effect assumptions of the survey are met, the asymmetric CI will be wider than expected if sample size is calculated with the traditional formula. The updated manual uses an updated sample size formula that is consistent with the recommendation to calculate asymmetric Wilson intervals. Finally, it should be noted that the Wilson intervals will be nearly symmetric if the sample size is large or if the coverage estimate falls near 50% so there is no need to use different CI formulae for different situations. The Wilson interval should perform well across all EPI coverage surveys. ("Perform well" meaning: a) yield CIs that are no wider than promised in the sample size calculation if the survey data are consistent with the sample size assumptions, b) yield CIs that contain the population coverage estimate about 95% of the time if the survey is unbiased, and c) yield CIs that are narrower compared with some other asymmetric CI formulas, such as Clopper-Pearson.)

2.2) Country experiences with probability sampling

We heard about experiences implementing probability sampling in Kenya, Uganda, Zambia and Pakistan.

Kenya's study was supported by the United States Centers for Disease Control and Prevention (CDC). They agreed on a design with counties as strata. The inferential goals were classification of coverage after a measles

supplementary immunization activity (SIA). Kenyan representatives only accepted this approach upon learning that county[3]-level coverage estimates would still be produced as part of the classification method. They used 1-sided inference to classify county-level coverage, and counties were grouped as clearly achieving 95% coverage (if the lower end of the CI was over 95% coverage); clearly not achieving 95% coverage (if the upper end of the CI was below 95% coverage); and indeterminate (if the CI straddled 95% coverage). A large proportion of counties fell into the indeterminate category, and it was difficult to interpret these findings. The country found that no more than two counties, out of 46, had coverage that clearly did not achieve 95%. CDC is not aware of what actions, if any, the country took based on the results of the study[4]. The CDC presenter shared a list of factors that enabled the successful implementation of this survey in Kenya (Annex E).

Uganda used the 2015 draft Survey Reference Manual to design a recently-completed district-level survey of routine infant immunization, TT and HPV coverage in each of the 112 districts, using Open Data Kit (ODK) for data collection. This survey was done soon after a DHS. Two key challenges were highlighted. First, they experienced many duplicate reports in the ODK dataset, an experience that was echoed by meeting participants from other countries. Second, they discussed how running different versions of ODK Collect on the tablets can cause problems. These issues where however addressed for the majority of cases during data collection, and for some few cases, after the collection process. The Uganda participating team recommended that the final Survey Reference Manual should provide more information about handling duplicate records and the importance of syncing software versions, calendars and clocks on tablets and smartphones.

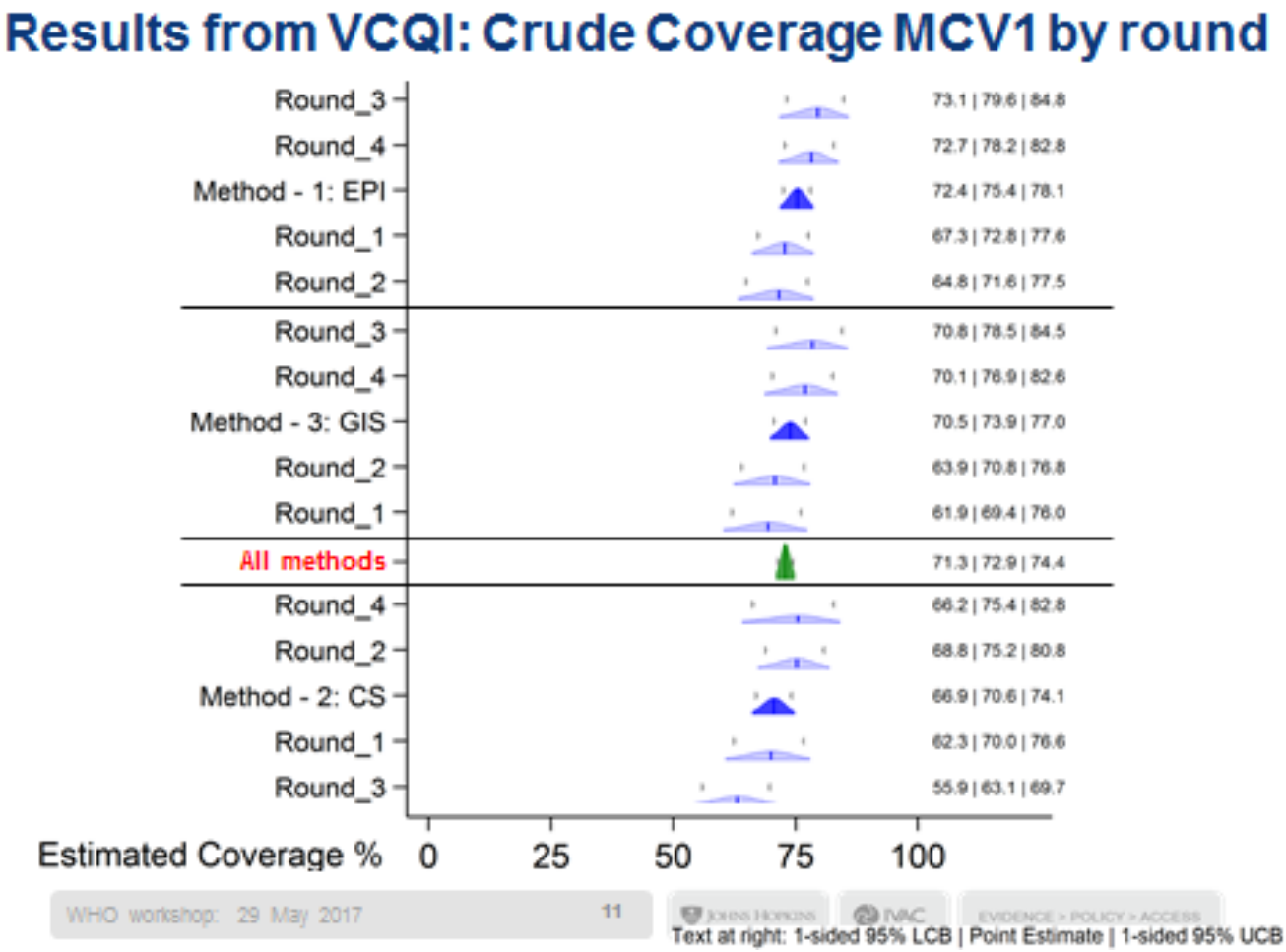
The Zambia example discussed a post-cholera vaccination (OCV) campaign survey conducted in selected neighborhoods of the capital, Lusaka. The study used a spatial sampling technique to select a simple random sample of starting locations. It was discussed whether this approach would result in a simple random selection of persons resulting in a design effect of one because the locations represent a different number of households/people. An important finding from this survey was that many persons had already moved between receiving OCV1 and OCV2. This highlights the issue of mobility of persons in poor urban areas which may affect survey planning and implementation.

Pakistan presented on a large upcoming survey, which will be representative at the district, division, province and national levels. The survey will be guided by the revised Survey Reference Manual and implemented by a third party. It will also provide information about sources of vaccinations, reasons for un/under vaccinations, information about vaccine card availability, and socio-demographic characteristics. One advantage is the close collaboration with the Pakistan Bureau of Statistics and a monitoring framework being established to ensure survey quality in each step and throughout the country.

The International Vaccine Access Center (IVAC) from Johns Hopkins University presented on a separate study conducted in Karachi, Pakistan. The study compared different sampling methods including the EPI 30x7, compact segment sampling, and Geographic Information System (GIS)/Grid-based cluster sampling; it did not consider the sampling advice in the revised Survey Reference Manual, which was not yet available when the study was designed. The differences in coverage depending on the sampling method were shown on slide 11 of the presentation (pasted below). However, it was observed that workers sometimes opted to record vaccine histories as recall rather than from cards, as it was less work to enter.

[3] Equivalent to district in other countries

[4] Representatives from Kenya's EPI were invited to attend this meeting but no response was received.



2.3) Implications of combining SIA and RI surveys

WHO presented some considerations for how adding a RI component to a post-SIA survey will affect the scope and implementation of a post-SIA survey. Adding RI to an SIA survey can significantly increase the time needed. RI will likely increase the number of households visited (because RI surveys are usually looking for a narrower age range than SIA surveys); the number of interviews conducted (because coverage is usually lower in RI than SIA so to achieve the same precision, a higher sample size is needed, and the intracluster correlation coefficient - ICC in some cases is greater for RI than SIA); and the length of each interview session (due to the many additional questions to capture vaccination history and the time required to transcribe all the dates). Data entry, management and analysis are also much more complex for RI than SIA alone. RI surveys may include health facility visits which would not be necessary for a SIA survey alone. It was concluded that adding RI to a post-SIA survey is possible, but only if planning is timely and adequate, and that addition does not hamper the quality and timeliness of the post-SIA survey, given that to minimize recall bias, post-SIA surveys must be done as soon as possible after the campaign is completed. WHO's overview of the trade-offs associated with combining SIA and RI surveys was reinforced by a presentation on day 4 of the meeting, which showed estimated costs for different survey designs. See Topic 7: Costs.

The meeting participants split into two groups: GIS and grid-based sampling and EPI needs for surveys in special populations.

2.4) GIS and grid-based sampling

The first sub-group discussed a presentation on gridded population sampling that described motivation for the approach, several sources of gridded population data, and an R package 'GridSample' that is under development. Gridded sampling can be a good option when (a) census data are outdated or inaccurate, (b) you desire population and spatial oversampling to improve small area estimates, and/or (c) existing primary sampling units are not of appropriate sizes. This is an active area of research that should be mentioned in the final Survey Reference Manual.

2.5) EPI needs for surveys in special populations

Participants in the second sub-group discussed special populations that are difficult to capture in surveys; oftentimes, these are the same populations with low vaccination coverage. The group conceptualized two types of special populations: those who are excluded from the frame entirely, and those who are in the frame but not adequately sampled for a variety of reasons. Country examples included: rural areas cut off at certain times of year; persons with no fixed abode in urban areas; refugees integrated into host populations; internally displaced people; migrant populations; nomadic populations without a set residence; unregistered individuals; indigenous populations; people working in the black market; areas with security concerns; gang populations; and communities that refuse to participate because they have been over-surveyed in the past, or see no benefits coming to them based on the survey. Solutions included negotiating with leaders to access hard to reach areas; combining surveillance, survey and administrative data to inform micro plans; conducting rapid assessments; and sequential study designs which first identify high-risk populations through broad coverage surveys, and subsequently conduct more focused studies in the high-risk populations, such as targeted marketing studies, KAP studies and collecting additional socioeconomic information. Participants expressed a need for a standardized set of tools for conducting these types of focused follow-up studies and rapid assessments, as well as guidance on when to use each and how to take action depending on the results.

Topic 3: Vaccination status ascertainment and recall

The end of day 2 and morning of day 3 were dedicated to discussing challenges associated with vaccination ascertainment and recall, and innovations to overcome these challenges. These topics also raised a broader question of what we are really measuring through vaccine coverage surveys: immunization coverage; the ability to find reliable immunization documents; the ability to exploit documents found; or the ability of caregivers to remember vaccination history.

3.1) Recall bias

There was significant debate around if and how recall should be considered in estimating vaccination coverage. A 2013 systematic review by Miles et al. demonstrated that recall has low sensitivity and specificity when compared to other sources such as facility records. As schedules become more complex, including expanding to older age groups, it is logical that recall is increasingly unreliable. It was shown in analysis of RI surveys conducted in high risk local government areas (LGAs) of Nigeria that recall data is also complicated further by missing data when caregivers are allowed to respond "Don't know" to questions related to whether a child received a specific vaccine, or to questions on how many doses of a particular vaccine a child received. However, as demonstrated by an experience from Nigeria, using cards alone may actually under-estimate coverage, if not all doses are recorded.

Moving forward, electronic immunization registries may become more common, but in the meantime participants discussed ways to improve the functional design of home-based records (HBRs), including the utilization of user-centered design and coordinating with other programmes using child health cards, such as nutrition. Additionally, improving the use and availability of HBRs will depend on a well-trained health workforce. There can also be improvements to the formulation of recall questions in surveys. For instance, we heard that the HPV vaccine would be better recognized as the "cancer vaccine" in some settings. Also, it was discussed that for vaccines targeting older children (e.g., HPV, measles rubella campaigns with broad target age ranges), mothers' recall may need to be supplemented by the child's recall, especially when vaccination takes place in schools. Finally, there is a need to research how visual cues can improve recall.

Several participants advocated for adding or switching to a vaccination coverage metric based exclusively on doses documented in a card or other record. It was debatable if this would result in more or less accurate coverage estimates, but card only coverage will likely underestimate coverage in most settings. Some participants argued that it would incentivize countries to ensure that cards are provided, used and retained. We were reminded that vaccination cards' central purpose is not to inform coverage surveys, but to serve as a medical record, so incentivizing the use of cards would have larger benefits beyond improving survey accuracy.

The issues of whether to drop recall altogether versus try to improve it versus try to deal with it during analysis were discussed; most people seem to acknowledge the need for it, but no consensus was reached. A working group on vaccination ascertainment may be in order.

3.2) Photographing vaccination cards

Participants shared experiences photographing vaccination cards in Lebanon, Bolivia and South Africa. In Bolivia separate cameras were used, as data collection was done using paper forms. By placing the card on top of the form with the form ID and household and child ID visible, matching cards to children was possible, though the renaming of picture files was time consuming and tedious. Pictures were used to review data and for a qualitative study about the HBRs (available in the meeting DropBox). In the South Africa DHS, a practical difficulty arose from tablets with cameras only on the front side of the device, which resulted in "unexpected selfies". In Lebanon, pictures were mainly used to extract vaccination data given the multiplicity of cards and schedules in the country, where a large proportion of private providers exist and where many refugees have entered the country in recent years.

In Bolivia and South Africa, the images were largely legible, as the cards themselves were mostly in good condition. In Lebanon, many cards were in poor condition, illegible, or otherwise difficult to use.

Photographs can now even be taken by the same tablet used to collect data. However, it is not certain that these photos are yet being used to their maximum potential, and more thought is needed on how to leverage them for purposes beyond quality control.

Further activity is needed to consolidate the lessons learned from these experiences and begin populating a repository of the protocols and field team training approaches for imaging home-based records. There have been calls in TechNet-21 for developing a practical field guide that incorporate professional expertise in digital imaging and archiving of documents that remains practical and not overly technical.

3.3) Visiting health facilities

The 2015 draft Survey Reference Manual includes a section on visiting health facilities to search documentation on vaccination status. Several countries shared their experiences implementing this. DHS has mainly conducted facility visits in former Soviet countries which have high-quality health facility records. They also recently implemented a health facility visit in the 2016 Ethiopia DHS. This was made possible by the fact that facilities routinely record vaccination information in a registry (child by child). However, many challenges emerged including children receiving vaccinations from several sources, and therefore not having all the information in one place; lack of standardization in records across facilities; poor organization of information; and inconsistency in children's names. In Senegal's experience, very little additional information was gained by visiting health facilities (as 97% of children had a vaccination card available), and it may not have been not worth the effort required.

Going forward, we must think carefully about when it is worthwhile to include health facility records in the coverage survey. For instance, the manual could help define whether it is preferable to do health facility trace-back for all children, or just those without a HBR. Also, pilot testing this aspect may need to be a condition to determine whether it is feasible. In some settings, a separate team may be needed to do the visits to health facilities. Additionally, there may be ways to increase the utility of facility visits, by collecting other information while there, such as cold chain information, data verification (as is done in data quality assessments), health worker interviews, and more.

Topic 4: Data collection

Afternoon sessions on day 3 discussed challenges related to training, monitoring, supervision, and data collection, particularly on electronic platforms. It was emphasized that although the statistical aspects of the updated Survey Reference Manual are more robust, this does not necessarily lead to high quality surveys. While most sources of potential bias are predictable, data quality ultimately depends on the skill of the personnel and working conditions in the field.

4.1) Training, supervision and field work

A presentation on data collection highlighted the importance of well-trained staff. Typically, there should be no more than 20 people per session, with a minimum 5 days training that includes at least 1 day of practical exercises and at least 2 days (and ideally 3 days) practical work in the field; classroom-based role-plays are not adequate by themselves. Best practice is to train more people than are needed and only hire the top performers, although this approach may meet resistance in some settings. Supervisors require a different set of skills, and ideally should receive training before and during the enumerator training. If conducting health facility visits, it is also necessary to include team members who are trained on the health facility context. For field work, careful planning is needed to maximize the ratio of time spent on household visits versus travel. Proper supervision and monitoring is at the core of data quality. As electronic data collection becomes more common, there are more opportunities for standardized real-time quality assurance tools.

Participants felt that the Manual and accompanying tools need to address these issues in greater detail and in a more prescriptive manner.

4.2) Electronic data collection

The DHS representative summarized the advantages and disadvantages of CAPI. On the positive side, CAPI can: automate skip patterns and eligibility; give warnings and messages; allow for more than one card format; photograph cards; display images on the questionnaire; and transfer data to a central office daily for real-time quality monitoring. However, they come with some drawbacks including: the need for charging; breakage, theft and viruses; increase technical assistance requirements; clunky interfaces; and interviewers learning shortcuts they wouldn't use on paper that compromise data quality.

A participant from the International Vaccine Access Center - Johns Hopkins University (IVAC) shared a monitoring tool that he developed in the DropBox, but was unable to present it to the entire group due to time constraints. This tool is also included in this report as annex F.

It was briefly discussed that electronic data collection will need dedicated support, in addition to the investment in devices and dedicated training and skilled interviewers. If no experience/support is available in a country, it will be better to use paper forms. Data entry in the field may help reduce the time to have the databases ready and help solve data questions in more real-time.

There are also significant data entry errors, particularly for dates on touchscreen devices. A study was presented comparing the accuracy of date data entry using three different touchscreen interfaces. It concluded that even for the best interface, data entry errors were high (with errors in more than 3% of dates), and that the default ODK interface on a smartphone (used in many surveys) had the worst error rate of all with errors in 10% of dates. There was also variation by participant, including some who likely cheat to make the task easier. Participants agreed that more needs to be done to reduce error rates to something below 1%, which is the standard for paper and keyboard double-data entry.

A summary of key considerations related to electronic data collection produced by CDC is available in annex G.

Topic 5: Survey Analysis

5.1) Coverage analysis and weighting

Several ideas were discussed for post-hoc adjustments and weights that can be made to coverage data. IVAC presented a *latent class statistical model* for adjusting survey-based vaccination coverage estimates using a third source of data. In the example presented by IVAC, serological immune marker assessments were introduced as the third data source in an effort to overcome the inaccuracy of vaccine coverage surveys due to unmeasurable verbal recall biases, low HBR retention and low sensitivity of HBRs. The presentation stressed that similar adjustments could be made using a non-serological additional data source, such as facility-based health records. Precise alignment between this additional data source and vaccination history is not required for such latent class statistical models. A key challenge for this work is the lack of a true "gold standard" to validate the models.

Participants again split into two groups:

The first sub-group of participants also discussed issues related to weighting and non-response, and noted that it would be helpful to have analytical tools and spreadsheets to address these issues. They also discussed functionality of the Vaccination Coverage Quality Indicators (VCQI) software. Documentation for VCQI is available in the meeting Dropbox.

5.2) Additional analyses

The second sub-group of participants focused on how survey results could be more useful, including looking beyond the coverage point estimates.

Many potential additional analyses were identified, including: reviewing survey results with other data sources; producing estimate for different sub-groups; looking at the timing and source of vaccination; analysis of drop-out rate and reasons; using surveys to understand administrative data weaknesses; comparisons of data over time; and examining simultaneity of vaccination and conducting a missed opportunities analysis. In fact, many of these analyses can be conducted using existing data (and are included in the VCQI software), so the group discussed several reasons why they are not conducted, including a lack of foresight about survey objectives and analysis plans; low availability of datasets; lack of country analytical capacity; and lack of standardized survey reports. Participants suggested that WHO play a more proactive role in publicizing existing analyses and tools such as its equity analyses. Another suggestion was creating a decision helper for programme managers that links survey findings to potential actions.

Another theme, reiterated from the first day, was the need to identify or develop a rapid monitoring tool to inform local decision making, with the caveat that it will not be useful if conducted poorly and that results should not be interpreted as a coverage survey. The Pan American Health Organization (PAHO) has such a tool, which other countries may be interested in adapting. It will soon be added to the meeting DropBox.

Topic 6: Collaboration, roles and standardization

6.1) Collaboration and networks

Several countries and partners shared their survey collaboration experiences, including UNICEF, Lao PDR, Lebanon, Mongolia, Nepal, Pakistan, Swaziland, Uganda, and the Agence de Medecine Preventive (AMP) at Cote d'Ivoire.

A UNICEF representative described how MICS surveys are organized at the country level and how collaboration with DHS has been encouraged. UNICEF Headquarters (HQ) monitors which countries are planning to implement MICS and, when possible, coordinates with national EPI programmes to encourage collaboration on planning and training. There have been several examples of such collaboration at the country level.

In Pakistan, the Pakistan Bureau of Statistics (PBS) conducts census and biannual province-level social indicators surveys, while the National Institute of Population Science (NIPS) conducts DHS and related surveys; MICS are conducted by provincial Bureau of Statistics. PBS is assisting the current coverage evaluation survey with mapping and sample design, but not household selection. Technical assistance is provided by WHO. Collaboration with others will be done for quality control activities.

Lao PDR conducted a Gavi-supported RI plus SIA coverage survey in 2015, and took advantage of previous experience with MICS by using a similar questionnaire and collaborating with the National Bureau of Statistics.

The MICS survey framework was also employed in designing a post-SIA coverage survey in Swaziland, but pre-sampling of HHs was complicated because the Central Statistics Office maps did not include individual HH locations. Because coverage survey plans were developed after the campaign, fingermark verification of

individual vaccination was no longer feasible. The cards which were issued during the campaign lacked individual children's identification and were poorly retained, which forced reliance on verbal histories.

In Mongolia, the Ministry of Health (MOH), WHO and UNICEF coordinated to integrate MICS, Reproductive Health and DHS survey methodologies in 2013. They agreed upon a set of indicators to be measured from each survey, including an emphasis on measles vaccination coverage due to a large measles outbreak in 2014-16. In winter 2016, MOH decided to conduct a measles and rubella serosurvey, supported technically and financially by WHO. MOH took the lead in coordinating the National Statistical Office (NSO), WHO, CDC and other agencies.

Several countries highlighted the importance of establishing clear roles. For instance, in Uganda a Memorandum of Understanding was signed between the School of Public Health and the MOH to define roles ahead of a national vaccination coverage survey; the Bureau of Statistics is also supporting sampling, while partner agencies provide technical and financial support.

One such technical assistance provider is AMP, which provides technical support to field vaccination coverage surveys, but has not yet employed the revised WHO survey guidelines. Most recently, AMP provided assistance to surveys in Benin, Cote d'Ivoire and Mauritania. AMP believes the National Bureau of Statistics need to be engaged earlier and in a more comprehensive fashion in survey design, planning and implementation.

Finally, on the topic of collaboration and networks, participants again raised concerns about avoiding potential duplication of DHS, MICS and EPI surveys, as well as excessive intervals between surveys. In many settings one survey, either DHS or MICS or EPI, should be conducted every 3-5 years, but again, this needs to be based on the monitoring needs of the country, rather than be a partner driven requirement. To ensure that EPI collaborates with DHS, MICS, and others doing surveys that include immunization questions, DHS and MICS survey schedules should be included in countries' comprehensive multi-year strategic plans and/or annual plans of action. This will allow the MOH and partners to plan accordingly to ensure optimization of resources.

6.2) Ensuring standardization

The DHS representative presented on their approach to standardizing survey practices. DHS surveys are conducted in response to government requests, and use questionnaire instruments that are translated into local languages in a standardized format. DHS questionnaires are pre-tested. Overall, training may take up to 4 weeks with EPI-related questions receiving about one day's training. Geographic position system (GPS) verification of enumeration areas is employed to ensure that teams go to the right locations. DHS reports are usually published about a year after the survey is completed and country datasets and documentation are made publicly available.

Lessons learned by DHS include the importance of arranging timely payment of field workers; a minimum of 3 HH revisits at different times of day should be conducted; and quality monitoring and clear communications with field teams are critical activities. Quality monitoring includes face-to-face contact, use of checklists, and setting targets for the proportion of vaccination cards seen. Data quality is checked using StatCompiler computer software (available as a DHS Programme App for iPhone and Android platforms) and error-checking protocols.

The SMART representative described their standardized manual, developed with best practices for sampling, training, survey implementation and analysis. A SMART website offers a set of tools, training slides, examples of questionnaires and field experiences. There was interest in developing similar online tools for the Survey Reference Manual. SMART methodology includes data quality checking, standardized statistical testing

calculating design effects and confidence intervals, user-friendly software for automated analyses, and standardized results templates. The methodology places major emphasis on the standardization and quality of enumerator training, with extensive practice sessions on data collection and entry.

The DHS representative commented on the complexity of finding a balance between tailoring survey questions to local needs and the desire to standardize questions for inter-country comparison. For instance, separating routine and supplementary vaccination coverage may generate valuable information of specific concern to certain countries. Obtaining source of vaccination (public, private, other) was seen as valuable and an area to be added to DHS and MICS as possible. Also, collecting ethnicity may be too sensitive in certain countries, but can be considered when appropriate. Finally, a participant from Gavi, the Vaccine Alliance encouraged WHO to promote more consistency with DHS and MICS methodologies.

6.3) Reporting

WHO presented on challenges in reporting survey findings and datasets. EPI survey reports are often published many months after surveys are completed, by which time events may have moved on and the results may be too late to inform programme modifications. These reports rarely use standardized presentation templates, which complicates the comparison of results across countries. Few EPI vaccination coverage survey datasets are made publicly available for further analysis. When they are available, they may be saved in a variety of formats (eg: excel, access, other software), and code books may not be available. Consequently, WHO recommends that more datasets be made available and that the data sharing agreement be part of the survey protocol and discussion with stakeholders funding or supporting the survey from the beginning. Memorandums of Understanding (MOUs) and contracts with governments should include provisions to make datasets publicly available. The Bill and Melinda Gates Foundation representative noted that studies funded by the Gates Foundation are already required to produce a public dataset. A meeting participant noted that Bangladesh has had success with graduate students conducting analysis on publicly-available datasets. In later discussion, it was proposed that DropBox could be used as a mechanism for sharing datasets. The potential role of the TechNet-21 website could also be explored.

Topic 7: Costs

Survey costs are affected by several factors including survey objectives, sample size (driven by the precision required), quantity and quality of survey data to be collected, logistics, data entry, and analysis methods. A presentation showed how costs can be affected by adding RI to an SIA survey and the level of representativeness desired.

It estimated a cost of around $75,000 USD for a national-level post-SIA measles-rubella survey sampling 40 clusters of 10 children (400 children total, adequate to measure coverage of 95% with 95% CI of +/-5%, assuming a design effect (DEFF) of 2 – as per annex B of the WHO Survey Manual). If this plan was then expanded to include 12 provincial-level strata, the costs would be multiplied approximately 5 times. If the 12-strata plan was then expanded to include both RI and SIA coverage evaluation, the costs would be multiplied approximately 10 times compared to a national post-SIA survey. These estimates include enumerating HHs and allows for 2 separate trips – cost of travel was done on a per-day basis not specifying how far in advance enumeration was done.

These back-of-the-envelope figures are largely corroborated by real expenditures recorded in post-SIA surveys implemented recently. Experience shows that national surveys are relatively practical and inexpensive, whereas

sub-national strata massively increases costs and powering a sub-national survey for precise RI outcomes increases data collection complexity. For example, a recent stratified post-SIA survey in Kenya may have cost nearly as much as the SIA operational costs to vaccinate about 1 million children. Hence, investing in improving administrative data collection quality through improved training and supervision may be more cost-effective than implementing stratified surveys. The presenter concluded that RI vaccination coverage surveys are more complex and resource-intensive than post-SIA surveys. If the quality of data entered on HBRs and clinic registers is poor, then the results will not be reliable. If the timing of publishing the survey results is delayed or the results are controversial, the survey may not result in effective action to improve programme performance. It may instead be more useful and cost-effective to conduct other types of studies, such as health facility assessments, data quality assessments, missed opportunities studies, and targeted probability sampling coverage surveys.

A representative from the Neglected Tropical Diseases (NTD) area presented a second survey costing study, this time in the context of preventive chemotherapy (PC), i.e., mass drug administration (MDA). Post-MDA coverage evaluations are acknowledged as very important, but are rarely implemented due to several operational challenges. To date, the old EPI cluster-survey methodology had been widely adopted because it is most familiar. However, it is now recognized that the methodology produces potentially biased and therefore unreliable results with negative implications for public health outcomes. The NTD Strategic Technical Advisory Group for Monitoring and Evaluation reviewed data from field studies and recommended the use of probability sampling with segmentation (PSS)[5]. A study comparing all three methods (EPI, LQAS, PSS) showed costs that on average range from $3,600-$3,800 per district. Note that these surveys are much simpler than RI surveys; there are important differences in the time required to complete the different surveys and the generalizability of the results. The costs for NTD surveys may not be directly transferable to EPI routine immunization surveys.

There was a brief discussion around the tension arising from countries' desire for precise sub-national coverage data and the highly resource-intensive methodology required to achieve that level of precision. Some participants proposed that WHO may wish to discourage countries from trying to undertake district-level probability sample household surveys. Others noted that the intended audience for the Survey Reference Manual is senior technical staff in MOHs and not health facility staff, which explains why the manual assumes a relatively high level of familiarity with statistics, survey design, sampling and data analysis.

Overall, there is a need to better define the role of different tools, and the pros and cons of each. This question was addressed in a recent paper (Cutts et al, 2016) and continues to be an area requiring theoretical and practical guidance.

Next Steps

In the final session, the next steps for actions, operational research, and survey manual revisions (presented at the top of this report) were reviewed. Participants also agreed to take part in a short online survey following the meeting. Finally, it was agreed that working groups should be formed to move forward on the highest priority topics.

[5] Report of the WHO Strategic and Technical Advisory Group for Neglected Tropical Diseases, April 2016. http://www.who.int/neglected_diseases/NTD_STAG_report_2016.pdf?ua=1

Annex A. Agenda

Tuesday 18 April 2017
Topics: Introductions and context, new WHO Survey Manual, survey coverage estimates, and introduction to accuracy, precision and sampling
Chairs: Marta Gacic-Dobo (WHO)/ Mamadou Diallo (UNICEF)
Rapporteur: Augusto Llosa & Emily Dansereau (consultants)

Time	*Topic*	*Facilitator/ Speaker*
8:30 – 9:00	Registration	
9:00 – 9:15	Welcome	Jean-Marie Okwo-Bele (WHO)
9:15 – 9:30	Agenda and objectives Introductions Practical information / announcements	Marta Gacic Dobo (WHO) Carine Cruz (WHO)
9:30 – 10:15	Presentation: Setting the stage - Why we assess vaccination coverage?, the role of Vaccination Coverage Surveys, Gavi requirements Discussion: Uses of survey vaccination coverage estimates by countries, partners and donors, researchers	Carolina Danovaro (WHO)
10:15 – 10:45	Coffee Break	
10:45 – 11:15	Presentation: Intro to new WHO Vaccination Coverage Survey Reference Manual	Carolina Danovaro (WHO)
11:15 – 11:45	Q&A	
11:45 – 12:15	Surveys to understand barriers and enablers for vaccination	Maya Van Den Ent (UNICEF)
12:15 – 14:00	Lunch Break	
14:00 – 14:30	Presentation: Comparison of coverage estimates from DHS, MICS and EPI surveys	David Brown (Consultant)
14:30 – 15:00	Summary presentation and panel: Approaches to coverage surveys that collect vaccination data – DHS, MICS, other surveys	Carolina, Joanna Lowell (DHS), Mamadou Diallo and Maya Van Den Ent (UNICEF), WHO
15:00 – 15:30	Presentation: Combining traditional HH surveys with EPI surveys: MICS/NICS in Nigeria, Q&A	Nigeria
15:30 – 16:00	Coffee Break	
16:00 – 16:30	Presentation: Literature reviews on survey methodology	Xavier Bosch-Capblanch (SCIH) Emily Dansereau (Consultant)
16:30 – 17:00	Presentation: Overview of accuracy, precision and probability sampling	Dale Rhoda (Consultant) Tony Burton (Consultant)
17:00 – 17:15	Wrap-up	Marta Gacic-Dobo (WHO)
17:15 – 17:30	Group Picture	
18:00	Welcome Cocktail	

Wednesday 19 April 2017

Topics: Sampling and introduction to vaccination ascertainment
Chair: Kathleen Wannemuehler (CDC)
Rapporteur: Dale Rhoda (Consultant) & Mamadou Diallo (UNICEF)

Time	*Topic*	*Facilitator/ Speaker*
9:00 – 10:30	Panel: Country experiences with probability sampling - Multi-country overview	CDC, Uganda, Zambia, Pakistan
10:30 – 11:00	Coffee Break	
11:00 – 11:30	Presentation: Considerations for combining RI with SIA surveys Discussion	Carolina Danovaro
11:30 – 12:30	Facilitated discussion: Sample size implication of survey designs	Tony Burton
12:30 – 14:00	Lunch Break	
14:00 – 15:15	Break-out sessions: Innovation to overcome sampling challenges (2 groups) 1. GIS, grid-based sampling, rolling-survey data collection 2. Surveys in special populations, what are the EPI needs?	Facilitators Group 1. Mamadou, Kathleen Group 2. Maya, Marta
15:15 – 15:45	Coffee Break	
15:45 – 16:30	Facilitated discussion: Action and research priorities for sampling	Aaron Wallace (CDC) Report back from group work
16:30 – 17:00	Presentation: Overview of ascertainment challenges and topics, including recall, home-based records, health facility records and question formulation	Marta Gacic Dobo
17:00 – 17:15	Wrap-up and session assessment	Kathleen Wannemuehler (CDC)

Thursday 20 April
Topic: Ascertainment of vaccination status, data collection and analysis discussions
Chair: David Brown (consultant)
Rapporteur: Adam MacNeill (CDC) & Augusto Llosa (consultant)

Time	*Topic*	*Facilitator/ Speaker*
9:00 – 10:00	Presentations and Panel: Recall studies and experiences - Overview - Nigeria survey in selected LGAs - HPV recall	David Brown (Consultant) Kathleen Wannemuehler (CDC) Vivien Tsu (PATH)
10:00 – 10:15	Discussion on caregiver vaccination recall	

10:15 – 10:45	Coffee Break	
10:45 – 11:45	Innovative methods to improve vaccination status ascertainment Presentations: - Photographing immunization cards in Bolivia and Lebanon - DHS experience visiting health facilities Panel: - Experience in Bangladesh, Bolivia (PAHO), Burkina Faso, Lebanon, Senegal, Uganda	Carolina and TBD (Lebanon) Joanna Lowell (DHS) Bangladesh, Burkina Faso, Lebanon, Senegal, Uganda
11:45 – 12:00	Discussion of ascertainment	
12:00 – 13:30	Lunch Break	
13:30 – 14:15	Presentation: Overview of data collection challenges, including training, monitoring, supervision	David Koffi (consultant)
14:15 – 14:50	Panel: Paper vs. electronic. Country data collection experiences, and the pros/cons of using tablets/phones	David Koffi and Eric Diboulo, Uganda, Lebanon, DHS for Ethiopia.
14:50 – 15:00	Date recording in electronic platforms	Dale Rhoda
15:00 – 15:20	Coffee Break	
15:20 – 15:40	Facilitated discussion: Action and research priorities for ascertainment and data collection	Adam McNeill (CDC)
15:40-16:15	Special study: Adjusting survey-based vaccination coverage estimates with serology results. Q & A	Wenfeng Gong (J. Hopkins)
16:15 – 17:15	Breakout sessions on analytical issues (2 groups): - Analytical approaches: tools, imputation, weighted analysis, post-hoc adjustments - How to better use surveys to inform EPI planning and improvement: Additional analyses, using surveys to understand and improve data quality	Facilitators Group 1. Dale and Mamadou Group 2. Carolina and Marta
17.15 – 17.45	Reports from previous break-out sessions on analytical issues	Person selected from each group

Friday 21 April

Topic: Collaboration, survey reports and data sharing, and next steps
Chair: Felicity Cutts (consultant). *Replaced by Maya Van Den Ent*
Rapporteur: Robin Biellik & Emily Dansereau (consultant)

Time	*Topic*	*Facilitator/ Speaker*
9:00 – 9:45	Panel: Collaboration and roles - Collaborating with DHS, MICS Panel: Collaborating with National Statistical Offices (NSO), research organizations, national institutes and other organizations (Lao PDR, Lebanon, Mongolia, Nepal, Pakistan, Swaziland, Uganda, AMP, JSI, PATH)	Carolina, Mamadou, WHO Regional staff
9.45 – 10:15	Examples: Ensuring standardization and quality and establishing networks (DHS, MICS). Survey networks (SMART)	Mamadou Diallo, Joanna Lowell, Eva Leidman (CDC, SMART)
10.15 – 10:40	Presentation: Survey Reports- Completeness and quality. Availability of databases, codebooks and analytical code	Marta Gacic-Dobo
10:40 – 11:00	Coffee Break	
11:00 – 11:30	Interactive exercise: Research agenda prioritization	Carolina
11.30-12.00	Agreement on knowledge gaps and research agenda	Mamadou Diallo
12:00 – 13:45	Lunch Break	
13:45 – 15:15	Presentations: Survey costs - Key issues - Neglected Tropical Diseases (NTD) survey costing experience - Discussion	Felicity Cutts Pamela Mbabazi (WHO)
15:15 – 15:40	Coffee Break	
15:40 – 16:45	Discussion and Presentation: What's next - Agreement on knowledge gaps and research agenda - Discussion and agreements on priorities for manual finalization - Supporting EPI surveys	Carolina
16:45 – 17:00	Wrap-up and meeting assessment	Marta Gacic-Dobo

Annex B. List of Participants

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Annex C. Changes to the Survey Reference Manual and supporting tools

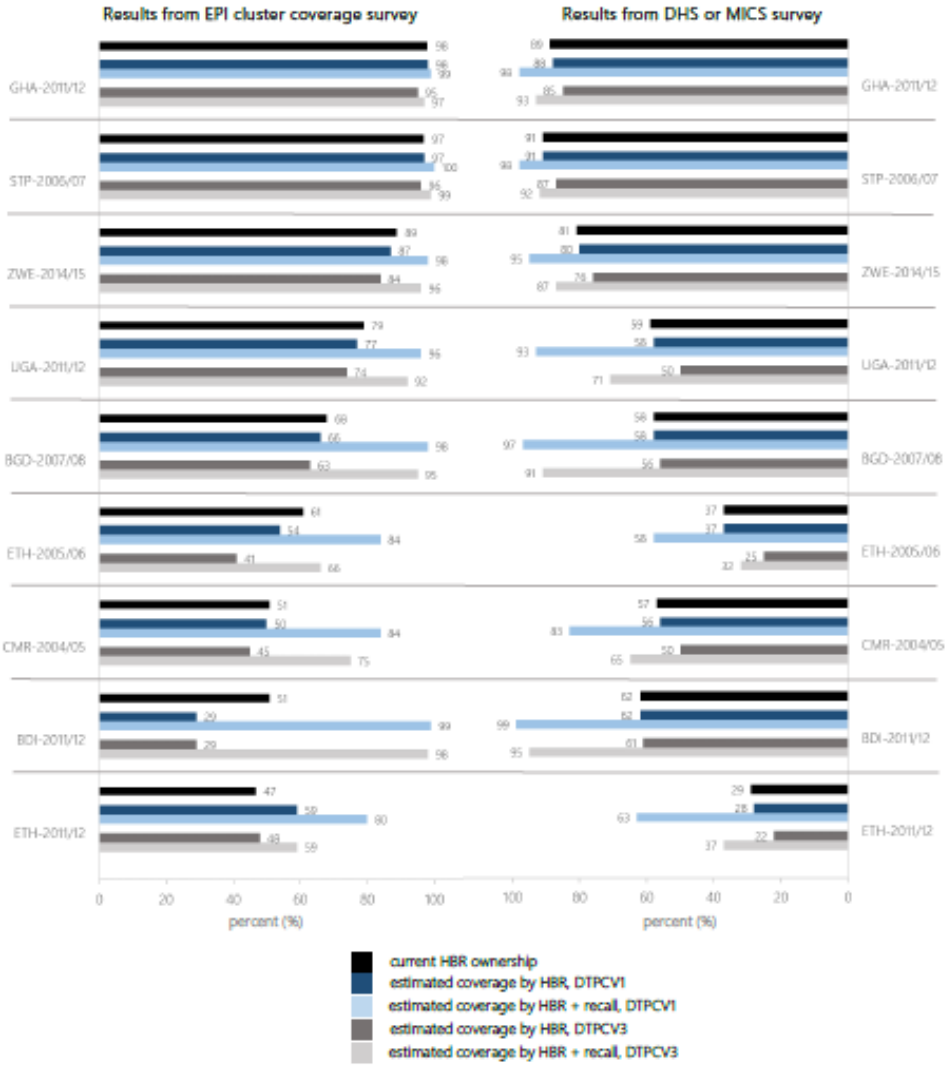
- Chapter 1, 2: More context on the role of surveys, encouraging users to carefully consider if and what type of survey is needed
- Chapter 1, 2: Clarification and guidance around when it is appropriate to conduct district-level surveys, emphasizing that other activities may be more useful and cost-effective
- Chapter 3: Mention grid-based sampling
- Chapter 3: More guidance on household listing procedures
- Chapter 3: More guidance on knowledge, attitudes and practice questions (KAP)
- Chapter 3: Direct users to resources on grid-based sampling
- Chapter 3, 4: More guidance on including hard-to-reach special populations in coverage surveys, including explicit mention of how to include/sample urban slums
- Chapter 3, 4: How to determine which facility to visit when children have received vaccines from multiple sites
- Chapter 3, 4: Highlight the need to include team members who are familiar with the health facility context and data collection tools used, if conducting health facility visits
- Chapter 4: Provide tools for real-time quality assurance
- Chapter 6: Provide tools and spreadsheets for weighting and handling non-response
- Chapter 6, 7: Advise on the possible types of analysis, depending on the data quality and coverage scenario
- Chapter 7: Include a "decision helper" for programme managers, linking survey findings to potential actions
- Annex I: More guidance on handling electronic data collection challenges, including duplicate records and the importance of syncing software versions
- Overall: Check for consistency with DHS and MICS methodologies

Annex D. Comparison of Home-based record availability and DTP1 and DTP3 coverage estimates between EPI Cluster Coverage Survey and a DHS or MICS within one year and on the same year

By David Brown, manuscript in preparation

COMPARISON OF ESTIMATED CURRENT HOME-BASED RECORD (HBR) OWNERSHIP AND VACCINATION COVERAGE LEVELS FOR DTPCV1 AND DTPCV3 AMONG 8 COUNTRIES CONDUCTING EITHER A DHS OR MICS SURVEY FOLLOWED BY AN EPI CLUSTER COVERAGE SURVEY WITHIN ONE YEAR

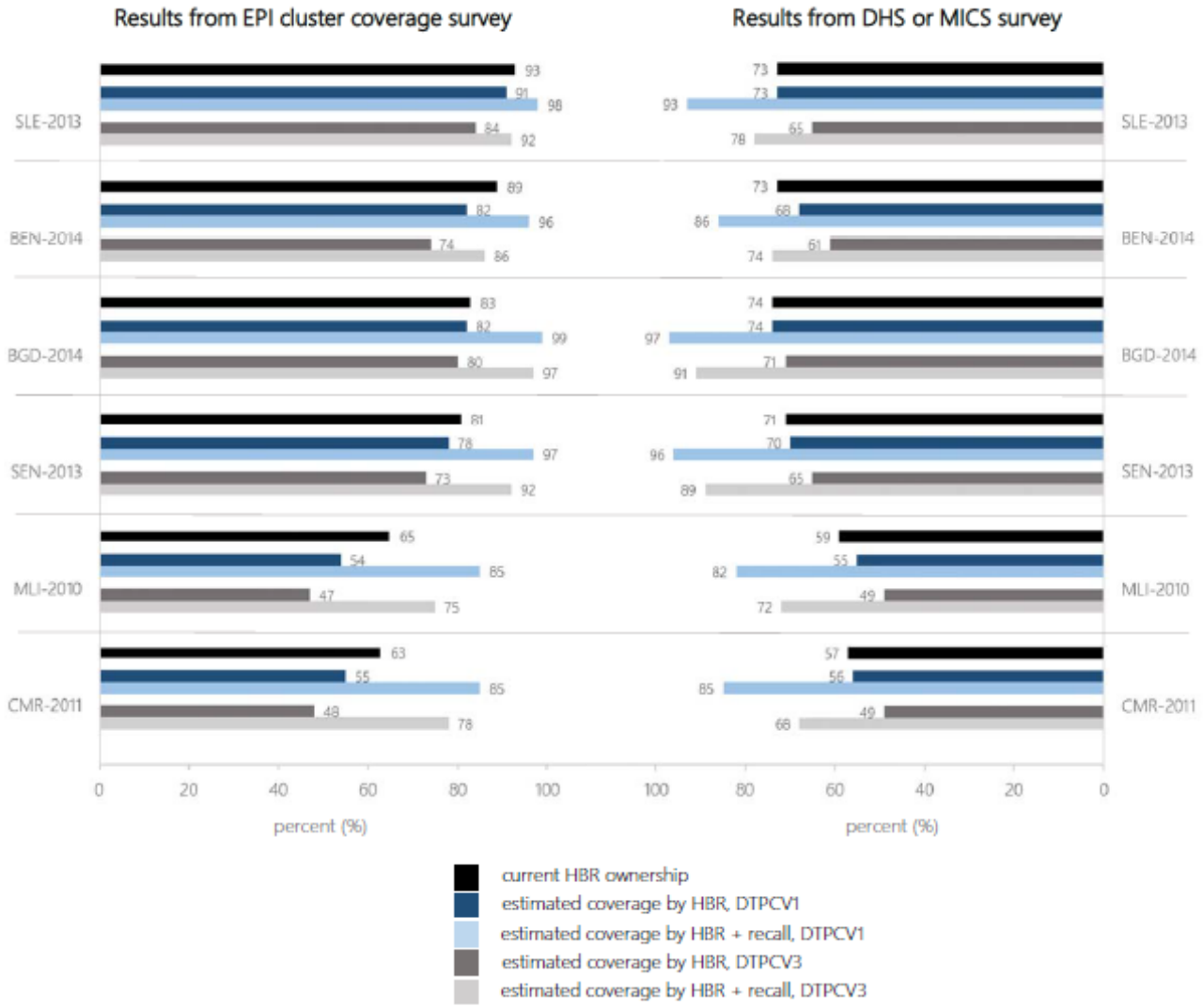
ACROSS THE EPI/DHS/MICS SURVEYS CONDUCTED IN 8 COUNTRIES SHOWN BELOW, ESTIMATED CURRENT HBR OWNERSHIP IN THE EPI SURVEY EXCEED THAT OBSERVED IN THE DHS/MICS SURVEY IN 7 INSTANCES BY MORE THAN 5%-POINTS, WHILE THE CURRENT HBR OWNERSHIP IN THE EPI SURVEY WAS LESS THAN THAT OBSERVED IN THE DHS/MICS SURVEY IN 2 INSTANCES. SIMILARLY, ESTIMATED VACCINATION COVERAGE BY DOCUMENTED EVIDENCE IN HBRS FOR DTPCV1 AND DTPCV3 IN EPI SURVEYS EXCEEDED LEVELS ESTIMATED IN DHS/MICS SURVEYS BY MORE THAN 5%-POINTS IN 7 INSTANCES.



ISO3 key: BGD, Bangladesh; BDI, Burundi; CMR, Cameroon; ETH, Ethiopia; GHA, Ghana; STP, Sao Tome and Principe; UGA, Uganda; ZWE, Zimbabwe

Comparison of estimated current home-based record (HBR) ownership and vaccination coverage levels for DTPCV1 and DTPCV3 among 6 countries conducting both an EPI cluster coverage survey and either a DHS or MICS during the same year

ACROSS THE 6 COUNTRIES, ESTIMATED CURRENT HBR OWNERSHIP IN THE EPI SURVEY EXCEED THAT OBSERVED IN THE DHS/MICS SURVEY IN ALL 6 COUNTRIES BY MORE THAN 5%-POINTS. ESTIMATED VACCINATION COVERAGE BY DOCUMENTED EVIDENCE IN HBRS FOR DTPCV1 AND DTPCV3 IN EPI SURVEYS EXCEEDED LEVELS ESTIMATED IN DHS/MICS SURVEYS BY MORE THAN 5%-POINTS IN 4 OF THE 6 COUNTRIES.



ISO3 key: BGD, Bangladesh; BEN, Benin; CMR, Cameroon; MLI, Mali; SEN, Senegal; SLE, Sierra Leone

Annex E. Enablers and challenges in survey implementation using the WHO 2015 Vaccination Coverage Survey Reference Manual

By HM Scobie, manuscript in preparation

Table 1. Factors enabling successful implementation of the revised coverage survey methodology in Kenya

Survey area	Factors
Partnership	• Strong survey leadership by MOH, including partner coordination and survey monitoring • Partners with strong technical capacity and previous survey experience, including survey design, sampling and electronic data collection
Planning timeline	• Delays in campaign implementation from November to May allowed adequate planning • Coverage survey meetings began in January for June-July implementation • Regular meetings and conference calls to coordinate partner efforts and monitor progress towards survey timeline
Funding	• Adequate funding support from WHO ($550,000) and CDC ($57,000) • Earlier availability CDC funds for electronic equipment and ONA contract made electronic data collection possible
Survey design & sampling	• Strong statistical/technical support for survey design and development of survey materials from CDC and WHO • Existence of national survey frame and recently updated HH censuses • Strong technical support from national KNBS staff who did probability-based selection of clusters and HH prior to survey start • Adequate inflation of sample size (i.e., % HH eligibility varied by county, 10% non-response, 90% probability of obtaining target number of HHs per cluster) resulted in desired sample size in 87% of counties, despite high observed % of vacant HHs
Human resources & training	• Large pool of local permanent and temporary KNBS staff (with different language abilities) allowed full staffing of specified 48 county teams for survey implementation • Regional training strategy with direct training of interviewers by experts on survey methods and electronic data collection
Survey implementation	• Maps and HH numbering system, along with facilitation by KNBS cluster enumerators and village elders, allowed efficient and accurate navigation to HHs • Use of official survey badges, MOH announcement, and campaign paraphernalia (e.g., visors, folders) facilitated community acceptance of survey • Short and simple questionnaire, with one mother and her children selected per HH and only campaign and routine measles vaccination collected (took 10-30 minutes per HH) • Interviewers cited faster speed and preference for data collection by mobile phone
Monitoring & supervision	• High supervision ratio: one supervisor per team of three interviewers • Field deployment of 25 regional coordinators for monitoring 48 teams • Coordination and real-time review of data by three national staff; improvisational support required for intensive effort to query

	supervisors in real-time on data errors • GPS coordinates collected for each HH but not systematically monitored because cluster GPS points unavailable, but threat of monitoring left strong impression on interviewers
Information & communication technology	• Strong technical support provided by ONA for developing electronic form (XLS Forms) and online monitoring platform, and providing IT support during survey • ODK Collect worked smoothly for electronic data collection on Samsung Galaxy mobile phones, with no major issues reported • Swahili translation of form available at any time during use through toggle button • Power banks only needed in bush when teams worked several days without charging • Mobile network and wireless internet generally allowed almost daily data upload • Collection of contact details for staff allowed efficient communication about survey challenges and data errors through RapidPro SMS for interviewer/supervisors and WhatsApp for coordinators
Data management & analysis	• Availability of sampling probabilities (1st and 2nd stage) from KNBS • Technical support from CDC for required data management and complex statistical analysis

Table 2. Challenges with implementing the revised coverage survey methodology in Kenya

Survey area	Factors
Planning timeline	• Difficulty prioritizing coverage survey from start of campaign planning, despite advanced planning required for partner engagement and high quality implementation
Funding	• Government desire for county-level results required revising survey goal to coverage classification to reduce budget and soliciting outside funding (not covered by GAVI operational campaign funds) • Delays in finalizing budget (1 month prior to campaign) and transfer of funds from WHO to MOH (until 3 days after campaign), resulting in delays in sending funds to peripheral levels and training
Survey design & sampling	During design phase, we struggled to weigh added value with additional burden of data collection for following issues and found current draft WHO guidance insufficient: • Listing every HH member (e.g., adult men) at start of survey (recommended to reduce selection bias?) vs. listing all eligible mothers/children (saved time and collection of unused data) • Collecting data for all eligible children and all mothers in HH (recommended) vs. randomly selecting one eligible mother and her children (allowed filling one HH form and accounted for digital selection probability in weight) • Applying one inflation factor for % HH eligibility across counties (seems to be recommended) vs. adjusting by county to account for varying fertility (teams assigned to individual counties so no added complexity in field and ensured adequate sample size for county-level analytic goal)

	• Updating HH census lists (recommended if "recent" lists unavailable) vs. using lists last updated in 2012-2016 (saved on time and budget but probably resulted in increased proportion of vacant HH) • Accepting default 50% probability of obtaining target cluster sample size (no recommendation) vs. inflating for 90% probability (gave extra buffer in sample size calculation)
Human resources & training	• WHO coverage survey consultant not hired until just before campaign and responsibilities included other campaign activities • Plan for training of alternate interviewers not implemented; one substitute interviewer had high number of errors, and interviewer illnesses led to delays in some counties
Survey implementation	• Logistical challenges including flooding, large distances and inaccessibility of five clusters because of insecurity or population movement • Challenges securing borrowed government cars and limited transport budget for rentals led to delays in some counties • Teams not using lists of selected HHs resulted in required revisits in two clusters • Proportion of vacant HHs (14%) higher than assumed 10% non-response related to time elapsed since update of cluster censuses and urban communities with high turnover • Interviewers complained about collecting child birthdates for eligibility section and then again for child vaccination section (required notes on paper or repetition of questions) • Few children had finger markings because of poor marker quality and 4 week lapse since campaign • Interviewers documented less vaccination card availability than expected (28% vs. 75%); may have marked "by recall" even if card observed to avoid filling vaccination dates and save time
Monitoring & supervision	• Underestimated work burden related to real-time data monitoring and querying errors; would have been a full-time job for 1-2 people in Nairobi • Frequent errors by some interviewers included selecting wrong cluster and HH number (despite confirmation prompts), or starting new form during return HH visit instead of opening old form • Some supervisors not catching data errors before data upload; a best observed practice was supervisors tracking HH visits on paper lists and cross-referencing electronic forms before upload
Information & communications technology	• Poor mobile service and lack of wireless internet in some counties prevented timely upload and central data checking, and prevented immediate release of teams from field at end of survey • Online data monitoring platform not compatible with monitoring child-level variables (i.e., because multiple sets of child variables existed in a single HH record)
Data management & analysis	• Last minute changes after pilot testing led to several mistakes in skip patterns and missing data • Because database "flat" (i.e., one record per HH) with repeat variables for child eligibility, mother selection, and child vaccination, database very large (>800 variables) and complex to manage • Analysis accounting for survey design not compatible local training and experience • Unclear programmatic implication for many counties with "indeterminate coverage" result

Annex F. Tools to facilitate near-time data quality inspection

From Wenfeng Gong, International Vaccine Access Center (IVAC), Johns Hopkins Bloomberg School of Public Health (JHSPH)

Near-time data inspection for household surveys refers to periodic activities to monitor data collection progress, evaluate data quality, detect systematic errors, generate data queries, and correct data values during survey implementation. Near-time data inspection should be performed every day or following data entry in every cluster. Unlike real-time data inspection during interviews, which is only possible when electronic data entry devices are used, near-time inspection is feasible for paper-based surveys if data are entered promptly.

Well-designed protocols and tools are required to ensure effective near-time data inspection. DHS and SMART surveys have implemented advanced computer programs to facilitate near-time data inspection. However, such tools are rarely available for vaccine coverage cluster surveys. Given limitations in resources and expertise for EPI survey managers to develop *ad hoc* tools, a user-friendly, generalizable, and customizable tool package adapted for EPI surveys would be valuable.

Rationale for near-time data quality inspection

Errors occur during surveys and many can be identified by data inspection, including:

Recording errors by interviewers and data entry personnel. For example, use of an incorrect ID number in a survey form can result in duplication of the ID in the database, and entering a date of vaccination earlier than the date of birth can create conflicts between variables that can be identified through data inspection.

Protocol deviations or violations by interviewers and data enterers. For example, an interviewer who does not ask to see the vaccination card according to protocol may have a significantly lower card retention rate than other interviewers, and failure to submit data or the loss of questionnaires may lead to discontinuity in ID numbers.

Misunderstanding questions or incorrect probing techniques due to insufficient training. For example, frequent missing values may suggest the question was not asked correctly.

Suboptimal questionnaire. For example, when the option “other” is frequently selected and subsequent specifications often contain the same text value, this text value should be added as a new response option.

Technical errors. For example, database design flaws and software bugs may cause duplicated records or incomplete data.

Corrective actions are easier when errors are detected early. Surveyors can often correct errors during household revisits (if necessary) or by cross-checking data with logs and interviewer notes. When potential systematic problems are promptly detected, surveyors can conduct further investigations and prevent similar mistakes through refresher trainings and modifications of data collection tools.

When electronic data collection devices are used, near-time data inspection is a necessary supplement to real-time data inspection. Electronic data collection tools usually prevent invalid data entry and can

display warnings when unreasonable values are entered according to pre-specified rules. However, not all errors are predictable and many errors are not preventable by simply restricting entered values.

Key considerations for near-time data inspection facilitating tools

The data inspection process should follow a set of pre-specified rules ("checkpoints") covering the data quality dimensions listed in Table 1, as well as detect unexpected responses such as excessive missing values. The set of rules should be modifiable and expandable during survey implementation in response to new observations. For a survey with a long questionnaire and many "checkpoints", near-time data inspection is feasible only if computer-based tools are used to automate the inspection process.

Data inspection tools should generate data queries and list all potential data issues. The data queries should reflect current data each time they are generated but should also distinguish new, pending, and resolved queries.

Near-time data inspection is more effective if the process involves senior data managers and frontline field data monitors. The field data monitors, who observe field practices and interact with interviewers, often have a better understanding of the underlying problems suggested by the data queries. They can promptly provide feedback to field supervisors and senior data managers in response to data queries. When data monitors are reliable and well supervised, they may be permitted to correct erroneous values in response to data queries.

All data queries, responses, corrections, and the evidence supporting those corrections should be documented. The process of correction should be replicable and reversible.

The data inspection facilitating tool interface should be user-friendly. Excel spreadsheets are recommended for data queries, responses, and change requests. For example, data monitors can request edits to a specific value in a database by specifying the record ID, the variable name, the old and new values, as well as the evidence and rationale for changes in the spreadsheet, which can then be input by the facilitating tool.

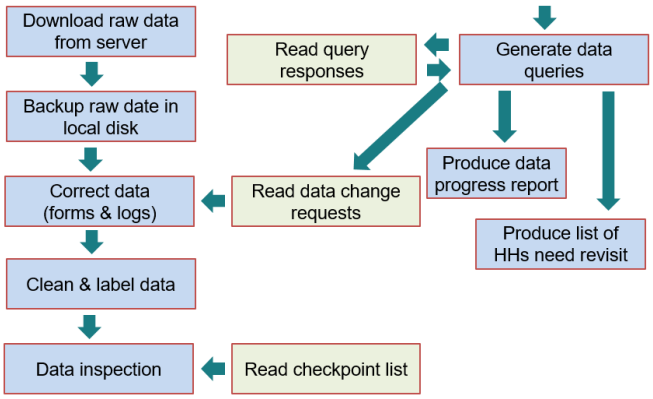
Cooperation between the senior data manager and multiple field data monitors at different locations may require the facilitating tools to be operated on multiple computers. Therefore, the tools should download data from a single server each time data inspection is performed. Data queries, responses, and change requests should be synchronously updated. Cloud storage, such as Dropbox (for de-identified data) and Box may be helpful.

Table 1: Data quality dimensions for near-time inspection

Data quality dimensions	Definition
Completeness	All required records and all required values are available
Conformity	Types, precision, formats, codes, domain, and ranges are stored in required formats
Consistency	No conflicting facts between questions, between forms, or between forms and logs
Continuity	Time of data collection (or ID) has no unexpected breaks in series
Uniqueness	Each record has unique identifier and is only stored once
Uniformity	No unexpected significant difference across interviewers, teams, and time, which cannot be explained by difference across clusters and seasons

An example tool designed by IVAC

We developed a data inspection and cleaning tool in 2016 for a vaccine coverage survey methodology study in Karachi, Pakistan. The tool was developed with Stata but uses Excel spreadsheets as the interface for data queries and data change requests. More than 100 "checkpoints" were included in the inspection process. The functions of the tool are summarized in the diagram.



The data change requests are illustrated in the following screenshot. Data monitors specify the household ID, targeted variable name, and old and new values of this variable. The facilitating tool attempts to make the change and displays if the change was made ("PASS") or not ("ERROR").

	A	B	C	D	E	F	G	H	I	J	K	L
1	ID	F1_0(HOU	F1_1_1(VI	variable	original	new	delete_rec	responsibl	date	change_m	K	
2	1	133-024-3	1	f1_1_4stat	0	1	NO	WG	1/30/201	PASS		
3	2	124-027-3	2				YES	WG	1/30/201	PASS		
4	3	124-027-4	2				YES	WG	1/30/201	PASS		
5	4	111-138-4	1	f1_1_4stat	0	1	NO	NA	1/31/201	ERROR	cannot find this ID i	
6	5	124-146-3	1	f1_1_4stat	0	1	NO	NA	2/2/2016	PASS		
7	6	124-146-3	1	f1_1_4stat	1	0	NO	NA	2/2/2016	PASS		
8	7	122-144-7	1	f1_0house	122-144-7	122-141-7	NO	NA	2/2/2016	PASS		

Data queries are illustrated in the following screenshots. The facilitating tool generates a list of queries each time it is operated based on prespecifed "checkpoints." The queries contain description of the checkpoint, values of relavant variables, potential solutions, and contexture information. Data monitors sign their names to the queries, investigate reasons, leave comments, and edit the data using the data change requests. The tool then processes the responses and updates the query status.

	A	B	C	D	E	F	G	H	I	J
1	checkpoint	HH_ID	Child_ID	Visit_Num	FW_ID	Date	Status	Respo nsible	Comment	Form
2	1902	.	17006	0			New			Consentcount
3	1902	.	25017	0			Pending			Consentcount
23	1902	.	15079	0			Resolved-need_confirm			Consentcount
30	1	111-007-405	.	1	14	01-03-16	Pending	NA	Two records but one is the second visit recoded by	Form1
55	11	111-13								
56	14	111-13								

	K	L	M	N
	Description	Variables	Potential_solutions	Critical_level
nt	Consent 1 received when Form1 question 1 does NOT indicate enrollment (f1_1_4s!=1/8/9) [NOT realtime check; depend on log update		Check for unsubmitted data;	Urgent
nt	Consent 1 received when Form1 question 1 does NOT indicate enrollment (f1_1_4s!=1/8/9) [NOT realtime check; depend on log update		Check for unsubmitted data;	Urgent
nt	Consent 1 received when Form1 question 1 does NOT indicate enrollment (f1_1_4s!=1/8/9) [NOT realtime check; depend on log update		Check for unsubmitted data;	Urgent
	More than one record found with same household ID and visit number in Form 1	f1_1_4st atus=1;	1. fix data change log which may	Urgent
	Form1 show interview not started but Form 3 is found (f1_1_4s!=1/8/9)	f1_1_4st atus=.;	Check paper or digital From 3 for	Urgent
	Initial visit's date and cluster number do not match fieldwork calendar		Check for HH ID error; check for	High

Annex G. Consideration for electronic data collection

From the Global Immunization Division at the US CDC

Key Hardware Considerations

- ☐ **Network connectivity:** To connect to cellular data networks, look for "global unlocked GSM" models that accept SIM cards. Dual SIM cards allow use of 2 networks. There are 2 common types of cellular technologies, GSM and CDMA. Generally, devices intended for American "CDMA" networks (Sprint or Verizon) may not be able to connect in other countries. Most of the rest of the world uses GSM. There are 4 major GSM frequencies (850/900/1800/1900 MHz). Some countries only use certain bands and some cheaper cell phones do not support all 4 bands. It is important to select a quad band phone to ensure it will work in all countries (or verify that the device is compatible with the frequency used by the network in the study area). Refer to: http://www.pcmag.com/article2/0,2817,2407896,00.asp
- ☐ **Battery life:** Some devices offer substantially longer battery which is an asset for fieldwork. Compare mAh specs. Replaceable batteries are an advantage, though this is becoming less common. Devices with more than 8 hours of battery life are strongly recommended.
- ☐ **GPS quality:** Mobile devices may or may not have GPS receivers included. There are 2 main types of GPS that are on mobile devices. Standard GPS receivers depend solely on GPS satellites to determine a locations coordinates. Assisted GPS (A-GPS) and Simultaneous GPS (S-GPS) are methods that use network cellular towers to assist getting a GPS fix and may help improve the speed of your GPS lock. Devices listing AGPS functionality should have a standard GPS receiver as well, but in practice some of the cheaper models do not, and therefore the GPS may not work if there is no network connection. GPS hardware performance can vary and can be difficult to evaluate ahead of deployment. It is preferable to pilot systems and use software measures to increase chances to achieving acceptable levels of precision. Additional hardware specifications that aid in GPS navigation include accelerometers and magnetometers, which are not always standard on mobile devices. Refer to: https://en.wikipedia.org/wiki/Assisted_GPS
- ☐ **Autofocus camera:** Required for reading barcodes or taking useable pictures. Fixed focus cameras will likely be unable to read barcodes. Low-end autofocus cameras may not read some higher density barcodes. It is advised to test with the study barcode before purchasing a device. The unit of resolution of a camera is megapixel. To an extent, the higher the megapixel, the better the image quality and more likely it will work with barcodes. Refer to : http://www.bardecode.com/en1/image-resolution-and-barcode-reading/
- ☐ **Size:** Large smartphones or small tablets between 5.5" and 8" generally work well for field work. Smaller devices are more portable and generally have a longer battery life (due to smaller screen size). Larger devices are easier to view and use since the on screen keyboard is larger. Size does not correlate with functionality.

Other Considerations

- ☐ **Type:** Tablet vs Smartphone: Some tablets do not have cellular hardware and can only utilize Wi-Fi. Phones may be a better value and will all have cellular data connectivity, whereas tablets may be preferable for administering large questionnaires. In settings such as health facilities,

where Wi-Fi may be readily accessible, tablets may be preferred. In remote areas without access to connectivity, more portable smartphones may be a better option.

- ☐ **Accessories:**
  - Protective cases: Cases and screen protectors to protect from accidental drops or damage are strongly recommended. Special cases to protect for conditions such as high temperatures, sunlight, dust and humidity may also be useful.
  - Alternative power sources: Mobile chargers, car or solar charging adapters, chargers that supply multiple devices are useful.
  - Alternative Wi-Fi sources: If your devices do not have wireless connectivity, it is possible to use a different with connectivity to create one's own Wi-Fi hotspot to connect to local cellular data networks. It is also possible to create a Wi-Fi hotspot using a satellite hotspot or BGAN
  - Spare parts: Spare devices for replacements, chargers, memory/sim cards and styli to support fieldwork efforts.
- ☐ **Procurement:** Refurbished or discontinued products may represent a good value but may not be available in bulk. Some vendors may delay large purchases.

Software Specific Requirements

Open Data Kit

- Recommend at least a "mid-grade" device (encryption support, autofocus camera, sufficient battery, less prone to failure)
- Minimum software requirements: Runs on all modern Android devices (technically supports Android 1.6+, current version is 7x, generally makes sense to look for 5+))
- See https://opendatakit.org/help/faq/ → What Android phone/tablet/device should I use?

EpiSample

- Recommend "mid-high grade" device with GPS receiver, accelerometer and magnetometer. Also needs Wi-Fi and a long battery life is recommended.
- Minimum software requirements: Runs on all modern Android devices (technically supports Android 5.1 or more current).