Evidence of high bednet usage from a list randomization experiment in rural Gambia

Joe Brew (joebrew@gmail.com)
Barcelona Institute for Global Health https://orcid.org/0000-0002-4119-0117

Margaret Pinder
Medical Research Council Unit

Umberto Dalessandro
Medical Research Council

Steven W Lindsay
Durham University

Carloine Jones
Wellcome Trust Kemri

Elisa Sicuri
Barcelona Institute for Global Health

Research

Keywords: Malaria, List randomization, Long-lasting insecticidal nets, Gambia

Posted Date: November 20th, 2019

DOI: https://doi.org/10.21203/rs.2.17453/v1

Version of Record: A version of this preprint was published on July 13th, 2020. See the published version at https://doi.org/10.1186/s12936-020-03322-5.

Abstract

Background Recording behaviours that have the potential to impact health can be doubly challenging if the behaviour takes place in private spaces that cannot be observed directly and where there is potential for social desirability bias, i.e. where the respondent may give an answer that they think the recorder wants to hear. Sleeping under a long-lasting insecticidal net (LLIN) is an important intervention for malaria prevention, yet it is difficult to gauge the extent to which coverage (how many nets are in the community) differs from usage (how many people sleep under a net). We employed a novel method, list randomization, which partially obscures respondents' answers to sensitive questions, as a mean to provide an accurate estimate of LLIN usage in The Gambia.

Methods We surveyed 196 residents from 196 households recruited into a randomised controlled trial assessing the effect of a housing intervention on malaria. In the current experiment, 98 of the 196 study participants were randomly assigned to the control group and received a four-question list about non-sensitive behaviours; the other participants in the intervention group, received the same list, with the addition of one question on a sensitive behaviour; whether or not they had used a bednet the previous night. Participants were read the list of questions and then said how many of the statements were true. We estimated bednet usage by calculating the difference in means between the total number of affirmative items between the two groups, and quantified uncertainty using a t-test.

Results The mean number of affirmative responses in the control group was 2.60 of four statements (95% confidence interval, 95% CI, = 2.50-2.70), compared with 3.68 (95% CI = 3.59-3.78) in the intervention group. Such difference (1.08; 95% CI = 94.9-100%) suggests approximately 100% bednet usage.

Conclusions Our findings suggest complete universal bednet usage in the study area. Further validation of the list randomization method in areas with lower net coverage is required.

Introduction

From 2000 to 2015, malaria has declined substantially in sub-Saharan Africa, with the prevalence of falciparum malaria declining by a half, with 663 million cases averted (1). This extraordinary achievement is due to the massive deployment of long-lasting insecticidal nets (LLINs), indoor residual spraying and prompt an effective treatment with antimalarials. Despite these gains, progress has slowed recently and in 2017 there were still 403,000 malaria deaths in the region (WHO 2018).

Scale up of LLINs and prompt and effective case management contributed averting 68% of cases (Bhatt et al. 2015). LLINs protect users by providing a physical barrier to night-time biting mosquitoes and killing them upon contact with the net. At around $2 dollars a net, they are a highly cost-effective intervention (2–4). LLIN coverage in sub-Saharan Africa has never been higher, with 80% of households having at least one net in 2016, and 43% of households having one or more nets for every two people (5). However, there are concerns about how ‘coverage’ is measured and whether 80% coverage translates to 80% of the population being protected by an LLIN.

Coverage is defined as the number of nets relative to the number of people in the household, a metric that can be verified by counting the number of nets compared to the number of sleeping places. However, assessing whether an individual sleeps under a net (bed net use) is more difficult than assessing coverage. For example, while a household may still own a LLIN (coverage) its use may diminish after mass distribution campaigns due to product “wear and tear” (6), changes in use by season, social events and other factors. Assessments of LLIN usage often occur immediately after they are distributed, which may result in overestimating usage rates that are likely to decline over time. For example, a recent multi-country study suggested a 50% reduction in usage in the 23 months following LLIN distribution (7). Perhaps of greater concern is the difficulty of estimating LLIN usage without directly observing people sleeping; it usually relies on questionnaires or observing the presence of a hung net in a house. A recent meta-analysis estimated that self-reported rates of LLIN use were 13.6% greater than directly observed rates (8). The extent of the gap between observed and reported usage is highly variable by country and social group (9) but exists in all studies examined.

The existence of this gap suggests that LLIN usage is potentially a *sensitive* behaviour. Reporting sleeping under a net the previous night is likely to be biased, since most recipients have been told that the net is protective and have been given the net as a gift. As a matter of politeness, or perhaps even fear of negative repercussions (in the case of government-organized LLIN campaigns), respondents are likely to say they have used the net, even when they have not, so as to avoid giving offence. One method by which social desirability bias can be reduced is list randomization (10,11). In a list randomization experiment, participants are divided into “control” and “treatment” groups. The control group is given a series of yes/no questions about everyday activities (communication, transportation, eating, and work), but instead of answering each question individually, participants simply tally the number of “yes” responses and report that number to the researcher. The experiment group is provided with the same questions, but with an additional question on sensitive behavior. Using list randomization, participants from both groups are able to hide their item-specific responses from the researcher, but the data generated from the process allows for aggregate comparison between the groups, with the difference in total “yes” items approximating the population-level “yes” prevalence.

List randomization has previously been used to reduce data bias pertaining to sensitive topics such as personal finance (12), intimate partner violence (13), illegal migration (14), and attitudes regarding homosexuality and gender (15). To our knowledge, despite its relevance to public health campaigns and its sensitive nature, there are no published reports on list randomization applied to the question of LLIN use. Here we employ list randomization to estimate LLIN use in an area of seasonal malaria transmission in The Gambia.

Materials And Methods

Study location

The study was carried out in the Upper River Region (URR) of The Gambia (13.12 N, 14.1 W). The climate consists of a long dry season from January to June, with rainfall occurring between June-July and October. Most clinical malaria cases are observed in October-December (16). The URR is an area of open Sudanian savanna and is divided into north and south banks by the River Gambia. The Gambia has a long tradition of bednet use in rural areas (17).

Study design

The study was carried out from the end of November 2017 (after the September peak) to mid-January 2018 (when mosquito density was very scarce).

For the purposes of the list randomization experiment, we classified the “control” and “non-trial” households into one group (i.e., a total of 133 non-intervention houses), since at the time of the list randomization experiment both groups’ houses were unimproved. A free LLIN distribution campaign organized by the trial investigators took place in 2016 before the trial commenced and a national campaign carried out by the National Malaria Control Programme (NMCP) distributed free LLIN in July 2017, just before the list randomization experiment

Randomization to select participants was stratified by river bank (north vs south), ethnic group (with the purposely selection of one, Jagajari, for being the only Serrehule village in the trial), and size. 91 villages were enrolled in a household-clustered randomized controlled trial assessing the impact of house improvement on malaria outcomes (18). Fifteen of the 91 trial villages were randomly selected for an ancillary longitudinal socio-economic study. A total of 196 household heads were enrolled in this study. Each household head was associated with a house in one of three groups: (1) 63 “intervention” houses that were thatch-roofed houses modified to have metal roofs and ventilated, (2) 65 “control” houses that were unmodified thatch-roof houses and (3) 68 “non-trial” households, which included thatch and metal-roofed houses..

Enrolled households were randomly assigned to one of two “question lists”: 97 received the control questionnaire and 99 the experiment questionnaire. The control questionnaire contained four questions about daily activities; the experiment questionnaire contained the same questions, with an additional question asking whether the participant slept under a LLIN the previous night (Table 1). The order of statements in all questionnaires was randomized at the individual level, thus, every household had its own randomly assigned questionnaire. The maximum number of statement combinations [N*(N-1)] was 12 (4*3) in the control group and 20 (5*4) in the experimental group. Therefore, 12 and 20 different typologies of questionnaires were randomized to the households.

Table 1: List randomization question list

Control	Experiment
I used a telephone yesterday.	I used a telephone yesterday.
I used transportation other than walking yesterday.	I used transportation other than walking yesterday.
I ate benachin yesterday.	I ate benachin yesterday.
I worked yesterday.	I worked yesterday.
	I slept under a mosquito net last night.

The statement in bold represents the “experimental” item.

A trained field worker administered the question list to the household heads. Participants were asked not address individual statements, but instead to count on their fingers (held behind their backs, so as to block the view of the interviewer) the number of statements which were true for them. The reported number (0 to 4 for the control group, 0 to 5 for the experimental group) was recorded.

Statistical analysis

The sample size of 196 participants was calculated to be sufficient for the calculation of a 95% confidence interval on a LLIN usage point estimate of 85%. We aimed to estimate unbiased LLIN usage levels for the area through the use of the statement about bednet use in our list randomization question list. Though the individual bednet status of participants is unknown to the interviewer and researcher, aggregating by group allows for a comparison through which one can estimate the percentage of participants who agreed with the experimental statement, since in all other aspects the participants should be identical. In simple terms, the difference between the average number of agreements in the two groups is equivalent to the fraction of participants in the experiment group which agreed with the experimental statement. We tested the hypothesis that the two groups had the same means using an unequal variances t-test. We assume that the introduction of the experimental statement has no effect on the answers to the non-experimental statements (i.e. the “no design effect assumption”) and do not require that the agreements with non-experimental statements be true, but rather that they be equally truthful between groups. The mean difference between the two groups provides an estimate of the proportion of bednet use in the study population.

Since true bednet usage could not be directly observed, we exploited data gathered on self-reported bednet use among children residing in houses with our study participants, performing a robustness check of our results by assessing the correlation between child bednet use (via trial survey response) and adult bednet use (via list randomization). For this group, we compared, at the aggregate level, the association between household children sleeping under a bednet (per self-report) and the adult head of household

sleeping under a bednet (per list randomization), with the assumption that a high level of correlation suggests a high level of list randomization reliability (since it is reasonable to assume that intra-household adult and child net usage is likely correlated).

Ethics

Participants were enrolled into the study provided they gave their full and informed consent. The study was approved by the Gambia Government and Medical Research Council's joint ethics committee.

Results

196 people were randomly selected to participate in the list randomization experiment. Comparison of important variables were similar in both experimental groups (Table 2).

Table 2: Characteristics of study groups

		List randomization group	
Variable	**Category**	**Control**	**Treatment**
Housing improvement intervention	Intervention	30 (30.9%)	33 (33.3%)
	Control	34 (35.1%)	28 (28.3%)
	Not in study	33 (34.0%)	35 (35.4%)
Ethnicity	Fula	60 (61.9%)	61 (61.6%)
	Mandinka	33 (34.0%)	33 (33.3%)
	Sarahule	4 (4.1%)	4 (4.0%)
	Unknown	0	1 (1.0 %)
Village size	Large	33 (34.0%)	33 (33.3%)
	Small	64 (66.0%)	66 (66.7%)
River bank	North	31 (32.0%)	33 (33.3%)
	South	66 (68.0%)	66 (66.7%)

Unbiased bednet coverage estimates via difference in means

The mean number of agreements in the control group was 2.6 (95% confidence intervals, CI =2.50-2.70) of four questions. In the experiment group, the mean number of agreements was 3.68 (95% CI = 3.59 to 3.78) of five questions. The difference of 1.1 is consistent with 100% bednet usage among the study population. Using a simple t-test, we estimate the 95% confidence interval of the difference is 94.9-100% ($t = 15.67$, $p < 0.001$). Surprisingly, we observed *no* respondents reporting the minimum (zero) or maximum (four or five, depending on the group) number of activities from our list (see Discussion).

Robustness check

Although it was not feasible to directly observe bednet usage in the study, we validated the results of the study by comparing them with related datasets. Of the 196 households in this list randomization experiment, self-reported LLIN usage was available for 87 of the 128 households in the housing intervention study (Pinder et al. 2016). 83% of children were reported to sleep under LLIN at the time of data collection. In the group reporting that the household children slept under a bednet, the difference in means between the number of agreements in the experiment group (3.61) and the control group (2.61) was exactly 1, suggesting 100% adult coverage. Since it is reasonable to assume that an adult sleeping under a bednet is a reasonable proxy for a young child doing the same, this suggests high fidelity between the two methods.

Discussion

Our list randomization experiment indicates near universal bednet use by the adult population of eastern Gambia, in the year following an LLIN distribution campaign. Though, for feasibility reasons, we did not carry out a direct estimation to assess the validity of our results as some other studies have done (19), the high figures suggest high LLIN usage, at least during the period in which the study took place (towards the end of the transmission season, when coverage is likely to be highest). In fact, the near 100% coverage found in this study was significantly higher than previous studies (16). For example, net coverage in 2010 in the Upper River Region was only 68% (20)..

This study showed very high LLIN use among rural Gambian adults, using a low bias method, in the year following nationwide distribution. Irrespective of the potential limitations in our implementation of the list randomization method, the finding of high LLIN usage is plausible given that the study took place at the end of the high transmission season(21), the study was part of a clinical trial setting (with the associated behavioural effects) and the NMCP had embarked on a net distribution campaign one month earlier.

High usage in a context of high coverage is good news for public health practitioners worried about disuse and misuse, and is consistent with previous research showing high LLIN use even when not

purchased (22–24). Net distribution campaigns should take into account these results when estimating effectiveness and planning time between interventions. List randomization may be a useful tool for malaria control programs, but at the same time more research should be carried out on this promising method's robustness, susceptibility to context, and applicability to the specific area of bednet usage.

Our results suggest that virtually all adults in our study area slept under LLIN. Though this may be true, four factors lead us to question the reliability of our results: (1) the estimate of usage is extremely high, even for an area with universal coverage, (2) we lacked any reliable method for validating responses (i.e., direct observation), (3) our study took place in an area where a great deal of health research had already taken place, opening the door to the possibility that our population was not representative of The Gambia as a whole (especially since they had already been sensitized to malaria-related issues given their participation in the housing improvement trial), and (4) the nature of our responses (no minimum or maximum item responses) suggests that there may have been some social desirability bias despite the method. We conclude that our data are indicative of high bednet usage, but more detailed study of the list randomization method in the context of LLIN use is needed, particularly a means of questionnaire-item optimization (to avoid the issue of insufficient response heterogeneity experienced in this study) and external validation (to reliably compare list responses with an objective, observable outcome).

Importantly, among our 196 participants, none stated that they did the minimum (zero) or maximum (four or five, depending on the group) number of activities from our list. There are two possible explanations for this finding. First, it is possible that our list items were poorly chosen and did not provoke sufficient heterogeneity in responses. Second, the list randomization method, though meant to anonymize item-specific responses, may not work in certain contexts. We believe that the second explanation is more likely. The study was carried out in an area where a great deal of health research had been carried out previously, and the field worker was known to be an employee of a health research facility. One potential explanation is that some study participants may have inflated the number of affirmative responses to reduce suspicion by the fieldworker that they were sleeping without a mosquito net. In other words, social desirability bias may have occurred in our study, despite our best efforts to avoid it. Further implementation research is required on both (1) the correct selection of list items, and (2) how the context (who the fieldworker is, etc.) may affect results.

Our approach mirrors that of a recent analysis of sexual behaviours (19) and intimate partner violence (13). However, there are number of limitations to this study. Firstly, it was carried out in an area where considerable research has taken place, and therefore may not be generalizable to the population at large, particularly areas with less research activity. The Medical Research Council Unit in The Gambia have been active in the study area for many years, which might affect knowledge and practices around LLINs, as well as social desirability bias. Our fidelity test between whether children were reported to sleep under a bednet and whether an adult reported (via list randomization) to do the same lacks obvious comparability due to the likely differences in behaviour by age and relatively low number of households where children’s status could be identified. Additionally, we could not validate the reliability of either method (self-reporting or list randomization) through direct observation, due to privacy concerns. Though

a movement logger could theoretically be used as a validation tool, the awareness of the logger itself might also bias results, since one can assume that an individual is more likely to use an LLIN if they know their use is being directly monitored. Finally, though our sample size was sufficient for an overall assessment of bednet coverage based on a two-group comparison, we did not have sufficient statistical power to identify the potential determinants of bednet use, such as gender, ethnicity, age, or socioeconomic status. Nonetheless the list randomization test offers a promising new method for exploring LLIN use in study communities.

Our list randomization experiment indicates near universal bednet use by the adult population of eastern Gambia, in the year following an LLIN distribution campaign. Though, for feasibility reasons, we did not carry out a direct estimation to assess the validity of our results as some other studies have done (19), the high figures suggest high LLIN usage, at least during the period in which the study took place (towards the end of the transmission season, when coverage is likely to be highest). In fact, the near 100% coverage found in this study was significantly higher than previous studies (16). For example, net coverage in 2010 in the Upper River Region was only 68% (20)..

This study showed very high LLIN use among rural Gambian adults, using a low bias method, in the year following nationwide distribution. Irrespective of the potential limitations in our implementation of the list randomization method, the finding of high LLIN usage is plausible given that the study took place at the end of the high transmission season(21), the study was part of a clinical trial setting (with the associated behavioural effects) and the NMCP had embarked on a net distribution campaign one month earlier.

High usage in a context of high coverage is good news for public health practitioners worried about disuse and misuse, and is consistent with previous research showing high LLIN use even when not purchased (22–24). Net distribution campaigns should take into account these results when estimating effectiveness and planning time between interventions. List randomization may be a useful tool for malaria control programs, but at the same time more research should be carried out on this promising method's robustness, susceptibility to context, and applicability to the specific area of bednet usage.

Our results suggest that virtually all adults in our study area slept under LLIN. Though this may be true, four factors lead us to question the reliability of our results: (1) the estimate of usage is extremely high, even for an area with universal coverage, (2) we lacked any reliable method for validating responses (i.e., direct observation), (3) our study took place in an area where a great deal of health research had already taken place, opening the door to the possibility that our population was not representative of The Gambia as a whole (especially since they had already been sensitized to malaria-related issues given their participation in the housing improvement trial), and (4) the nature of our responses (no minimum or maximum item responses) suggests that there may have been some social desirability bias despite the method. We conclude that our data are indicative of high bednet usage, but more detailed study of the list

randomization method in the context of LLIN use is needed, particularly a means of questionnaire-item optimization (to avoid the issue of insufficient response heterogeneity experienced in this study) and external validation (to reliably compare list responses with an objective, observable outcome).

Importantly, among our 196 participants, none stated that they did the minimum (zero) or maximum (four or five, depending on the group) number of activities from our list. There are two possible explanations for this finding. First, it is possible that our list items were poorly chosen and did not provoke sufficient heterogeneity in responses. Second, the list randomization method, though meant to anonymize item-specific responses, may not work in certain contexts. We believe that the second explanation is more likely. The study was carried out in an area where a great deal of health research had been carried out previously, and the field worker was known to be an employee of a health research facility. One potential explanation is that some study participants may have inflated the number of affirmative responses to reduce suspicion by the fieldworker that they were sleeping without a mosquito net. In other words, social desirability bias may have occurred in our study, despite our best efforts to avoid it. Further implementation research is required on both (1) the correct selection of list items, and (2) how the context (who the fieldworker is, etc.) may affect results.

Our approach mirrors that of a recent analysis of sexual behaviours (19) and intimate partner violence (13). However, there are number of limitations to this study. Firstly, it was carried out in an area where considerable research has taken place, and therefore may not be generalizable to the population at large, particularly areas with less research activity. The Medical Research Council Unit in The Gambia have been active in the study area for many years, which might affect knowledge and practices around LLINs, as well as social desirability bias. Our fidelity test between whether children were reported to sleep under a bednet and whether an adult reported (via list randomization) to do the same lacks obvious comparability due to the likely differences in behaviour by age and relatively low number of households where children's status could be identified. Additionally, we could not validate the reliability of either method (self-reporting or list randomization) through direct observation, due to privacy concerns. Though a movement logger could theoretically be used as a validation tool, the awareness of the logger itself might also bias results, since one can assume that an individual is more likely to use an LLIN if they know their use is being directly monitored. Finally, though our sample size was sufficient for an overall assessment of bednet coverage based on a two-group comparison, we did not have sufficient statistical power to identify the potential determinants of bednet use, such as gender, ethnicity, age, or socioeconomic status. Nonetheless the list randomization test offers a promising new method for exploring LLIN use in study communities.

Declarations

Ethics approval and consent to participate

The study was approved by the Gambia Government and Medical Research Council's joint ethics committee. All participants gave informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analysed during this study are not publicly available since they include identifiable protected health information of a sensitive nature. Researchers interested in accessing the data can contact any of the authors, who will put them in touch with the Medical Research Council's ethics committee, and will facilitate access to raw data in the case of ethical approval being obtained

Competing interests

The authors have no competing interests to declare.

Funding

JB is funded by the Erasmus Mundus Joint Doctorate Fellowship, Grant Agreement 2016-1346.

Authors' contributions

JB analyzed the data pertaining to list randomization. MP, UD,SL, CJ, and ES contributed to study design, interpretation of the analysis, contextualization, and the writing of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable

References

1. Bhatt S, Weiss DJ, Cameron E, Bisanzio D, Mappin B, Dalrymple U, et al. The effect of malaria control on Plasmodium falciparum in Africa between 2000 and 2015. Nature [Internet]. 2015 Oct 8;526(7572):207–11. Available from: http://dx.doi.org/10.1038/nature15535
2. White MT, Conteh L, Cibulskis R, Ghani AC. Costs and cost-effectiveness of malaria control interventions–a systematic review. Malar J [Internet]. 2011 Nov 3;10:337. Available from: http://dx.doi.org/10.1186/1475-2875-10-337
3. Sedlmayr R, Fink G, Miller JM, Earle D, Steketee RW. Health impact and cost-effectiveness of a private sector bed net distribution: experimental evidence from Zambia. Malar J [Internet]. 2013 Mar 18;12:102. Available from: http://dx.doi.org/10.1186/1475-2875-12-102

4. Hansen KS, Ndyomugyenyi R, Magnussen P, Clarke SE. Cost-effectiveness analysis of three health interventions to prevent malaria in pregnancy in an area of low transmission in Uganda. Int Health [Internet]. 2012 Mar;4(1):38–46. Available from: http://dx.doi.org/10.1016/j.inhe.2011.10.001
5. WHO. World Malaria Report 2018 [Internet]. 2018. Available from: http://apps.who.int/iris/bitstream/handle/10665/259492/9789241565523-eng.pdf;jsessionid=6798443DFD31EF826F38EFAF3195CA01?sequence=1
6. Ranasinghe S, Ansumana R, Bockarie AS, Bangura U, Jimmy DH, Stenger DA, et al. Child bed net use before, during, and after a bed net distribution campaign in Bo, Sierra Leone. Malar J [Internet]. 2015 Nov 18;14:462. Available from: http://dx.doi.org/10.1186/s12936-015-0990-y
7. Bhatt S, Weiss DJ, Mappin B, Dalrymple U, Cameron E, Bisanzio D, et al. Coverage and system efficiencies of insecticide-treated nets in Africa from 2000 to 2017. Elife [Internet]. 2015 Dec 29;4. Available from: http://dx.doi.org/10.7554/eLife.09672
8. Krezanoski PJ, Bangsberg DR, Tsai AC. Quantifying bias in measuring insecticide-treated bednet use: meta-analysis of self-reported vs objectively measured adherence. J Glob Health [Internet]. 2018 Jun;8(1):010411. Available from: http://dx.doi.org/10.7189/jogh.08.010411
9. Vanden Eng JL, Thwing J, Wolkon A, Kulkarni MA, Manya A, Erskine M, et al. Assessing bed net use and non-use after long-lasting insecticidal net distribution: a simple framework to guide programmatic strategies. Malar J [Internet]. 2010 May 18;9:133. Available from: http://dx.doi.org/10.1186/1475-2875-9-133
10. Corstange D. Sensitive Questions, Truthful Answers? Modeling the List Experiment with LISTIT. Polit Anal [Internet]. 2009;17(01):45–63. Available from: http://dx.doi.org/10.1093/pan/mpn013
11. Kraay A, Murrell P. Do Random Response Questions Really Elicit Truthful Answers to Sensitive Questions? The Case of the Mississippi Personhood Initiative. SSRN Electronic Journal [Internet]. 2016; Available from: http://dx.doi.org/10.2139/ssrn.2876622
12. Karlan D, Zinman J. List Randomization for Sensitive Behavior: An Application for Measuring Use of Loan Proceeds [Internet]. 2011. Available from: http://dx.doi.org/10.3386/w17475
13. Peterman A, Palermo TM, Handa S, Seidenfeld D, Zambia Child Grant Program Evaluation Team. List randomization for soliciting experience of intimate partner violence: Application to the evaluation of Zambia's unconditional child grant program. Health Econ [Internet]. 2018 Mar;27(3):622–8. Available from: http://dx.doi.org/10.1002/hec.3588
14. McKenzie D, Siegel M. Eliciting illegal migration rates through list randomization. Migration Studies [Internet]. 2013;1(3):276–91. Available from: http://dx.doi.org/10.1093/migration/mnt018
15. Indurkar A. Generating Prevalence Estimates of Sensitive Behaviors Through List Randomization: Survey Experiment Among Indian Males [Internet]. 2017. Available from: https://books.google.com/books/about/Generating_Prevalence_Estimates_of_Sensi.html?hl=&id=gApCtAEACAAJ
16. Mwesigwa J, Achan J, Di Tanna GL, Affara M, Jawara M, Worwui A, et al. Residual malaria transmission dynamics varies across The Gambia despite high coverage of control interventions.

PLoS One [Internet]. 2017 Nov 2;12(11):e0187059. Available from: http://dx.doi.org/10.1371/journal.pone.0187059

17. D'Alessandro U, Aikins MK, Langerock P, Bennett S, Greenwood BM. Nationwide survey of bednet use in rural Gambia. Bull World Health Organ [Internet]. 1994;72(3):391–4. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8062396
18. Pinder M, Conteh L, Jeffries D, Jones C, Knudsen J, Kandeh B, et al. The RooPfs study to assess whether improved housing provides additional protection against clinical malaria over current best practice in The Gambia: study protocol for a randomized controlled study and ancillary studies. Trials [Internet]. 2016 Jun 3;17(1):275. Available from: http://dx.doi.org/10.1186/s13063-016-1400-7
19. Haber N, Harling G, Cohen J, Mutevedzi T, Tanser F, Gareta D, et al. List randomization for eliciting HIV status and sexual behaviors in rural KwaZulu-Natal, South Africa: a randomized experiment using known true values for validation. BMC Med Res Methodol [Internet]. 2018 May 25;18(1):46. Available from: http://dx.doi.org/10.1186/s12874-018-0507-9
20. Mwesigwa J, Okebe J, Affara M, Di Tanna GL, Nwakanma D, Janha O, et al. On-going malaria transmission in The Gambia despite high coverage of control interventions: a nationwide cross-sectional survey. Malar J [Internet]. 2015 Aug 14;14:314. Available from: http://dx.doi.org/10.1186/s12936-015-0829-6
21. Aikins MK, Pickering H, Alonso PL, d'Alessandro U, Lindsay SW, Todd J, et al. A malaria control trial using insecticide-treated bed nets and targeted chemoprophylaxis in a rural area of The Gambia, West Africa: 4. Perceptions of the causes of malaria and of its treatment and prevention in the study area. Trans R Soc Trop Med Hyg [Internet]. 1993;87:25–30. Available from: https://www.sciencedirect.com/science/article/pii/003592039390172M
22. Koenker H, Yukich JO. Effect of user preferences on ITN use: a review of literature and data. Malar J [Internet]. 2017 Jun 1;16(1):233. Available from: http://dx.doi.org/10.1186/s12936-017-1879-8
23. Cohen J, Dupas P. Free Distribution or Cost-Sharing? Evidence from a Randomized Malaria Prevention Experiment\ast. Q J Econ [Internet]. 2010 Feb;125(1):1–45. Available from: https://doi.org/10.1162/qjec.2010.125.1.1
24. Comfort AB, Krezanoski PJ. The effect of price on demand for and use of bednets: evidence from a randomized experiment in Madagascar. Health Policy Plan [Internet]. 2017 Mar 1;32(2):178–93. Available from: http://dx.doi.org/10.1093/heapol/czw108