Seasonal Malaria Chemoprevention in Nigeria: Coverage surveys 2017

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Contents

Summary of findings

Background

Malaria remains a major public health problem in Nigeria. According to World Health Organization estimates there were 57 million cases of malaria and 100,000 malaria deaths in Nigeria in 2016. [1] The greatest malaria burden is in the northern states where malaria is highly seasonal. [2] Seasonal malaria chemoprevention (SMC), which involves giving children monthly treatment with antimalarial drugs sulfadoxine-pyrimethamine plus amodiaquine for four months during the rainy season to prevent malaria, was included in the 2014-2020 National Malaria Strategic Plan for Nigeria. Nine northern states have the highly seasonal malaria that SMC was designed to prevent, and have a population of about 12 million children who could benefit from SMC. SMC was first implemented in 2013 and 2014 in pilot schemes in Katsina and Kano states, and then introduced in Sokoto and Zamfara states in 2015 and 2016, through the ACCESS-SMC project, targeting a population of about 1.8 million children. This programme was shown to be highly effective, with a protective efficacy of monthly SMC treatment of 83% in large case-control studies carried out in Sokoto and Zamfara states in 2016. In 2017 the implementation area was expanded to include parts of Katsina and Jigawa states.

In view of the potential to implement SMC in all nine states, it was important to assess the effectiveness of SMC distribution through coverage surveys to estimate the proportion of children receiving SMC and the equitability of access to SMC, to ensure that as SMC is scaled-up the distribution can reach all eligible children. Coverage surveys rely on SMC cards and caregiver's recall to establish whether a child was treated in each of the four months of the campaign. We therefore surveyed immediately after each cycle, so that caregiver's reports would be most reliable. At the final survey we asked about treatment in each of the previous months, and compared these estimates of monthly coverage with the estimates obtained immediately after each cycle, to find out whether coverage assessment could be done in future through a single survey after the final SMC cycle.

In 2017, SMC was administered in 4 monthly cycles, the first cycle starting at the end of July, the last cycle at the end of October. A total of about 6.9 million treatments were administered. About 3,000 children were surveyed after each cycle in 66 communities that were selected, with probability proportional to population, to be representative of the implementation areas.

Percentage of children who received SMC

72.5% of children received SMC in cycle 1, 73% in cycle 2, 60% in cycle 3 and 60% in cycle 4. The mean coverage per cycle was 68%. 45% of children received SMC 4 times. These results represent a significant improvement on the coverage in 2016, when the mean coverage per cycle was 55% and 21% of children received 4 treatments. Coverage was lower in Sokoto than in the other states, the mean coverage per cycle was 81% in Zamfara, 64% in Jigawa/Katsina, and 48% in Sokoto, and the percentage of children who received SMC four times was 59% in Zamfara, 48% in Katsina/Jigawa and 18% in Sokoto.

Results for cycle 1

In the first SMC cycle, 73% of children aged 3-59 months received SMC. Of these, 74% had the first dose administered by the health worker, with the remaining two doses of amodiaquine left with the caregiver to administer over the next two days. For 26% of the children who received SMC, the whole blister pack was left with the caregiver who had to administer the dose of SP and the first dose of AQ on the first day, as well as the doses of AQ on the next two days. In total, 95.5% of children who received SMC received all three daily doses according to caregiver reports. When blister packs were inspected, left-over medication was rarely seen. In 59% of households, the caregivers knew in advance the date when the SMC distribution would happen in their community, through announcements by criers, local radio, neighbours, and health workers. The survey included children up to 7 years of age in order to determine if SMC was being given to children outside the recommended age range. About half (51.5%) of children aged 6 to 7 years received SMC. Coverage of SMC, supervision of the first dose, and awareness of SMC campaign dates varied between the states. In Zamfara, 89% of children received SMC, and for 99.9% of these treatments the first dose was administered by the community health worker (CHW). Of the children who received SMC, 97.3% received all three daily doses according to caregivers. 95% of households knew SMC campaign dates in advance. In Sokoto, 54% of children received SMC, and of these only 25.5% had the first dose administered by the CHW. Of children who received SMC, 91.5% received all three daily doses according to caregivers. 28% of households knew of SMC campaign dates in advance. In the SMC areas in Katsina and Jigawa, 78% of children received SMC, 90% with the first dose given by the CHW. 98.3% of treated children were reported to have received all 3 daily doses. 41% of households heard the dates of the campaign in advance. The percentage of older children who received SMC was only slightly lower than the percentage in the target age group. In Zamfara, 79% of 6-7-yr-olds received SMC, in Sokoto 42%, and in Katsina/Jigawa 22%.

Results for cycles 2, 3 and 4

In cycle 2, coverage was similar to cycle 1, 73% of children received SMC. 88% of treatments were supervised (the first dose administered by the CHW). In Sokoto the percentage of first doses supervised increased to 66% compared to 25.5% at cycle 1. In cycles 3 and 4, overall coverage was slightly lower: 60% in cycle 3 and 60% in cycle 4. In Zamfara, coverage was 72% in cycle 3 and 75% in cycle 4, in Jigawa/Katsina dropped to 45% in cycle 3 and increased to 63% in cycle 4. In Sokoto, coverage was 48% in cycle 3 falling to 31% in cycle 4.

Awareness of the dates of SMC campaigns

In Zamfara, the percentage of households who knew the dates of SMC campaigns in advance was 95% for cycles 1 and 2, 77% for cycle 3 and 76% for cycle 4. In the other states, the majority of caregivers were not aware of the dates of cycles 2, 3 or 4 in advance. When caregivers were asked the reasons that their children had missed SMC monthly treatments, the reasons given in the vast majority of cases, in each cycle, were that the CHW did not visit.

Equitability of SMC distribution

When coverage was compared in relation to socioeconomic status, as determined in the basis of a list of household assets, the mean coverage across the 4 cycles was 60% (95%CI 47%,74%) in the poorest of the 5 wealth rankings and 69% (61%,76%) in the highest. The

proportion of children who received 4 treatments was 37.3% in the poorest group and 46.9% in the highest group. SMC was more equitable in Zamfara than in Sokoto. In Zamfara, the percentage of children who received 4 treatments was 58.7% in the poorest group and 51.8% in the highest group, odds ratio 0.70 (95%CI 0.26,1.83). In Sokoto, only 5% in the poorest fifth of the population received 4 treatments compared with 31% in the highest fifth, odds ratio 8.4 (95%CI 1.4,51). Coverage was similar in boys and girls. 11% of children did not receive any SMC treatment (2.3% in Zamfara, 28% in Sokoto, 7% Jigawa and 12% Katsina). Improving equitability will rely on improving coverage in Sokoto.

Caregiver understanding of SMC

Caregivers were asked 10 questions about SMC including the purpose of SMC, the number of tablets to be taken daily, completing the course of treatment, and reporting of side effects. The mean score on a 10-point scale was 5.4, (4.1 in Sokoto, 6.1 in Zamfara, and in 5.0 in Katsina/Jigawa), somewhat lower than scores obtained in similar surveys in other SMC countries (Chad: 8.1; Burkina Faso: 9.1).

Adherence of CHWs to guidelines for SMC administration, as reported by caregivers

Caregivers were also asked about the process of SMC administration by the CHW, including whether the CHW checked the child's age, checked if the child had fever, asked about recent use of other medicines and history of allergy to medicines, explained how to administer doses, about common side effects, and the need to report any side effects. CHW performance was then rated on an 8-point scale. The mean score was 4.6 (3.2 in Sokoto, 4.7 in Zamfara, 6.2 in Katsina and 5.0 in Jigawa). CHWs generally checked age and explained how to give SMC, but were less consistent in checking for fever, asking about allergies, and explaining about side effects.

Use of insecticide-treated bednets in SMC distribution areas at cycle 4

39% of households had at least one LLIN for every two household members. Out of the household members who slept in the house the night before the survey, 60% slept under a bednet but only 33% slept under an LLIN (12.5% in Sokoto, 45% in Zamfara, 55.5% in Katsina and 6.4% in Jigawa). Bednet use was lowest in the age group 10 to 19 years.

Population changes

The surveys included all eligible children who were resident in the survey segments at the time of the survey. The population of children in the survey segments fluctuated during the 4 months of SMC distribution, with an increase of 30% in cycles 2 and 3 compared to cycle 1, and then a return to the cycle 1 level at cycle 4. This occurred primarily in Sokoto. However there was no evidence that this directly affected coverage.

Quality control

Consistency of results obtained when survey interviews were repeated by supervisors, and verification of SMC treatment dates from images of SMC cards, are summarised in the Annex. Key variables showed a high level of repeatability. Care retention was poor and checking against images of cards was possible only in 19 cards, but these showed SMC treatment dates had been accurately captured.

Recommendations

1) The mean coverage per cycle in 2017 was 68% from the final survey, a significant improvement on 2016 when the mean coverage per cycle was 55%. The high coverage achieved in Zamfara (mean of 81% per cycle) shows that higher levels of coverage are feasible. Further improvement in coverage will rely on improving delivery in Sokoto where mean coverage per cycle was 48% and where 28% of children did not receive SMC.

2) Coverage was better in areas where caregivers were made aware of the date of the SMC campaign in advance. Steps should be taken to ensure that communities are informed of the date of the campaigns, before each of the four cycles.

3) Children 6 years and older frequently received SMC. If treatment packs are distributed without the CHW seeing the recipient child, the CHW cannot verify the child's age. It is therefore possible that administration of SMC to older children is more extensive in Sokoto where, in cycle 1, 75% of treatment took place without direct observation. This may be a factor contributing to the low coverage. The first dose of SMC should consist of Directly Observed Therapy (DOT), addressing the lack of DOT may be necessary to reduce treatment of older children in Sokoto, and thus to ensure there are sufficient drugs available to cover all children in the target age range. During survey supervision visits, one community health worker reported that he ran out of drugs each cycle, but did not make his supervisor aware. SMC supervisors and CHWs were aware of the importance of limiting SMC to children under five years but could not verify the age if blister packs were handed over without seeing the child. In-depth interviews with CHWs, SMC supervisors, and members of the community, should be conducted in order to better understand factors affecting SMC delivery in Sokoto. CHWs should alert supervisors if they run out of drugs, and it may be useful to tally the number of households or caregivers during SMC distribution so that the relative number of children per caregiver or household can be monitored, this would give an indication of the extent of treating older children and help to check completeness of distribution.

4) Reported adherence to the two doses of amodiaquine on days 2 and 3 was lower in children whose first dose was not supervised by the CHW than among children whose first dose was administered by the CHW. This is an added reason for ensuring that SMC first dose treatments are always supervised. Reported adherence to the 3-day regimen, when the first dose was supervised, was generally very high and when blister packs were inspected left-over medication was rarely found. However, caregiver-reported adherence may not be very reliable, and it is known that poor adherence to the amodiaquine doses on days 2 and 3 reduces protection of SMC against malaria[3]. It may therefore be useful to assess adherence more carefully, for example through direct observation, and to highlight in CHW training the importance of emphasising adherence.

5) Treatment of older children needs to be taken into account when attempting to reconcile survey estimates of coverage with administrative estimates based on number of treatments from tally sheets divided by the estimate target population, and when forecasting drug demand for SMC campaigns. A high percentage of children 6-7yrs of age received SMC but we did not survey children above 7 years of age to determine

whether children above 7 are routinely receiving SMC. Treating children above 5 years of age should be avoided as the drug dose was designed for under 5's, under-dosing in older children will not give full protection, will increase selection pressure for drug resistance, and will exhaust supplies of SMC drugs preventing high coverage in the target age group being achieved. If wastage and treatment of older children remains unchanged, the number of treatment packs administered will need to be increased from 2017 levels by a factor of 1/(mean coverage per cycle), i.e. by about 2-fold in Sokoto and by 20% in Zamfara, to be able to achieve 100% coverage.

6) SMC is not intended as a replacement for other preventive measures: LLIN use is low and steps should therefore be taken to improve LLIN coverage. SMC training should include messages about the importance of using an LLIN.

7) Coverage should continue to be monitored annually, until acceptable levels of coverage are achieved. Our results show that when coverage per cycle is assessed after the fourth cycle, the results are sufficiently accurate for practical purposes as compared with estimates obtained immediately after the each cycle. Only 10% of children in our final survey had a card for inspection and only half of the treatments indicated on these cards had dates of treatment recorded. Cards should ideally be issued to all children receiving SMC as a record for the caregivers and to allow assessment of coverage. Caregivers should be asked to retain the cards, and CHWs should be trained to record treatment dates on the card.

Background

Malaria continues to be a major public health problem in Nigeria. A nationally representative sample of children under the age of 5 years, conducted from October to November 2015, found that 27% were infected with *Plasmodium falciparum*[1]. Nigeria is the most populous country in Africa, with a population of nearly 200million. WHO estimated that there were 100,000 deaths from malaria in Nigeria in 2016[2]. The greatest malaria burden is in the northern states, with an average prevalence of 37% in the north-west region, 32% in the north-central region, and 26% in the north-east region [1]. The population in these regions are poorer and under-5 mortality rates are higher than in southern regions of the country (Table 1). Seasonal Malaria Chemoprevention, which involves giving children monthly treatment with antimalarial drugs sulfadoxine-pyrimethamine plus amodiaquine for four months during the rainy season to prevent malaria[3], was included in the 2014-2010 National Malaria Strategic Plan for Nigeria, and started to be introduced in the north-west region, the region with the highest malaria prevalence (Table 2), in 2013. Following pilot schemes in 2013-2014 in Katsina, Jigawa and Kano states, SMC was introduced in Zamfara and Sokoto states through the ACCESS-SMC project in 2015 and 2016, an area including 37 Local Government Areas (LGAs) and 1.8 million children. In 2017 SMC distribution was expanded to include 4 LGAs in Katsina state and 2 LGAs in Jigawa state, a total of 43 LGAs, coordinated by Malaria Consortium in partnership with the National Malaria Elimination Programme and funded by Unitaid and through a Givewell-directed funding framework, mostly supported by Good Ventures. In 2017, SMC was administered in 4 monthly cycles, the first cycle starting at the end of July, the last cycle at the end of October (Figure 1). Cluster-sample surveys were conducted shortly after each cycle to assess coverage. This report described the methods and final results from these surveys.

Table 1: Population indicators and malaria prevalence in the regions of Nigeria[#]

Region	Lowest	Low	Wealth rank Middle	High	Highest	Population (2017†)	% women literate‡	*P.falciparum* prevalence in children*	Under-5 mortality (5q0)/1000
North Central	12.1%	29.1%	28.4%	17.9%	12.5%	38,594,880	39.7%	32.0%	100
North East	26.9%	27.9%	23.9%	15.3%	6.0%	22,757,677	32.8%	25.9%	160
North West	42.9%	26.8%	14.7%	8.9%	6.7%	50,481,198	22.4%	37.1%	185
South East	2.3%	7.9%	21.4%	36.0%	32.4%	18,777,041	80.7%	13.7%	131
South South	0.2%	7.6%	22.9%	38.4%	31.0%	29,752,358	72.7%	19.3%	91
South West	3.5%	7.3%	15.2%	24.5%	49.5%	39,509,876	77.9%	16.6%	90

†estimates projected from 2006 census; *by microscopy, survey Oct-Nov 2015 in children 6-59 months old ‡able to read a sentence or part sentence in English, Hausa, Yoruba or Igbo #sources: National Malaria Elimination Programme (NMEP), National Population Commission (NPopC), National Bureau of Statistics (NBS), and ICF International. 2016. Nigeria Malaria Indicator Survey 2015. Abuja, Nigeria, and Rockville, Maryland, USA: NMEP, NPopC, and ICF International. Census data: http://www.nigerianstat.gov.ng/

Table 2: Prevalence of malaria in children in 2015 in North-West Region:

	P.falciparum prevalence*
Jigawa	27.9%
Kaduna	36.7%
Kano	27.7%
Katsina	27.8%
Kebbi	63.6%
Sokoto	46.6%
Zamfara	62.6%

Figure 1: Timing of SMC distribution and surveys in 2017
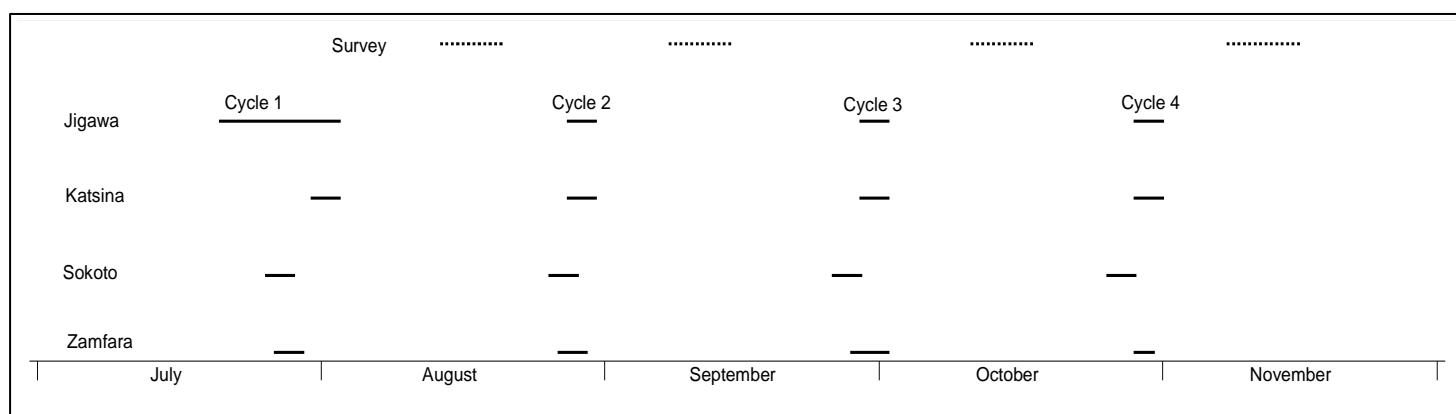
Table 3: Dates of SMC distribution in 2017 and dates of coverage surveys

	SMC distribution dates				
Cycle	Jigawa	Katsina	Sokoto	Zamfara	Survey dates
1	27th-30th Jul	26th-29th Jul	31st-Jul-3rd Aug	31stJul-3rd Aug	14th-21st Aug
2	27th-30th Aug	26th-29th Aug	28th-31st Aug	28th-31st Aug	8th-15th Sep
3	28thAug-2nd Sep	26th-29th Sep	29thSep-2nd Oct	29thSep-2nd Oct	11th-18th Oct
4	29th-31st Oct	26th-29th Oct	29thOct-1st Nov	29th Oct-1st Nov	8th-16th Nov

Seasonal Malaria Chemoprevention

SMC involves administration of a course of treatment of sulfadoxine-pyrimethemine plus amodiaquine over three days, once per month for four months of the malaria transmission season, to prevent malaria. Children aged at least 3 months and less than 5 years are eligible to receive SMC, however children who were under 5 years of age at the first month continue to receive all four monthly treatments even if they reach the age of 5 during the 4-month period of SMC distribution. Each monthly treatment consists of a dose of sulfadoxine-pyrimethamine and a dose of amodiaquine, administered on the first day, and a dose of amodiaquine on each of the next two days. The drugs are distributed by community health workers (CHWs) who visit door to door to administer the first day's doses and leave the blister pack with the caregiver with instructions to administer the remaining

amodiaquine doses. CHWs check the age of the child and select the appropriate blister pack (lower dose for infants, higher dose for children 12-59 month), ask about allergies to SMC drugs, check whether the child has been given sulfadoxine-pyrimethamine or amodiaquine or any sulfa-containing antibiotic in the last 4 weeks, and check if the child has a fever. Children are eligible if they do not have known allergies to the drugs, have not been given amodiaquine or sulfa-containing medication in the last 4 weeks, and are not unwell. Children who are unwell should be referred to the nearest health centre where they can be appropriately treated, including treatment with an ACT if they have malaria. If they do not have malaria, they may receive SMC at the clinic. CHWs should also remind caregivers to bring the child to the health centre if the child becomes unwell at any time after taking SMC, that the child can still develop malaria and so the guidance to seek treatment promptly in case of fever should continue to be followed, and that all household members should sleep under a treated bednet. Each course of SMC treatment provides about 90% protection from malaria for 28 days so that four treatments one month apart can provide a high degree of personal protection for 4 months. Introduction of SMC with high coverage has been found to reduce the incidence of malaria, severe malaria, and malaria deaths substantially. To maximise the impact of the intervention, it is important that the first SMC cycle is timed to start at the beginning of the main transmission period; cycles should take place at monthly intervals, high coverage of four monthly treatments should be achieved, and caregivers should ensure children adhere to the daily regimen each month. Insecticide treated bednets should continue to be used – SMC should be an additional measure not a substitute for bednets. The survey therefore included questions about receipt of SMC, adherence to the regimen, the process of SMC administration by the CHW, and bednet use by children and other members of the household.

Survey methods

SMC was delivered in four cycles, at the end of July/early August, the end of August, the end of September/early October, and the end of October/early November 2017. Four surveys were conducted, the first after cycle 1, from 14th-21st August, the second after cycle 2, from 8th-15th September, the third after cycle 3, from 11th-18th October, and the fourth after cycle 4 from 8th-16th November. The first three surveys used a short questionnaire to assess SMC coverage, the fourth survey recorded SMC treatments received in each of the four cycles and asked additional questions about bednet use, socioeconomic status of caregivers, and about the process of SMC administration. We did not attempt to follow individuals cycle-to-cycle in a cohort study, this would have required issuing individual ID to caregivers or children, which was considered undesirable as, knowing they were part of a cohort, it may have influenced SMC uptake by caregivers, defeating the objective of estimating coverage. SMC cards could not be used as they are linked to receipt of SMC, and were also not widely used in Nigeria. The same survey segment was visited each time and field workers instructed to include every dwelling, and every child, at each visit. Data were captured on tablet PCs using the Iform platform (for cycle 1) and using the Dharma platform (for cycles 2, 3 and 4). Data were uploaded to the server at LSHTM at the end of each day of data collection or as soon as the survey team could access an internet connection.

Sixty-six settlements (villages or urban quarters) were selected with probability proportional to population size, 60 from Sokoto and Zamfara states and 6 from the parts of Katsina and

Jigawa states where SMC was distributed in 2017 (Figures 2 and 3). Sampling methods are described in detail in Annex A2. The primary outcome was the proportion of eligible children treated in each cycle. The key comparisons of interest were to compare estimates obtained after cycle 1, 2 and 3 with estimates for those cycles obtained in the final survey. The proportion of children who received 4 treatments and the mean coverage per cycle were key outcomes of the final survey. The sample size was chosen to have a margin of error of about +/6% for an overall estimate of coverage, if coverage was about 80% and assuming a rate of homogeneity of 0.3 based on previous surveys, while having adequate precision in important subgroups (e.g. about +/- 10% in each of 3 equal geographical strata if coverage is 80% and somewhat better precision for groupings that are primarily within clusters, for example for 5 wealth rankings if these were within-cluster groupings there would be an expected margin of error on a coverage of 80% of about +/-8%).

Figure 2: Location of survey clusters in Sokoto, Zamfara, Katsina and Jigawa
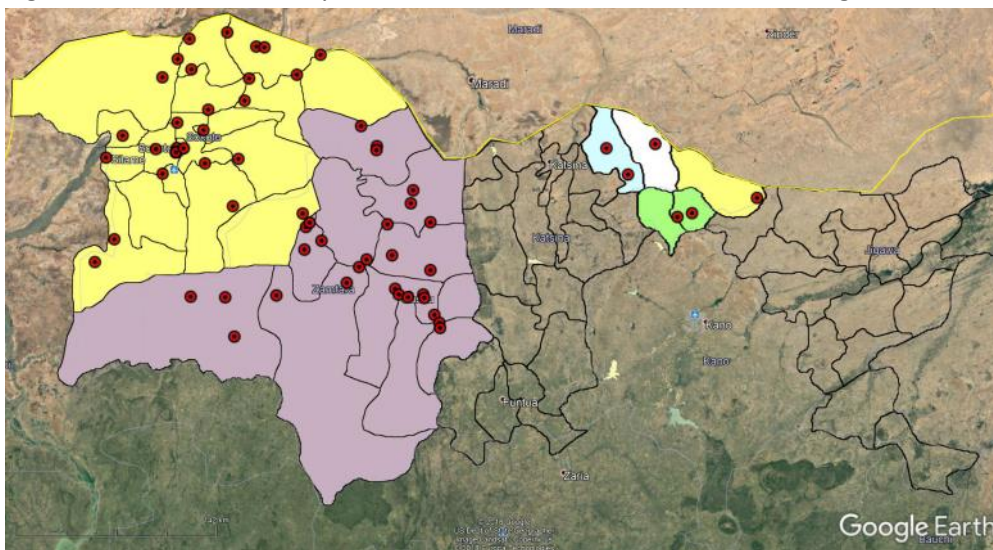
Figure 3: Location of the survey area in Nigeria
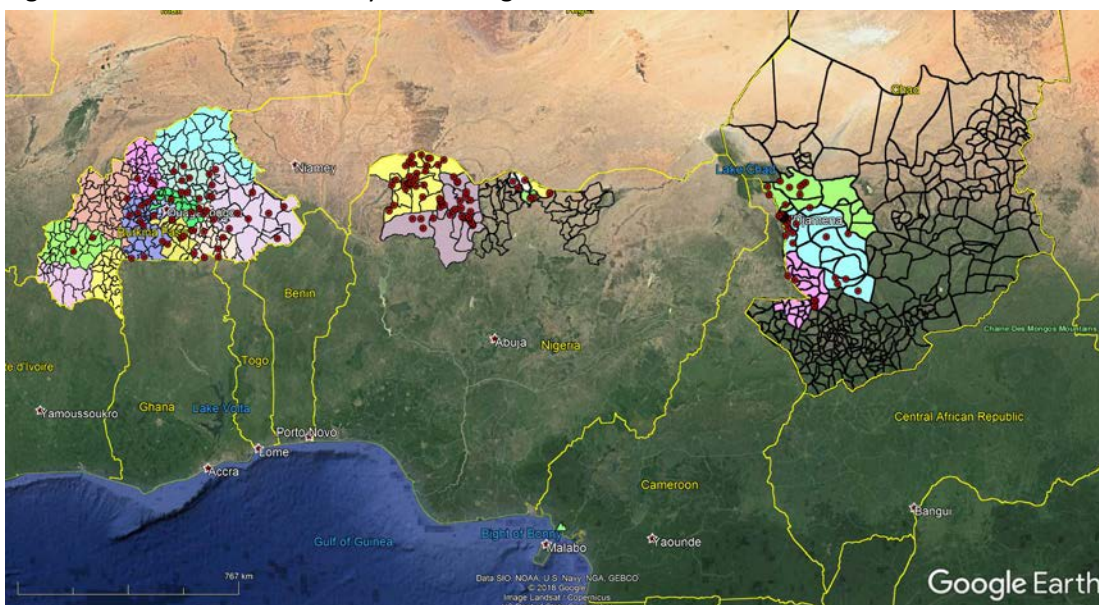
In each selected settlement, area sampling was used to select households to be surveyed. Each settlement was divided into segments, one segment chosen at random, and all households in the selected segment were included in the survey. This reduces the scope for selection bias as it avoids the need for listing households, which is known to be prone to bias, reduces subjectivity in selecting households, and makes it easier for supervisors to check completeness of survey work. The sketch map of the cluster showing the segments was photographed and the image uploaded. The number of segments was entered into the tablet PC which then selected one segment at random. The GPS location of each dwelling visited was also automatically recorded by the tablet PC (Figure 4). In each household, caregivers of children were asked about SMC treatments their child had received, and SMC record cards were inspected and photographed. All children aged 3 months to 7 years were included in order to determine coverage in the target age group (children aged at least 3 months and who were less than 60 months at the time of cycle 1 that year) and to determine the proportion of children in the two years above the recommended age limit who received treatment. In addition, all persons who slept in the household the night before the survey were listed, all bednets owned by the household were also listed and inspected, and for each person, the net they slept under, if any, was noted. (Bearing in mind that ages are not always reported precisely (for children above 1 year, the age may be given in whole years without always reporting the number of months), the following groupings can be defined for purposes of reporting SMC coverage, see Annex, Table A5).

Figure 4: Key steps in the survey process
A-   Rough sketch map is made to divide the survey village into segments
B – GPS locations of dwellings surveyed are automatically recorded
C – lists of dwellings are kept for noting non-response and data captured on tablet PCs
D - signed consent is sought from caregivers after explaining the survey
E – front and reverse of SMC cards are photographed and uploaded for verification
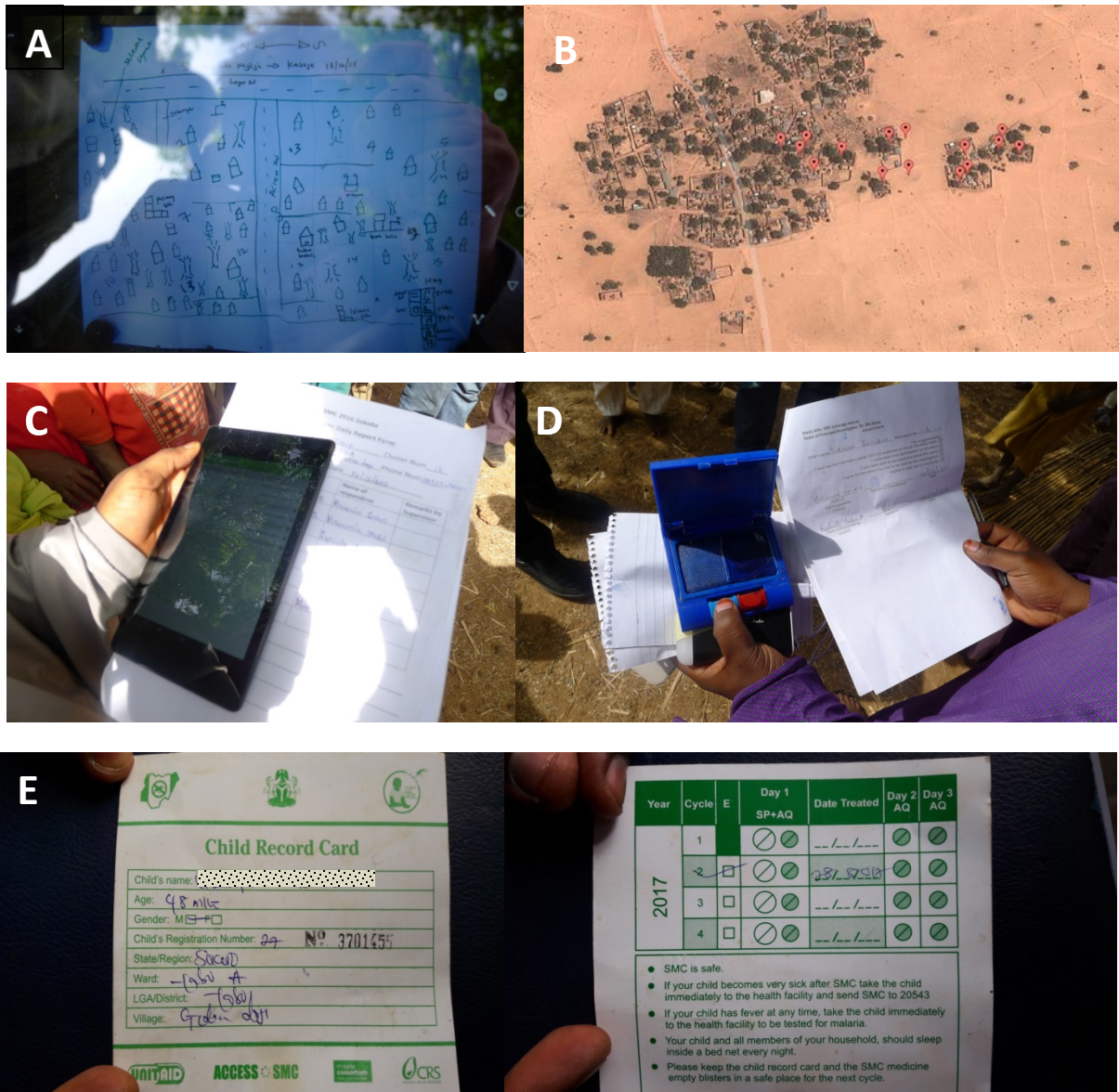
Figure 5: Images of SMC cards are uploaded and incorporated in the Access database for comparison with the data from the card captured by the field worker

Training, piloting and data collection

Approval was obtained from the health research ethics committees of the four participating states. All households with eligible children resident in the household at the time of the survey within the chosen segment were visited. In each household, all children within the age range 3 months to 7 years were included. We included and interviewed all the caregivers in each household. Signed informed consent (written or finger-printed) was obtained from caregivers and details collected for each of their children. SMC status was assessed from dates on the child's SMC card and from caregiver recall, or only from recall when the card was not available. The receipt of SMC was defined as treatment (and therefore excludes SMC contacts where the child was seen but excluded due to illness, allergy or concurrent medication). In the first cycle we were unable to conduct the survey in one selected community of Sokoto State due to security problems. In each selected community, a sketch map was drawn identifying key features that can be easily recognised on the ground (main road(s), paths, Mosque, school, etc.). Then the main blocks of habitation were indicated. The community was divided into a number of segments, with the aim of there being a total population of approximately 100 individuals (of all ages) in each segment. An estimate of the total village population was used to calculate the number of segments needed. The number of segments needed was calculated as the approximate village population total divided by 100, rounded down to the nearest whole number. For example, with a total population of 660 people, 660/100 = 6.6, but 6 segments should be used so that the total population in each segment is slightly more than 100. Having decided on the number of segments, the sketch map of the community was divided into the required number of segments and the segments labelled on the map. Segments were not exactly equal in terms of number of dwellings, some variation is acceptable if this makes them easier to identify on the ground. A random number was selected to choose which segment to be visited using an electronic tool on the tablet. The chosen segment was

indicated on the map with an arrow by writing 'selected'. The sketch map was labelled with district, village and date. Photos were taken of the completed map using the tablet, while the paper version of the map was also retained.

Composition of field teams

During the first cycle coverage survey we derived the total number of households in the selected segment. This total number of households was used to verify that all households in the segment were visited during subsequent cycles 2-4 of SMC cluster coverage survey. The survey was managed by three survey groups, one in Sokoto, one in Zamfara, and one for Jigawa and Katsina. Each group was led by a survey coordinator (coordinators were medical doctors with postgraduate public health training and at least 5 years' field experience). Each group comprised a data manager (with academic qualifications in computer science or information technology with training in data management and 10 years' experience including electronic data collection), a logistics officer (with training in management and experience providing logistic support for research teams) and data collector teams. There were 10 teams (4 in Sokoto, 4 in Zamfara, and 2 in Katsina/Jigawa). For surveys after cycles 1, 2 and 3, each team comprised a supervisor and two (female) interviewers. Supervisors and interviewers had bachelor's degrees in health or science-related fields. For the final survey, there were three female interviewers in each of the 10 teams. Each team was allocated its vehicle and driver that transported them to and from the field. In some instances motorcycles and canoes were employed as means of transportation in hard to reach areas. In each selected community, a local community guide facilitated entry to the community and alerted the community that the survey was taking place. Data was collected by enumerators and directly entered using android tablets. A power bank for each data collector ensured uninterrupted data collection. The collected data was uploaded at the end of each day and checked by the data manager in London.

Training

Each team was allocated a specific number of communities to visit after each SMC cycle of drug distribution. Training over one day was organised for each team before each of the surveys (12 sessions in total). Training consisted of lectures and practical demonstrations covering logistics and preparing for field work, how to approach the community and introduce the survey, mapping and segmentation, household selection, and conducting interviews using the survey questionnaire on handheld devices. A short questionnaire was used for cycles 1-3, and a more detailed questionnaire for cycle 4 which consisted of three separate forms, a household roster, a bednet survey, and a main survey. During the training for cycle 1 the field workers were trained with i-Form builder, the training for cycles 2-4 were based on Dharma. The enumerators found this software easier to use, however there were some problems with configuring the GPS, and difficulties in uploading data.

Supervision arrangements and quality control

Call-backs were arranged to minimise non-response during the team's stay in the community. A record was kept of all households in the segment, noting those with non-response or with missing information. Households requiring completion of missing information were contacted via mobile phones if possible.

On a daily basis we implemented a tracking system that was used to monitor the performance of all teams and its members. On the spot corrections were done by the

supervisors to ensure that the data collectors complied with data collection guidelines. At the end of each day, data collection meetings were held with all team members to share lessons and plan for the next day's activities. Two quality control interviews were conducted per cluster. A repeat interview was conducted in an already enumerated household by an enumerator from another team. The results of the control interviews were compared with original interviews to identify problems with data accuracy, completeness and consistency, and further training of data collectors arranged if necessary.

Detailed results

65 clusters were surveyed in cycles 1 and 2, 66 cycle 3, and 64 in cycle 4. The number of children seen fluctuated, reflecting changes in population during the season, with higher numbers available for the survey in cycles 2 and 3 than in cycles 1 and 4. Response rates were high with a small number of non-responders in each survey. Assessment of coverage was based primarily in caregiver recall as few children had been issued with cards. At the final survey, 36% of children who were eligible for 4 treatments had received a card, of these 28% had cards available for inspection, so that in total 10% of children had an SMC card that could be inspected. Of 196 cards inspected at the final survey (for children eligible for 4 treatments), the total number of SMC treatments indicated was 670, and of these 305 (46%) had a treatment date. Coverage in each cycle, among children eligible to receive SMC at that cycle, is shown in Table 4 and, by state, in Table 5. Geographical variation in coverage at cycle 1, and supervision of first doses at cycle 1, are shown in Figure 7 and Figure 8.

Table 4: Summary of results from the four surveys (all states combined)

Cycle	No. of households surveyed	No. of children 3-59mths	Clusters	% households that heard the date of the SMC campaign	% children 3-59 months who received SMC	% treatments administered DoT	Adherence to both unsupervised doses	% of 6-7yrs who received SMC
1	1,383	2,200	65	58.5%	72.5%	74.4%	95.5%	51.5%
2	1,658	2,868	65	51.2%	73.0%	88.2%	98.0%	49.7%
3	1,734	2,771	66	43.8%	60.1%	90.0%	98.7%	42.8%
4	1,321	1,978	64	49.7%	60.1%	82.6%	98.9%	42.5%

Table 5: Summary of results from the four surveys, for Jigawa and Katsina, Sokoto and Zamfara:

Jigawa/Katsina	Heard the date of SMC	% children 3-59 months received SMC	% treatments administered DoT	Adherence to both unsupervised doses	% of 6-7yrs received SMC	Households	Children 3-59 months	Clusters
1	40.7%	77.8%	89.7%	98.3%	21.7%	125	240	6
2	11.6%	68.5%	97.0%	99.0%	37.0%	153	278	6
3	1.8%	45.2%	88.8%	99.2%	42.3%	166	308	6
4	12.8%	63.4%	81.0%	100.0%	69.4%	114	196	5
Sokoto								
1	28.1%	54.3%	25.5%	91.5%	42.1%	634	960	31
2	6.5%	59.2%	65.9%	94.8%	42.1%	651	1176	32
3	1.8%	48.0%	69.1%	98.3%	29.6%	574	994	32
4	9.8%	31.1%	44.1%	96.8%	21.4%	394	601	31
Zamfara								
1	95.2%	89.3%	99.9%	97.3%	78.5%	624	1000	28
2	94.9%	86.1%	99.7%	99.6%	60.3%	854	1414	27
3	76.7%	72.3%	99.9%	98.8%	55.3%	994	1469	28
4	75.8%	74.7%	91.3%	99.1%	62.9%	813	1181	28

SMC coverage was associated with the percentage of households aware of the date of SMC in advance (Figure 6A), and with the percentage of treatments (first doses) supervised by the CHW (Figure 6B). Adherence to the 3-day regimen is associated with the percentage of treatments (first doses) supervised by the CHW (Figure 6C). These associations may just reflect generally poorer supervision in the low coverage areas. But part of the reason for poor coverage may be lack of publicity about specific dates of SMC – residents need to know when to be at home (Fig 6A). It is possible that where DoT is not practiced, drugs are being distributed more indiscriminately and CHWs are subsequently running out before completing their assigned circuit (Fig 6B). Adherence to the 3-day regimen is improved if the first dose is supervised (Fig 6C).

Figure 6: A: SMC coverage is associated with the percentage of households aware of the date of SMC in advance
B: SMC coverage is associated with the percentage of treatments (first doses) supervised by the CHW
C: Adherence to the 3-day regimen is associated with the percentage of treatments (first doses) supervised by the CHW

Figure 7: Map showing coverage of SMC at cycle 1 (% eligible children treated), per LGA

Figure 8: Map showing % of treatments Directly Observed Therapy at cycle 1, per LGA
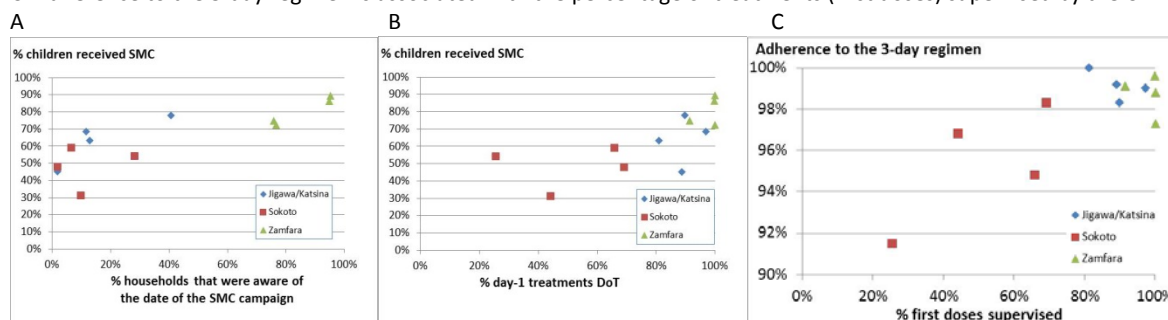
Comparison of coverage estimates for cycles 1-3 from the final survey with the estimates after each cycle

63 clusters were included in all 4 surveys. SMC coverage was estimated in the age group of children that were 3 to 59 months at cycle 1 and hence eligible for 4 treatments. The estimates of coverage in cycle 1, cycle 2 and cycle 3 obtained from the final survey are compared with the estimates obtained immediately after each cycle, in Table 6. There was very close agreement in the overall figures for the 4 states combined. The estimates for cycle 1 were 72% (post cycle) and 73% (final survey); for cycle 2, 72% and 71%; and for cycle 3, 60% and 67%. When coverage was considered by state, a similar close level of agreement was observed in Zamfara (89% and 87% for cycle 1, 86% and 84% for cycle 2, and 72% and 80% for cycle 3). In Sokoto, the corresponding estimates were 54% and 42% for cycle 1, 58% and 48% for cycle 2, and 47% and 47% for cycle 3. IN Katsina/Jigawa, the estimates were 76% and 85% for cycle 1, 62% and 70% for cycle 2, and 45% and 58% for cycle 3. In Katsina/Jigawa, the final survey over-estimated coverage by 8% to 13% but the sample sizes were small and coverage estimates imprecise. The estimates in Sokoto may have been affected by population movement: the number of children available for the final survey was lower than the number seen in the earlier surveys in the same survey segments (560 at the final survey compared with 960 at cycle 1, 1,125 at cycle 2 and 968 at cycle 3). These differences occurred mainly in the clusters in Goronyo, Gada, Wurno, Sabon Birni and Yabo LGAs.

The majority of children did not have SMC cards so these estimates are based primarily on caregiver recall. The excellent agreement suggests caregivers are able to accurately recall the treatments their children received.

Table 6: Comparison of coverage estimates after each cycle with those from the final survey:

	Cycle 1	Cycle 2	Cycle 3
No. of clusters	66	66	66
All states combined:			
No. of clusters visited in all 4 cycles	63	63	63
No. aged 3-59 months at cycle 1	2200	2843	2814
Coverage estimated after the cycle	**71.8%**	**72.4%**	**60.0%**
Coverage per cycle from final survey (N=1934)	**72.7%**	**71.2%**	**67.0%**
Difference between estimates	0.8%	-1.2%	7.1%
(95%CI)	(-6.5%,8.1%)	(-9.3%,6.9%)	(0.0%,14.1%)
Zamfara:			
No. of clusters visited in all 4 cycles	27	27	27
No. aged 3-59 months at cycle 1	969	1403	1468
Coverage estimated after the cycle	**89.2%**	**86.3%**	**72.3%**
Coverage per cycle from final survey (N=1109)	**86.6%**	**84.3%**	**79.9%**
Difference between estimates	-2.6%	-2.0%	7.6%
(95%CI)	(-10.2%,5.0%)	(-12.5%,8.5%)	(-2.6%,17.8%)
Sokoto:			
No. of clusters visited in all 4 cycles	31	31	31
No. aged 3-59 months at cycle 1	960	1125	968
Coverage estimated after the cycle	**54%**	**58%**	**47%**
Coverage per cycle from final survey (N=596)	**42%**	**48%**	**47%**
Difference between estimates	-11.8%	-10.2%	0.3%

	(95%CI)	(-24.2%,0.6%)	(-23.6%,3.0%)	(-10.1%,10.7%)
Katsina/Jigawa:				
No. of clusters visited in all 4 cycles		5	5	5
No. aged 3-59 months at cycle 1		193	223	261
Coverage estimated after the cycle		**76%**	**62%**	**45%**
Coverage per cycle from final survey (N=190)		**85%**	**70%**	**58%**
Difference between estimates		9.6%	8.2%	13.3%
	(95%CI)	(0.1%,19.0%)	(-37.8%,54.1%)	(022.5%,49.1%)

Figure 9: Reliability of the coverage per cycle estimated in the final survey
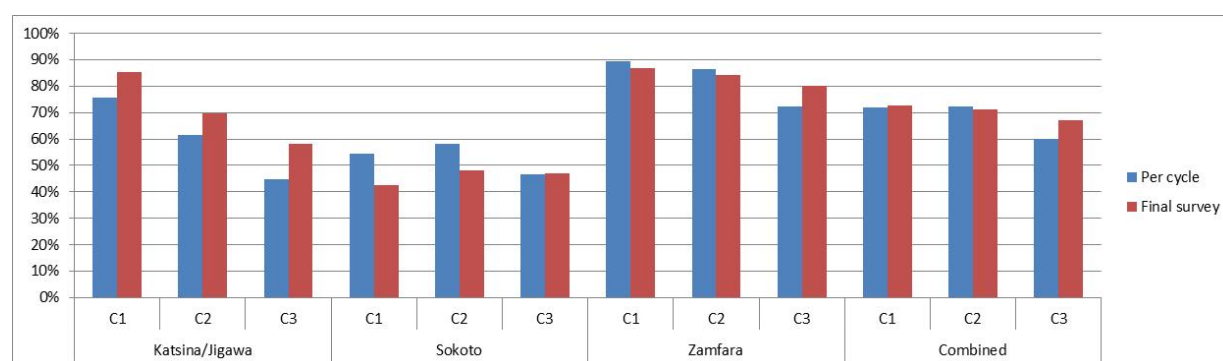
Results for Cycle 1 survey

2200 children aged 3-59 months were surveyed. The survey also included 777 children over 59 months (434 aged 5 years, 343 aged 6-7 years) to check whether older children are being treated. Coverage was good in Jigawa (86%), Katsina (74%) and Zamfara (89%). There seemed to be some problems in Sokoto, where only 54% of children received SMC. In every village surveyed at least some children received SMC so it is not the case that entire villages were omitted from the campaign. The most common reason given for not receiving SMC was that the health worker did not visit the house. When we asked if the caregiver had heard about the date of the SMC campaign, in Zamfara 95% said they had heard, whereas only 26% Sokoto, 33% in Katsina, 55% in Jigawa said they had heard. In Zamfara people heard about SMC from the radio, from criers, from friends and neighbours, and from health workers. In Jigawa and Katsina they did not hear from the radio. Overall, very few heard through the mosque or church. When we asked who administered the first SMC dose, there was a marked difference in the responses between Sokoto and the other states. In Zamfara, almost 100% of children who received SMC had the first dose administered by the health workers, the percentage was 90% in Jigawa and 88% in Katsina, but only 25% in Sokoto. In Sokoto, it seems that blister packs were given to caregivers who then had to administer the first dose themselves. Adherence to unsupervised doses appears to be very good based on caregiver replies and the fact that left over medication was rarely found. Among older children aged 6-7 years, 78% were treated in Zamfara, 42% in Sokoto, 22% in Katsina and 23% in Jigawa. It would seem, based on the results for Sokoto and Zamfara, that children aged 6 to 7 years were almost as likely to be treated as children under 5 years of age (Zamfara: 89% 3-59 months, 78% 6-7yrs; Sokoto 3-59 months 54%, 6-7yrs 42%). Looking at coverage by LGA, in Zamfara, 6/14 LGAs had coverage less than 90% but none less than 67%. In Sokoto, 5/20 LGAs had coverage above 90%, 8/20 had coverage less than 50%. One LGA could not be surveyed because of security problems. Of the four LGAs surveyed

in Katsina, coverage was higher in Dutsi and Mai'Adua than in Baure and Mashi. Only one LGA was surveyed in Jigawa (86% coverage). When caregivers were asked for their suggestions about how to improve the SMC programme, the most common suggestion was for health workers to visit every house.

Table 7: Coverage and adherence among eligible children aged 3-59 months (Cycle 1)

State	No. surveyed	% treated	% took 3 doses
Jigawa	76	86%	97%
Katsina	164	74%	100%
Sokoto	960	54%	95%
Zamfara	1,000	89%	98%
TOTAL	2,200	72.5%	97.2%

Table 8: Supervision of the first dose in cycle 1

Administration of first dose	Jigawa	Katsina	Sokoto	Zamfara	Total
CHW	66 (90%)	136 (88%)	164 (24%)	1,109 (99.7%)	1,475 (73%)
Caregiver, observed	7 (9.5%)	6 (3.9%)	110 (16%)	0 (0%)	123 (6.1%)
Caregiver, not observed	0 (0%)	13 (8.4%)	394 (59%)	0 (0%)	407 (20%)
Not given	0 (0%)	0 (0%)	2 (0.3%)	3 (0.27%)	5 (0.25%)

Table 9: Treatment in children older than 59 months at cycle 1:

Age	Jigawa	Katsina	Sokoto	Zamfara	Overall
Percent treated:					
5yrs	75%	60%	45%	82%	62%
6yrs	29%	29%	39%	75%	52%
7rs	0%	0%	63%	100%	58%
Number surveyed:					
5yrs	8	45	211	170	434
6yrs	7	31	143	117	298
7rs	2	10	19	14	45

Table 10: Coverage by LGA, cycle 1

LGA	Jigawa	Katsina	Sokoto	Zamfara	No. eligible
Kazaure	86%				76
Baure		93%			45
Mashi		87%			47
Dutsi		57%			40
Mai'Adua		50%			32
Bodinga			100%		30
Rabah			100%		33
Binji			97%		38
Tangaza			97%		30

Shagari	94%	35
Isa	81%	26
Sokoto North	81%	31
Wurno	80%	66
Sokoto South	63%	27
Illela	62%	52
Gwadabawa	55%	49
Wamako	54%	52
Sabon Birni	44%	72
Dange Shuni	43%	60
Kebbe	43%	28
Tambuwal	40%	50
Goronyo	39%	66
Gada	30%	120
Kware	13%	39
Yabo	13%	32
Silame	-	24
Anka	100%	40
Bakura	100%	38
Maradun	100%	33
Talata Mafara	100%	134
Bukkuyum	97%	79
Gummi	95%	41
Tsafe	94%	105
Maru	90%	59
Gusau	86%	88
Birnin Magaji/kiyaw	84%	75
Bungudu	80%	93
Zurmi	78%	93
Kaura Namoda	70%	56
Shinkafi	67%	66

(One cluster could not be surveyed due to security problems)

Figure 10: Awareness about the SMC campaign dates: proportion of households that heard the dates and the source of information (cycle 1).
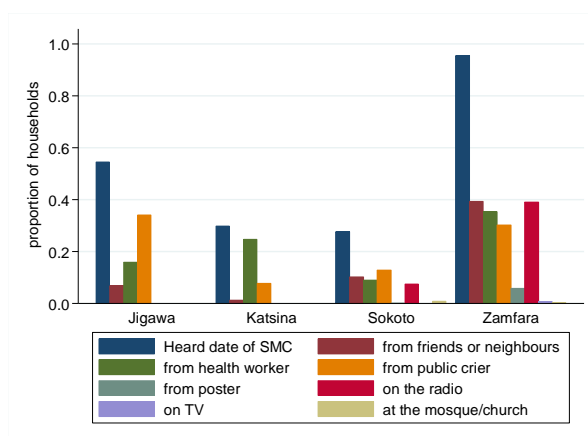
Table 11: Reasons for missed treatments (cycle 1)

Reason	Jigawa	Katsina	Sokoto	Zamfara
Health worker did not visit	10	19	396	80
Child unwell		11	5	11
Caregiver away		3	7	
Child was away on day of SMC			2	6
Child lives away from home		1	1	2
Problems at distribution point		4		
Unable to take child to health worker		3	2	2
Did not know about SMC		1	3	2
Did not know 4 treatments were needed		1		
Family refused			4	3
Other reason		1	3	6

Results for Cycle 2

The survey took place between 8th September and 13th September 2017, just after cycle 2 had been completed. A total of 1,658 households in 65 clusters were were visited, and 99.4% participated in the survey. Overall coverage among children aged 3-59 months was 73.0%, coverage was higher in Zamfara than in the other states (86.1% in Zamfara, 59.2% in Sokoto, 61.4% in Jigawa and 70.9% in Katsina). The overwhelmingly most common reason given for not receiving SMC was that the healthworker did not visit the household. In Zamfara, most caregivers had heard the date of the campaign but in other states most had not, suggesting that community activities using criers and other channels was not performed consistently in the other states. The first dose of SMC was administered by the health worker in most cases except in Sokoto where for 187/583 (32%) of children who were reported to be treated, the blister pack had been given to the caregiver to administer the dose of SP and the first dose of AQ, which was done after the health worker had left. 290 children 6 years and above were included in the survey; about half of these (49.7%) received SMC at cycle 2.

Figure 11: Awareness about SMC campagn dates, cycle 2
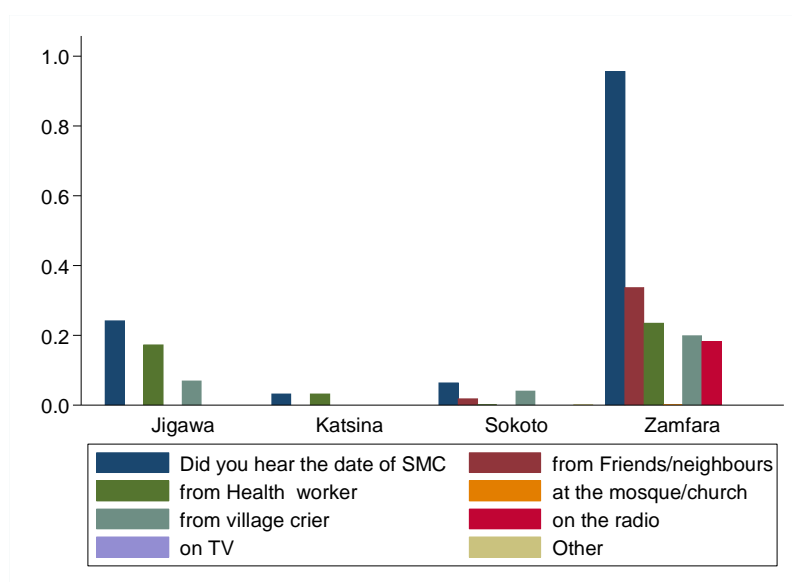
Table 12: Coverage of SMC in older children (cycle 2)

	n/N	%	95% CI
Number of older children sampled			
5-6yrs	446		
6yrs or more	290		
SMC Coverage - 6 or more	146/290	49.7	(39.7-60.9)
SMC Coverage 6+yrs, by State:			
Jigawa	2/8	25.0	(7.4-58.0)
Katsina	4/8	50.0	(9.5-90.5)
Sokoto	59/140	42.1	(28.1-57.5)
Zamfara	81/134	60.4	(44.1-74.7)

Table 13: Coverage of SMC amongst eligible children by LGA (Cycle 2)

	n/N	%	95% CI
SMC Coverage of Eligible – Overall	1916/2597	73.0	(65.3-80.8)
SMC Coverage of Eligible children by LGA			
Anka	19/19	100.0	
Bakura	52/56	92.9	
Baure	29/29	100.0	
Binji	14/25	56.0	
Birnin Magaji/kiyaw	91/99	91.9	
Bodinga	46/51	90.2	
Bukkuyum	109/110	99.1	
Bungudu	95/105	90.5	
Dange Shuni	27/41	65.9	
Dutsi	0/36	0.0	
Gada	24/79	30.4	
Goronyo	48/81	59.3	
Gummi	59/59	100.0	
Gusau	88/150	58.7	
Gwadabawa	31/53	58.5	
Illela	32/55	58.2	
Isa	23/28	82.1	
Kaura Namoda	71/114	62.3	
Kazaure	62/101	61.4	
Kebbe	56/63	88.9	
Kware	8/37	21.6	
MaiAdua	27/35	77.1	
Maradun	45/45	100.0	
Mashi	51/51	100.0	
Rabah	43/45	95.6	
Sabon Birni	35/95	36.8	
Shagari	42/42	100.0	
Shinkafi	57/88	64.8	
Silame	18/32	56.3	
Sokoto North	12/27	44.4	
Sokoto South	28/67	41.8	
Talata Mafara	188/198	94.9	
Tambuwal	24/45	53.3	
Tangaza	33/33	100.0	
Tsafe	150/166	90.4	
Wamako	40/65	61.5	
Wurno	26/55	47.3	
Yabo	7/7	100.0	
Zurmi	106/109	97.2	

Results for Cycle 3

The cycle 3 survey took place between 11th October and 15th[th] October 2017. A total of 1,734 households were visited and 99.1% agreed to participate in the survey, the reasons for non-response were, inability to find someone to speak with; no children aged between 3 months and 7 years and interviewers unable to access compound.

Table 14: Coverage of SMC Amongst eligible children by LGA, cycle 3

	n/N	%	95% CI
SMC Coverage of Eligible - Overall	1553/2563	60.1	(50.1-70.2)

SMC Coverage of Eligible children by LGA			
Anka	3/10	30.0	
Bakura	52/52	100.0	
Baure	53/53	100.0	
Binji	29/30	96.7	
Birnin Magajikiyaw	98/107	91.6	
Bodinga	31/44	70.5	
Bukkuyum	66/83	79.5	
Bungudu	39/149	26.2	
Dange Shuni	13/44	29.5	
Dutsi	0/50	0.0	
Gada	19/70	27.1	
Goronyo	2/67	3.0	
Gummi	48/51	94.1	
Gusau	66/128	51.6	
Gwadabawa	15/52	28.8	
Illela	8/57	14.0	
Isa	35/36	97.2	
Kaura Namoda	48/106	45.3	
Kazaure	54/95	56.8	
Kebbe	54/60	90.0	
Kware	30/34	88.2	
MaiAdua	0/34	0.0	
Maradun	47/47	100.0	
Maru	63/70	90.0	
Mashi	25/47	53.2	
Rabah	16/50	32.0	
Sabon Birni	13/42	31.0	
Shagari	28/30	93.3	
Shinkafi	49/93	52.7	
Silame	8/24	33.3	
Sokoto North	8/30	26.7	
Sokoto South	0/34	0.0	
Talata Mafara	193/224	86.2	
Tambuwal	26/48	54.2	

Tangaza	31/31	100.0
Tsafe	135/173	78.0
Wamako	27/61	44.3
Wurno	49/66	74.2
Yabo	6/6	100.0
Zurmi	66/75	88.0

Table 15: Reasons for missed treatments at cycle 3

	Jigawa	Katsina	Sokoto	Zamfara	Total
Caregiver not available	1	0	2	2	5
Child was away on the day	0	0	7	5	12
Child was living away from home	0	1	2	1	4
Child was unwell	1	0	0	3	4
Did not realise child should get SMC	0	0	3	2	5
Family refused	0	0	2	0	2
Other reason	0	1	2	0	3
Problems at distribution point	0	0	1	0	1
The health worker did not visit the household	39	104	442	354	939
Unable to take child to health worker	0	0	7	28	35
Total	41	106	468	395	1010

Results for final survey

The survey took place between 8th November and 17th November 2017. A total of 1321 households were included, there was only one refusal (Table 16). One village out of 66 villages (Sangi Skofa) could not be visited due to security issues.

Table 16: Final survey response rates and the number of households, children and other household members surveyed

Households surveyed	No. of households	%
Agreed to participate	1321	99.9
Refused to participate	1	0.1
TOTAL	1322	
Children Surveyed	**No. of children**	
Aged 3-59 months at cycle 4 survey (eligible for SMC at cycle 4)	1978	
Aged 3-59 months at cycle 1 (eligible for 4 SMC treatments)	1688	
Aged 5-6 years at cycle 4 survey	173	
Aged 6-7 years at cycle 4 survey (>5 years of age at cycle 1)	119	
Caregivers surveyed	1451	
Total population surveyed:	**No. of household members**	
Slept in the household the night before the survey	5863	
TOTAL	5863	

The percentage of households that were aware of the date of the campaign varied (Figure 12, Table 17), from 76% in Zamfara, to only 9.7% in Sokoto, 23% in Jigawa and 2.9% in Katsina.

Caregiver knowledge about SMC was poorer than has been recorded in surveys in other countries, with a knowledge score of 5.4 (Table 18, 20) compared to scores of 8 to 9 out of 10 in Chad and Burkina Faso. Adherence to guidelines by CHWs as reported by caregivers (Table 19, 20) was also poorer than in other countries. CHWs checked the child's age and explained to caregivers how to administer the tablets, but often did not perform other tasks such as checking for fever and explaining about side effects.

Figure 12: Public awareness about SMC, and about the dates of the most recent SMC campaign (cycle 4), and where caregivers heard about date of the campaign
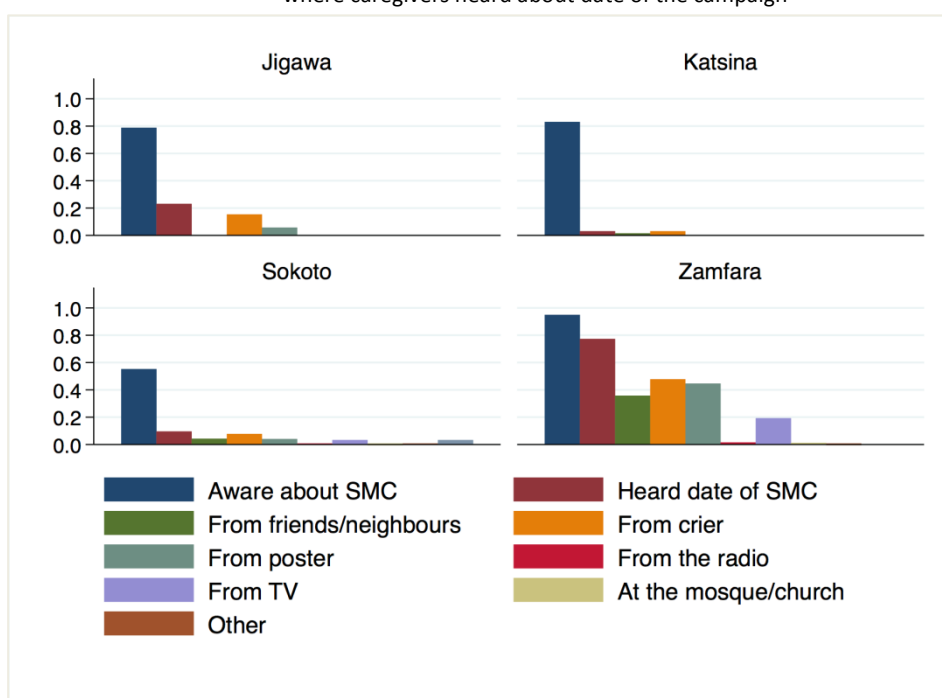
Table 17: Percentage of households that were aware of the SMC programme, had heard the date when cycle 4 would start in their village, and the source of the information

State		Household aware about SMC	Heard the date of cycle 4	From friends/ neighbour	From a health worker	From a crier	From posters	On the radio	On TV	At the mosque/church	Other*
	Jigawa	79.1	23.1	0.0	15.4	5.9	0.0	0.0	0.0	0.0	0.0
	Katsina	83.2	2.9	1.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sokoto	56.2	9.7	4.3	8.2	4.0	0.4	3.3	0.3	0.4	3.3
	Zamfara	94.9	75.9	36.8	50.0	41.9	1.3	19.3	1.2	0.2	0.0
Total		81.9	49.7	23.3	33.2	26.4	0.9	12.5	0.8	0.3	1.0

Table 18: Caregivers' knowledge scores on SMC

Question	Correct answer
1) For how many months should the child take SMC	4
2) SMC is given to prevent malaria	Yes
3) SMC can prevent other diseases	No
4) How many tablets should the child take on the first day?	2
5) How many tablets should the child take on the second day?	1
6) How many tablets should the child take on the third day?	1
7) The child should swallow all the medication	Yes
8) I can give the tablets to someone else who is unwell	No
9) The child should complete the 3-day course of treatment	Yes
10) I should take the child to the health centre if unwell after SMC	Yes

Table 19: CHW adherence to guidelines

Action	% of households who reported that the CHW performed the action at the last visit:
1 Check the child's age	73.8
2 Explain how to administer tablets	81.1
3 Check for illness or fever	53.1
4 Explain the common side effects of SMC drugs	35.5
5 Advise to bring the child to the health centre if they are unwell	47.6
6 Ask if the child had taken other medicines in the last 4 weeks	36.3
7 Ask if the child had side effects to SMC before	34.7
8 Ask about allergies to medicines	30.7

Table 20: Mean caregivers' knowledge scores, and CHW practice scores:

State	Average caregiver knowledge score (out of 10)	Average reported CHW score for adherence to guidelines (out of 8)
Jigawa	5.2	5.0
Katsina	5.0	6.2
Sokoto	4.1	3.2
Zamfara	6.1	4.7
Total	5.4	4.6

Table 21: Percentage of children who were definitely eligible at cycle 4 (aged 3-59 months), who received SMC, and of those who received SMC, the percentage who received all 3 daily doses:

State	Percentage treated	Percentage who received all 3 daily doses
Jigawa	76.3	100.0
Katsina	54.2	100.0
Sokoto	31.1	97.3
Zamfara	74.7	99.3
Total	60.1	99.0

Table 22: Out of those who received SMC at cycle 4, the percentage whose first dose was administered by the CHW, the percentage that received the second dose, and the percentage that received the third dose:

State	First dose administered by the CHW	Second dose given	Third dose given
Jigawa	82.4	100.0	100.0
Katsina	79.3	100.0	100.0
Sokoto	44.1	97.3	97.9
Zamfara	91.3	99.6	99.3
Total	82.6	99.3	99.1

Table 23: Reasons for not receiving SMC at cycle 4:

Reason	%
Caregiver not available	4.1
Child has history of allergies to drugs	0.4
Child was away at the time	1.3
Child was living away from home	0.6
Child was unwell	0.3
Family refused	0.3
Not applicable	1.5
Other reason	2.1
The health worker did not visit the household	88.6
Unable to take child to health worker	0.9

Table 24: Reasons for not administering doses 2 and 3 at cycle 4:

Reason	%
Reasons for not giving dose 2:	
Carer away	5.1
Child had side effects	3.2
Child refused	3.5
Lost the tablets	0.9
Did not understand	2.6
Other[a]	84.8
Reasons for not giving dose 3:	
Carer away	6.3
Carer too busy	2.1
Child had side effects	3.0
Child refused	3.3
Lost the tablets	1.1
Did not understand	3.3
Other[b]	80.9

a) Other reasons for dose 2: Caregiver refused (5.3%), Child does not need drug (1.3%), Child not given SMC (1.3%), Child was away from home (4.0%), Child was sick (5.3%), Didn't collect SMC (4.0%), Don't know (1.3%), Health worker did not visit household (77.6%)

b) Other reasons for dose 3: Caregiver refused (7.1%), Child does not need drug (3.8%), Child was away from home (1.8%), Child was sick (7.4%), Didn't collect SMC (3.8%), Gave 2 tablets on day 2 (1.8%), Health worker did not visit household (77.0%)

Table 25: Primary caregiver present at SMC administration

Who waited with the child	% of households
Cousin	0.1
Family Friend	0.1
Father	2.0
Grandmother	1.4
Mother	95.2
Neighbour	0.1
Other	0.5
Sister	0.5

Table 26: Time caregiver spent waiting for SMC:

How do you rate the time:	% of respondents
Spent waiting in total:	
All Day	0.2
Very Long	0.2
Long	0.8
Neither Short Nor Long	4.7
Short	63.2
Very Short	30.9
Time spent waiting for the CHW:	
Less than 1 hour	70.0
1-2 hours	0.2
A full day	0.3
Don't know	29.4
Time taken to administer SMC in the household:	
Less than 15 minutes	70.7
15-30 minutes	3.5
30 minutes - 1 hour	0.9
1-2 hours	0.1
Long wait of more than 2hrs	0.2
Don't know	24.5

Table 27: SMC coverage among children eligible for four treatments, by state:

Region or State	Mean number of treatments	% that received SMC at each cycle:			
		Cycle 1	Cycle 2	Cycle 3	Cycle 4
Jigawa	3.40	91.2	91.3	80.9	76.4
Katsina	2.34	83.2	56.9	42.6	51.5
Sokoto	1.71	42.8	48.1	48.3	31.9
Zamfara	3.28	87.9	85.7	80.3	74.3
TOTAL	2.73	73.6	72.2	67.7	59.5

Table 28: SMC coverage among children eligible for four treatments, by socioeconomic ranking:

		% that received SMC at each cycle:			
Wealth ranking	Mean number of treatments	Cycle 1	Cycle 2	Cycle 3	Cycle 4
Lowest	2.41	69.7	59.4	61.7	54.0
Low	2.90	76.5	75.3	74.4	65.6
Middle	2.79	76.2	75.7	70.6	62.7
High	2.64	68.4	69.9	65.9	55.2
Highest	2.75	76.4	79.2	64.9	60.0

Table 29: Mean coverage over the 4 cycles, percentage received 4 treatments, and percentage who did not receive SMC, by wealth ranking in each state:

Wealth ranking	Zamfara			Sokoto			Katsina/Jigawa		
	Mean coverage per cycle	% received 4 SMC	% received no SMC	Mean coverage per cycle	% received 4 SMC	% received no SMC	Mean coverage per cycle		% received 4 SMC
Poorest	82.3%	60.3%	1.8%	32.7%	4.9%	33.2%	55.3%	37.3%	21.9%
Poor	85.6%	66.5%	1.0%	51.9%	21.6%	16.4%	73.2%	41.0%	0.0%
Middle	82.7%	61.3%	1.6%	30.7%	10.1%	42.7%	59.2%	36.0%	7.1%
High	77.9%	57.5%	4.3%	37.5%	16.5%	35.3%	85.2%	70.3%	0.0%
Highest	76.4%	52.0%	4.1%	51.7%	30.8%	20.9%	83.8%	74.9%	10.8%

Figure 13: Wealth ranking of households, by state:
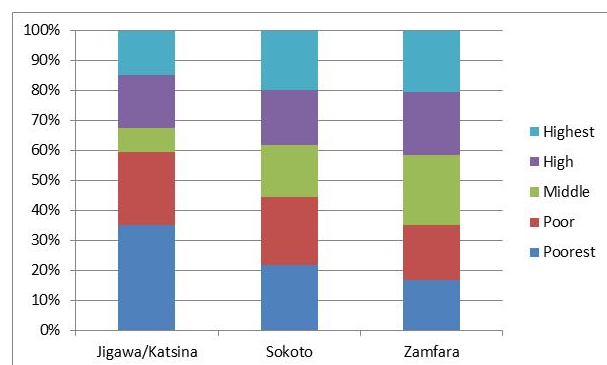
Table 30: SMC coverage among children eligible for four treatments, by gender:

		% that received SMC at each cycle:			
Gender	Mean number of treatments	Cycle 1	Cycle 2	Cycle 3	Cycle 4
Female	2.70	74.6	71.1	66.0	58.4
Male	2.76	72.6	73.5	69.6	60.8

Table 31: Number of SMC treatments: percentage of children who received SMC 0, 1, 2, 3 or 4 times:

	% children who received SMC 0,1,2,3,4 times				
State	**0**	**1**	**2**	**3**	**4**
Jigawa	7.3	1.5	11.9	2.9	76.4
Katsina	11.8	12.4	37.2	7.1	31.6
Sokoto	28.4	24.8	13.1	14.8	19.0
Zamfara	2.3	5.6	14.5	17.0	60.6
TOTAL	11.4	11.9	15.4	14.9	46.4

Table 32: Percentage of children by SMC cycles received:

Received SMC at cycle:

1	**2**	**3**	**4**	**% of children**
0	0	0	0	11.4
0	0	0	1	1.3
0	0	1	0	2.5
0	1	0	0	2.7
1	0	0	0	5.4
1	1	0	0	8.3
1	0	1	0	0.9
1	0	0	1	2.4
0	1	1	0	1.3
0	1	0	1	0.3
0	0	1	1	2.3
1	1	1	0	8.0
1	1	0	1	8.3
1	0	1	1	1.6
0	1	1	1	4.7
1	1	1	1	46.4

Table 33: Treatment of children above the age limit for SMC (aged 6-7 years at the survey):

		% Treated at cycle					
State	**Mean number of treatments**	**Cycle 1**	**Cycle 2**	**Cycle 3**	**Cycle 4**	**Given an SMC card**	**Number surveyed**
Jigawa	4.0	100.0	100.0	100.0	100.0	50.0	2
Katsina	1.7	73.2	23.8	23.8	48.5	73.2	4
Sokoto	1.2	28.3	41.2	25.1	25.0	6.8	61
Zamfara	2.8	84.1	68.0	64.2	60.2	34.7	52
Overall	1.9	55.4	53.2	43.4	42.5	22.2	119

Table 34: Percentage of eligible children who received an SMC card, and the percentage with a card available for inspection during the survey:

State	Given SMC card	Card available for inspection
Jigawa	30.1	5.1
Katsina	44.8	2.1
Sokoto	27.7	
Zamfara	41.3	27.7
TOTAL	36.7	29.5

Table 35: Agreement between caregiver report and SMC card:

Cycle	Card 0 Carer 0	Card 1 Carer 1	Card 0 Carer 1	Card 1 Carer 0	% Agreement	kappa
1	33	157	17	3	90.5	0.710
2	15	169	19	7	87.6	0.468
3	8	182	18	2	90.5	0.403
4	45	149	7	9	92.4	0.798

Table 36: Percentage of children 3-59months who slept under a bednet (of any type) the night before the survey:

State	Slept under a net (of any type) last night
Jigawa	73.6
Katsina	71.9
Sokoto	34.7
Zamfara	82.4
TOTAL	66.8

Table 37: Percentage of household members who slept under a bednet, out of those who slept in the household the night before the survey, by state:

State	Any net	LLIN	Intact net	Net <2yrs old	No. surveyed
Jigawa	64.9	6.4	1.7	0.4	228
Katsina	59.3	55.5	29.0	9.2	327
Sokoto	27.3	12.5	6.6	3.4	1526
Zamfara	79.2	45.4	32.2	10.4	2587
TOTAL	59.8	33.1	21.8	7.4	4668

Table 38: Percentage who slept under a bednet, out of those who slept in the household the night before the survey, by age group:

Age	Any net	LLIN	Intact net	Net <2yrs old	No. surveyed
<10yrs	64.5	35.4	23.7	8.0	2135
10-14yrs	31.5	21.3	7.7	4.1	239
15-19yrs	41.3	23.5	15.3	6.3	174
20-24yrs	64.7	34.6	23.1	6.9	353
25-30yrs	69.4	41.1	29.9	9.6	374
30-39yrs	60.5	33.4	22.6	8.0	851
40+yrs	49.6	25.9	15.3	5.1	542
TOTAL	59.8	33.1	21.8	7.4	4668

Table 39: Percentage who slept under a bednet, out of those who slept in the household the night before the survey, by wealth ranking:

Wealth quintile	Any net	LLIN	Intact net	Net <2yrs old	No. surveyed
Lowest	58.5	30.5	21.0	8.6	854
Low	56.8	29.7	17.5	3.6	1044
Middle	63.0	38.5	27.3	8.9	885
High	59.0	32.1	22.5	10.0	926
Highest	61.0	33.1	20.2	7.0	887

Table 40: Percentage who slept under a bednet, out of those who slept in the household the night before the survey, by gender:

Gender	Any net	LLIN	Intact net	Net <2yrs old	No. surveyed
Male	56.8	31.1	20.8	7.1	2143
Female	62.3	34.8	22.6	7.7	2525

Table 41: Percentage of the population who could sleep under a net if two people slept under each net: (values in the main part of the table are row percentages):

No. who slept in the household last night	No. of nets in the household (of any type):									No. of households	% could sleep under net if 2/net
	0	1	2	3	4	5	6	7	8+		
1	77.1	4.9	18.0	0.0	0.0	0.0	0.0	0.0	0.0	6	22.9
2	21.3	1.2	72.6	4.9	0.0	0.0	0.0	0.0	0.0	85	78.7
3	22.0	1.8	9.6	66.0	0.3	0.0	0.0	0.3	0.0	359	77.4
4	26.8	0.9	8.8	19.9	43.6	0.0	0.0	0.0	0.0	255	72.7
5	33.6	0.7	6.2	9.6	9.0	41.0	0.0	0.0	0.0	144	64.8
6	28.2	2.3	4.3	11.5	11.1	13.6	29.0	0.0	0.0	98	68.8
7	35.0	0.0	5.1	1.9	5.3	7.3	9.2	36.1	0.0	58	62.5
8+	37.1	7.1	1.4	4.5	3.3	2.9	5.9	18.2	19.5	67	53.3
TOTAL	27.2	1.7	12.9	29.8	12.9	7.3	3.6	3.3	1.3	1072	71.2

Table 42: Percentage of the population who could sleep under a LLIN if two people slept under each net: (values in the main part of the table are row percentages):

No. who slept in the household last night	No. of nets in the household (LLINs):									No. of households	% could sleep under net if 2/net
	0	1	2	3	4	5	6	7	8+		
1	82.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	6	18.0
2	48.5	2.3	46.8	2.3	0.0	0.0	0.0	0.0	0.0	85	51.5
3	52.5	1.2	7.5	38.5	0.0	0.0	0.0	0.3	0.0	359	47.1
4	65.2	0.0	4.1	11.9	18.8	0.0	0.0	0.0	0.0	255	34.8
5	60.4	0.7	4.4	8.1	4.9	21.6	0.0	0.0	0.0	144	38.3
6	63.4	3.4	2.0	8.6	4.7	6.2	11.8	0.0	0.0	98	33.7
7	55.3	0.5	5.1	1.9	5.3	5.1	9.2	17.6	0.0	58	41.9
8+	69.9	2.9	1.4	3.1	0.0	0.0	6.1	13.4	3.4	67	26.0
TOTAL	58.6	1.2	8.6	18.0	5.7	3.7	2.0	2.0	0.2	1072	40.4

Table 43: Percentage of households with at least one net, and percentage of households with at least one net for every two people who slept in the household the night before the survey:

State	Net of any type		LLIN		Intact net		Net <2yrs old		No. of households
	1 or more	At least 1 per 2	1 or more	At least 1 per 2	1 or more	At least 1 per 2	1 or more	At least 1 per 2	
Jigawa	83.6	78.9	7.0	4.7	2.3	2.3	2.3	0.0	42
Katsina	65.3	61.9	60.3	56.8	33.8	27.0	14.0	9.0	58
Sokoto	36.0	30.3	14.2	12.5	7.9	6.9	4.3	3.3	298
Zamfara	89.4	86.4	54.5	51.8	41.1	38.0	14.3	12.7	674
TOTAL	72.8	68.9	41.4	38.9	29.5	27.0	10.9	9.3	1072

Table 44: Adverse drug reactions reported after cycle 4:

No. children reported unwell	29 (1.5%)			
		No. of times per day:		
Symptoms reported:		1	2	3+
Vomitting	11 (37.9%)	2	3	6
Diarrhoea	12 (41.4%)	3	3	6
		Severity*:		
		mild	moderate	severe
Yellow eyes	2 (6.9%)	2	0	0
Rash	1 (3.4%)	1	0	1
Abdominal pain	5 (17.2%)	2	1	2
Loss of appetite	9 (31%)	0	3	4
Fever	25 (86%)	4	18	3
Drowsiness	3 (10%)	1	2	0
Itchiness	1 (3.4%)	0	1	0

*mild: does not prevent play; moderate: prevents normal play; severe: caregiver believed the child needed to see a healthworker about these symptoms

Annex

A1. Quality control

Repeat interviews

These were organised by supervisors to check the accuracy of each interviewer's recordings. A total of 115 households were visited twice, with the agreement being checked manually each time for each data field, as part of field worker supervision. The data on the agreement between original and supervisor interviews are shown below for two variables: the number of eligible children in the household and the number of children who received SMC. There was 90% agreement for each variable, indicating good repeatability for these key variables.

Number of eligible children:

First interview	Repeat interview			
	1	**2**	**3**	**4**
1	68	0	1	0
2	6	31	1	0
3	0	1	5	0
4	0	0	2	0

Number of children treated:

First interview	Repeat interview			
	0	**1**	**2**	**3**
0	40	3	0	0
1	3	43	0	1
2	0	2	16	1
3	1	0	1	4

Comparison of data captured from cards with card images

A sample of 19 card images were compared with the data entered for the same child, to check field worker accuracy. 13 records had all details correct, 4 records disagreed with the card on treatment dates but agreed with caregiver recall, suggesting these fieldworkers entered treatments if the caregiver said the child had been treated but the card was blank. 2 records had minor discrepancies (in one case the date was correct but entered under the wrong cycle, in the other, the day of the month was wrongly entered). Relatively few cards were available for this comparison. Only 10% of children had cards available for inspection in the survey, and of these only 19 cards were photographed on the front and reverse. Dates can be entered under the wrong cycle on the card, so during analysis the date is used to determine if the child was treated in a particular cycle.

unique_id	Captured on tablet PC								Card image								Comment
	TreatC1	DateC1	TreatC2	DateC2	TreatC3	DateC3	TreatC4	DateC4	TreatC1	DateC1	TreatC2	DateC2	TreatC3	DateC3	TreatC4	DateC4	
1883579	Yes	2017-09-30	Yes	.	Yes	.	Yes	.	Yes	2017-09-30	Yes	.	Yes	.	Yes	.	Correct
1893033	No	.	Yes	2017-08-28	Yes	.	Yes	.	**Yes**	**2017-08-28**	**No**		Yes	.	Yes	.	Minor error (Card shows treatment was C1, not C2. Date is correct.)
3192943																	Correct (no treatments on the card).
1899183	Yes	2017-08-18	Yes	2017-09-20	Yes	2017-10-29	No	.	Yes	2017-08-18	Yes	2017-09-20	Yes	2017-10-29	No	.	Correct
1920483	Yes	2017-07-28	Yes	2017-08-28	Yes	.	Yes	.	Yes	2017-07-28	Yes	2017-08-28	Yes	.	Yes	.	Correct
1920485	Yes	2017-07-28	Yes	2017-08-28	Yes	.	Yes	.	Yes	2017-07-28	Yes	2017-08-28	Yes	.	Yes	.	Correct
1944532	Yes	28/07/2017	Yes	28/08/2017	Yes	29/09/2017	Yes	29/10/2017	Yes	28/07/2017	Yes	28/08/2017	Yes	29/09/2017	Yes	29/10/2017	Correct
1944533	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	Yes	28/10/2017	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	Yes	28/10/2017	Correct
1944200	No	.	Yes	2017-08-29	Yes	2017-09-28	Yes	2017-10-29	No	.	Yes	2017-08-29	Yes	2017-09-28	Yes	2017-10-29	Correct
1944360	No	.	Yes	28/08/2017	Yes	.	Yes	.	No	.	Yes	28/08/2017	Yes	.	Yes	.	Correct
1944535	Yes	2017-07-29	Yes	2017-08-29	Yes	2017-09-28	Yes	2017-10-29	Yes	2017-07-29	Yes	2017-08-29	Yes	2017-09-28	Yes	2017-10-29	Correct
1931274	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	No	.	Yes	**28/07/2017**	Yes	**29/08/2017**	Yes	29/09/2017	No	.	Minor error (C1 should be 28th, C2 should be 29th).
1931466	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	No	.	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	No	.	Correct
1931468	Yes	28/07/2017	Yes	29/08/2017	Yes	29/11/2017	No	.	Yes	28/07/2017	Yes	29/08/2017	Yes	29/11/2017	No	.	Correct
1931275	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	No	.	Yes	29/07/2017	Yes	28/08/2017	Yes	29/09/2017	No	.	Correct
1957317	Yes	.	Yes	28/08/2017	Yes	.	Yes	.	Yes	**28/08/2017**	Yes		Yes	.	Yes	.	Card shows date was C1 not C2. No other treatments on card but caregiver said child had 4 treatments.
1943136	Yes	28/07/2017	Yes	.	Yes	30/08/2017	Yes	29/11/2017	Yes	28/07/2017	**No**	.	Yes	30/08/2017	Yes	29/11/2017	No indication on card for treatment at C2. Caregiver said child received 4 treatments.
1942094	Yes	28/08/2017	Yes	.	Yes	30/09/2017	Yes	29/10/2017	Yes	28/08/2017	**No**	.	Yes	30/09/2017	Yes	29/10/2017	No indication on card for treatment at C2. Caregiver said child received 4 treatments.
1957040	Yes	31/07/2017	Yes	28/08/2017	Yes	.	Yes	.	Yes	31/07/2017	Yes	28/08/2017	**No**	.	**No**	.	No indication of treatments at C3 and C4. Caregiver said child received 4 treatments.

A2: Sampling methods

The surveys were conducted in the States of Sokoto, Zamfara, Jigawa and Katsina, after each SMC cycle. SMC was delivered at the end of July/early August, the end of August, the end of September/early October, and the end of October/early November. Four surveys were conducted, the first after cycle 1, from 14th-21st August, the second after cycle 2, from 8th-15th September, the third after cycle 3 from 11th-18th October, and the fourth after cycle 4 from 8th-16th November.

60 communities in Sokoto and Zamfara were selected with PPS for surveys in 2016 and the same communities were surveyed in 2017. The total estimated population size of the states of Sokoto and Zamfara was 13,184,985 based on the population estimates provided by the states. A sampling interval of 13,184,985/60=219,750 was used to select 60 settlements with probability proportional to size, using systematic sampling from a list of all 17,410 settlements in the 2 states, after sorting LGAs geographically to give an implicit stratification. An additional 6 communities were selected with PPS in Jigawa and Katsina in 2017. In Katsina, the LGAs to be surveyed were Baure, Dutsi, Mai'Adua and Mashi, and in Jigawa, Roni and Kazaure LGAs. The total population in these 6 LGAs was 1,532,720. A sampling interval of 1,532,720/6=255,453, was used to select 6 settlements with PPS using systematic sampling from a list of 2,207 settlements sorted by LGA.

A rough sketch map of each selected settlement was made showing areas of habitation and local landmarks. Each map was then divided into segments of approximately equal size, the number of segments being chosen so that one segment would be expected to yield approximately the required number of children, based on the estimated total population size, while as far as possible taking advantage of local features to facilitate identification of segment boundaries on the ground. The same clusters were surveyed after each of the four cycles and the same segments were used.

Children aged at least 3 months and less than 7 years at the time of the survey were eligible for inclusion. It was assumed that this age group represents about 20% of the total population. A total sample size of about 1000 children was required in Sokoto and Zamfara, i.e. 1000/60=17 children on average from each village. Each village was therefore divided into S=floor(Nix0.2/17) segments, where Ni was the population from the census. In 2017, the 6 additional clusters were segmented in the same way. The segments were numbered on the map and then the number of segments created was entered into a tablet PC which used simple random sampling to select a segment number to be surveyed. At each survey, every dwelling within the chosen segment was then visited and every child between the ages of 3 months and 7 years who had stayed in the house the night before the survey was included in the survey. The GPS location of each dwelling visited was automatically recorded by the tablet PC used to collect interview data. The number surveyed in each settlement therefore could vary but the average was expected to be about 15 if the population data were accurate. The sampling probabilities were, in Sokoto and Zamfara, $p_i=60\times(N_i/N_T)\times(1/S_i)$, for individuals in settlement i. N_i is the population of village i from the census, N_T is the total population of Sokoto and Zamfara states, and S_i the number of segments created in village i.

In Katsina and Jigawa the sampling probabilities were $p_i=6\times(N_i/N_T)\times(1/S_i)$ with N_T now referring to the total population of the 6 LGAs. The sampling weight for each child (the number of children in the population that each child surveyed represents) was $1/p_i$ (Table A2). Standard errors of estimates of indicators were computed using linearized variance formulae for ratio estimators (Table A3). For binary variables, confidence intervals for proportions were obtained after using a logit transformation, to ensure the confidence limits fell in the range (0,1). Design effects were calculated for each indicator as follows. $Deff_{cluster}$, the design effect due to clustering, was obtained from $Deff_{clustering}= Deff_{overall}/ Deff_{weighting}$, where $Deff_{overall}$ is the overall design effect and $Deff_{weighting}$ the

design effect due to weighting. The rate of homogeneity, roh, was calculated as $(Deff_{cluster}-1)/(b-1)$, where and b is the weighted mean cluster size, $b=\sum n_i^2/\sum n_i$ (where n_i is the number of respondents in cluster i).

Table A1: List of clusters

State	LGA	Ward	Village
Jigawa	Kazaure	Ba'auzini	Badado Habe Yamma
Jigawa	Kazaure	Ung.Gabas	Gamji
Katsina	Baure	Taramnawa	Dogon Gamji Bayan Famfo
Katsina	Dutsi	Yamel A	Makaurachi
Katsina	Mai'adua	Maikoni B	Yankara Fulani
Katsina	Mashi	Tamilo A	Sauna/Tsamiya
Sokoto	Binji	Soron Gabas	Shiyar Wakili
Sokoto	Bodinga	Sifawa Lukuyawa	Gidan Abba Magaji Jabbi
Sokoto	Dange Shuni	Ge-Ere/Gajara	Shawawa
Sokoto	Dange Shuni	Wababe/Salau	Salam Kwakwaram
Sokoto	Gada	Gilbadi	Gadabo Shiyar Masallaci
Sokoto	Gada	Kaffe	Kaffe Shiyar Danhasan
Sokoto	Gada	Kyadawa Holai	Zangon Danbirema
Sokoto	Goronyo	Kagara	Gidan Bunu
Sokoto	Goronyo	Shinaka	Tuluske
Sokoto	Gwadabawa	Asara	Shiyar Galadima
Sokoto	Gwadabawa	Mamman Suka	Gidan Zomo
Sokoto	Illela	Damba	Kwakwara Yamma
Sokoto	Illela	Illela	Tudun Dukiya
Sokoto	Isa	Isa South	Yarmakafi
Sokoto	Kebbe	Girkau	Jabga
Sokoto	Kebbe	Sangi	Sangi Skofa
Sokoto	Kware	Bankanu	Kalalawa Shiyar Sabon Gari
Sokoto	Rabah	Rarah	Shiyar Marafa A
Sokoto	Sabon Birni	Lajinge	Lanjegu Shiyra Ta Gabasgarin Maza
Sokoto	Sabon Birni	Tsamaye	Tsamaye Magaji
Sokoto	Shagari	Kajiji	Kesoje D
Sokoto	Silame	Maje	Tungar Mamba
Sokoto	Sokoto North	Sarkin Adar Gandu	Gidan Dere
Sokoto	Sokoto South	Gagi A	N Bare Bari
Sokoto	Tambuwal	Dogon Daji	Mana I&ii
Sokoto	Tambuwal	Tambuwal	Chakari
Sokoto	Tangaza	Salewa	Gidan Makera
Sokoto	Wamako	Arkilla	Gawon Nama
Sokoto	Wamako	Wamakko	Boye Makera
Sokoto	Wurno	Achida	12.shiyar Rafi
Sokoto	Wurno	Magarya	7.Akalawa
Sokoto	Yabo	Yabo A	Addam Gidan Daji
Zamfara	Anka	Galadima-Ank	Tungar Mani

State	LGA	Ward	Village
Zamfara	Bakura	Birnin Tudu	Tudawa
Zamfara	Birnin Magaji/Kiyaw	Danfami Sabon Birni	Damfami B
Zamfara	Birnin Magaji/Kiyaw	Nassarawa Mailayi	Akuzo A
Zamfara	Bukkuyum	Adabka	Kyambane
Zamfara	Bukkuyum	Masama	Sabuwar Tunga
State	**LGA**	**Ward**	**Village**
Zamfara	Bungudu	Bingi North	Gidan Kade
Zamfara	Bungudu	Gada/Karakai	Dan Durumi
Zamfara	Bungudu	Sankalawa	Kurmi
Zamfara	Gummi	Birnin Tudu/Gmm	Nasarawa Kaura B
Zamfara	Gusau	Madawaki	Gidan Dutsin A
Zamfara	Gusau	Rijiya	Geba Mai Duruwa
Zamfara	Gusau	Tudun Wada	Mareri Fulani
Zamfara	Kaura Namoda	G/D/Galadima	Shiyar Ramu
Zamfara	Kaura Namoda	Kyambarawa	Kyambarawa Fege
Zamfara	Maradun	Janbako	Gidan Tukku Gurmu
Zamfara	Maru	Bingi-Mrr	Matseri B
Zamfara	Maru	Dan Sadau-Mrr	Tsamiya
Zamfara	Shinkafi	Badarawa	Ruguzawa
Zamfara	Shinkafi	Kware	Gobirawa
Zamfara	Talata Mafara	Galadima	Zango
Zamfara	Talata Mafara	Kayaye	Tungar Danga
Zamfara	Talata Mafara	Sauna	Gidan Madugu
Zamfara	Tsafe	Dauki	Dauki Kango
Zamfara	Tsafe	Tsafe Central	Sabon Gida
Zamfara	Tsafe	Yanware	Asaula
Zamfara	Zurmi	Dauran/B/Tsaba	Bbaba Shiyar Marafa
Zamfara	Zurmi	Y/Dutsi	Keta

Table A2: Sampling weights

Village	Population	No. of segments	Sampling probability	Weight
BaAuzini: Badado Habe Yamma	1200	12	0.000391	2554.53
Unguwar Gabas-Gamji	730	7	0.000408	2449.55
Taramnawa: Dogon Gamji Bayan Famfo	460	4	0.000450	2221.33
Yamel A: Makaurachi	994	9	0.000432	2312.96
Maikoni B: Yankara Fulani	510	5	0.000399	2504.44
Sauna/Tsamiya	662	6	0.000432	2315.29
Soron Gabas: Shiyar Wakili	1410	14	0.000458	2181.91
Sifawa Lukuyawa: Gidan Abba Magaji Jabbi	755	7	0.000491	2037.41
Ge-eregajara: Shawawa	1740	10	0.000792	1262.93
Wababesalau: Salam Kwakwaram	975	9	0.000493	2028.46
Gilbadi: Gadabo Shiyar Masallaci	1455	14	0.000473	2114.43
Kaffe: Kaffe Shiyar Danhasan	1725	17	0.000462	2165.65
Kyadawa Holai: Zangon Danbirema	840	8	0.000478	2092.85
Kagara: Gidan Bunu	980	9	0.000496	2018.11
Shinaka: Tuluske	4800	48	0.000455	2197.50
Asara: Shiyar Galadima	2110	21	0.000457	2187.08
Mamman Suka: Gidan Zomo	810	8	0.000461	2170.37
Damba: Kwakwara Yamma	770	7	0.000501	1997.73
Illela: Tudun Dukiya	1210	12	0.000459	2179.34
Isa South: Yarmakafi	755	7	0.000491	2037.41
Girkau: Jabga	1560	15	0.000473	2112.98
Sangi: Sangi Skofa	475	4	0.000540	1850.52
Bankanu: Kalalawa Shiyar Sabon Gari	970	9	0.000490	2038.92
Rarah: Shiyar Marafa A	650	6	0.000493	2028.46
Lajinge: Lanjegu Shiyra Ta Gabasgarin Maza	1135	11	0.000470	2129.73
Tsamaye: Tsamaye Magaji	4780	47	0.000463	2160.72
Kajij: Kesoje D	1505	15	0.000457	2190.20
Maje: Tungar Mamba	810	8	0.000461	2170.37
Sarkin Adar Gandu: Gidan Dere	1260	12	0.000478	2092.85
Gagi A: N Bare Bari	780	7	0.000507	1972.11
Dogon Daji: Mana I&ii	925	9	0.000468	2138.11
Tambuwal: Chakari	765	7	0.000497	2010.78
Salewa: Gidan Makera	675	6	0.000512	1953.33
Arkilla: Gawon Nama	260	2	0.000592	1690.38
Wamakko: Boye Makera	430	2	0.000978	1022.09
Achida: 12.shiyar Rafi	3927	39	0.000458	2182.39
Magarya: 7.Akalawa	898	8	0.000511	1957.68
Yabo A: Addam Gidan Daji	1165	11	0.000482	2074.89
Galadima-ank: Tungar Mani	165	1	0.000751	1331.82
Birnin Tudu: Tudawa	800	8	0.000455	2197.50
Danfami Sabon Birni: Damfami B	1820	9	0.000920	1086.67
Nassarawa Mailayi: Akuzo A	1028	10	0.000468	2137.64
Adabka: Kyambane	1645	16	0.000468	2137.38

Masama: Sabuwar Tunga	975	9	0.000493	2028.46
Bingi North: Gidan Kade	1400	14	0.000455	2197.50
Gadakarakai: Dan Durumi	650	6	0.000493	2028.46
Sankalawa: Kurmi	2075	20	0.000472	2118.07
Birnin Tudugmm: Nasarawa Kaura B	600	6	0.000455	2197.50
Madawaki: Gidan Dutsin A	1175	11	0.000486	2057.23
Rijiya: Geba Mai Duruwa	1540	15	0.000467	2140.42
Tudun Wada: Mareri Fulani	1380	13	0.000483	2070.11
Gdgaladima: Shiyar Ramu	1155	10	0.000526	1902.60
Kyambarawa: Kyambarawa Fege	3995	10	0.001818	550.06
Janbako: Gidan Tukku Gurmu	866	8	0.000493	2030.02
Bingi-mrr: Matseri B	300	3	0.000455	2197.50
Dan Sadau-mrr: Tsamiya	800	8	0.000455	2197.50
Badarawa: Ruguzawa	1945	19	0.000466	2146.66
Kware: Gobirawa	2170	21	0.000470	2126.61
Galadima: Zango	847	8	0.000482	2075.56
Kayaye: Tungar Danga	935	9	0.000473	2115.24
Sauna: Gidan Madugu	794	7	0.000516	1937.34
Dauki: Dauki Kango	3410	34	0.000456	2191.05
Tsafe Central: Sabon Gida	1445	14	0.000470	2129.06
Yanware: Asaula	4655	46	0.000461	2171.53
Dauranbtsaba: Bbaba Shiyar Marafa	1923	10	0.000875	1142.74
Ydutsi: Keta	3975	39	0.000464	2156.04

Table A3: Standard error, design effect and rate of homogeneity for the main indicators

Indicator	Value	s.e.	95%CI	Deff	Deff_weight	Deff_cluster	roh	b
Mean number of treatments per child	2.73	0.151	2.43,3.03	18.73	1.033	18.13	0.413	42.45
Coverage of 4 cycles	0.464	0.056	0.356,0.576	21.24	1.033	20.56	0.472	42.45
Coverage of cycle 1	0.736	0.034	0.662,0.799	10.17	1.025	9.93	0.215	42.45
Coverage of cycle 2	0.722	0.041	0.633,0.797	14.34	1.040	13.79	0.309	42.45
Coverage of cycle 3	0.677	0.047	0.578,0.763	16.75	1.038	16.14	0.365	42.45
Coverage of cycle 4	0.595	0.053	0.488,0.695	19.36	1.030	18.80	0.429	42.45
Adherence	0.593	0.052	0.486,0.692	22.28	1.029	21.65	0.505	41.90
Adherence (amongst those who received SMC)	0.990	0.004	0.977,0.996	2.15	1.032	2.09	0.026	42.45
LLIN coverage in children	0.668	0.035	0.596,0.733	10.59	1.037	10.22	0.224	42.13
SMC directly observed	0.825	0.036	0.741,0.886	10.59	1.048	10.10	0.220	42.45
Caregiver knowledge about SMC	5.4	0.145	5.1,5.7	8.42	1.032	8.16	0.173	42.45
CHW adherence to guidelines	4.6	0.249	4.1,5.1	8.07	1.041	7.75	0.166	41.78
Awareness of SMC dates	0.494	0.054	0.389,0.600	15.35	1.031	14.89	0.336	42.31
LLIN coverage (all ages)	0.331	0.044	0.249,0.425	41.01	1.025	40.01	0.423	93.22
Proportion that could sleep under LLIN (if 2/net)	0.404	0.051	0.303,0.505	11.59	1.029	11.26	0.507	21.24
Proportion of households with an LLIN	0.414	0.051	0.317,0.518	11.53	1.029	11.20	0.504	21.24
Proportion of households with 1 LLIN per 2 people	0.389	0.049	0.297,0.491	10.89	1.028	10.59	0.474	21.24

Table A4: Population estimates by LGA

Sokoto		Zamfara		Jigawa		Katsina	
LGA	Pop.	LGA	Pop.	LGA	Pop.	LGA	Pop.
Binji	221,230	Anka	183,065	Kazaure	290,184	Baure	321,625
Bodinga	263,245	Bakura	181,675	Roni	226,545	Dutsi	195,074
Dange Shuni	344,280	Birnin Magaji/Kiyaw	290,002			Mai'Adua	271,203
Gada	658,040	Bukkuyum	450,055			Mashi	228,089
Goronyo	381,041	Bungudu	590,947				
Gudu	141,830	Gummi	254,699				
Gwadabawa	405,564	Gusau	763,124				
Illela	388,015	Kaura Namoda	584,824				
Isa	314,630	Maradun	276,395				
Kebbe	287,972	Maru	542,166				
Kware	201,435	Shinkafi	362,716				
Rabah	274,540	Talata Mafara	586,020				
Sabon Birni	451,265	Tsafe	664,569				
Shagari	349,490	Zurmi	310,833				
Silame	241,025						
Sokoto North	353,995						
Sokoto South	243,160						
Tambuwal	439,630						
Tangaza	248,030						
Tureta	197,190						
Wamako	251,716						
Wurno	276,197						
Yabo	210,375						
TOTAL	7,143,895		6,041,090		516,729		1,015,991

Table A5: Age groups for reporting SMC coverage

Age of children:	Eligibility:	Analysis:
Final survey:		
>3months and <5yrs at survey	definitely eligible for cycle 4	coverage at cycle 4
>3months at cycle 1 and <5yrs at survey	definitely eligible for 4 cycles	coverage of 4 cycles
≥6yrs at final survey	not eligible for SMC	coverage outside age range
<3 months at cycle 4	not eligible	excluded
>5yrs and <6yrs at survey	possibly eligible	excluded
Cycle1:		
<3 months at survey	not eligible	excluded
>3months and <5yrs at survey	definitely eligible for cycle	coverage at cycle
>5yrs at C1	not eligible	coverage outside age range
Cycle 2 and 3:		
<3 months at survey	not eligible	excluded
>3months and <5yrs at survey	definitely eligible for cycle	coverage at cycle
>5yrs and <6yrs at survey	possibly eligible	excluded
≥6yrs at survey	not eligible for SMC	coverage outside age range

Table A6: Comparison between coverage estimates in each LGA at cycle 1, from the cycle 1 survey and from the final survey:

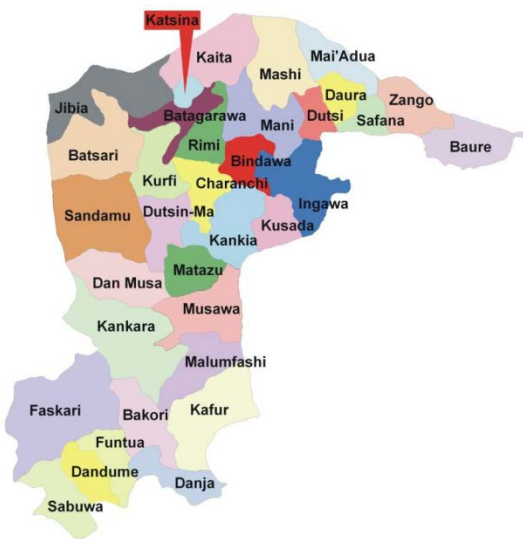| Sokoto	Cycle 1	Final survey	Cycle 1	Final survey	Zamfara	Cycle 1	Final survey	Cycle 1	Final survey
	Number surveyed		Coverage			Number surveyed		Coverage	
Binji	38	24	97%	46%	Anka	40	13	100%	92%
Bodinga	30	26	100%	42%	Bakura	39	56	100%	100%
Dange Shuni	60	33	37%	4%	Birnin Magaji	75	92	83%	93%
Gada	120	71	30%	33%	Bukkuyum	79	83	97%	78%
Goronyo	66	11	41%	38%	Bungudu	93	99	80%	69%
Gwadabawa	49	49	55%	24%	Gummi	41	55	95%	95%
Illela	52	40	63%	41%	Gusau	88	95	86%	76%
Isa	26	34	81%	56%	Kaura Namoda	56	106	72%	89%
Kebbe	29	28	43%	79%	Maradun	33	36	100%	81%
Kware	39	12	13%	25%	Maru	59	84	90%	88%
Rabah	33	16	100%	50%	Shinkafi	66	89	67%	100%
Sabon Birni	72	39	45%	34%	Talata Mafara	134	130	100%	89%
Shagari	35	19	94%	89%	Tsafe	105	136	94%	83%
Silame	24	9	0%	67%	Zurmi	93	84	84%	99%
Sokoto North	31	33	81%	30%	Total	1000	1158	89%	87%
Sokoto South	27	22	63%	64%	Katsina				
Tambuwal	50	27	41%	50%	Baure	45	43	93%	100%
Tangaza	30	32	97%	59%	Dutsi	40	32	58%	75%
Wamako	52	24	47%	23%	Mai'Adua	32	43	50%	67%
Wurno	66	33	79%	49%	Mashi	47	0	87%	-
Yabo	32	3	13%	0%	Jigawa				
Total	960	585	54%	42%	Kazaure	76	73	86%	92%
					Total	240	191	76%	85%

Figure A1: Local Government Areas

Sokoto

Zamfara

Katsina

Jigawa