

# REPRESENTATIVE SURVEYS IN INSECURE ENVIRONMENTS: A CASE STUDY OF MOGADISHU, SOMALIA

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We conducted a representative survey of Mogadishu's population—the first in 25 years—in March 2012. We overcame challenges related to lack of data and poor security with the use of remote sensing, the systematic development of local contacts through the Somali diaspora, the flexible deployment of staff, and mobile technology. This article demonstrates the value of using transparent sampling methods to produce reliable estimates for humanitarian response and policy makers. The article also highlights shortcomings and lessons learned from our approach, with the goal of improving future data collection efforts in insecure environments.

## 1. INTRODUCTION

Residents of Somalia's capital city of Mogadishu endured more than two decades of state failure and conflict. The Islamist insurgent group Al-Shabaab unexpectedly withdrew from the city on August 6, 2011, triggering a scramble for territory among various armed groups, some of which were led by individuals affiliated with the transitional government. Al-Shabaab's withdrawal

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created an opportunity for international organizations to resume operations in the city and begin to assess the critical humanitarian situation caused by years of insecurity and famine. Implementing a representative survey posed challenges due to Mogadishu's poor security, the fragmented nature of authority within the city, and the lack of data for creating a sampling frame. This article describes the methods used to overcome these challenges, which include remote sensing, the systematic development of local contacts, the flexible deployment of staff, and the creative use of mobile technology. The article also highlights shortcomings and lessons learned from our approach, with the goal of improving future data collection efforts.

The article proceeds as follows. Section 2 discusses the methods used to create a sampling frame in the absence of demographic data via remote sensing. Section 3 analyzes the response rate and bias in the sampling frame. Sections 4 and 5 discuss the strategies used to ensure the safety of the project staff during survey implementation and the unanticipated challenges encountered. Section 6 uses our survey data to describe life in Mogadishu. Section 7 concludes.

## 2. SAMPLING

Conducting a representative, population-based survey requires up-to-date, reliable, and systematic data on how the population is distributed throughout the survey area. Such data are not readily available for Mogadishu. The government's ability to collect population data deteriorated years before the collapse of the state in 1991. Although the World Bank and the United Nations Development Programme completed an ambitious socioeconomic survey in 2002, only a small percentage of the 300 survey clusters were located in Mogadishu; the survey was not detailed enough to provide within-city estimates (World Bank and UNDP 2002). More recent surveys in the city, funded by internationals and implemented by local nongovernmental organizations, have relied on problematic sampling strategies involving city landmarks and have not produced reliable estimates of the city's population or welfare. For example, the large-scale food security survey conducted by the World Food Programme (2012, p. 13) in fall 2011 explicitly did not use random sampling due to insufficient data and insecurity.<sup>1</sup> To our knowledge, the most recent population-based survey of Mogadishu occurred in 1987 and focused

1. A more general problem for surveys in insecure environments concerns the conflict of interest that occurs when the organizations providing relief on the ground are also hired to implement surveys that estimate need or measure impact. For example, the Mogadishu-based organization that is the primary distributor of food aid for international organizations such as the World Food Programme is also the primary collector of health and nutrition data in the city. This conflict of interest led the UN Security Council to question the reliability of the food aid data and recommend that World Food Programme strengthen its auditing procedures (UNSC 2010, 2011).

exclusively on disadvantaged groups, such as street children (Davies 1987). Therefore, our study is the first representative survey of Mogadishu in 25 years—although our results are subject to caveats and limitations, discussed later.

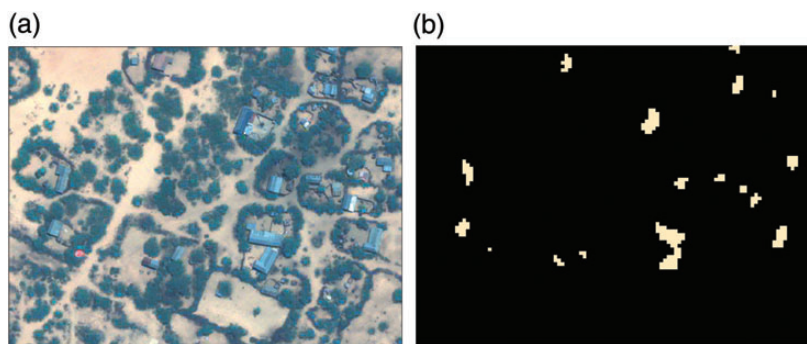
Mogadishu's demographics have changed since the last official maps were produced in the 1980s. To overcome the challenges posed by a lack of data, we combined remote sensing methods with commercially available high-resolution satellite imagery of Mogadishu. We used the square footage of inhabitable spaces in the city as an initial proxy for relative population in our sampling assumptions. Remote sensing, the acquisition of information without physical contact, has previously been used to derive sampling frames for refugee camps by using satellite imagery to identify houses, either manually (Lowther et al. 2009) or through an automated process (Giada, De Greove, and Ehrlich 2003). The method used for this survey is similar to the method used by Kemper et al. (2011) and relies on per-pixel image classification combined with visual interpretation by the researcher. To ensure comprehensive coverage, the survey area encompasses the entire urban area of Mogadishu, which is geographically compact and easily identifiable from satellite images.

Four high-resolution, nearly cloud-free images of Mogadishu and the surrounding area, taken by the QuickBird satellite on May 7, 2011, were stitched together to form a continuous mosaic. The resolution of these images is approximately 60 cm per pixel, which allows for the identification of various types of structures, including internally displaced persons (IDP) shelters. We combined this information with data on the boundaries of IDP camps from the UN Operational Satellite Applications Programme (UNOSAT), also derived through satellite imagery. The satellite imagery was processed according to maximum likelihood classification using the IDRISI Taiga software package. We identified training pixels that represented 23 different categories of land use in the satellite image.<sup>2</sup> The software then used these training pixels to classify the remaining pixels in the image. Thirteen iterations of the procedure were conducted until no easily identified errors were found during visual inspection. The 23 land use categories were then simplified into a binary raster (dot matrix data structure representing a generally rectangular grid of pixels) of inhabitable versus noninhabitable spaces. To improve accuracy, the binary raster was first processed through a  $3 \times 3$  adaptive box filter using 2 standard deviations as a filter criterion, which replaces a pixel's value with the average value of neighboring pixels if the value deviates from those neighbors by more than 2 standard deviations. The raster was then processed again by a mode filter, which replaces each pixel's value with the modal value of surrounding pixels. This procedure removed much of the noise in the image and produced more coherent clusters of pixels identifying inhabitable spaces.

2. Categories included (but were not limited to) "sand," "trees," "cement roof," "paved road," and "rusted zinc."

We define “inhabitable spaces” as all residential structures with intact roofs, including temporary roofs made of tarpaulin. Uninhabitable spaces include structures that lack roofs and outdoor areas. Note that this is a sampling assumption only. As a matter of practical implementation, if these structures turned out to be inhabited, the families were eligible for inclusion in the survey by our method and are included in our estimates. This sampling strategy is biased against roofless or outdoor residents, although the bias is likely to be negligible because roofless residents would most likely be located in IDP areas defined by the UNOSAT data. Of course, not all inhabitable spaces should be included in the sampling frame. Commercial buildings, government ministries, military bases, and market areas were removed from the raster using spatial data provided by UNOSAT. Because of the rapidly changing IDP situation in 2011–12, we updated our raster image with IDP estimates and the boundaries of IDP camps, derived by UNOSAT based on high-resolution satellite imagery from August 2011. The IDP camps were assumed to be fully occupied within the boundaries specified in the data set. Figure 1 shows close-up images of inhabitable structures before and after the image classification procedure. Figure 2 depicts a simplified raster image of central Mogadishu. The white pixels indicate inhabitable spaces and are used to create a population-based sampling frame.

Assessing the accuracy of the final raster image is a vital part of the classification process and the subject of a large literature in the earth sciences (for an overview see and Stehman and Czaplewski 1998 and Foody 2002). We selected a random sample of 500 pixels from the classified image and compared them to the original images through visual inspection (Hess and Bay 1997). Inhabitable spaces in the original satellite image had a 73.4 percent probability of being classified as inhabitable space in the final raster image; uninhabitable spaces were 99.2 percent likely to be classified as uninhabitable.



**Figure 1.** Extracting inhabitable spaces via remote sensing. (a) Residential structures in a satellite image. (b) Simplified raster of inhabitable spaces, identified by white squares.



**Figure 2.** Inhabitable spaces in central Mogadishu, identified by white squares.

A Moran's  $I$  test, the most common measure of whether points in space demonstrate a spatial relationship, revealed no spatial clustering among the misclassifications ( $p = 0.85$ ), thus the measurement error can be assumed to be randomly distributed across the sampling frame.<sup>3</sup> This estimate of relative population was later discovered to be error-prone due to differences in occupancy rates, multiple-occupancy homes, and the sizes of housing structures across the city. This classification, however, was used only to assign selection probabilities to the enumeration areas (EAs) and does not affect the estimates derived from the survey data once the survey weights are adjusted.

EAs were created by overlaying the city's image with a grid of 160 m  $\times$  160 m squares, known as a "fishnet." These dimensions correspond to approximately two city blocks. The boxes are rotated to run roughly parallel to major streets. Because streets in central Mogadishu are oriented differently from streets in the city's east and west areas, two different fishnet masks were used. Although most of the EAs are square, there are seams of irregularly shaped EAs at the boundaries of the two fishnet masks and at the city's edge. In all, the full extent of Mogadishu was covered by 3,862 EAs.

The number of pixels of inhabitable space (excluding nonresidential structures and IDP camps) was computed for each EA. Pixels identified as IDP shelters were computed separately based on the boundaries provided by UNOSAT. Each pixel within the IDP camps' boundaries was coded as inhabitable space. The number of IDP pixels in each EA was first multiplied by

3. See [Bivand, Gomez-Rubio, and Pebesma \(2008\)](#) for an extensive discussion of the Moran's  $I$  with applications.

0.734 to account for measurement error, then multiplied by 6 to account for the higher population density in the camps. The 6x multiplication factor is based on the following assumptions, derived through interviews with Mogadishu residents and satellite imagery:

- Each IDP shelter contains on average 4 individuals.
- Each single-family home contains on average 12 individuals.
- The average IDP shelter measures 3 m × 3 m.
- The average single-family home measures 9 m × 18 m.

Combining these assumptions implies that residential homes contain three times as many individuals, on average, as a single IDP shelter, but 18 IDP shelters can fit inside the footprint of a single residential home. In terms of population, therefore, IDP camps are six times as dense as residential areas.

The selection process assigned a random order to all 3,862 EAs through repeated random draws without replacement. Initially, EAs with random order 1 through 240 were selected for the survey. Later, EAs with random order 241–70 were added to the sample to compensate for the large number of EAs located in recently evacuated parts of the city due to ongoing military operations. Because the initial random order was obeyed, expanding the sample did not compromise the integrity of the selection procedure. The 270 EAs in the expanded sample comprise 6.99 percent of all possible EAs.

The probability of selection for EA  $i$  was determined by a probability proportional to estimated size. The estimated population of each EA is assumed to correlate with a weighted sum of pixels representing inhabitable spaces and IDP settlements contained within the EA boundaries. The measure of size (MOS) for EA  $i$  is:

$$\text{MOS}_i = S_i + 0.734 \cdot 6D_i, \quad (1)$$

where  $S_i$  represents the number of pixels of inhabitable space in EA  $i$ , as determined through the image classification process, and  $D_i$  represents the number of pixels of IDP camp, as determined by maps provided by UNOSAT. It is worth noting that 329 of the 3,862 EAs had a zero probability of selection, due to the fact that no pixels of inhabitable space or IDP camps were recorded within their boundaries. Most of these EAs contained markets or active government buildings; others were empty lots or desert areas on the fringes of the city. The lack of housing structures for all of these excluded EAs was confirmed through visual inspection of the satellite imagery.

To derive the selection probability, we first calculate the probability that EA  $i$  is selected in the first round:

$$p_i = \frac{\text{MOS}_i}{\sum_i \text{MOS}_i}. \quad (2)$$



A relatively small percentage of EAs (6.99 percent) were selected for the survey, so the overall selection probability is approximately equivalent to that obtained through selection with replacement. The selection probability,  $s_i$ , can be computed as the converse of the probability that EA  $i$  is *not* selected during the 270 draws. From the binomial theorem, we have:

$$s_i = 1 - (1 - p_i)^{270}. \quad (3)$$

For small selection probabilities, such that  $270p_i \ll 1$ , equation 3 simplifies to the more familiar expression:

$$s_i \approx 270p_i. \quad (4)$$

Unfortunately, our sample frame includes EAs with a very high selection probability and the simplified calculation in equation 4 could not be used. For example, the EA with the largest measurement of size (MOS) had a 79 percent probability of inclusion, whereas the median and mean probabilities of inclusion were 3 percent and 6 percent, respectively. This highly skewed distribution of selection probabilities resulted in a survey sample dominated by EAs with high selection probabilities. Ideally, this issue would have been identified and addressed prior to fieldwork; it was not. This problem could have been avoided by creating a scale that links pixels to an estimated number of households per EA, ranging from a minimum of one to a reasonable maximum number of households (perhaps 50) per enumeration area. Alternatively, we could have used the logarithm of the size measure, rather than the raw pixel count. Using either method, the MOS of each EA would have less variance and, presumably, a higher correlation between selection probability and population.

The probability of selection for any given EA is proportional to the number of pixels of inhabitable space and/or IDP camps and not necessarily the population contained inside the EA. Using a measure that is assumed to correlate with population (rather than the true population) can create two sources of error. First, there could be a coverage bias caused by classification errors related to the amount of inhabitable space. As already described, only 73.4 percent of inhabitable space was detected through the image classification process. These errors were not spatially clustered and therefore do not influence any estimates derived from the data. No corrective factors are necessary, because the probability of selection for EA  $i$  is relative to all other EAs. The classification error affects both the numerator and the denominator of the selection probability, and each EA  $i$  is assumed to be equally affected by the classification error. Second, and more troubling, the sampling frame may be biased by variation in the probability that inhabitable spaces are actually inhabited. Some parts of town may contain structurally intact houses that remain vacant due to insecurity. These parts of town would be over-represented in the survey

sample, resulting in upward-biased estimates of insecurity and other conflict-related indicators. We measure and correct for this bias in section 3.

Each enumerator was given approximately two EAs to visit each day, as well as a random start and a “gender start” written on a piece of paper. The random start consisted of two numbers produced by a random number generator: a number between 1 and 4 that applied to households in permanent structures, and a number between 1 and 24 that applied to households in temporary IDP shelters. A household was defined as a group of people who cook together and share expenses. If a structure contained more than one household, such as an apartment building, enumerators counted each household separately. Uninhabited structures were not counted by the enumerators during the selection process. A structure was deemed uninhabited if the enumerator did not see any evidence of people living there (such as bedding or cooking items). If an inhabited structure was unoccupied at the time of selection, enumerators were instructed to return to the house twice before leaving the EA. If no eligible adult could be found after three visits, the enumerator geotagged the location and departed.

On entering an EA, an enumerator began the survey by selecting households in permanent structures, beginning with the random start for houses and then surveying every fourth household thereafter until all households in the EA were counted. Next, if any IDP shelters were present in the EA, the enumerator used the random start for IDP shelters to select the first shelter for the survey and then surveyed every 24th shelter until all shelters were counted. The preliminary survey weight  $\pi_{i,j}$  for household  $j$  in EA  $i$  is calculated as  $4/s_i$  for a household in a permanent structure and  $24/s_i$  for a household in an IDP shelter.

The enumerators used smartphones linked to a Google Maps account with files that marked the spatial boundary of each EA. Using their GPS location in conjunction with Google Maps, they were trained to verify that each selected house fell within the EA boundaries and that all inhabited structures in the EA were counted. Ninety-three percent of surveys fell within the EA boundaries according to the geotags embedded in the survey files. Survey responses were recorded and compiled using the Open Data Kit platform.

Once houses were selected, the enumerators delivered a short consent script to any available adult, and then a longer consent script to the head of the household. Because all survey questions focused on the household situation, and not individual welfare, enumerators generally interviewed the male or female head of household. To maintain gender balance, enumerators were instructed to alternate between male and female respondents. The “gender start” informed the enumerator which gender should be surveyed in the first household; the gender of the respondent was alternated in each subsequent household. During the consent process, enumerators would ask to speak with the male or female head of household, depending on the required gender. If the head of the household was not available, the enumerator was instructed to survey any adult member of the household who matched the specified gender.



If no adults of the specified gender were available, the enumerator was instructed to survey any adult member of the household. Because the survey is only concerned with household-level characteristics and we faced a difficult security environment, we opted to forgo the extra time required for within-household randomization.

Figure 3 depicts the 270 EAs selected for the survey, as well as the outcome of the implementation, which occurred during March 18–30, 2012. The teams conducted surveys in 185 EAs, although only 136 of these EAs were discovered to be inhabited. Uninhabited EAs were areas that had been completely evacuated. Forty-eight EAs were inaccessible due to fighting or because permission was denied by local authorities. Another 37 EAs fell within a recently created military zone, in which civilians were ordered to evacuate due to military operations against the Al-Shabaab militants. Our staff could not enter these areas to verify the reported absence of civilian residents.

The survey weights were adjusted through a poststratification process to account for the inaccessible EAs in each of the city's districts. Neighborhoods of Mogadishu are similar in terms of population density, and when an EA could not be reached, it was usually for idiosyncratic security reasons (e.g., daily variation in fighting) that should not affect underlying demographics. Therefore, inaccessible EAs were assumed to have similar populations as other



**Figure 3.** Selected EAs and survey outcome.

EAs in the same district. The average number of surveys per accessible EA was computed for each of Mogadishu's 13 districts and then increased for the number of inaccessible EAs. This number estimates the additional surveys that would have been collected had the survey teams reached all EAs in the district. The estimated additional surveys are added to the number of surveys collected and then divided by the number of surveys collected. This produces a scalar weight multiplier for inaccessible EAs,  $F_k$ , that adjusts the weights of surveys in each district  $k$ :

$$F_k = \frac{N_e + N_c}{N_c} \geq 1, \quad (5)$$

where  $N_e$  is the estimated number of additional surveys if the inaccessible EAs in the district had been reached and  $N_c$  is the number of surveys completed in the district.

In addition to the household survey, we implemented a parallel market survey throughout the city to record prices in dollars (based on the exchange rate between the U.S. dollar and Somali shillings) for a basket of goods: rice, pasta, sugar, red beans, sorghum, vegetable oil, milk, meat, cowpeas, bananas, flour, charcoal, cigarettes, fuel, and qat. Our thinking at the time was that variation in prices could reflect insecurity (e.g., the risk that items will be looted or destroyed) or the added transportation cost of crossing roadblocks to reach certain parts of town; theoretically interesting variation might have also been discovered between imported and locally produced goods. The survey recorded current prices and also asked market sellers to recall the price of the goods one year previous, when Al-Shabaab still controlled half the city. Enumerators traveled to all 11 of Mogadishu's major markets and randomly selected between 12 and 30 market sellers in each location.<sup>4</sup> The enumerators continued the random selection process until at least one price observation was collected for each good in the basket.

### 3. RESPONSE RATE AND SAMPLING BIAS

In total, 781 households were selected for participation in the baseline survey and 649 took part in the survey, for an unweighted household-level response rate (AAPOR2) of 83.1 percent. The survey was conducted in 185 EAs, with enumerators failing to reach 48 EAs (21 percent), not including the 37 EAs located in the (supposedly unoccupied) military cordon area. All 649 of the surveyed households provided responses to at least 80 percent of the required questions. In addition to participating in the baseline survey, 424 households

4. The following markets were surveyed: Argentin, Bacaad, Bakara, Bulo Hubey, Hamar Jadiid, Hamar Weyne, Jungale, Kaaran, Macmacanka, Madina, and Mahabolyo. Only one market seller was interviewed in Macmacanka due to time and security constraints.

(54 percent) provided their mobile number and consented to participate in follow-up surveys via SMS text messages and voice calls. Two hundred six market sellers were interviewed for the market survey.

Although the household survey was designed to be stratified evenly between men and women, 61 percent of the respondents were women. Households in Mogadishu were usually occupied by women during the day, both for cultural reasons and because of the prevailing insecurity at the time. Qualitative interviews in the field revealed that many Mogadishu residents believed that it was safer for men to travel around the city.

The sampling probability of the EAs was based on various assumptions regarding the number of household members and household size. Based on interviews and satellite imagery, we assumed that households in IDP shelters consisted of an average of four people sharing a 3 m × 3 m shelter. The survey results indicate these households have an average of eight members. A visit by one of the authors to an IDP camp, however, revealed that households in these camps tend to occupy a cluster of shelters, rather than a single shelter. Furthermore, households in permanent structures reported an average of 9 members, rather than the assumed 12 members, but more than one household often occupied a single 9 m × 18 m permanent structure. Since the number of shelters per household in IDP camps and number of households per structure were not recorded, it was not possible to determine whether the factor of 6 between IDP camp and structure was accurate.

Because every fourth household was selected in every EA, the number of surveys collected allows for an assessment of the sampling frame. In general, the sampling frame overestimated the number of households in each EA, mostly due to high numbers of abandoned and damaged buildings that were found to be uninhabited. In total, the sampling frame estimated 5,405 houses in the non-IDP EAs selected for the survey, which would have yielded 1,351 surveys. According to the survey, however, those EAs contained 1,888 occupied houses, only 35 percent of the estimate.

This overestimate would pose no problem for the survey analysis if it were randomly distributed across the sampling frame. Unfortunately, the errors in the sampling frame was spatially dependent. For example, EAs in the Hamar Weyne district had, on average, only 23 percent of estimated number of occupied houses, whereas EAs in the Abdi Aziz district had 156 percent of the estimated number of households, indicating a greater-than-expected population density. Recall that the EAs were selected based on the number of pixels of inhabitable space contained within their boundaries. As emphasized before: There was no spatial correlation in misclassification of pixels in the sampling frame, so the bias results solely from variation in the probability that an inhabitable structure was actually occupied by a household. This is similar to the problem of “empty listings” analyzed by Kish (1965). To compensate for these errors, the sampling weight of household  $j$  in EA  $i$  is multiplied by a scalar,  $G_i$ , calculated as the number of pixels of inhabitable space per

household in the EA, as estimated by the number of surveys in the EA, divided by the average number of pixels per household among all surveyed EAs:

$$G_i = \frac{\text{MOS}_i / \hat{n}_i}{\sum \text{MOS}_i / \sum \hat{n}_i}, \quad (6)$$

where  $\hat{n}_i$  is the number of households in EA  $i$ , as estimated by the number of surveys in the EA. Adjusting the weights to account for sampling frame bias affects our overall proportion estimates by between 1 and 8 percent.

Subsequent data analysis revealed a flaw in our sampling frame, which prevents us from confidently reporting a population total for the city. The root of the problem is the heterogeneity in the selection probability among EAs in the sampling frame, mostly due to our assumptions about how to incorporate IDP camps into the sampling frame. For example, although many EAs had a reasonable probability of selection of 2–10 percent, a number of EAs had selection probabilities of more than 70 percent. Although our sample of EAs displayed reasonable spatial coverage of the city, we learned only after the survey was completed that it was dominated by EAs with high selection probabilities.

The selection probability and number of households in each EA (based on the number of surveys conducted) are significantly correlated with a factor of 0.4 ( $p < 0.01$ ). Despite this correlation, however, many EAs with a high selection probability had relatively few occupied houses. This combination of high selection probability and low population is partly due to the large number of unoccupied structures in some parts of the city, and partly due to the lack of on-the-ground information (which caused many nonresidential structures to be classified as inhabitable space). The sample is therefore dominated by EAs with relatively high selection probabilities, but not necessarily large populations. Any overall population estimate would be biased downward and have very large confidence intervals due to the influence of these observations. Two primary changes would allow future research teams to re-create the sampling frame and avoid similar errors. First, one could base the sampling probabilities more closely on the number of households using a scale or logarithm, as described in section 2, rather than relying on raw pixel counts. Second, one could stratify the sampling among the city's districts, as well as between IDP camps and permanent neighborhoods. Our proportion estimates within the city are unbiased, however, and as such form the basis of the summary statistics reported later.

#### 4. ENUMERATOR SAFETY

In April 2011, one year before implementation, one of the authors traveled to Mogadishu to ask permission from the Transitional Federal Government of Somalia (TFG). We received a signed letter from the Deputy Prime Minister

and Minister of Planning. This allowed us to make the case to both institutional stakeholders (i.e., the University of California, San Diego, and the National Science Foundation) and representatives of the Somali diaspora in San Diego that a survey would be both feasible and valuable. We felt that receiving the permission of the internationally recognized government, despite its limited authority in the city, was an important precedent for frontier research in politically contested spaces. We also secured permission from various nonstate local authorities.<sup>5</sup> We precommitted to an empirical strategy and articulated safety red-lines to stop the research. These safety red-lines included various indicators of escalating hostilities, including the use of artillery in the city and battles involving Al-Shabaab forces in previously “cleared” neighborhoods.

Our connections with the San Diego Somali diaspora had tangible benefits for survey implementation and security. An officer of a Somali diaspora organization accompanied one of the authors to Mogadishu and used his family ties to arrange safe accommodation, training facilities, and transportation. We recruited our staff through a Mogadishu-based institution recommended to us through our diaspora contacts. All of our staff were Mogadishu residents with university degrees. Many of them had prior survey experience, and they represented a broad range of subclans and neighborhoods. Over the course of four days, the staff were trained in survey sampling and practiced the questionnaire. During implementation, the enumerators were deployed to their home areas, which increased their safety and access. We believe that any biases that might arise by having individuals contacted by a neighborhood resident were negligible—certainly when weighed against the risks to enumerators wandering around unfamiliar parts of the city. To limit the enumerators’ visibility and risk, the survey was conducted on generic smartphones, and the enumerators used public transportation to reach the enumeration areas. Furthermore, the survey was designed to be completed very quickly, requiring only 10–15 minutes. Data saved on the phones were retrieved and archived daily. We centralized data collection on a single laptop, which was carried physically out of the country upon completion of the survey.

Safety considerations also led us to limit the types of questions included in the survey. We did not ask about clan identity or political beliefs, on the assumption that asking those questions would cause either enumerators or respondents to question our motives and impugn the overall integrity of the data. The survey never asked respondents to state an opinion, but focused instead on objective indicators of stability and welfare. Questions captured neighborhood and household characteristics, for example “How often do TFG forces patrol this neighborhood?” or “How many hours of electricity do you have each day here?”

Flexible deployment of staff increased the survey coverage without compromising enumerator security. Each morning the staff gathered in a hotel

5. For more detail, see UCSD’s IRB Project 111743: Statebuilding Somalia.

conference room and provided a security briefing to one of the authors based on information gathered through personal ties and the local media. This information was then used to determine, in consultation with the staff, which areas of the city could be safely enumerated on that particular day. Sporadic fighting among clan militias and the detonation of improvised explosive devices meant that several neighborhoods were temporarily considered too insecure for the survey. Most of these areas were safely enumerated a few days later as the security situation improved.

## 5. UNANTICIPATED CHALLENGES

Transferring money to Mogadishu proved to be difficult. The *hawala* (informal banking) system is currently the only means of transferring money into Somalia, a country that lacks a banking system. The *hawala* system became increasingly regulated after the 2001 USA PATRIOT Act, and scrutiny of *hawala* agents intensified after the emergence of Islamic insurgent groups such as Al-Shabaab in 2006. Although there are many registered *hawala* agents in San Diego, these agents were reluctant to send large amounts of cash without extensive documentation. Receiving the money was also a challenge, as the security situation did not allow either of the authors to claim the *hawala* transfer. By traveling with a member of the Somali diaspora, we were able to safely claim the money under his name. Funds were distributed to the staff via mobile money (electronic funds distributed via cell phones) to reduce the risk of theft or targeted violence.

There were also the generic security concerns associated with anarchic spaces. A car bomb detonated at the entrance to the hotel where one of the authors was staying, killing one bystander and injuring a policeman. The explosion caused some of the enumerators to be confined to the hotel for several hours, while the rest of the staff continued their work in other neighborhoods and provided updates on the security situation. Toward the end of survey implementation, fighting between Hawaadle and Abgaal clan militias erupted in the Dharkenley and Wadajir districts. This fighting caused the suspension of survey activities in these areas for a period of three days and resulted in several inaccessible EAs. In one case, an enumerator operating in the Hodan district was detained by a local authority, but was soon released after clan elders and a government official intervened on our behalf. Finally, our survey team was denied entry into the Badbaado IDP camp, one of Mogadishu's main IDP camps. Each of Mogadishu's IDP camps is controlled by a "camp lord" and various local security groups. All organizations operating in the IDP camps, including TFG officials, must secure permission from these local authorities before entering a camp. Our survey team had secured permission from the TFG, the camp lord, and the local TFG military commander. For all other camps in the city, these permissions were sufficient for a smooth



survey implementation. When enumerators entered Badbaado, however, they were confronted by a local police organization, which denied them access. The camp militia intervened on the survey team’s behalf, but this intervention threatened to escalate into violence. In response, the enumerators evacuated the camp and did not return.

6. RESULTS

Policy professionals tasked with humanitarian relief in urban war zones are the primary beneficiaries of this sort of representative survey data. We construct the proportion estimates using the Horvitz-Thompson estimator:

$$\hat{\mu}_x = \frac{1}{\hat{N}} \sum_{i,j,k} F_k G_i w_i X_j,$$
(7)

where  $\hat{N}$  is the estimated population total based on the adjusted survey weights,  $F_k G_i w_i$  is the final sampling weight for household  $j$  (and  $w_i$  is the inverse of the selection probability,  $s_i$ ), and  $X_j$  is the variable of interest. Estimates and confidence intervals account for the clustered sample and were constructed using the survey package in R (Lumley 2010).

Table 1 displays city-wide estimates from the survey data. Nearly half of Mogadishu’s households self-reported as being displaced, based on the survey question “Are you currently displaced” (Hadda miyaa lagu soo baro kiciyey?). A similar proportion of households had some access to electricity and 62 percent of households had at least one child in school, based on the survey questions “Do any boys in this household currently attend school?” (Wiilasha gurigan deggan, wax iskuul aada ma jiraa?); “Do any girls in this household currently attend school?” (Gabhaga gurigan deggan, wax iskuul aada ma jiraan?); and “How many hours of electricity do you have each day here?” (Imisa saacadood ayaad heshaa korontada maalin walba?).

Table 1. City-wide estimates

|   | Proportion | Std.<br>error | 95%<br>confidence | <i>n</i> |
|---|------------|---------------|-------------------|----------|
| Displaced households                                      | 0.44       | 0.035         | 0.37–0.50         | 648      |
| Reported fighting in neighborhood during<br>previous week | 0.27       | 0.035         | 0.20–0.34         | 641      |
| At least one child in school                              | 0.62       | 0.034         | 0.55–0.69         | 648      |
| Access to electricity                                     | 0.46       | 0.041         | 0.38–0.54         | 649      |
| Received food free of charge during<br>previous week      | 0.15       | 0.023         | 0.11–0.20         | 643      |
| Willing to reveal clan affiliation if asked               | 0.25       | 0.028         | 0.19–0.30         | 600      |

NOTE: Data exclude Badbaado displacement camp.

Approximately one quarter of households experienced fighting in their neighborhood in the previous week, and a similar percentage claimed they would feel comfortable revealing their clan identities to a surveyor, if asked (we did not ask). These data are based on the survey questions “In the past week, has there been fighting on this street?” (Toddobaadkii la soo dhaafey, wax dagaal ah ma dhacay waddadan?) and “We are not going to ask you about your clan, but if another survey asked you, would you be comfortable telling them your clan?” (Ma rabno inaan ku weydiino qabiilkaaga, haddiise su’aalo kuwan oo kale ah lagugu weydiyo ma u sheegi lahayd qabiilkaaga?). Finally, 15 percent of residents reported receiving some form of food assistance from family, mosque groups, or aid organizations, based on the survey question “In the past week, did you receive food free of charge?” (Toddobaadkii la soo dhaafey miyaa heshay raashin lacag la’aan ah?). Note that these data exclude the Badbaado displacement camp, although it would be possible to construct estimates for the Badbaado camp by using data from other nearby displacement camps.

Our data also allow for a fine-grained analysis of variation across Moga-dishu’s districts, depicted in table 2. Life is dramatically different in different parts of the city. The proportion of displaced households in each district ranges from 16 percent to 82 percent. Fighting in the week prior to the survey was experienced by 83 percent of households in Karaan district, and no one reported fighting in either Abdi Aziz or Hamar Weyne districts. Willingness to reveal clan identities also varies. None of the 14 households surveyed in Abdi Aziz reported a willingness to reveal their clan identity, despite the lack of

**Table 2. District-level estimates**

| District      | Displaced households | Reported fighting | Willing to reveal clan | <i>n</i> |
|---------------|----------------------|-------------------|------------------------|----------|
| Boondheere    | 0.53 (0.13)          | 0.12 (0.08)       | 0.21 (0.12)            | 52       |
| Abdi Aziz     | 0.82 (0.13)          | 0.00 (0.00)       | 0.00 (0.00)            | 14       |
| Dharkenley    | 0.17 (0.13)          | 0.05 (0.05)       | 0.06 (0.05)            | 26       |
| Hawl Wadaag   | 0.62 (0.11)          | 0.16 (0.08)       | 0.24 (0.08)            | 85       |
| Hodan         | 0.32 (0.07)          | 0.17 (0.07)       | 0.30 (0.07)            | 142      |
| Karaan        | 0.16 (0.10)          | 0.83 (0.06)       | 0.29 (0.14)            | 37       |
| Shibis        | 0.78 (0.02)          | 0.57 (0.14)       | 0.00 (0.00)            | 15       |
| Waaberi       | 0.45 (0.13)          | 0.05 (0.02)       | 0.21 (0.09)            | 61       |
| Wadajir       | 0.45 (0.08)          | 0.35 (0.08)       | 0.25 (0.06)            | 161      |
| Wardhiigleey  | 0.57 (0.11)          | 0.16 (0.09)       | 0.13 (0.05)            | 66       |
| Hamar Jaabjab | 0.16 (0.08)          | 0.15 (0.05)       | 0.30 (0.13)            | 39       |
| Hamar Weyne   | 0.28 (0.17)          | 0.00 (0.00)       | 0.72 (0.17)            | 11       |
| Yaaqshiid     | 0.57 (0.08)          | 0.52 (0.10)       | 0.28 (0.07)            | 72       |

NOTE: Standard errors in parentheses. Dharkenley data exclude Badbaado displacement camp.

fighting in the district. This reluctance to discuss kinship ties—central to personal security in Mogadishu—could hint at local-level tension in the district due to the high proportion of displaced residents seeking shelter there. By contrast, a large proportion (72 percent) of Hamar Weyne households were willing to discuss their clan affiliation, more than double the proportion in any other district. We speculate that this is related to the fact that Hamar Weyne is a bustling and relatively secure commercial center.

## 7. CONCLUSION

The explosion of mobile and satellite technologies in recent years means that representative surveys can be conducted in even the most challenging environments. Though these kinds of surveys demand extensive and careful planning to mitigate risks to research teams and subjects, the potential benefits are substantial. Representative surveys are obviously not perfect tools—indeed, we discovered that our sampling frame was systematically biased across Mogadishu and unable to produce reliable population estimates. Nevertheless, using transparent, systematic sampling data means that most shortcomings can be offset through statistical weights. Addressing such biases would simply not be possible if we had used second-best sampling strategies (e.g., random walks or landmark-based sampling).

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