 doi:10.20944/preprints201910.0320.v1

Feasibility of innovative tools and methods to improve household surveys in complex urban settings: Multiple methods analysis of the Surveys for Urban Equity (SUE) study in Kathmandu, Dhaka, and Hanoi

Dana R. Thomson,[1,*] Radheshyam Bhattarai,[2] Sudeepa Khanal,[2] Shraddha Manandhar,[2] Rajeev Dhungel,[2] Subash Gajurel,[2] Joseph Paul Hicks,[3] Duong Minh Duc,[4] Junnatul Ferdoush,[5] Tarana Ferdous,[6] Nushrat Jahan Urmy,[5] Riffat Ara Shawon,[5] Khuong Quynh Long,[4] Ak Narayan Poudel,[3] Chris Cartwright,[3] Hilary Wallace,[7] Tim Ensor,[3] Sushil Baral,[2] Saidur Mashreky,[5] Rumana Huque,[6] Hoang Van Minh,[4] Helen Elsey[3]

* Corresponding author
1. Department of Social Statistics, University of Southampton, Southampton UK
2. Health Research and Social Development Forum-International, Kathmandu, Nepal
3. Nuffield Centre for International Health and Development, University of Leeds, Leeds UK
4. Hanoi University of Public Health, Hanoi, Vietnam
5. Centre for Injury Prevention and Research – Bangladesh, Dhaka Bangladesh
6. Advancement through Research and Knowledge Foundation, Dhaka Bangladesh
7. School of Medicine, The University of Notre Dame Australia, Freemantle WA Australia

 doi:10.20944/preprints201910.0320.v1

ABSTRACT

Background: The methods used in low- and middle-income countries (LMICs) household surveys have not changed in four decades; however, LMIC societies have changed substantially. This mismatch may result in unintentional exclusion of vulnerable and mobile urban populations. We compare three survey method innovations with standard survey methods in Kathmandu, Dhaka, and Hanoi, and summarize feasibility of our innovative methods in terms of time, cost, skill requirements, and experiences.

Methods: We used descriptive statistics and regression techniques to compare respondent characteristics in samples drawn with innovative versus standard survey designs and household definitions, adjusting for sample probability weights and clustering. Feasibility of innovative methods was evaluated using a thematic framework analysis of focus group discussions with survey field staff, and via survey planner budgets.

Results: We found that a common household definition excluded single adult (46.9%) and migrant headed households (6.7%), as well as non-married (8.5%), unemployed (10.5%), disabled (9.3%), and studying (14.3%) adults. Further, standard two-stage sampling resulted in fewer single adult and non-family households than an innovative one-stage design; however, two-stage sampling resulted in more tent and shack dwellers. Our survey innovations provided good value for money and field staff experiences were neutral or positive. Staff recommended streamlining field tools and pairing technical and survey content experts during fieldwork.

Conclusions: This evidence of unintentional exclusion of vulnerable and mobile urban populations in LMIC household surveys is deeply concerning, and underscores the need to modernize survey methods and practices.

KEY WORDS

Nepal, Vietnam, Bangladesh, gridded population sampling, GridSample, OpenStreetMap, GeoODK, cross-sectional design, urban, household survey

 doi:10.20944/preprints201910.0320.v1

SUMMARY BOX

What is already known?

- Researchers and practitioners increasingly raise concerns about exclusion of vulnerable and mobile urban populations from LMIC household surveys on conceptual grounds: sample frames are usually outdated; typical two-stage designs require a long time gap between household listing (final sample frame) and interviews; and paper-based field tools and protocols developed 40 years ago are not well-suited to modern complex urban settings.
- LMIC urban settings pose numerous challenges to survey fieldwork including atypical housing arrangements, large numbers of migrant workers, rapid expansion of new – often informal – dwellings, and high mobility of residents.
- The challenges of conducting surveys in LMIC cities are only going to worsen as urbanization, population mobility, and socio-economic disparities increase, particularly in African and Asian cities.

What are the new findings?

- This study quantifies rates of exclusion among vulnerable and mobile sub-populations in Kathmandu Valley, and areas of Dhaka and Hanoi where these populations concentrate.
- We describe and evaluate innovative survey methods that might improve accuracy of household surveys in LMIC cities, including evaluation of feasibility.

What do the new findings imply?

- Alternative sample frames, such as gridded population estimates, are a viable alternative to outdated or inaccurate census sample frames. New types of sample frames can enable new survey designs, such as one-stage sampling, which improve coverage of vulnerable and mobile urban populations in surveys.
- Until urban areas can be stratified by deprived / not-deprived areas, or some other area classification that reflects urban disparities, household surveys are unlikely to accurately sample tent and shack dwellers in slum-like areas.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

INTRODUCTION

In low- and middle-income countries (LMICs), household survey methods have remained consistent for over forty years. However, in the same period, population trends and available technologies to measure populations have changed substantially. Continued use of census sample frames, two-stage sampling, and paper-based mapping and listing in LMICs has likely led to exclusion of vulnerable and mobile urban populations,[1] particularly in Africa and Asia.[2] A global shift to urban living is dramatically changing the structure and nature of communities and households,[3] and survey methods must change in response.

The largest survey programmes in LMICs include the Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), and Living Standard Measurement Surveys (LSMS), which essentially use the same sample frames, survey designs, and implementation methods.[4] Crucially, surveys are used to measure progress against one-fourth of the Sustainable Development Goal (SDG) indicators.[5] If current survey methods systematically under-represent vulnerable and mobile urban populations, our understanding of progress towards the SDGs is fundamentally flawed.

In the standard survey workflow, census enumeration areas (EAs) are sampled with probability proportional to population size (PPS), households in selected EA clusters are mapped and listed, approximately 20 households are selected in each cluster, and interviewers return later to administer questionnaires.[6–8] The mapping-listing protocols influence which households are listed, and eligibility criteria and interviewer interpretations influence who is recorded as a household member.[9]

The DHS and MICS define household members as: (i) usual residents or slept in the dwelling (living space) the previous night, (ii) share living arrangements, and (iii)share food.[6,7] The LSMS defines household membership as: (i) slept in the dwelling three or more of the last 12 months and (ii) share food.[8] By all definitions, households in both residential and commercial buildings should be included,[6–8] guards and servants are subsumed into the household of their employment,[6–8] and seasonal and migrant populations are usually intentionally excluded.[10]

Conversely, unintentional exclusion of vulnerable and mobile populations occurs in at least three ways. First, as a result of outdated EA sample frames. In LMICs, the urban population grew roughly 30 percent between 2005 and 2015.[2] Yet, since 2000, the average DHS sample frame was 7 years old with many exceeding 10 years.[11] Second, two-stage sample designs require a gap of several months between the mapping-listing and interview activities, resulting in exclusion of recently settled households.[a] Third, exclusion can result from poorly-defined or difficult to operationalize mapping-listing protocols, for example assuming that one household occupies each dwelling.[12]

To address problems of unintentional exclusion of vulnerable and mobile households in surveys, the Surveys for Urban Equity (SUE) project piloted and evaluated three survey innovations in Kathmandu, Dhaka and Hanoi: (1) use of modelled gridded population data as a sample frame, (2) one-stage sample design, and (3) mapper-lister protocols including a script, OpenStreetMap and OpenDataKit tools, and a broadened household definition. Here, we present results of the pilot including the extent to which populations were unintentionally excluded from a standard survey design. Further, we evaluate the feasibility, cost and skills required to implement our novel methods in complex urban settings.

[a] In most surveys, if a household moves away and is replaced, then the new household is interviewed. If the household is not replaced, then members will be recorded as non-responders and be accounted for in the sample weights.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

METHODS

We compared the ability of three survey innovations to identify different types of households and individuals than standard surveys. To establish feasibility of the innovations, we recorded costs and team skills required and conducted focus group discussions (FGDs) to explore enumerator experiences.

Setting

We selected Kathmandu Nepal, Dhaka Bangladesh and Hanoi Vietnam, as they typify different points on the urbanisation trajectory. The pace of growth in South Asia has particularly strained urban housing markets increasing the number of people living in atypical arrangements and locations.[2] While some poorer households live in informal settlements, others live in economically heterogeneous neighbourhoods.[2] In Kathmandu and Dhaka, for example, it is common for the building owner to occupy the top floor, rent the middle floor to a middle-class family, and rent the bottom floor to multiple low-wage workers. In Vietnam, old, cramped buildings continue to house the economically and socially vulnerable, while migrant labourers live in multiple-occupancy inadequate structures near work.[13] We sampled the entire Kathmandu Valley, and purposefully chose to survey a slum and an economically mixed ward in Dhaka, and an economically mixed district with a large migrant population in Hanoi. The Hanoi survey occurred soon after a government campaign to evict illegal occupants.

Innovations

We used several innovative datasets, protocols and tools which aimed to improve representation of vulnerable and mobile populations in surveys (Figure 1). SUE survey planning and field manuals are available elsewhere.[14]

1. One-stage sample design

One-stage sampling means that all households in a cluster are sampled, allowing the household listing and interviews to occur on the same day. One-stage sampling also allowed us to broaden the household definition to include all usual residents or people who slept in the cluster the previous night, including hostel-dwellers, long-term occupants of guesthouses, and street-sleepers. In the questionnaire, we collected information about living arrangements, meals, and length of time at the dwelling to identify individuals and households that met DHS/MICS and LSMS definitions.

2. Sample frame

We used WorldPop gridded population datasets as sample frames rather than older censuses. At the time of planning, the last censuses in Nepal (2011), Bangladesh (2011) and Vietnam (2009) were seven or more years old.[15] WorldPop is modelled with a machine-learning approach that disaggregates population counts from administrative areas to approximately 100x100m grid cells based on dozens of spatial covariates derived from satellite imagery and GIS data.[16] The small size of grid cells enabled one-stage sampling.

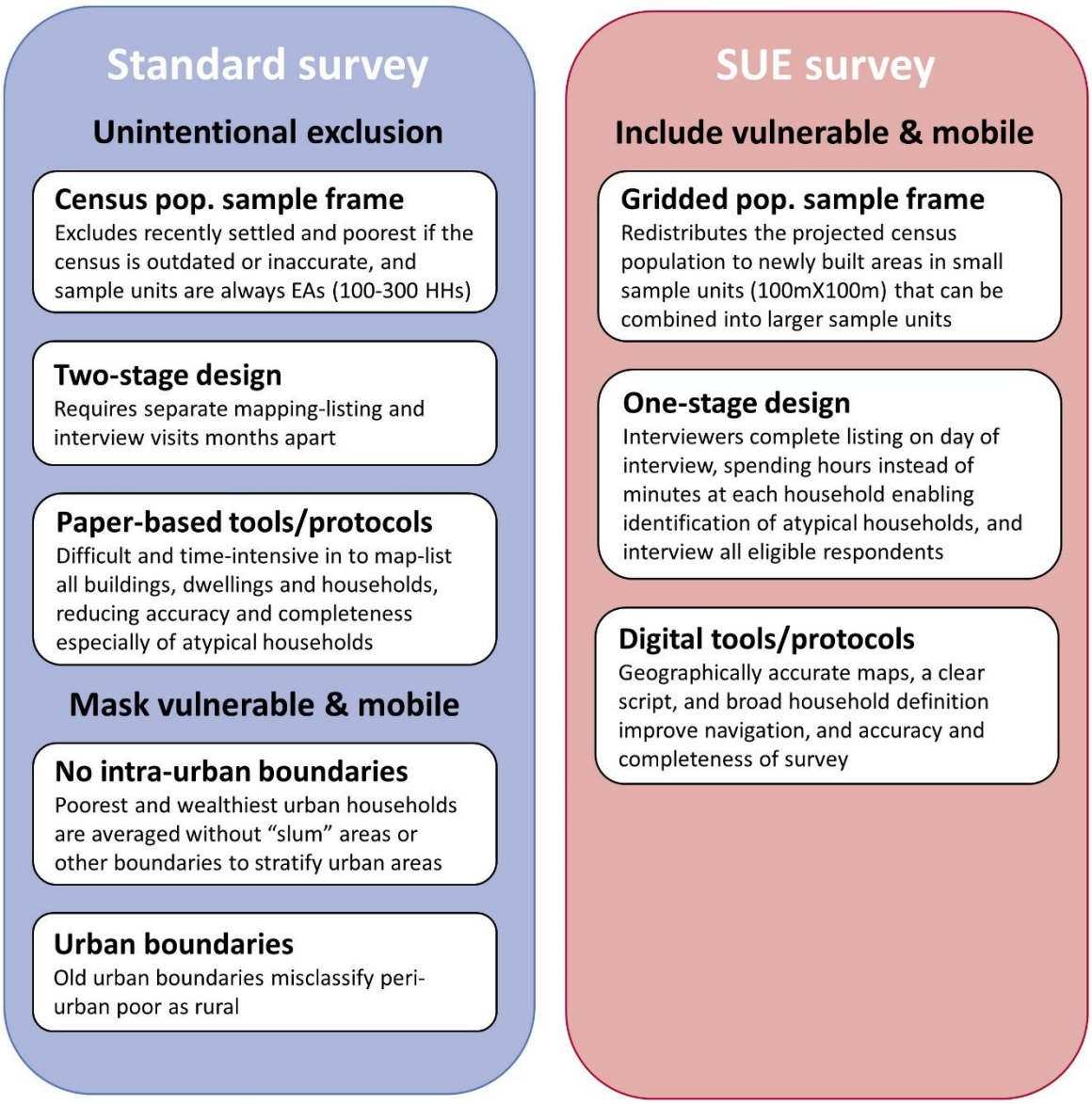
3. Mapping-listing tools

We replaced standard hand-drawn field maps with geographically accurate maps. Before fieldwork, we updated building, road, and pathway data for each cluster in OpenStreetMap using the iDeditor

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

tool.[17] In ArcGIS, we created a map for each cluster showing the OpenStreetMap base layer and cluster boundary.[18] In the field, we noted changes on the paper map and updated OpenStreetMap accordingly. Both the household listing and interviews were collected in GeoODK, an OpenDataKit-based application.[19]

Figure 1. SUE survey coverage in Kathmandu, Dhaka, and Hanoi, and example two-stage and one-stage cluster field maps



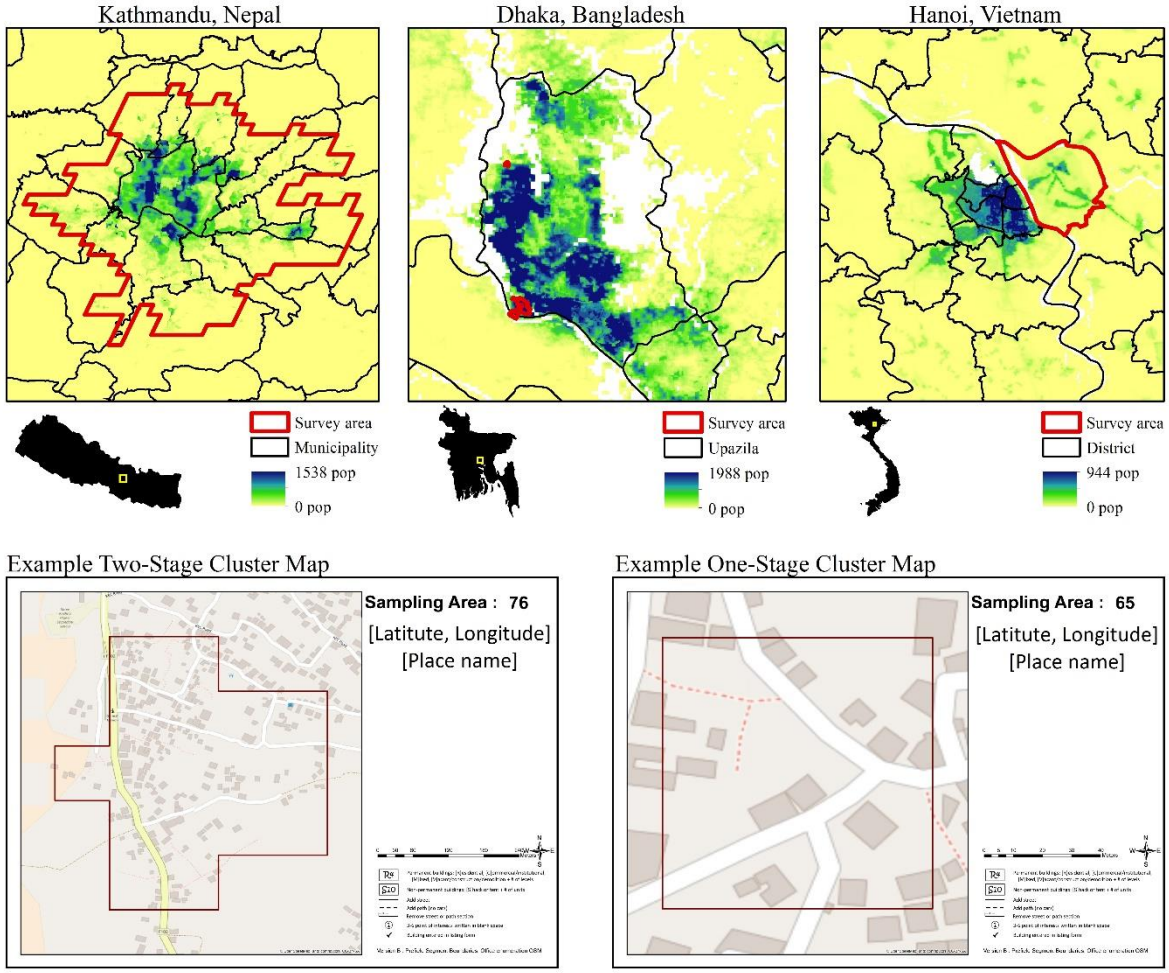
Study design and protocol

In 2017 and 2018, we conducted three cross-sectional household surveys in Kathmandu, Dhaka and Vietnam.[20] The survey in Kathmandu estimated depression and injury prevalence in Kathmandu targeting 1200 households in 60 clusters (sample size calculation[20]). We used the Global Human Settlement (GHS) layer of 1x1km grid cells to define the city boundary because old municipality boundaries only included the city centre, while new municipality boundaries included rural communities beyond the Kathmandu peri-urban reach.[21] We randomized half of the clusters to a

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

one-stage arm and the other half to a two-stage arm to compare survey designs, and drew randomly from 18 (30%) backup clusters when a main cluster lacked residential buildings. The Kathmandu sample was drawn from the 2017 WorldPop dataset[15] using the GridSample R package[22] by selecting 100x100m "seed" cells with PPS and then "growing" clusters to a minimum of 200 households by randomly adding neighbouring cells. In clusters randomized to the one-stage arm, we used the 100x100m "seed" cell as the cluster boundary (Figure 2).

Figure 2. SUE survey coverage in Kathmandu, Dhaka, and Hanoi, and example two-stage and one-stage cluster field maps



The sample sizes in Dhaka and Hanoi were smaller, each targeting 400 households in 20 clusters with 6 (30%) additional backup clusters. The aim of these surveys was to evaluate transferability of our methods and tools across settings. An additional 4 clusters were sampled in Hanoi because more than 6 clusters were dropped. Both the Dhaka and Hanoi surveys used only a one-stage design, and clusters were selected with GridSample from 2020 WorldPop estimates with PPS.[15,22] In Dhaka, clusters were each 100x100m cells drawn from one ward and one slum community, while in less-dense Hanoi, clusters were 200x200m cells drawn from one district.

Following standard survey methods, geospatial specialists mapped and listed household in Kathmandu's two-stage sample, while public health specialists conducted interviews later. In Kathmandu and Dhaka's one-stage samples, geospatial experts listed dwellings, but the household

listing was performed by interviewers on the day of interview. In Hanoi, mapping, listing, and interviews were wrapped into one activity. The trainings for the mapping-listing(-interview) teams were each one-week and involved lectures, role-play, group discussion and a field test.

In the field, mappers-listers followed a script to approach residents, and upon request, distributed a written description of the survey. In all three surveys, respondents provided written informed consent, were 18+ years of age and usually a senior household member. The interviewers were mostly female, and read questions and recorded responses on a tablet. The household questionnaire collected demographics, assets, income/savings/expenditures, social capital, migration, and injury information. One adult in each household was randomly selected using the Kish method to complete an individual questionnaire with mental health and migration questions.[23]

Days worked by each staff member and costs were recorded by the survey coordinator in each country. Time spent by survey coordinators to develop and learn the novel methods was excluded from cost calculations. However, time spent training mappers-listers and interviewers was included. In Kathmandu, we estimated costs for the one-stage and two-stage survey separately by holding constant costs of administration, training, and durable goods, and varying days of fieldwork.

Public involvement

Members of the public, including survey respondents, were not involved in setting the research questions, outcome measures, design, or implementation of the study, nor the dissemination of study results.

Statistical evaluation

Sample weights were calculated separately according to the SUE and DHS/MICS household definitions. In the one-stage samples in all cities, we evaluated whether use of the DHS/MICS household definition resulted in different estimates of individual and household characteristics compared to use of the SUE household definition using means or percentages, and linear or multinomial regression at 5% alpha level. In the Kathmandu sample, we used the same statistical techniques to compare whether individual and household characteristics differed in the one-stage versus two-stage sample; first, holding the DHS/MICS household definition constant, and second, comparing two-stage-DHS/MICS with one-stage-SUE households. Household characteristics included building type, household member configuration, slum household, and migration status of household head. Individual characteristics included age-gender groups, employment status, marital status, and highest level of education. A reference group was selected for each variable to make statistical comparisons, and observations were dropped if they lacked data to determine household definition eligibility. We analysed survey results in Stata 14.0, adjusting for sample weights and clustering of observations. The analysis in Kathmandu was stratified by arm (one-stage/two-stage), and the analysis in Dhaka was stratified by community (ward/slum). This meant that in Kathmandu, the two-stage arm represented more weighted households than the one-stage arm because two-stage clusters had larger populations.

Qualitative evaluation

An FGD was held with each of mapping-listing teams using the same guide covering topics of OpenStreetMap enumeration, mapping-listing, and workflow. Additional questions exploring differences in one-stage and two-stage clusters were included in the Kathmandu FGD. FGDs were facilitated and audio recorded by two trained qualitative researchers, and conducted in the local language. The recordings were transcribed into the local language and then translated into English.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

We performed a thematic Framework Analysis in NVivo 11, coding every line by theme and summarizing positive/neutral experiences, challenges, and recommendations.[24]

Ethics

Ethics approvals were obtained from the University of Leeds (ref:MREC16-137), University of Southampton (ref:26819), Nepal Health Research Council (ref:1761), Bangladesh Medical Research Council (ref:BMRC/NREC/RP/2016-2019/317), and Hanoi University of Public Health (ref:324/2017/YTCC-HD3).

RESULTS

In Kathmandu, 11% of clusters were dropped and replaced. No clusters were dropped in the targeted areas of Dhaka, and 30% were dropped in the Hanoi district where the sample frame was older (Table 1). Due to high density in Dhaka, and larger clusters in Hanoi, nearly all clusters in those cities required segmentation to achieve 20 households per cluster (Table 1). Household response rates were 96.8% in the Kathmandu two-stage arm, 88.3% in the Kathmandu one-stage arm, 98.7% in Dhaka, and 82.7% in Hanoi (Table 1).

Table 1. Sample design, number of clusters, and households (unweighted) by survey

Sample design	Kathmandu, Nepal		Dhaka, Bangladesh	Hanoi, Vietnam
Coverage & target population	Kathmandu Valley – general population		1 ward – economically mixed 1 slum – poor	1 district – economically mixed, incl. migrants
Stages	Two-stage	One-stage	One-stage	One-stage
Cluster definition	Multiple 100x100m cells	Single 100x100m cell	Single 100x100m cell	Single 200x200m cell
Field visits & activity	1 – List households 2 – Conduct interviews	1 – List dwellings 2 – List households & conduct interviews	1 – List dwellings 2 – List households & conduct interviews	1 - List households & conduct interviews
Mapping-listing team	Undergraduate geospatial training, mostly male		Undergraduate geospatial training, mostly male	Undergraduate public health training, mostly female
Interview team	Undergraduate public health training, even mix of male and female		Undergraduate public health training, all female	
Sample frame				
Date estimated	2017		2020	2020
Date of production	2017		2017	2013
Clusters				
Targeted	30	30	20	20
Dropped and replaced	6	3	0	9
Sampled	30	30	20	20
Segmented	15	7	20	18
Households				
Targeted	600	600	400	400
Sampled - SUE	581	599	382	463
Sampled - DHS/MICS (% of SUE definition)	578 (99%)	538 (90%)	318 (83%)	412 (89%)
Sampled - LSMS (% of SUE definition)	578 (99%)	538 (90%)	343 (90%)	434 (94%)
Household response rate	581/600 (96.8%)	599/678 (88.3%)	382/387 (98.7%)	463/560 (82.7%)

Unintentional exclusion due to household definition

Across the one-stage samples, applying the DHS/MICS or LSMS household definition resulted in exclusion of approximately 10% of households compared to the SUE definition (Table 1). When we compared characteristics by household definition in one-stage samples, we found that a substantial portion of individuals from certain sub-groups were excluded by the DHS/MICS definition. In Kathmandu, nearly half (46.9%) of single adult households and sizable portions of migrant-headed

households (6.7%), non-married (8.5%), unemployed (10.5%), disabled (9.3%), and studying (14.3%) adults were excluded by the DHS/MICS definition (Table 2).

In the Dhaka and Hanoi surveys targeting vulnerable communities, sizable portions of single adult households (95.0% and 47.6%), non-married (48.1% and 37.3%), unemployed (32.6% and 23.9%), retired (70.5% and 27.6%), disabled (48.9% and 55.2%), studying adults (81.4% and 84.0%), young people (59.4-79.8% and 88.5-92.7%), and adult women (50.6% and 18.4%) were excluded by the DHS/MICS household definition (Table 2).

Unintentional exclusion due to sample design

Applying the DHS/MICS household definition, we compare one-stage and two-stage samples in Kathmandu to understand how sample design might influence types of respondents (Table 3). We found average household size was smaller in the one-stage sample but dwellings had more occupants (household size: 3.5 vs. 3.9, dwelling size: 5.0 vs. 3.9) (Table 3). Further, the one-stage design had more non-family households (6.0% vs. 1.9%), but the two-stage design included more shack and tent dwellers (0.7% vs. 3.8%) (Table 3).

Unintentional exclusion due to sample design and household definition

Building off the previous analysis, we compared the one-stage sample with SUE definition and the two-stage sample with DHS/MICS definition in Kathmandu to understand the combined effects of survey design and household definition. In the one-stage-SUE sample, there were more single adult (10.4% vs. 4.5%) and non-family households (6.0% vs. 1.9%), plus inclusion of hostel dwellers (3.8%), street sleepers (1.0%), and long-term guesthouse residents (0.1%) who did not meet DHS/MICS household definition (Table 3). However, the two-stage-DHS/MICS sample included more shack and tent dwellers (0.6% vs. 3.8%) (Table 3).

Time and cost

In Kathmandu, a one-stage gridded population survey with a target of 600 households in 30 clusters would cost approximately US$26,769, or US$45 per household, while a comparable two-stage survey would cost approximately US$35,284, or US$59 per household. One-stage survey costs per household in Dhaka (US$34) and Hanoi (US$76) differed due to cost of living and limited economy of scale due to smaller sample sizes. The main cost difference between Kathmandu's one-stage and two-stage survey was the mapping-listing activity; costs were 2.5 times greater in a two-stage survey due to larger clusters and need for an advanced mapping-listing team.

Skill mix

The skills required to plan and implement the SUE surveys were similar to standard household surveys. The main difference was skillset of the mapping-listing team. In a standard survey, mapping-listing staff are required to have a secondary school education.[25] To use SUE tools and methods, the mapping-listing staff should additionally have training in geography, GIS, or related fieldwork, and be comfortable using mobile technologies for data collection and navigation. The skillsets of other staff including survey planners, trainers, and interviewers were identical to a standard household survey. At the time of planning, the GridSample R package was the only available tool for gridded population sampling and it required intermediate R programming and GIS skills. However, a free point-and-click tool called gridsample.org was since released, allowing non-technical design and implementation of gridded population surveys.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

Table 2. Unintentional exclusion due to household definition: Percent of population who would be excluded using the standard DHS/MICS versus SUE household definition in Kathmandu, Dhaka, and Hanoi

Households in each one-stage sample were split by those who (a) met the SUE and DHS/MICS household definitions, and (b) met the DHS/MICS household definition only. We present the percent of households excluded from the DHS/MICS household definition, and regression coefficient p-value comparing (a) and (b).

Indicator	**Kathmandu One-stage sample only**				**Dhaka One-stage sample**				**Hanoi One-stage sample**			
	N-wgt all	N-wgt DHS/MICS only	% excluded by DHS/ MICS	p-value†	N-wgt all	N-wgt DHS/MICS only	% excluded by DHS/ MICS	p-value†	N-wgt all	N-wgt DHS/MICS only	% excluded by DHS/ MICS	p-value†
Households												
Configuration												
Single adult	22	12	46.9	<0.001	24	1	95.0	<0.001	43	23	47.6	0.002
One woman with children	10	10	0.0	<0.001	9	8	7.9	0.967	6	2	66.7	0.006
Nuclear family	91	91	0.6	Ref.	205	188	8.3	Ref.	231	228	1.4	Ref.
Other family *	73	73	0.6	0.906	143	128	10.6	0.579	147	136	7.0	0.042
Non-family	13	13	0.0	<0.001	1	0	89.5	0.013	35	20	42.6	0.001
Slum household ** (with security of tenure)												
No	171	163	5.1	Ref.	256	213	16.9	Ref.	31	25	17.7	Ref.
Yes	37	35	6.4	0.835	126	113	10.8	0.146	425	383	10.0	0.485
Missing	0	0	--	--	0	0	--	--	7	2	72.3	0.120
Slum household ** (without security of tenure)												
No	178	167	5.0	Ref.	277	231	16.8	Ref.	451	400	11.3	Ref.
Yes	30	28	7.1	0.757	105	95	10.0	0.182	9	8	9.1	0.846
Missing	0	0	--	--	0	0	--	--	3	2	31.1	0.109
Migration status (head)												
Non-migrant	46	46	0.3	Ref.	174	156	10.6	Ref.	155	140	10.0	Ref.
Migrant	162	151	6.7	0.016	208	169	18.5	0.170	308	270	12.1	0.483
Adults 18+												
Marital status												
Not married	184	169	8.5	0.001	247	128	48.1	<0.001	331	208	37.3	0.001
Married	364	355	2.3	Ref.	779	548	29.6	Ref.	868	794	8.6	Ref.
Missing	0	0	--	--	1	1	0.0	<0.001	3	2	32.0	0.310
Employment status												
Full-time employed	267	262	1.6	Ref.	538	493	8.3	Ref.	702	653	6.9	Ref.
Part-time, underemployed	10	10	0.0	<0.001	37	32	12.5	0.556	39	37	7.0	0.989
Unemployed	27	24	10.5	0.001	46	31	32.6	0.003	92	70	23.9	0.007
Retired	20	19	1.9	0.839	307	91	70.5	<0.001	46	33	27.6	0.041
Homemaker	123	122	1.5	0.860	2	1	46.6	0.133	215	184	14.4	0.004

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

Disabled "unable to work"	17	16	9.3	0.009	34	18	48.9	0.002	21	9	55.2	<0.001
Student	82	70	14.3	0.003	57	11	81.4	<0.001	82	13	84.0	<0.001
Missing	2	0	100.0	<0.001	6	2	75.2	0.012	5	4	19.0	0.448
Individuals												
Gender and age group												
Male <12	55	54	1.4	0.139	206	47	77.3	<0.001	207	22	89.6	<0.001
Female <12	48	47	1.6	0.291	180	36	79.8	<0.001	157	18	88.5	<0.001
Male 12-17	31	30	4.9	0.822	105	42	59.8	<0.001	78	6	92.7	<0.001
Female 12-17	32	31	3.4	0.442	87	35	59.4	<0.001	47	4	90.7	<0.001
Male 18+	297	280	5.7	Ref.	512	422	17.5	Ref.	536	460	14.2	Ref.
Female 18+	251	244	2.8	0.203	514	254	50.6	<0.001	665	543	18.4	<0.001
Missing	0	0	--	--	2	2	0.0	<0.001	0	0	--	--
Level of education												
Less than primary	171	163	4.7	0.733	906	443	51.2	0.062	340	69	79.8	<0.001
Primary	124	118	4.6	0.711	353	195	44.9	0.803	232	149	36.0	0.012
Secondary+	377	362	3.9	Ref.	233	131	43.6	Ref.	960	813	15.4	Ref.
Missing	42	42	0.0	<0.001	113	70	38.1	0.449	158	23	85.5	<0.001

* includes living with servants and/or extended family, sometimes with non-family household members as well
** defined as lacking improved water, improved sanitation, a durable structure, sufficient sleeping space (based on DHS/MICS household member definition), or insecure tenure
† multinomial logistic regression
N-wgt – weighted count

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

Table 3. Unintentional exclusion due to sample design and household definition: Kathmandu sample characteristics comparing a) two-stage DHS/MICS versus one-stage DHS/MICS, and b) two-stage DHS/MICS versus one-stage SUE

Indicators	Two-stage DHS/MICS (Ref.)		One-stage DHS/MICS			One-stage SUE		
	N-wgt	Mean or Percent	N-wgt	Mean or Percent	p-value†	N-wgt	Mean or Percent	p-value†
Survey Metrics								
HH size	928	3.9	191	3.5	0.014	208	3.4	0.013
Dwelling size	928	3.9	191	5.0	<0.001	208	5.3	0.001
HHs per PSU	928	19.5	191	23.4	0.016	208	24.9	0.051
Households								
Building Type								
Residential	681	73.4 %	137	71.8 %	Ref.	142	68.2 %	Ref.
Mixed	206	22.2 %	50	26.4 %	0.595	52	25.0 %	0.594
Commercial	6	0.7 %	3	1.2 %	0.447	2	1.2 %	0.450
Shack or tent	35	3.8 %	1	0.7 %	0.009	1	0.6 %	0.009
Hostel	0	--	0	--	--	8	3.8 %	<0.001
Street sleeper	0	--	0	--	--	2	1.0 %	<0.001
Guesthouse	0	--	0	--	--	0	0.1 %	<0.001
Configuration								
Single adult	42	4.5 %	11	5.8 %	0.256	22	10.4 %	0.040
One woman with children	29	3.2 %	10	4.9 %	0.093	10	4.7 %	0.096
Nuclear family	480	51.7 %	88	46.1 %	Ref.	91	43.9 %	Ref.
Other family*	360	38.8 %	70	36.8 %	0.600	73	35.1 %	0.603
Non-family	17	1.9%	12	6.3%	0.029	13	6.0%	0.030
Slum household** (with tenure)								
No	718	77.3 %	157	82.5 %	Ref.	171	82.3 %	Ref.
Yes	210	22.7%	34	17.5 %	0.341	37	17.7 %	0.360
Migrant (Head)								
No	280	30.1 %	44	23.2 %	Ref.	46	22.1 %	Ref.
Yes	648	69.9 %	147	76.8 %	0.244	162	78.0 %	0.173
Adults 18+								
Marital status								
Not married	861	32.5 %	163	32.2 %	0.924	185	33.7 %	0.107
Married	1,786	67.5 %	344	67.8 %	Ref.	363	66.3 %	Ref.
Employed full-time								
No	1,430	54.0 %	253	49.9 %	0.253	280	51.1 %	0.430
Yes	1,217	46.0 %	254	50.1 %	Ref.	267	48.7 %	Ref.
Missing	0	--	0	--	--	1	0.3 %	<0.001
Individuals								
Age, Gender group								
Male <12	334	9.4 %	52	7.9 %	0.149	55	7.7 %	0.089
Female <12	232	6.5 %	46	6.7 %	0.875	48	6.7 %	0.710
Male 12-17	170	4.8 %	29	4.3 %	0.287	31	4.4 %	0.275
Female 12-17	181	5.1 %	30	4.5 %	0.330	32	4.5 %	0.275
Male 18+	1,329	37.3 %	271	40.8 %	Ref.	297	41.6 %	Ref.
Female 18+	1,318	37.0 %	236	35.6 %	0.202	251	35.2 %	0.118
Education								
Less than primary	957	26.9 %	157	23.8 %	0.412	171	23.9 %	0.440
Primary	599	16.8 %	115	17.3 %	0.880	124	17.4 %	0.906
Secondary+	1,774	49.8 %	351	52.9 %	Ref.	377	52.8 %	Ref.
Missing	234	6.6 %	41	6.1 %	0.601	42	5.9 %	0.494

* includes living with servants and/or extended family, sometimes with non-family household members as well
** defined as lacking improved water, improved sanitation, a durable structure, sufficient sleeping space, or insecure tenure
† linear regression coefficient (continuous) or multinomial logistic regression (categorical)
N-wgt – weighted count

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 28 October 2019 doi:10.20944/preprints201910.0320.v1

Table 4. Comparison of time and budget to perform one-stage versus two-stage survey (estimated) in Kathmandu, Dhaka, and Hanoi

Budget Item	**Kathmandu, Two-stage**		**Kathmandu, One-stage**		**Dhaka, One-stage**		**Hanoi, One-stage**	
	Time	Cost USD	Time	Cost USD	Time	Cost USD	Time	Cost USD
Planning & Administration	75 days		60 days		60 days		20 days	
Salaries		9,240		8,006		4,305		7468
Mapping-Dwelling/HH listing-GIS	35 days × 6 mapper-listers 1 GIS specialist		12 days × 6 mapper-listers, 1 GIS specialist		36 days × 8 mapper-listers, 1 GIS specialist		8 days × 12 listers	
Salaries, per diem		7,641		3,056		4,926		6128
Materials		291		218		120		68
Interviews & Data Management	19 days × 8 interviewers		15 days × 8 interviewers		24 days × 7 interviewers		13 days × 12 interviewers	
Salaries, per diem		5,723		4,518		2,345		11,872
Materials, including pilot		2,106		2,106		872		574
Incentives, local collaborators		0		0		0		3,089
Ethics review		1,998		1,998		238		1,362
Equipment								
Laptops / hard drives		1,193		1,193		167		0
Tablets *		1,212		1,212		382		1,714
Overhead	(20% direct costs)	5,786	(20% direct costs)	4,367	(20% direct costs)	2,671	(10% direct costs)	3,228
TOTAL		35,284		26,769		16,026		35,503
Per household		**59**		**45**		**34**		**76**

Experiences

Feedback from the mapper-lister FGDs was generally neutral or positive, and staff resoundingly said they would prefer SUE tools and protocols to a conventional paper-based protocol. The SUE survey fieldwork, however, was not without limitations.

Key challenges. In Kathmandu, the mapping-listing staff were comprised of university geospatial students. Several described approaching residents as their greatest challenge, as well as their greatest reward. One mapper-lister explained, "It was fun to work at the social level and interacting with the local people. We always used to be limited to using the computers before. This time we got to go to the field and visit the people in their homes to collect the data. This was a new experience for me." Other mappers-listers agreed and added that role-play and practical activities prepared them for fieldwork, though additional training on the survey aims would have helped to explain the survey's purpose to residents. In Nepal, mapping-listing staff were able to enumerate 20-30 households per day initially, and this increased to 40-50 households per day after a week.

The main challenges in Dhaka and Hanoi were different. In these cities, the survey planners were trained about field tools and protocols but were not able to accumulate field experience before training field teams. As a result, mapping-listing staff, including the geospatial students in Dhaka, described challenges learning how to use the tablet applications during the first few days of fieldwork. In Hanoi, staff additionally struggled with navigation. Several of the teams in Hanoi even enlisted local guides who often informally took on the role of approaching residents and introducing the survey.

Across cities, mappers-listers described working in pairs to be essential because it provided them with "mutual support" and allowed them to adapt to the moods and reactions of residents, interact in more languages, and to work faster and more accurately by supporting each other with navigation and recording details. Overwhelmingly, mappers-listers recommend that teams be comprised of one geospatial expert who focuses on navigation and mapping, and one public health expert who approaches residents and lists dwelling or household information.

Response rates. In all three cities, mapping-listing staff found that residents seemed to omit mention of neighbours who did not have official mortgages or rental contracts, presumably for fear of evictions or fines. This was a particular challenge in Hanoi where "people tended to answer our question following their household record book," an official registry of households administered by the government. On mapper-lister-interviewer explained, "For residents who were living in evacuated houses, they felt worry and scare as if something wrong could happen."

The Hanoi planning team thus decided to hire several guides from the community to accompany teams. Together guides and teams returned to each cluster multiple times to build trust with residents and identify households not reported during previous visits. While the presence of guides likely improved response rates in Hanoi, it also meant that these survey teams were limited by the availability of guides. Most teams performed the listing and interviewed households in the evenings when guides were home from work, though this meant that residents were trying to eat dinner and often rushed to answer questions or refused to participate in the survey. Mapper-listers and interviewer in Kathmandu and Dhaka, however, performed most of their work during the day.

Residential building access was a problem across cities. The Hanoi teams faced secured apartment buildings without a guard. In these situations, the planning team contacted the building management boards and were usually able to gain access to these buildings, however once inside, mappers-listers-interviewers often found that residents knew little about their absent neighbours.

Kathmandu had wealthy "VIP" neighbourhoods, and mapping-listing staff also reported substantial scepticism and non-response in these neighbourhoods.

Travel. Mapping-listing staff commuted to clusters via bus, rickshaw, motorbike, and foot. In Kathmandu, most staff never travelled more than one hour from home to a cluster, however a team working in peri-urban Kathmandu spent three hours commuting one way to one particular cluster due to the absence of buses or taxis. In Dhaka, where traffic is notoriously bad, commute times from the office to clusters ranged from 1.5 to 3 hours. Across the three cities, mapping-listing staff recommended hired vehicles to save time.

One-stage versus two-stage clusters. Mappers-listers in Kathmandu reported different experiences in one-stage and two-stage clusters they visited. The two-stage clusters were, by definition, at least ten times the area of one-stage clusters, however due to variability in the WorldPop estimates, several two-stage clusters were even larger resulting in extra days of work and more physical barriers such as hills or rivers to navigate. In addition to being much larger, the two-stage clusters required much more information than one-stage clusters, resulting in longer interactions and higher levels of scepticism among residents. "We had to explain everything to the people from the very beginning in the two-stage [clusters]. That is because we required a lot of information in that stage. On the contrary, we did not require a lot of information in the one-stage [clusters]. We had to only ask them whether there was anyone living in those houses or not."

Residents were generally willing to report number of apartments/dwellings per building, however, they were reluctant to specify the number of households per dwelling and to give household head names. In many two-stage clusters, Kathmandu teams approached a business owner in the ground level who gave number of dwellings on the above floors, but refused to give household-level information and instead directed the mapping-listing staff to the building owner. One way that mappers-listers addressed this challenge was to approach people at a local grocery store, and start a conversation about their household and neighbouring households away from their building. In this context, residents were less likely to feel they were speaking on behalf of the landlord and were more open. This approach allowed mappers-listers to gather helpful information about neighbouring buildings, as well.

Technology. Across sites, mapping-listing staff faced challenges with the tablet applications. While some challenges could have been averted with more, or better, training, other challenges were inherent to the tools and protocols used. First, although OpenStreetMap was updated by mappers-listers before visiting clusters, the map updates to various applications occurred on different schedules resulting in different versions of the same map in the field. Specifically, updates to ArcGIS (from which paper field maps were printed), GeoODK (where building GPS points were collected as part of the listing), OSMAnd and MAPS.ME (both used for navigation) were all updated 1 to 30 days after a change was made to OpenStreetMap. A mapper-lister in Kathmandu explained this challenge with an example, "When we looked at the OSMAnd, it showed us that there is a house at a location. But when we used to work with the plug-in of the GeoODK, there were no houses there. So, there was problem with the maps being updated in the GeoODK and OSMAnd. The paper maps were also prepared using old satellite images which does not match with the current on-field structures. So, it would be easier for us to work if there was data consistency in the three tools that we used."

A second problem was the number of applications that the mapping-listing staff were expected to use. It was time consuming and confusing to switch between MAPS.ME to navigate to a cluster, OSMAnd to navigate within a cluster and visualize its boundary against the tablet location, GeoODK to manually record a GPS point over each building, and finally CamScanner to submit daily reports to the planning team. Despite the multiple applications plus paper map meant to help find each cluster,

mappers-listers in all cities reported delays and difficulty navigating to clusters. Once in a cluster, however, mappers-listers did not report any challenges identifying the cluster boundaries, despite their blocky shapes. Mappers-listers across cities also found recording the listing data in GeoODK for by building was arduous, and they often took notes on paper when speaking to residents then entered the information into the tablet immediately after.

Third, the location precision within OSMAnd and GeoODK were poor, often showing a large circle up to 36 metres in which the tablet could be located, obfuscating the purpose of this feature. Location precision was a particular problem in high density areas (presumably with tall buildings blocking or refracting signals), and resulted in more than one instance of a mapping-listing team starting their work, and then realizing part-way through that they were recording data one or two streets away from the cluster.

DISCUSSION

By comparing DHS/MICS and SUE household definitions across one-stage samples, and by comparing a one-stage and two-stage sample in Kathmandu, Nepal, we found evidence that standard household survey methods unintentionally omit single adults and non-family households, both of which are more likely to represent disjoined households, or be mobile compared to stable nuclear family households.[10,26,27] To our knowledge, this is among the first studies in a LMIC context to evaluate under-coverage due to survey design and methods in face-to-face surveys; such studies tend to be conducted in high-income countries.[12,28]

Although the same protocols and household definitions were used to identify households in Kathmandu's one-stage and two-stage arms, the quality of the household listing data likely differed because interviewers listed household in one-stage clusters, rather than mappers-listers. Interviewers had more skills to interact with the public and substantially more time at each building (2.5 to 3 hours per interview). As LMIC urban contexts are increasingly defined by complex living arrangements and mobile and temporary residents, there might be a need to move the household listing responsibility to interviewers using one-stage survey designs. Indeed, this argument has been made by others who provide evidence that standard household definitions are no longer suitable in complex LMIC cities, and that individuals and communities are more appropriate units of measurement.[27,29]

Without urban strata, the two-stage sample in Kathmandu was better able to measure tent and shack dwellers than the one-stage sample, likely due to the larger area of two-stage clusters. The only way to ensure representative survey samples of shack/tent dwellers and other vulnerable populations concentrated in slums is to treat slum/non-slum areas as strata, in both one-stage and two-stage designs.[30]

We found that response rates in many one-stage clusters were lower than in two-stage clusters, particularly if the household witnessed a neighbour or landlord refusing participation. This may have been due to the greater proportion of vulnerable and mobile households measured in one-stage clusters if they were less willing to participate, more likely absent, or felt disempowered to respond. Readers who are interested in one-stage survey designs should take account of lower response rates and potentially higher design effects due to similarity among immediate neighbours when calculating sample size.[31] The surveys conducted in Dhaka and Hanoi focused on vulnerable and mobile communities, so rates of exclusion may be higher than the general population.

Societal changes, particularly rapid urbanization in LMICs, have likely caused decay in survey data accuracy due to increased complexity in living arrangements, urban disparity, and population

 doi:10.20944/preprints201910.0320.v1

mobility. Not only are vulnerable and mobile populations at risk of unintentional, unmeasured exclusion from standard household surveys, their data are masked in urban averages when they are sampled. Given the importance of household survey data to policy-making, planning, and monitoring progress toward development goals, it is time to evaluate new survey tools and protocols that ensure inclusion of all households.

REFERENCES

1. Lucci P, Bhatkal T, Khan A. Are we underestimating urban poverty? *World Dev* 2018;**103**:297—310. doi:10.1016/j.worlddev.2017.10.022
2. UN Habitat. Urbanization and Development: Emerging Futures. World Cities Report 2016. Nairobi: UN-Habitat; 2016. http://wcr.unhabitat.org/wp-content/uploads/2017/02/WCR-2016-Full-Report.pdf. Accessed October 24, 2019.
3. Vlahov D, Freudenberg N, Proietti F, et al. Urban as a determinant of health. *J Urban Heal* 2007;**84**(Suppl. 1):16-26. doi:10.1007/s11524-007-9169-3
4. UN Statistics Division. Household Sample Surveys in Developing and Transition Countries. New York, NY: United Nations; 2005. https://unstats.un.org/unsd/HHsurveys/pdf/Household_surveys.pdf. Accessed October 24 2019.
5. UN Department of Economic and Social Affairs. Sustainable Development Goals. Sustain Development Knowledge Platform. https://sustainabledevelopment.un.org/sdgs. Published 2018. Accessed October 24, 2019.
6. ICF International. Demographic and Health Survey Sampling and Household Listing Manual. Calverton, MD: ICF International; 2012. https://dhsprogram.com/pubs/pdf/DHSM4/DHS6_Sampling_Manual_Sept2012_DHSM4.pdf. Accessed October 24, 2019.
7. Multiple Indicator Cluster Surveys. MICS5 Tools: Manual for Mapping and Household Listing. New York, NY: UNICEF; 2013. http://mics.unicef.org/tools?round=mics5. Accessed October 24, 2019.
8. Grosh ME, Munoz J. A Manual for Planning and Implementing the Living Standards Measurement Study Survey. LSMS Working Paper No. 126. Washington, DC: The World Bank; 1996. http://documents.worldbank.org/curated/en/363321467990016291/A-manual-for-planning-and-implementing-the-living-standards-measurement-study-survey. Accessed October 24, 2019.
9. Randall S, Coast E, Compaore N, Antoine P. The power of the interviewer. *Demogr Res* 2013;**28**(27):763—792. doi:10.4054/DemRes.2013.28.27
10. Tumbe C. Missing men, migration and labour markets: evidence. *Indian J Labour Econ* 2016;**58**(2):245—267. doi:10.1007/s41027-016-0017-4
11. ICF International. Available datasets. The DHS Program. https://dhsprogram.com/data/available-datasets.cfm. Published 2017. Accessed October 24, 2019.
12. Eckman S. Do different listers make the same housing unit frame? Variability in housing unit listing. *J Off Stat* 2013;**29**(2):249—259. doi:10.2478/jos-2013-0021
13. Research Center for Employment Relations. Living Wage Report: Urban Vietnam. Ho Chi Minh City: ERC; 2016. https://www.isealalliance.org/sites/default/files/resource/2017-12/Urban_Vietnam_Living_Wage_Benchmark_Report.pdf. Accessed October 24, 2019.
14. Leeds Institute of Health Sciences. Surveys for Urban Equity (SUE). https://medicinehealth.leeds.ac.uk/directory_record/960/surveys_for_urban_equity. Published 2017. Accessed October 24, 2019.
15. Elsey H, Poudel AN, Ensor T, et al. Improving household surveys and use of data to address health inequities in three Asian cities: Protocol for the Surveys for Urban Equity (SUE) mixed methods and feasibility study. *BMJ Open* 2018;**8**(11):e024182. doi:10.1136/bmjopen-2018-024182
16. Pesaresi M, Freire S. GHS settlement grid, following the REGIO model 2014 in application to GHSL Landsat and CIESIN GPW v4-multitemporal (1975-1990-2000-2015). European Commission Joint Research Centre. https://data.jrc.ec.europa.eu/dataset/jrc-ghsl-ghs_smod_pop_globe_r2016a. Published 2016. Accessed February 6, 2017.

17. WorldPop. Population / Individual countries 2000-2020. https://www.worldpop.org/geodata/listing?id=29. Published 2017. Accessed February 2, 2017.
18. Thomson DR, Stevens FR, Ruktanonchai NW, Tatem AJ, Castro MC. GridSample: An R package to generate household survey primary sampling units (PSUs) from gridded population data. *Int J Health Geogr* 2017;**16**:25. doi:10.1186/s12942-017-0098-4
19. Groves RM, Fowler FJ, Couper MP, Lepkowski JM, Singer E, Tourangaeau R. Survey Methodology. 2nd ed. Hoboken, NJ: Hohn Wiley & Sons, Inc.; 2009.
20. Stevens FR, Gaughan AE, Linard C, Tatem AJ. Disaggregating census data for population mapping using random forests with remotely-sensed and ancillary data. *PLoS One* 2015;**10**(2):e0107042. doi:10.1371/journal.pone.0107042
21. OpenStreetMap contributors. OpenStreetMap Base Data. www.openstreetmap.org. Published 2000. Accessed November 12, 2018.
22. ESRI. ArcGIS Release 10. ESRI; 2018.
23. GeoMarvel. GeoODK. http://geoodk.com/. Published 2017. Accessed June 9, 2017.
24. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol* 2013;**13**(117):1—8. doi:10.1186/1471-2288-13-117
25. ICF Macro. Training Field Staff for DHS Surveys. Calverton, MD: ICF Macro; 2009.
26. Carr-Hill R. Missing millions and measuring development progress. *World Dev* 2013;**46**:1—15. doi:10.1016/j.worlddev.2012.12.017
27. Oya C. Who counts? Challenges and biases in defining 'households' in research on poverty. *J Dev Eff* 2015;**7**(3):336—345. doi:10.1080/19439342.2015.1068358
28. Eckman S, Kreuter F. Undercoverage rates and undercoverage bias in traditional housing unit listing. *Sociol Methods Res* 2013;**42**(3):264—293. doi:10.1177/0049124113500477
29. Campbell L. Working with People and Communities in Urban Humanitarian Crises. London: ALNAP; 2017. https://www.alnap.org/system/files/content/resource/files/main/alnap-urban-people-and-communities-2017.pdf. Accessed October 24, 2019.
30. Lilford RJ, Oyebode O, Satterthwaite D, et al. Improving the health and welfare of people who live in slums. *Lancet* 2017;**389**:559—570. doi:10.1016/S0140-6736(16)31848-7
31. Kools L. One-stage versus two-stage cluster sampling, a simulation study. In: Essays on wealth, health, and data collection [dissertation]. Leiden: Leiden University; 2018.

ACKNOWLEDGEMENTS

We would like to thank the city and government authorities in Hanoi, Dhaka and Kathmandu who supported this study in their cities. We would also like to thank Forrest Stevens and Andrea Gaughan who generated a revised WorldPop gridded population dataset for the Nepal sample frame, and Bao Ngoc who contributed to early planning work for the Vietnam survey.

FUNDING

This study was funded by the Medical Research Council (MRC) Global Challenges Research Fund (GCRF) grant ID: MR/P024718/1. Dana R Thomson additionally received funding from the UK Economic and Social Research Council (ESRC) grant ID: ES/5500161/1.

DATA SHARING

De-identified participant data and a data dictionary defining each field is available upon request with ethics approval. Please submit requests to Joseph Paul Hicks (J.P.Hicks@leeds.ac.uk) and Helen Elsey (helen.elsey@york.ac.uk).

AUTHOR CONTRIBUTIONS

DRT, SB, HW, SM, RH, HVM, TE, and HE designed the study. DRT, SM, CC, and HE performed the literature search. Figures were developed by DRT, JPH, and ANP. Data were collected by SK, SM, RB, RD, SG, JF, NJU, TF, and DMD. Data analysis was performed by DRT, RB, JPH, RAS, KQL, and ANP. DRT wrote the first draft, and all co-authors reviewed and approved the final manuscript.