RELYING SOLELY ON MOBILE PHONE TECHNOLOGY: SAMPLING AND GATHERING SURVEY DATA IN CHALLENGING SETTINGS

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Abstract. This study develops a two-stage data collection methodology, combining (i) random dialing of phone numbers and Interactive Voice Recognition (IVR) surveys to sample and screen respondents and (ii) mobile phone surveys, to interview 2,265 respondents during the 2014 Ebola outbreak. Response, cooperation, refusal, and contact rates for the IVR survey were 51.97%, 52.62%, 41.85%, and 98.77%. Mobile phone surveys, which asked respondents sensitive information, were similarly successful. This method offers promise for data collection in developing countries, at low cost ($24 per survey), when a sampling frame is not available or fieldwork activities are excessively demanding.

Keywords: data collection; mobile phones; random dialing; Interactive Voice Recognition; challenge

Date: September 17, 2019.

1. Introduction

More and more researchers collect survey data through the use of mobile phones. Mobile phone technology has removed significant barriers inherent to traditional survey data collection: it helps in gathering high-frequency panel data (Dillon, 2012, Hoogeveen et al., 2014, Ballivian et al., 2015), it provides timely access and monitoring of data collected through face-to-face surveys, and it allows for fast and low-cost data collection. Yet, while mobile phones are widely used as data collection tool in developed countries where everyone has access to them, this survey method is still in infancy in developing settings.

Researchers collecting primary survey data often face implementation challenges[1], such as appropriately selecting the sample of interest, developing data collection methods which are feasible, and selecting survey content that is culturally acceptable and non-sensitive (Grosh and Glewwe, 2000). Given the rise in mobile phone penetration rates in developing economies (World Bank, 2016), mobile phone surveys are increasingly used to gather national statistics and to conduct monitoring, bio-surveillance and disaster management (Gallup, 2012, Twaweza East Africa, 2013, Bauer et al., 2013, Hoogeveen et al., 2014, van der Windt and Humphreys, 2014, Garlick et al., 2019). However, gathering data in developing settings, where there might be weak institutions, limited resources and infrastructure, cultural constraints and low literacy, can be even more demanding than in developed countries (Ganesan et al., 2012, Dabalen et al., 2016). In developing economies, for example, there is often no access to an initial list of contacts or public available data sources, and researchers need to gather baseline data themselves to have a sampling frame. Times of emergency situations, such as conflicts, infectious diseases or weather-related disasters, when it is hard to reach respondents in person for interviews, exacerbate these challenges.

Although limitations remain in the application of mobile phones as unique data collection device (Kempf and Remington, 2007), this technology can be used to overcome many of the difficulties intrinsic to data collection in these situations. Evidence regarding the use of mobile phones, both as a method to gather survey data as well as to select and screen an initial sample of respondents to interview, is still lacking. The methodology proposed in this project aims at overcoming two specific challenges related to sampling and screening respondents and data gathering in resource-constrained settings.

First, researchers begin field research by developing a sampling frame. Usually, they seek access to an initial list of contacts, such as a list of respondents from past studies or a list of phone numbers contained within the datasets from collaborating institutions (The World Bank Group, 2014, The World Bank Group, 2015). Alternatively, investigators may develop a sampling frame from public available data sources, such as large-scale national household surveys or population census, which provide the advantage of being nationally

[1]https://blogs.worldbank.org/impactevaluations/issues-data-collection-and-measurement.

representative; or, they simply gather data themselves through a face-to-face baseline survey. However, getting a sampling frame is challenging when data do not exist or face-to-face data collections are not feasible.

Second, especially at the time of emergency situations, reaching survey respondents in person for interviews can be challenging or the risks and costs associated to data collections to have a meaningful sample may be insurmountable. As weather-related disasters or infectious diseases remain a worldwide threat, especially in developing countries (United Nations Office for Disaster Risk Reduction, UNISDR, 2015), in-field data collections may not be always feasible.

This project uses mobile phone technology as the sole platform for all stages of data collection: (i) the selection and screening of respondents, and (ii) the survey data collection. The two-stage procedure uses random-dialing of phone numbers (RDD) and Interactive Voice Recognition (IVR) to select and screen respondents, respectively, followed by a full-length (30-45 minute) live-voice mobile phone survey deployed during the 2014 West Africa Ebola outbreak. By combining these established methods (RDD, IVR, mobile phones) in a novel manner, the project develops a data collection procedure, which does not require in person contacts, thus allowing researchers to gather survey data in high-risk settings.

This study also tests the feasibility of this approach, by conducting more than 2,200 interviews in a developing country, namely Liberia, between October 2015 and June 2016. Call outcomes, and response, cooperation, refusal, and contact rates were calculated according to the American Association of Public Opinion Research guidelines (AAPOR, 2016). Bias and quality in the data gathered through mobile phones were tested using as benchmark the nationally representative Demographic Health Survey (DHS) (Demographic Health Survey Liberia, 2013). Costs were also computed in comparison to past approaches used.

The proposed two-stage data collection methodology contributes to a small, but growing body of literature about data collection methods in developing countries. This method builds upon the RDD selection approach[2] outlined by Leo et al. (2015), in which the sample was randomly selected through an online platform and data collection was performed through IVR survey. The authors assessed whether mobile phone surveys were a feasible and cost-effective approach to collect data in four middle or low-income countries, focusing on whether the method could reach a nationally representative sample and how to improve its survey completion. Similarly, L'Engle et al. (2018) used RDD and IVR surveys to collect survey data in Ghana, assessing response rate and representativeness of the obtained sample compared to face-to-face national surveys. In these and similar studies, however, the IVR survey length (i.e. 10 or 20 questions) prevented researchers from ascertaining more detailed and sensitive information disclosed through a full-length survey.

[2]See Waksberg (1978) and Massey et al. (1997) for the use of RDD in the developed world.

Moreover, this project builds upon previous studies, which used live-voice mobile phone surveys to collect high frequency data. Hoogeveen et al. (2014) provided examples of phone surveys at high frequency in Tanzania and South Sudan through a call center. A similar approach was used by Dillon (2012) to elicit data regarding farmer expectations, production, and income levels over time. Demombynes et al. (2013) also used a similar high frequency survey approach, where the authors randomized the level of incentives and the phone equipment to increase response rate in South Sudan. Finally, Garlick et al. (2019) compared differing frequencies of in person or mobile phone interviews to micro-enterprises, and found no difference in data quality or response rates between high-frequency mobile phone interviews compared to low-frequency in person interviews.

To my knowledge, this is the first study to test the feasibility of combining (i) random-dialing of phone numbers[3] and IVR surveys to sample and screen respondents, and (ii) a full-length live-voice mobile phone survey to conduct interviews. Furthermore, this method was conducted in a developing country where this type of technology is needed the most. The two-stage procedure allows researchers to conduct the entire data collection relying solely on mobile phone technology, precluding the need for prior data or fieldwork activities to have a sampling frame or to gather survey data. While the studies mentioned above required at least one in person interaction in order to facilitate data collection through mobile phone interviews, the proposed two-stage methodology does not necessitate any physical contact with the respondents.

The paper is organized as follows: Section 2 highlights the methodology used to select and screen respondents, as well as to gather data; Section 3 provides a description of the results by estimating call outcomes and rates and by investigating data bias and quality; Section 4 discussed advantages and limitations of the approach; Section 5 concludes.

2. Methodology

The goal of the initial project was to study the political economy of the 2014 West Africa Ebola epidemic in Liberia (Maffioli, 2018), by gathering survey data on individuals' level of trust and perceived corruption towards several institutions, and their opinions on the government's actions during the response. However, successfully accomplishing this goal required surmounting significant survey data challenges. There was indeed no baseline data available to select respondents and gathering face-to-face data collection was impossible due to the high costs and risks at the time of the disease. Thus, the project relied solely on mobile phone technology for both stages of the data collection procedure: (1) sampling and screening of the respondents, and (2) data gathering, as described in details next.

[3]Also the RDD technique was improved by masking international phone numbers as they were local, to reduce potential non-response rate.

2.1. **Selection and screening of respondents.** Due to the lack of access to an initial sample in the pre-Ebola period, an online platform called VotoMobile[4] was employed to draw an initial list of respondents, through RDD. Given the known structure of the mobile phone numbers in Liberia, the platform created a list of randomly generated phone numbers that fits that structure through an algorithm. The platform was set up to select phone numbers from the two main Liberian phone companies at that time (Liberian Telecommunications Authority, 2012), LonestarCell/MTN with a share of 49.55% and Cellcom with a share of 40.36%[5]. These companies had a similar phone structure, but different mobile phone prefixes[6], which were exploited in the algorithm used for the random selection. The platform was set up to randomly select half of the numbers from LonestarCell/MTN and half from Cellcom. The platform also mimicked Liberian phone numbers, using the prefixes of these two main phone companies.

The platform went through the randomly generated phone numbers, placing 214,823 calls (Table 1). Once the phone number connects and a person picked up the call, implying that it was an existing Liberian phone number, a short pre-recorded survey (IVR) informed the respondent that she/he was selected for an interview. The IVR message asked the respondent three questions to gather her/his residence location at the beginning of the outbreak: (1) whether she/he lived in Montserrado county; (2) if not, in which other county did she/he live in; and (3) in which district did she/he live in. The aim was to gather a sample of individuals, some with experience of Ebola and some without, to be able to compare the two groups, and to limit respondents from Montserrado county, the most urbanized and populous region in Liberia. If the respondent answered all the three questions, then she/he would also be informed that someone would call back from the local NGO, and that, upon completion of the live-voice mobile phone interview, she/he would receive $1 free airtime for her/his phone as a sign of appreciation.

2.2. **Data gathering.** Screened respondents were called back by real enumerators of a local NGO[7] to conduct a 30-45 minute interview. The initial sample for the mobile phone interviews was selected among the phone numbers called in stage (1), for which the IVR survey

[4]https://www.votomobile.org/.

[5]Other companies are Comium and LiberCell with market shares of 8.34% and 1.29% respectively, and Libtelco, the designated national operator with a share of 0.46%.

[6]Both companies' phone numbers were 10 digit numbers: LonestarCell/MTN started with 0880, 0886, 0888, while Cellcom had prefixes 0770, 0775, 0776, 0777.

[7]The implementation partner was a local Liberian NGO called Parley, based in Gbarnga, Bomi County, who had past experience with phone surveys, also during the Ebola outbreak.

was either complete or partial, for a total of 3,779 phone numbers (Table 2).[8] The enumerators from the local NGO were instructed to call the full list of phone numbers multiple times to reach the respondents. They had also the flexibility to re-contact the respondents at their most preferred time and to call them back when the survey was interrupted for any reason. In total, data were collected on 2,271 respondents across the entirety of Liberia. Due to budget constraints, the main data collection by the local NGO proceeded in two rounds.[9]

Out of the 3,779 phone numbers, the local NGO called back 2,319 respondents in round 1, and 1,460 respondents in round 2 (Table 2). In round 1, 1,957 respondents completed the interview, while in round 2, due to the high marginal costs of interviewing additional respondents, the NGO stopped at 314 individuals interviewed. In fact, since phone number prefixes are associated to different phone companies and each phone company allows taking advantage of different call, text, or data promotions, it is common for Liberians to switch between phone companies and thus frequently change phone numbers. Six months after the selection and screening process, the NGO found that, of all the numbers provided for round 2 (1,460 phone numbers), 43% (634) of the numbers were permanently switched off and 28% (408) were not ringing. The final sample that was eligible for the initial research project (Maffioli, 2018) and consented to be interviewed, includes 2,271 individuals (1,957 from round 1 and 314 from round 2, Table 2). The analysis is conducted on 2,265 respondents, since for six of them their reported location did not match with the list of villages provided by the Liberian Institute of Statistics and Geo-Information Services (LISGIS).

3. Results

3.1. **Call outcomes and rates.**

3.1.1. *Selection and screening of respondents.* Table 1 describes the classification of the mobile phone numbers used, and response, cooperation, refusal and contact rates are computed according to the American Association of Public Opinion Research guidelines (AAPOR,

[8]The sample for the initial project was supposed to exclude respondents from Montserrado county. The local NGO was then provided with 2,733 phone numbers from complete responses and 1,276 phone numbers from incomplete responses, for those individuals who reported in the IVR survey (stage (1)) that they did not live in Montserrado county at the beginning of the Ebola outbreak. After interviewing the respondents through mobile phones (stage (2)), 14% of them confirmed that they lived in Montserrado county at the end of 2013, despite having answered differently in the IVR survey. These individuals were kept in the final sample. See Section 4.4.2 for limitations.

[9]However, it would be best to implement a unique round of data collection closer in time to stage (1) of selection and screening of the sample (see Section 4.2.3 for a discussion on limitations from the waiting time between stage (1) and (2) of this methodology). This should be considered specific to this project and not an example to follow in a future implementation.

2016). As no restrictions were placed on the selection process through IVR, any person answering the phone was considered eligible.[10] *Complete interviews* were defined as answering the three location questions to gather information on both the county and the district where the respondent resided at the beginning of the Ebola outbreak (12,761). *Partial interviews* were defined as answering the first two questions of the survey to gather the county, but not the district (1,216). Since the IVR survey was very short, both *break-offs and refusals* were defined as answering the first IVR question, i.e. whether the respondent resided in Montserrado county or not. We categorize conservatively 10,276 numbers in this category as phone numbers which were dialed, for which the phone rang but the respondent did not pick up the call. According to VotoMobile[11] in fact this cause may be also generated by internal network timers, but we are unable to distinguish whether the user did or did not deliberately respond to the call. *Unknown eligibility* was classified as phone numbers always busy (302). Finally, phone numbers that were dialed but could not be confirmed as known working numbers were classified as *not eligible*. This category includes: (i) phone numbers never responded because the call never got to the phone of the called party due to an error on the provider's end (107,967); these phone numbers were categorized as unknown if number is valid, since the call did not connect. (ii) phone numbers temporarily out of service (52,249); (iii) phone numbers which have specific technological issues to connect (31); (iv) phone numbers for which the call connected at the network level but a valid connection to an individual's mobile phone could not be confirmed (30,021). These numbers were categorized as phone numbers which connected, but there was no or invalid selection. Overall, a high number of not eligible calls was expected because of the automated nature of the RDD calling system[12].

The platform was set-up to attempt up to 4 calls to the same phone numbers: after the first attempt, the second call was placed after 5 minutes, while the third and the fourth calls were placed after 8 hours each. Most of the numbers were called on average 3.55 times. The data were collected between the 21 and 31 of October 2015, and the average duration was of only 1.11 minutes (min 0.408 - max 18.913), since the majority of eligible respondents (71%) who were from Montserrado county answered only two questions.

[10]Since "e", i.e. the proportion of all callers screened for eligibility who were eligible, is 100%, only the relevant response, cooperation, refusal and contact rates are reported. A restriction on adult respondents (18 years old or older) was applied at stage (2) of data collection.

[11]Please see https://freeswitch.org/confluence/display/FREESWITCH/Hangup+Cause+Code+Table for more details.

[12]Based on some basic calculations, VotoMobile expected that no more than 37% of the calls made by the online platform could be real phone numbers. In Liberia, there exist about 2.6 million owners of SIM cards. Since the platform tries 6 number of digits for each of the 7 Liberian prefixes, this would total up to 10^6 X 7 = 7,000,000 possible phone numbers. 2,600,000/7,000,000 corresponds to about 37% potential real numbers that we would have been able to reach.

AAPOR response rate 1 (&3), cooperation rate 1 (&3), refusal rate 1 (&2), and contact rate 1 (&2) were 51.97%, 52.62%, 41.85%, and 98.77% respectively (Table 1). AAPOR response rate 2 (&4), cooperation rate 2 (&4), and contact rate 3 were slightly higher at 56.92%, 57.63%, 42.37% and 100%. The majority of eligible respondents (91.3%) completed the interview, suggesting, in line with L'Engle et al. (2018), that this method is feasible and successful in developing countries.

3.1.2. *Data gathering.* Table 2 describes a similar exercise for the survey sample interviewed through mobile phones in stage (2). It is important to notice that phone numbers which were active during the IVR survey implemented in October 2015 might not be active anymore at time of the mobile-phone survey in 2016 (see section 4.2.3 for more details). Then, the classification of the mobile phone numbers, computed according to the American Association of Public Opinion Research guidelines (AAPOR, 2016), assumes that all phone numbers listed through the IVR survey needed to be called back to confirm they were still working phone numbers.

A restriction was placed on the selection process through mobile phones, by restricting the survey to respondents being at least 18 years old. "E", i.e. the proportion of all callers screened for eligibility who were eligible, is on average 99% for the two rounds of data collection. The majority of respondents (93%) answered the entire survey (about 100 questions) (Table A1 in Appendix). Since all respondents also answered more than half of the survey, all the interviews were considered *complete interviews*. *Refusals* were defined as not agreeing to participate in the survey (113), while *break-offs* were defined as phone numbers which were dialed, for which the phone rang but the respondent did not pick up the call (94). *Unknown eligibility* was classified as phone numbers not screened for eligibility, since respondents reported to have been already interviewed (15). Finally, *not eligible* phone numbers were classified as those numbers which (i) were ineligible because respondents were younger than 18 years old (50); (ii) phone numbers never responded because the call never got to the phone of the called party due to an error on the provider's end (602); these phone numbers were categorized as unknown if number is valid, since the call did not connect; (iii) were temporarily out of service (634);

Response, cooperation, refusal and contact rates were computed similarly following AAPOR standards: response rate 1 (&2), cooperation rate 1 (&3), refusal rate 1, and contact rate 1 were 91.10%, 91.65%, 8.30%, and 99.40% respectively (Table 2). The implementation of the mobile survey was more successful in round 1 compared to round 2, suggesting that a longer waiting time (in round (2)) between stage (1) and stage (2) of the methodology lead to a higher number of non eligible phone numbers as well as a higher proportion of refusals and break-offs.

3.2. **Bias and quality in the data gathered.** To assess the lack of representativeness of the sample, the study uses data from DHS (Demographic Health Survey Liberia, 2013) collected most recently in 2013, which is a nationally representative sample of household face-to-face interviews. 4,118 male and 9,239 female respondents between 15 to 49 years old were used as benchmark to the survey sample (2,265 respondents), to compare respondent and household socio-demographic characteristics. Table 3 describes a survey sample biased towards male, educated respondents, from urban areas, with access to mobile phones (column 3 vs 1). Survey respondents are also on average wealthier as defined by several measure of assets' ownership and improved sources of toilet, wall and roof material following WHO standards. Statistical testing was performed between means of respondent and household characteristics between DHS and survey sample, yielding mostly to statistically significant differences (at 5% level). The fact that the survey sample is not representative of the national Liberian population is not surprising, since both respondents' screening (stage (1)) and interviews (stage (2)) were conducted through mobile phones, and individuals needed to have access to a mobile phone at the time of the call: male, more educated and wealthier individuals from urban areas are more likely to own mobile phones (Demographic Health Survey Liberia, 2013). Furthermore, stage (1) was set-up to limit respondents from Montserrado county, the most economic developed and urban county, and a selection based on the county where respondent resided at the beginning of the outbreak was imposed to define the final sample frame (3,779 phone numbers, Table 2) which the local NGO used to interview respondents in stage (2). Table 3 confirms that the final sample of 2,265 respondents is very different from population surveys.

As an exercise (Table 3, columns 6-8), the survey sample was weighted[13] based on four socio-demographic characteristics: whether the respondent is a male, whether she/he has none or primary education, whether she/he owns a mobile phone and whether she/he lives in rural areas. To take into account the potential bias in the sample in these dimensions, 16 strata, given by the combination of the four socio-demographic characteristics, were constructed[14]. Conditional probabilities were derived in each stratum, and survey sample weights were reconstructed - as the proportion of respondents in DHS 2013 divided by the proportion of respondents in survey sample within each stratum- to perfectly match the nationally representative distribution from DHS 2013.

Table 3 columns 6-7 shows the mean and standard deviation estimates from the mobile phone survey weighted by selected characteristics. By construction, the weighted survey sample is identical to DHS 2013 in the four dimensions selected. After weighting, about 55% of the gaps found in the means between the weighted survey sample and the DHS sample

[13]See Valliant et al., 2013 and Himelein, 2014 for more information on weighting approaches.
[14]The analysis is limited to 16 strata to avoid having too few observations per stratum, given the total size of the sample.

are reduced (Table 3, columns 5 vs 8). However, even in the weighted sample, the variables reported in Table 3 remain statistically significant different from each other, suggesting that weighting did not solve entirely the bias.[15] [16]

Despite this limitation of the sample not being representative of the population, the mobile phone surveys showed the feasibility and success of gathering a variety of data. In addition to respondent and household socio-demographics, the survey tool collected data on: (1) political outcomes, such as self-reported level of trust in governmental and non-governmental institutions and people, perceived corruption towards similar institutions, and past voting behavior; and (2) Ebola-related questions, such as self-reported Ebola incidence in the community, the level of information received, the experience with the response, and perceptions about the government's performance.[17]

Table A1 in Appendix provides summary statistics of the main data collected and frequency of responses for each question, demonstrating that the response rate per each question was very high. Despite the questions asking sensitive opinions on how governments or other institutions handled the epidemic and political outcomes, the majority of respondents (93%) did not refuse to answer. The survey finds that respondents had high level of trust (more than 7 on a scale from 1 to 10) in the President, Ministry of Health, health workers, local and international NGO, friends and family, but lower trust in foreign people or people living outside the community (less than 4). Perceived corruption, as asked by whether the respondent disagrees or agrees (on a scale from 0 to 4) that an institution is corrupt, was higher towards the police, the government, the legislature and the revenue authority, but levels of perceived corruption towards other institutions were not so different, suggesting that perceived corruption is widespread in the country. In line with the election results, respondents were less likely to go to vote in Senatorial elections in 2014 (69% in 2014 vs 77% in 2011) and they showed less support for the incumbent party (26% in 2014 vs 34% in 2011).

[15]It is worthy to highlight, however, that, despite the variables compared in Table 3, being constructed in similar ways, the questions in DHS and in the survey were asked differently. As a result, the construction of similar but not identical variables such as occupation or improved assets might contribute to explain some of these differences.

[16]The survey in the initial research project was conducted to collect political outcomes. Another potential comparison would be to test the difference between political outcomes in survey sample and Afrobarometer data (2015). Unfortunately, trust and perceived corruption questions were asked so differently across surveys that it is hard to homogenize the outcomes. Future studies should take this into account, and they should consider asking questions in a similar format to existing national representative surveys to be able to weight the sample based on socio-demographic characteristics and compare the outcomes of interest.

[17]To avoid potential priming effects due to the order of the questions between political outcomes and experience with Ebola, half of the sample was randomized to receive the political outcomes section first, while the second half received the Ebola-related questions first. No statistically significant differences were found in the data collected between the two samples.

When asked about Ebola incidence, 19% of the respondents reported that their village was affected, and an average 0.92 number of cases was reported in the sample. In term of response to the epidemic, 92% of the respondents reported that someone came into the community during the Ebola epidemic, with the majority reporting local NGO (61%) and governmental health workers (54%). 93% received daily information on Ebola and how to prevent, with respondents trusting health workers and media outlets the most (76%). 89% confirmed that burial practices changed. In term of responsibility, 29% of respondents agreed that Guinea people brought Ebola to Liberia, 18% reported traders, while 16% accused the government to be responsible. This is in line with the fact that Ebola originated across the border with Guinea where trading activities are common, and the government initially under-estimated the epidemic. Overall, opinions were positive towards the response, with the majority of respondents reporting that international NGO (88%), people in general (69%), health workers (67%), local authorities (61%), and government (58%) well handled the relief effort. Still, government's failures were not absent: 13% of respondents reported that dead bodies were removed late (after 4 hrs), 13% reported that the ambulance was called, but arrived late (after 4 hrs), 3.8% reported that the patient was brought to the Ebola Treatment Unit, but he/she had to wait outside because of lack of beds. 4.1% of the respondents finally said there was some resistance to response efforts.

All together, the survey data highlight how the data collection through mobile phones was feasible in a developing country and at the time of the disaster. More importantly, it also shed light on how sensitive information could be asked through mobile phones without compromising the response rate.

4. Discussion

The two-stage data collection methodology developed in this project presents both advantages and limitations.

4.1. **Advantages.**

4.1.1. *International Phone Numbers.* A major ex-ante concern for the response rate of mobile phone surveys was the use of international phone numbers. In fact, respondents are found to be less likely to answer calls from international phone numbers, and this has been shown to be true also at the time of the Ebola outbreak (The World Bank Group, 2014). One initial challenge was to develop a system in which an international data collection partner (such as VotoMobile in Ghana or GeoPoll in USA) would use local (Liberian) phone numbers to contact respondents, masking the international nature of the service provider. Contrary to past studies (The World Bank Group, 2014, Leo et al., 2015, L'Engle et al., 2018) which used international phone numbers to conduct mobile phone interviews in developing countries, VotoMobile online platform piloted for the first time the approach to mask the international

phone numbers as local, and it successfully made the local prefix and the phone number appeared as they were Liberian. International phone numbers were instead not a problem for stage (2) of the data collection, since the interviews were performed by a local NGO, and Liberian enumerators used their personal phones.

The decision to conduct the selection and screening of respondents (stage (1)) using local phone numbers was intended to circumvent the low-response rates intrinsic to surveys using international numbers. Instead, the decision to use a call-center set-up in the country for the mobile phone interviews (stage (2)) derived from a need of experience (from the local NGO) in collecting sensitive data during the Ebola outbreak, more than to overcome the problem of avoiding international phone numbers.[18]

4.1.2. *Languages.* Another problem researchers might face is the use of the appropriate language for the country of interest. Because both the IVR survey and mobile phone interviews might be managed from international partners or call centers, it is critical that both surveys are conducted in the local languages.

In this project, both the IVR surveys and mobile phone interviews were conducted in (Liberian) English, the primary language commonly spoken by the entire population. As a precaution, enumerators also knew some of the tribal languages in case it was necessary to switch to specific dialects for some respondents, but in this study, enumerators never had to switch to a local language from (Liberian) English. However, it is important to keep in mind that this will not always be the case in other countries and researchers should be ready to collect survey data in tribal languages. The methodology could potentially be adjusted to serve this purpose in two ways: (i) the IVR survey could be recorded in several tribal languages and the respondent could choose their dialect upon starting the survey, and (ii) the mobile phone interviews could be conducted by enumerators who speak the tribal language or they could be passed to other enumerators who do.

4.1.3. *Screening.* An additional advantage of this methodology is that the mobile phone technology can be used not only to sample respondents, but also to screen them based on the sample needed for the project.

Stage (1) of the methodology links a call placed through the online platform to a short IVR survey, which allows researchers to select respondents. In this project, a 3-question IVR survey screened respondents based on where they were living at the beginning of the Ebola outbreak in order to vary the number of people who experienced Ebola in the total sample. However, several other criteria (gender, education, age, etc.) could be applied to select a sample similar to nationally representative surveys. Researchers could set quotas to

[18]The problem of international phone numbers should however be considered when live-voice mobile phone surveys are conducted from call-centers outside of the country, and researchers should consider that placing calls locally might cost less than conducting mobile phone interviews from an international call-center.

select respondents based on socio-demographics or geographical characteristics, asking any question that would be easily answerable through a limited number of keyboard options. It should be noted, however, that the length of the IVR survey is directly proportional to the costs.

4.1.4. *Costs.* Table 4 presents a summary of the costs by the stage of the methodology. The costs for stage (1) include the fixed initial cost of consulting for the use and maintenance of the platform, piloting costs, and airtime. The cost per each picked-up call in stage (1) was only $0.10. The cost of the IVR survey was higher ($1.49) for each survey (considering both complete and partial) and even higher ($1.63), considering only complete surveys.

Regarding the mobile phone survey (stage (2)), the costs depend on the country in which researchers work as well as constraints due to the emergency situation in act, lack of electricity to charge phones or lack of money to buy airtime. In this project, the costs included both common data collection costs and additional costs due to the high-risk nature of the area: enumerators' monthly salaries, human resources costs for survey programming, testing, and revisions, other data cleaning costs, internet, fuel for electricity generator, mobile phone airtime for enumerators and survey respondents (gift of $1 airtime), vehicle maintenance to bring enumerators in office during the Ebola outbreak, security and Ebola safety measures. Working with the local NGO partner resulted in a cost of about $13.49 per respondent they tried to reach, and $22.45 per complete survey. Completing a mobile phone survey after about six months from the sample selection and IVR screening, costs up to six times more than gathering the data right away ($162.36 vs $26.05). See Section 4.2.3. for more considerations regarding timing. In summary, the total cost of this novel methodology per complete survey (including both stages (1) - selection and screening - and stage (2) - data collection) is around $24.

Several studies estimated the costs of collecting data through different methodologies. More expensive data collections are face-to-face surveys which costs are at least $25, but can reach values as high as $150, depending on the complexity of the survey and the distances that have to be covered to find respondents. For example, Lietz et al. (2015) estimated a cost of $25 in Burkina Faso; Mahfoud et al. (2015) $36 per survey in Lebanon; Ballivian et al. (2015) $40 per survey in Peru and Honduras; Hoogeveen et al. (2014) and Dillon (2012) between $50-150 and $97 per survey, respectively, in Tanzania; Dabalen et al. (2016) $150 per survey in Malawi.

On the other hand, costs for mobile phone and IVR surveys have been estimated to be much lower than face-to-face surveys in a similar setting (Schuster and Brito, 2011, Mahfoud et al., 2015, Garlick et al., 2019). Mobile phone interviews cost between $4.10-7.30 per survey in Tanzania (Hoogeveen et al. 2014 and Dillon 2012), $5.80-8.80 per survey in Malawi (Dabalen et al., 2016), and between $4.44-22.20 in Lebanon (Mahfoud et al., 2015).

Similar lower costs have been estimated for IVR surveys, such as $17 in Ballivian et al. (2015), 4.95$ in L'Engle et al. (2018) and about $2 in Leo et al. (2015), depending on the length of the survey and the criteria applied to select the sample.

Compared to face-to-face data collections, this two-stage methodology is then advantageous by eliminating many of the implementation costs associated with in-field sampling and screening (in stage (1)), and face-to-face surveys (in stage (2)), such as personnel, logistics, and distribution of phones. Compared to a single mobile phone or IVR survey, this method might be more expensive. However, both mobile phone and IVR surveys require a list of phone numbers to start with. If this initial list of respondents is not available and selecting a sample through in person interviews is too costly or risky in resource-constrained settings or during emergency situations, then this methodology might still be a cost-effective solution. In fact, adding the costs of a baseline face-to-face data collection to gather the initial list of respondents to interview (stage (1)) to the costs of a mobile phone or IVR interview (stage (2)) to gather data, the combined costs would be as high as $160, compared to $24 for the methodology proposed in this study. It is also important to notice that the costs at each stage (IVR, $1.63 per survey; mobile phone survey $22.45, Table 4) are similar or lower than the estimated costs reported in other studies.

This does not indicate that this method is superior to others, rather it provides evidence that the two-stage methodology can be affordably implemented in challenging settings where in person data baseline collection is prohibitively costly or dangerous.

4.1.5. *Data Entry, Monitoring and Clarification.* This methodology, as other mobile phone data collection approaches (IVR, and mobile phone interviews), has a final advantage over paper surveys: data entry, monitoring and adjustments to the survey content are significantly easier.

First, data from both IVR survey and mobile phone interviews are directly entered and saved in online platforms and are accessible instantaneously. Compared to paper surveys, which require a two-stage transcription of data (one from the enumerator, one from the data entry staff), the use of mobile phone technology and automated data entry reduces errors and allows for immediate data access and monitoring.

Second, the supervision of mobile phone data collection allows for daily data analysis and instantaneous correction of enumerator mistakes. It also allows for immediate evaluation of enumerator performance through listening to interviews (recorded through the mobile phones), analyzing their timing and number of surveys per day, and evaluating the quality of the data collected.

Third, remaining actively engaged in the monitoring of the data provides researchers with the ability to check on the data quality right away and revise survey content immediately.

The reduced time between data collection and data analysis allows researchers to identify mistakes in the survey development and correct them in real time.

4.2. **Limitations.**

4.2.1. *Sample Selection.* The first limitation of this novel methodology is sample selection. Since the selection and screening are conducted through mobile phones, respondents need to have access to a mobile phone and pick-up the call. This group is often not representative of the general population of a country.

In Table 3 the survey sample was compared to nationally representative survey (Demographic Health Survey Liberia, 2013) and it was shown to be biased. Even after weighting on few socio-demographic variables, most of the other differences remain statistically significant (at 5% level). This is not surprising. and it is in line with other research in developed (Lee et al., 2010) and developing countries (Leo et al., 2015) where respondents interviewed through telephone surveys are different from the entire population, even after controlling for demographic characteristics. This limitation suggests that the methodology proposed in this study is not a good approach if researchers are interested in nationally representative samples.

However, a potential solution is to use fixed quotas in the IVR survey to select respondents based on pre-defined socio-demographic characteristics, and to reproduce a sample similar to nationally representative surveys. This would come at the expense of higher implementation costs in the IVR message, since several screening questions would be added to the survey tool. As the number of questions asked through the IVR survey increase along with sample specificity (for example, half women and half men, or a fixed number of respondents per geographical area), so does the difficulty and costs associated with finding the targeted sample (stage (1)).[19]

Thus, researchers face the trade-off between being able to gather data in challenging settings by relying solely on existing mobile phones owned by respondents, and selecting a non-nationally representative sample unless it is affordable to use fixed quotas in the IVR survey.

4.2.2. *Attrition, Participation and Confidentiality.* The second main problem researchers might face is attrition from the initial list of phone numbers generated by the online platform (stage (1)), to the completion of the mobile phone interview (stage (2)).

[19]In this study, no location specific quotas were established. Alternatively, one question in the IVR survey was intended to limit respondents from one county (Montserrado), where more than 30% of the population lives (Table A2, Appendix). Although fixed quota of respondents per county could have been used, the costs were too high given the budget available. Researchers should evaluate the costs of using quotas depending on the sample they want to select for their research.

World Bank researchers who performed phone surveys during the Ebola outbreak in Liberia reported that only 30% of the initial sample completed the survey (16% of the original sample, The World Bank Group, 2014). In Sierra Leone, the response rate was also lower than expected, given the nature of the survey and the difficult conditions under which it was conducted: about 69% of the sample with phone numbers completed the survey (45% of the original sample, The World Bank Group, 2015). In the former case, different reasons were conjectured about why the response rate was so low. One was related to the use of unknown foreign numbers, while the second reason was the lack of resources to pay for phone charging in a period of crisis. Other surveys, performed through face-to-face interviews in Montserrado county, reached 95% of the respondents (Blair et al., 2016). Follow-up phone surveys reached about 80% of the original sample. The initial in person interaction between the field enumerators and respondents during the baseline survey seemed to have been the main factor determining the lower attrition rate. Since this project was conducted starting in late 2015, when the outbreak was not at the peak and life was going back to normal, the response rate was expected to be higher than it is in the World Bank surveys. It was in fact computed to be 91.10% in this data collection (Table 2). Similarly, participation for confidentiality reasons was a related concern. First, although individuals never provided their phone numbers to enumerators, there was concern that respondents, once called back from the local NGO, would ask enumerators where they access their phone number from and refuse to participate. In Liberia, this was not a problem because people are used to receiving calls for advertisements or polls. However, researchers should take this into consideration when applying the method in other countries.

Second, because of the complete lack of in person interaction at both stages of data collection, there was a concern that respondents would not feel at ease to provide opinions to a stranger.[20] There was also a doubt that, due to the personal nature of the questions asked in this study (for example, about their experience with Ebola or their political views) respondents would be reluctant or they would refuse to stay at the phone for a long time (the survey lasted 30-45 minutes). Rather, only 113 respondents in both rounds of data collection refused to participate (Table 2), and once enumerators established a first phone contact and call at an appropriate time, individuals completed the mobile phone survey. Even though, in this case, the sensitive content did not preclude a reliable confidential data collection, researchers might face challenges in other settings. Thus, this limitation should be kept in mind and addressed on a country-by-country basis.

[20]There is a debate on whether face-to-face or mobile phone surveys allow respondents more confidentiality in their responses. Those in favor on mobile phone surveys argue that since mobile phone surveys do not allow enumerators to read the body language and facial expressions of the respondent, they might ensure more confidentiality. Respondents might feel more at ease providing opinions to a stranger by phone, than through personal interactions in front of an enumerator.

Third, respondents were provided with $1 airtime incentive[21] that was directly transferred upon the completion of the survey. Respondents were informed at the time of the sample selection, through the IVR survey, about this direct benefit. Recent phone surveys in developing countries found small differences in attrition when incentives were randomly varied (Gallup, 2012, Demombynes et al., 2013, Hoogeveen et al., 2014, Leo et al., 2015), therefore the incentive may have contributed to a lower non-response rate.

Finally, this method does not solve the problem of people sharing a phone number. Both for stage (1) and stage (2) whoever answered the call was interviewed. It is then possible that who picked up the call in stage (1) would not be the same person in stage (2). Even if that was the case, in this project, stage (1) only collected geographical location of the respondent, while the survey data were collected in stage (2). During the mobile phone interviews, the respondent was asked about her/his location again. If different from what was reported during the IVR survey, the respondent was confronted about it and was asked to confirm the correct location at the beginning of the outbreak. In about 16% of the case, individuals reported a different location at the two stages. Qualitatively, the majority of respondents said that they had problems with the speed of the IVR message and how they inputted their answers into the keyboard. For the analysis, the location data collected through mobile phones interviews were trusted more than the data collected through IVR. All these potential limitations should be taken into account for future feasibility tests of this methodology.

4.2.3. *Timing and Follow-up Surveys.* A last important lesson learned from this project relates to the time waited between the sample selection and screening (stage (1)) and the mobile phone data collection (stage (2)). For budgetary reasons, a mobile phone data collection (round 2) was added at a later date, and this caused a six month delay between stage (1) and stage (2) during round 2. In round 2, the local NGO found that 43% of the numbers were permanently switched off and 28% were not ringing (Table 2). While Liberians have the habit of owning multiple SIM cards and switch between them based on cost advantages for airtime, text messages and internet data, it is not clear whether this would happen in other countries. Still, it is advised that researchers limit the time window between the two stages of data collection as much as possible to reduce potential additional problems of not finding (at least temporarily[22]) working phone numbers.

A similar problem could result if respondents were called back for a follow-up mobile phone live-voice interview. Since this study did not collect follow-up data, the concern was

[21]See Brick et al., 2007, Oldendick and Lambries, 2013 for evidence on the effect of incentives on response rates, and see Singer and Ye, 2013 for a review.

[22]The local NGO, Parley, was instructed to call back the phone numbers not ringing or switched off a few times, but the calls back were concentrated in few days. Potentially, more respondents could have been reached with multiple calls at later dates or longer intervals if the phones were temporarily not working.

not addressed. However, as expected for any type of interview, attrition might increase along with the time between interviews. In this study, the local NGO confirmed the respondents' phone number, asked if they possessed multiple SIM cards and for a phone number of friend/relative, in case their phone would be switched-off in the future. This procedure would maximize the probability of reaching respondents for follow-up data collections and is recommended, but future research should shed light on the limits of follow-up surveys using this two-stage procedure.

5. Conclusion

This project proposes and describes a novel two-stage data collection methodology which combines: (1) random dialing of phone numbers (RDD) and Interactive Voice Recognition (IVR) survey to conduct sample selection and screening; and (2) data collection through mobile phone survey. This data collection procedure was used to conduct more than 2,200 interviews in the country of Liberia, at the time of the 2014 West Africa Ebola outbreak. By combining established data collection methods (RDD, IVR, mobile phones) in a novel manner, the main strength of the methodology is that, relying solely on mobile phone technology, precludes the need for prior data or fieldwork activities to have a sampling frame, and allows researchers to gather survey data in challenging, high-risk settings.

On the one hand, the method of sample selection and screening through IVR survey (stage (1)) has the clear advantage of being useful in any country with some phone access (Liberia has on average 65% of phone coverage, Table A2 in Appendix), and in total absence of any initial list of respondents. This approach could then be particularly valuable in countries with no access to public available data or in emergency situations, when reaching respondents in person might be unfeasible or too costly. In addition, the combination of stage (1) with mobile phone surveys (stage (2)) leads to several other advantages, including a reduction of costs, adaptability to languages and survey content in real time, and no required field infrastructure. On the other hand, depending on each country specific context, the limitations of the methodology might overcome the benefits. Network coverage might be insufficient, selection may create significantly biased samples, the use of fixed quotas in the IVR survey and follow-up surveys may be too costly, and phone enumerators might not completely ensure confidentiality.

Researchers must weigh the advantages and limitations of this approach before implementing it in any specific country or context. Yet, as the utilization of mobile phones for data collection and research is increasing in developing countries, the proposed data collection procedure improves the ability of researchers to gather information in challenging settings in developing economies. Despite some of the limitations discussed, successful call outcomes

and rates computed using widely accepted AAPOR standards and low costs of the implementation remain major advantages. The study calculated response, cooperation, refusal and contact rate of the IVR survey as 51.97%, 52.62%, 41.85%, and 98.77%. It also describes how sensitive information about political outcomes could be asked through mobile phones surveys without compromising the response rate (91.10%). It finally described how this two-stage data collection methodology could be cost-effective compared to past approaches, by costing on average $24. However, while this method appears to be feasible and successful in developing countries, the sample is shown not to be representative of the entire population. While nationally representative surveys are fundamental for research, this methodology offers a unique opportunity for data collections in settings in which alternative survey methods are not feasible or affordable. Future research should replicate the implementation of this approach in other settings and test its feasibility and its sample representativeness in other disaster situations.

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Main Tables.

Table 1. Call outcomes and rates for stage (1) - sample selection and screening through random dialing of phone numbers (RDD)

Interview (Category 1)	
Complete (1.1)	12,761
Partial (1.2)	1,216
Eligible, non-interview (Category 2)	
Break-off/Refusals (2.1)	10,276
Unknown eligibility, non-interview (Category 3)	
Always busy (3.12)	302
Not eligible (Category 4)	
Unknown if number is valid, call did not connect (4.31)	107,967
Temporarly out of service (4.33)	52,249
Technological issues (4.4)	31
Other (Call connected but no/invalid selection) (4.9)	30,021
Total phone numbers used	214,823
I = Complete interviews (1.1)	12,761
P = Partial interviews (1.2)	1,216
R = Refusal and break-off (2.1)	10,276
NC = Non contact (2.2)	0
O = Other (2.0, 2.3)	0
Calculating e:	
UH = Unknown household (3.1)	302
UO = Unknown other (3.2Ð3.9)	0
e	100%
Response rate	
Response rate 1 [&3]: I/(I+P)+(R+NC+O)+e(UH+OU)	51.97%
Response rate 2 [&4]: (I+P)/(I+P)+(R+NC+O)+e(UH+OH)	56.92%
Cooperation rate	
Cooperation rate 1 [&3]: I/(I+P)+R+O	52.62%
Cooperation rate 2 [&4]: (I+P)/(I+P)+R+O	57.63%
Refusal rate	
Refusal rate 1 [&2]: R/(I+P)+(R+NC+O)+e(UH+UO)	41.85%
Refusal rate 3: R/(I+P)+(R+NC+O)	42.37%
Contact Rate	
Contact rate 1 [&2]: (I+P)+R+O/(I+P)+(R+O+NC)+e(UH+UO)	98.77%
Contact rate 3: (I+P)+R+O/(I+P)+(R+O+NC)	100.00%

Notes: This table illustrates call outcomes and rates for stage (1) - sample selection and screening through random dialing of phone numbers (RDD), constructed using American Association for Public Opinion Research standards (AAPOR 2016).

Table 2. Call outcomes and rates for stage (2) - gathering data through mobile phone surveys

	ROUND 1	ROUND 2	Total
Interview (Category 1)			
Complete (1.1)	1,957	314	2,271
Partial (1.2)	0	0	0
Eligible, non-interview (Category 2)			
Refusals (2.1)	79	34	113
Break-off (2.1)	25	69	94
Unknown eligibility, non-interview (Category 3)			
No screener completed (3.21)	15	0	0
Not eligible (Category 4)			
Less than 18 years old	49	1	50
Call did not connect (4.31)	194	408	602
Temporarly out of service (4.33)	0	634	634
Technological issues (4.4)	0	0	0
Total phone numbers used	2,319	1,460	3,779
I = Complete interviews (1.1)	1,957	314	2,271
P = Partial interviews (1.2)	0	0	0
R = Refusal and break-off (2.1)	104	103	207
NC = Non contact (2.2)	0	0	0
O = Other (2.0, 2.3)	0	0	0
Calculating e:			
UH = Unknown household (3.1)	0	0	0
UO = Unknown other (3.2Ð3.9)	15	0	15
e	98%	100%	99%
Response rate			
Response rate 1 [&2]: (I+P)/(I+P)+(R+NC+O)+(UH+OU)	94.27%	75.30%	91.10%
Response rate 3 [&4]: (I+P)/(I+P)+(R+NC+O)+e(UH+OU)	94.28%	75.30%	91.10%
Cooperation rate			
Cooperation rate 1 [&3]: I/(I+P)+R+O	94.95%	75.30%	91.65%
Cooperation rate 2 [&4]: (I+P)/(I+P)+R+O	94.95%	75.30%	91.65%
Refusal rate			
Refusal rate 1: R/(I+P)+(R+NC+O)+(UH+UO)	5.01%	24.70%	8.30%
Refusal rate 2: R/(I+P)+(R+NC+O)+e(UH+UO)	5.01%	24.70%	8.30%
Refusal rate 3: R/(I+P)+(R+NC+O)	5.05%	24.70%	8.35%
Contact Rate			
Contact rate 1: (I+P)+R+O/(I+P)+(R+O+NC)+(UH+UO)	99.28%	100.00%	99.40%
Contact rate 1: (I+P)+R+O/(I+P)+(R+O+NC)+e(UH+UO)	99.29%	100.00%	99.41%
Contact rate 3: (I+P)+R+O/(I+P)+(R+O+NC)	100.00%	100.00%	100.00%

Notes: This table illustrates call outcomes and rates for stage (2) - gathering data through mobile phone surveys, constructed using American Association for Public Opinion Research standards (AAPOR 2016).

Table 3. Socio-demographic characteristics of national sample from DHS 2013 and survey sample 2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	DHS 2013 (weighted)		Survey Sample (unweighted)			Survey Sample (weighted)		
	[Obs=13357]		[Obs=2265]					
	Mean	SD	Mean	SD	(1)-(3)	Mean	SD	(1)-(6)
Resp male*	31	46	65	48	-34	31	46	0
Resp educ none or primary*	66	47	17	38	49	66	47	0
Has mobile phone*	60	49	96	20	-36	60	49	0
Rural*	60	49	30	46	30	60	49	0
Resp age	29.3	9.81	32.6	10.6	-3.3	34.3	13.0	-5
Married	62	49	49	50	13	50	50	12
Resp Christian	84	37	86	34	-2	80	40	4
Resp not working	36	48	25	43	11	13	34	23
Has electricity	6	24	36	48	-30	30	46	-24
Has radio	59	49	80	40	-21	74	44	-15
Has bank account	14	35	22	41	-8	7.9	27	6.1
Has refrigerator	3.8	19	6.4	24	-2.6	2.4	15	1.4
Has vehicle	13	34	17	38	-4	6.9	25	6.1
Improved toilet (WHO)	37	48	87	34	-50	81	39	-44
Improved wall material (WHO)	27	44	68	47	-41	57	50	-30
Improved roof material (WHO)	68	47	97	17	-29	96	18	-28
Has chickens	42	49	48	50	-6	56	50	-14
Has goats/sheep	12	33	8.3	28	3.7	10	30	2
Has pigs	3.2	18	2.7	16	0.5	1.7	13	1.5
Has cows	0.82	9	0.44	6.6	0.38	0.14	3.8	0.68
Resp hh size	6.62	3.61	6.88	3.53	-0.26	7.18	3.30	-0.56
Montserrado	16	37	14	35	2	15	35	1

Notes: This table illustrates the comparisons of means and standard deviations in socio-demographic characteristics between the national sample from Demographic Health Survey (DHS, 2013) and survey sample (2016). Columns 1-2 report summary statistics from DHS 2013; Columns 3-4 report summary statistics from the survey sample (unweighted); Columns 6-7 report summary statistics from the survey sample, weighted by selected socio-demographics characteristics (*).

Table 4. Costs, by stage and survey type

	Type Unit	No. units	Cost/Unit	Total cost
1. Sample selection and screening (RDD and IVR survey)				
Fix cost				
Platform Access/Support	Unit	1	$ 500.00	$ 500.00
Pilot				
Consulting services	Days	5	$ 400.00	$ 2,000.00
Airtime	Pilot	1	$ 500.00	$ 500.00
Data collection				
Complete surveys	Interview	4000	$ 3.15	$ 12,600.00
Call back additional 3 times*				$ 3,995.00
Consulting services	Days	3	$ 400.00	$ 1,200.00
Total costs				$ 20,795.00
Cost/call	Phone number	214,823		$ 0.10
Cost/complete and partial survey	Phone number	13,977		$ 1.49
Cost/complete survey	Phone number	12,761		$ 1.63
2. Mobile phone survey with local NGO				
Total costs				$ 50,980.73
Round 1+2				
Cost/call		3,779		$ 13.49
Cost/complete survey		2,271		$ 22.45
Round 1				
Cost/call		2,319		$ 21.98
Cost/complete survey		1,957		$ 26.05
Round 2				
Cost/call		1,460		$ 34.92
Cost/complete survey		314		$ 162.36

Notes: This table illustrates the costs for stage (1): the sample selection and screening process through the VotoMobile platform, and stage (2): data gathering through mobile phone surveys by the local NGO, and by round of data collection. * The cost of $3,395 to call back up to 3 additional times each phone number was estimated assuming that 150,000 calls are made, and (1) 15% of them would be picked-up a first time; thus, calling back 85% of phone numbers a second time would cost $1,275 (127,500 calls x $0.01 per call); (2) 12.5% of them would be picked-up a second time; thus, calling back 87.5% of phone numbers a third time would cost $1,116 (111,562 calls x $0.01 per call); (3) 10% of them would be picked-up a third time; thus, calling back 90% of phone numbers a fourth time would cost $1,004 (100,406 calls x $0.01 per call). The assumptions were made by VotoMobile based on their past experience. The total costs sum-up to $3,995 (1,275+1,116+1,004=$3,995).

Appendix A: Additional Tables.

Table A1.1: Mobile phone surveys responses: political outcomes

	Mean	SD	Obs
Trust in institutions (scale 0 to 10)			
Trust in President	6.36	3.21	2265
Trust in Government	5.70	3.17	2265
Trust in Legislature	4.81	3.20	2265
Trust in NEC	5.82	3.33	2265
Trust in Revenue Auth	4.26	3.21	2265
Trust in Local Auth	5.32	3.10	2265
Trust in Opposition	4.07	3.14	2265
Trust in Police	4.18	3.30	2265
Trust in MOH	7.43	2.74	2265
Trust in Health Workers	7.73	2.52	2265
Trust in INGO	7.99	2.42	2265
Trust in Local NGO	6.58	2.67	2265
Trust in people in general	4.96	3.08	2265
Trust in friends/family	6.88	2.84	2265
Trust in people in community	5.51	2.88	2265
Trust in people outside community	3.73	2.80	2265
Trust in Traditional Leaders	5.01	3.14	2265
Trust in Religious Leaders	8.17	2.51	2265
Trust in foreign people	3.24	2.92	2265
Corruption in institutions (scale 1 to 4)			
Corruption in President	2.61	0.70	2110
Corruption in Government	2.86	0.66	2188
Corruption in Legislature	2.87	0.66	2184
Corruption in NEC	2.56	0.65	2129
Corruption in Revenue Auth	2.92	0.62	2199
Corruption in Local Auth	2.71	0.61	2196
Corruption in Opposition	2.69	0.59	2077
Corruption in Police	3.11	0.69	2221
Corruption in MOH	2.47	0.66	2195
Corruption in Health Workers	2.37	0.59	2216
Corruption in INGO	2.26	0.58	2147
Corruption in Local NGO	2.46	0.59	2180
Corruption in Traditional Leaders	2.48	0.60	2118
Corruption in Religious Leaders	2.12	0.62	2216
Voting in past elections (%)			
Went to vote in 2011	77	42	2265
Went to vote in 2014	69	46	2265
Vote share for incumbent part in 2011	34	47	2232
Vote share for incumbent part in 2014	26	44	2248

Notes: This table illustrates summary statistics about political outcomes in the mobile phone survey (stage (2)) for 2,265 survey respondents.

Table A1.2: Mobile phone surveys responses: Ebola (EVD) related questions

	Mean	SD	Obs
Response during Ebola outbreak (%)			
Someone came	92	28	2254
Govnt health workers came	54	50	2254
NGO health workers came	61	49	2254
INGO health workers came	34	47	2254
Community taskforce came	23	42	2254
Other govnt people came	10	31	2254
Other local govnt people came	6.9	25	2254
Other people NGO came	15	35	2254
Other people INGO came	7.7	2.7	2254
Others came	2.6	16	2254
Any resistance in community	4.1	20	2265
Dead bodies removed late (4hrs)	13	34	2259
Any burial change in community	89	31	2245
Ambulance came late (4hrs)	7.0	25	2258
Patient waiting at ETU	3.8	19	2256
Ebola incidence (self-reported)			
Any EVD case in village (%)	19	39	2265
No. EVD cases in village	0.92	3.22	2265
Perceptions on response to Ebola (%)			
Well handle EVD - local authorities	61	49	2243
Well handle EVD - health workers	67	47	2258
Well handle EVD - INGO	88	33	2221
Well handle EVD - people	69	46	2260
Well handle EVD - government	58	49	2248
Perceptions on being hit by Ebola (%)			
Community badly hit by EVD	21	41	2265
Family badly hit by EVD	7.1	26	2265
Liberia badly hit by EVD	98	12	2265
Information levels and trust (%)			
Info EVD - received daily	93	26	2265
Info EVD - trust health workers	76	42	2265
Info EVD - trust radio/tv	76	43	2265
Info EVD - trust local authorities	13	33	2265
Info EVD - trust family/friend/neighb	22	42	2265
Info EVD - trust poster/board	13	34	2265
Info EVD - trust traditional healers	1.4	12	2265
Info EVD - trust sms/hotline	9.4	29	2265
Info EVD - trust religious leaders	6.7	25	2265
Responsibility of institutions for Ebola (%)			
Responsible for EVD - white people	2.0	14	2265
Responsible for EVD - UNMIL	0.044	2.1	2265
Responsible for EVD - Government	16	37	2265
Responsible for EVD - traders	18	39	2265
Responsible for EVD - Guinea people	29	45	2265
Responsible for EVD - Sierra Leone people	6.7	25	2265
Responsible for EVD - foreign NGO	0.18	4.2	2265
Responsible for EVD - god	4.2	20	2265
Responsible for EVD - witch	0.40	6.3	2265

Notes: This table illustrates summary statistics about Ebola related questions in the mobile phone survey (stage (2)) for 2,265 survey respondents.

Table A2: Summary statistics, by county

County	Pop (2014)	Pop (%) (2014)	Pop density (pop/sq mile) (2014)	Rural (%) (2012)	Phone coverage (%) (2012)	No. resp (2015)	No. resp (%) (2015)
Bomi	94,418	2.41	127	79.94	91.37	75	3.30
Bong	401,500	10.23	119	70.30	86.22	431	18.98
Gbarpolu	93,598	2.38	24	88.71	40.00	20	0.88
Grand Bassa	251,938	6.42	84	74.11	55.90	169	7.44
Grand Cape Mount	142,304	3.62	77	91.96	72.29	59	2.60
Grand Gedeh	140,594	3.58	34	61.83	58.13	60	2.64
Grand Kru	65,004	1.66	43	93.26	17.98	15	0.66
Lofa	300,747	7.66	78	70.65	84.13	235	10.35
Margibi	235,625	6.00	227	60.50	90.69	316	13.91
Maryland	152,582	3.89	172	60.27	69.93	13	0.57
Montserrado	1,255,152	31.97	1,729	8.08	89.89	320	14.09
Nimba	522,155	13.30	117	76.09	78.70	499	21.97
River Gee	74,966	1.91	34	74.02	53.63	7	0.31
Rivercess	80,264	2.04	41	96.52	47.16	14	0.62
Sinoe	114,927	2.93	30	83.61	32.06	38	1.67
Total/Average	3,925,773	100	105	51.22	64.54	2,271	100

Notes: This table illustrates summary statistics by county, comparing available data sources provided by LISGIS (Liberian Institute of Statistics and Geo-Information Services) and the survey sample.