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Descriptive Finding

Sample selection bias in adult mortality estimates from mobile phone surveys: Evidence from 25 low- and middle-income countries

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Abstract

BACKGROUND

Mobile phone surveys are gaining traction in low- and middle-income countries, but mobile phone ownership (MPO) is not universal, potentially introducing sample selection bias in ensuing estimates.

OBJECTIVE

To evaluate MPO-associated sample selection bias in adult mortality estimates from sibling survival histories (SSH) administered to women of reproductive age.

METHODS

Using data from 25 Demographic and Health Surveys, we (1) used logistic regression to assess the association between MPO and sociodemographic background characteristics; (2) used SSH to compare the probability of dying in adulthood ($_{45}q_{15}$) in a general population sample of women of reproductive age and a subsample of women who own a mobile phone, (3) and evaluated the use of post-stratification weighting to correct bias in adult mortality estimates derived from the subsample of mobile phone owners.

RESULTS

MPO correlated with sociodemographic characteristics in a predictable fashion. Summary indices of adult mortality ($_{45}q_{15}$) using data on siblings from respondents who owned a mobile phone aligned with the general population estimate in 20 out of 25 countries. Significant bias was identified in Papua New Guinea, Burundi, Rwanda, Haiti, and Zimbabwe, with the estimate being typically lower when based on reports of mobile phone owners. Where it existed, bias was most pronounced at either end of the age

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spectrum (15–24 and 45–59). Post-stratification weighting alleviated this bias to levels that were no longer statistically significant, but the correction was not always in the desired direction.

CONCLUSIONS
MPO-associated selection bias in adult mortality estimates from SSH is generally modest. Post-stratification weighting on respondents' background characteristics does not always produce a correction in the expected direction and is to be used with caution.

CONTRIBUTION
This study advances our understanding of sample selection bias in mobile phone survey estimates of demographic indicators.

1. Introduction

Civil Registration and Vital Statistics (CRVS) systems are the gold standard for tracking mortality and causes of death. However, the availability and functionality of such systems varies, and death registration is often defective in high-mortality settings, where they are most needed. The World Bank estimated that over 110 low- and middle-income countries (LMICs) have deficient CRVS systems (World Bank Group 2018), leading to a striking 60% of deaths left unregistered (Mikkelsen et al. 2015).

In the absence of comprehensive death registration, other data sources – including censuses and household surveys – are used as alternatives. These are often costly, time consuming, and impractical during conflicts, disasters, or health crises. For example, COVID-19 resulted in the suspension and/or delay of many face-to-face data collection activities (UNICEF 2020; USAID 2022), precisely when timely data were needed to formulate a policy response. The World Health Organization (WHO) reports that only 16 of the 106 Member States in African, Eastern Mediterranean, South-East Asian, and Western Pacific regions had empirical data enabling the calculation of excess COVID-19 deaths (WHO 2020).

Mobile Phone Surveys (MPS) are an attractive alternative for demographic data collection in LMICs, due to their cost-effectiveness and convenience. They require little or no interviewer travel and can be implemented when mobility is restricted, including in conflicts, natural disasters, and disease outbreaks (L'Engle et al. 2018). However, there is a legitimate concern that this interview modality might introduce or exacerbate biases in demographic estimates. The evidence suggests that mobile phone owners (henceforth referred to as owners) in LMICs are more often male and wealthier, higher educated, and more likely to reside in urban areas than the general population. These attributes are potentially correlated with demographic indices, and that could introduce selection bias in the ensuing estimates (Blumenstock and Eagle 2012; Wesolowski et al. 2012). A prior study reveals potential biases in fertility and under-5 mortality rates when estimates rely solely on data from women who own or have access to mobile phones (Sánchez-Páez et al. 2023). Although poststratification using the respondents' sociodemographic background characteristics could mitigate bias in mortality estimates for young children, it appears ineffective in correcting biases in fertility estimates. Whether adult mortality estimates from owners are also biased remains uncertain.

The Demographic and Health Surveys (DHS) are one of the main sources of data on adult mortality in LMICs. Some DHS include a module on Sibling Survival Histories (SSH) to obtain mortality estimates for adults aged 15–59. In SSH, the respondent is asked about the number and survival status of their maternal siblings, and either the age at survey or the age and time of death of siblings. In this way, SSH inflate the sample size by obtaining information on brothers and sisters, allowing for the estimation of sex-specific adult mortality with reasonable precision (Merdad, Hill, and Graham 2013). The SSH module is generally administered to women of reproductive age, but some older surveys also included the module in men's questionnaire (Merdad, Hill, and Graham 2013).

Data on siblings are widely used to track mortality trends (Schumacher et al. 2024; WPP 2022) and to estimate conflict-related mortality (Wagner et al. 2019) and the impact of health programs (Bendavid et al. 2012). SSH are also one of the main inputs for estimating maternal mortality, as the module contains questions for identifying pregnancy-related deaths.

An assessment of DHS sibling data indicates that there are few missing responses (usually less than 1%) on the sex of siblings, survival status, or age at the time of the survey (Ahmed, Li, and Scrafford 2014). Missing data on age and years since death are more frequent, with important variations across surveys. A validation study in Senegal also shows that respondents underestimate the ages of living siblings, ages at death, and the time since deaths. These reporting errors can introduce downward biases in mortality estimates (Masquelier et al. 2021). Comparisons of mortality trends across successive surveys also suggest that the completeness of death reporting declines as the reference periods extend into the past (Timæus and Jasseh 2004).

Recent DHS also ask about respondents' mobile phone ownership (MPO), and this allows us to investigate sample selection bias in SSH from a mobile phone survey.

In this study, first, we use DHS to investigate the association between MPO and the sociodemographic background characteristics of the respondents. Second, we compare adult mortality estimates from a subsample of owners with those from the total sample. Third, we evaluate whether post-stratification weights can be used to correct sample selection bias in adult mortality estimates if the SSH is only administered among owners. With post-stratification weighting, the distribution of survey respondents is adjusted to match the overall population characteristics, improving the external validity of the estimates (Smith 1991).

2. Materials and methods

We utilized data from available DHS surveys containing information on MPO and adult mortality (Table 1). None of the DHS surveys collected both MPO data and SSH from male interviewees, restricting our analysis to female respondents. Out of the 25 identified surveys, 20 were conducted in sub-Saharan Africa, and two in Eastern and Southeastern Asia. These surveys covered 25 low- and middle-income countries and were conducted between 2015 and 2021.

We first examined the prevalence of MPO in each survey. We then employed logistic regression to evaluate the relationship between MPO and the sociodemographic characteristics of female respondents, including age, educational level (less than primary, at least primary), wealth, marital status (married or cohabiting, not married nor cohabiting), area of residence (urban or rural), region of residence (capital region or other), and household size (below 5, 5–9, or more than 9 residents). We used a binary variable on access to electricity as a proxy for wealth in this study. The results shown are from a model which adjusts for all the characteristics mentioned.

Finally, we calculated age-specific mortality rates for 5-year age groups (${}_{n}M_{x}$), converted these rates into 5-year probabilities of surviving, and obtained the summary probability of dying between ages 15 and 60 (${}_{45}q_{15}$) by chaining together the age-specific probabilities of surviving. The mortality estimates referred to a window of 0–6 completed years before the survey. We computed these adult mortality indices for (1) the entire sample of female respondents, (2) the sample of MPOs, and (3) the sample of MPOs after applying post-stratification weights to mimic the effect of post-stratification weighting in a sample of owners. Post-stratification weights were computed using iterative proportional fitting (raking) so as to match the marginal distributions of the weighing variable (age, education, wealth, type and region of residence, and household size) in the sample of owners to that in the total population.

We calculated the ratio of age-specific mortality rates (${}_{n}M_{x}$) and the summary index ${}_{45}q_{15}$ for owners versus the full sample of women of reproductive age. Ratios that are significantly different from 1 are taken as evidence of MPO-associated selection bias. We also present the ratios after applying post-stratification weights to the subsample of MPO in order to ascertain whether this offers a correction for this bias. Estimates are presented along with bootstrapped confidence intervals. These were generated from 2,500 samples with replacement while considering the DHS sample design and, where applicable, the post-stratification weights. We used the 2.5th and 97.5th percentiles to construct the 95% confidence interval (95% CI) around each indicator. Our analyses were conducted using Stata 16 and Matlab (StataCorp 2019; The MathWorks Inc. 2022).

3. Results

3.1 Mobile phone ownership (MPO) prevalence

MPO varied substantially between countries and was typically lower in low-income countries and among women (Table 1). In four surveys (Burundi, Malawi, Ethiopia, Papua New Guinea), less than 40% of women of reproductive age owned a mobile phone. By contrast, five countries (Cambodia, Mauritania, South Africa, the Gambia, Zimbabwe) had a female MPO above 70%. In Mali, where the absolute gender difference in MPO was the largest, 87% of men owned a mobile phone, as opposed to 58.3% of women (Table 1).

Female MPO correlated in a predictable manner with sociodemographic background characteristics (Table 2). MPO was highest in mid-adulthood (25–29, 30–34, and 35–39 age groups) and was almost always least likely in the 15–19 age group. Compared to women with less than primary education, women who completed primary education were more likely to own a mobile phone in all surveys. The highest odds ratios (OR) associated with completing primary education were observed in Burundi (OR 5.55; 95% CI 4.8, 6.39) and Ethiopia (OR 7.02, 95% CI 5.61, 8.78), where female MPO was the lowest.

Wealth, approximated by access to electricity, was positively correlated with MPO in all surveys. Residence in rural areas was negatively associated with MPO in most surveys, most notably in Sierra Leone (OR = 0.32; 95% CI: 0.27, 0.38) and Ethiopia (OR = 0.35; 95% CI: 0.25, 0.5) where MPO among women was low. The association was not significant in South Africa. A bigger household size was almost always negatively correlated with MPO.

MPO among women tended to be significantly more likely in the region of the country where the capital is located. The exceptions were Malawi and Papua New Guinea, where residence in the capital region had significantly lower odds of MPO, compared to other regions. In 9 surveys the association was not significant (Table 2).

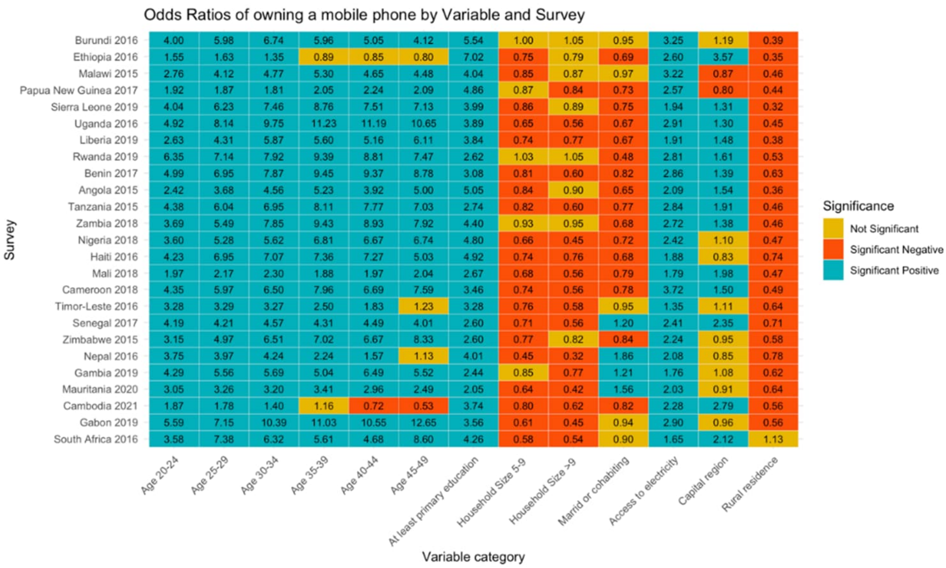
Table 1: Mobile phone ownership by survey, World Bank income level, and sex

Survey *	World bank income level	Sample size	Ownership % (95% CI)	
			Male	Female
Burundi 2016	Low	17,269	45.8 (43.5, 48.0)	23.6 (21.6, 25.5)
Ethiopia 2016	Low	15,683	53.7 (50.7, 56.6)	27.3 (24.2, 30.4)
Malawi 2015	Low	24,562	52.1 (49.9, 54.2)	32.8 (30.7, 35.0)
Papua N. Guinea 2017	Lower-middle	15,198	50.4 (47.3, 53.4)	34.3 (31.3, 37.3)
Sierra Leone 2019	Low	15,574	64.2 (62.0, 66.5)	42.6 (40.1, 45.1)
Uganda 2016	Low	18,506	65.8 (63.8, 67.9)	45.5 (43.2, 47.8)
Liberia 2019	Low	8,065	61.1 (57.4, 64.8)	46.7 (42.3, 51.2)
Rwanda 2019	Low	14,634	61.1 (59.2, 63.1)	47.9 (45.9, 50.0)
Benin 2017	Lower-middle	15,928	79.6 (78.2, 80.9)	51.1 (49.0, 53.2)
Angola 2015	Low	14,379	70.2 (67.3, 73.1)	51.2 (48.0, 54.5)
Tanzania 2015	Lower-middle	13,266	68.8 (66.7, 71.0)	52.2 (49.6, 54.8)
Zambia 2018	Low	13,683	66.0 (63.9, 68.1)	53.0 (50.0, 56.0)
Nigeria 2018	Lower-middle	41,821	81.2 (80.0, 82.4)	55.3 (53.4, 57.2)
Haiti 2016	Lower-middle	15,513	67.3 (65.2, 69.4)	55.5 (53.2, 57.8)
Mali 2018	Low	10,519	87.5 (86.0, 89.0)	58.3 (55.4, 61.3)
Cameroon 2018	Lower-middle	14,677	76.9 (74.6, 79.1)	63.1 (59.9, 66.3)
Timor-Leste 2016	Lower-middle	12,607	76.2 (73.9, 78.5)	65.6 (63.7, 67.5)
Senegal 2017	Lower-middle	16,787	84.2 (82.9, 85.6)	68.0 (65.6, 70.3)
Zimbabwe 2015	Lower-middle	9,955	73.8 (71.9, 75.6)	69.5 (67.3, 71.6)
Nepal 2016	Lower-middle	12,862	89.3 (88.1, 90.6)	72.6 (70.6, 74.7)
Gambia 2019	Low	11,865	86.5 (84.8, 88.2)	76.4 (74.8, 78.0)
Mauritania 2020	Lower-middle	15,714	85.7 (84.1, 87.2)	76.7 (74.7, 78.8)
Cambodia 2021	Lower-middle	19,496	91.3 (90.3, 92.3)	84.8 (83.6, 86.1)
Gabon 2019	Upper-middle	11,043	89.8 (88.5, 91.1)	88.9 (87.8, 89.9)
South Africa 2016	Upper-middle	8,514	88.5 (86.8, 90.1)	91.2 (90.2, 92.2)

Notes: * Surveys are arranged by the MPO rates among women (from lowest to highest).

Whereas the social gradient in MPO is consistent across surveys, and particularly in countries where the mobile phone penetration is low, the association between MPO and marital status is more heterogenous. Married or cohabiting women typically had lower odds of owning a phone than women who were not married or living together, most notably in Rwanda (0.48, 95% CI 0.42 – 0.52). Senegal, Nepal, Gambia, and Mauritania are the only surveys where the OR was above 1, suggesting a positive association. The association of MPO with marital status was insignificant in Timor-Leste, Zimbabwe, Gabon, and South Africa after controlling for other covariates (Table 2).

Table 2: Odds ratio of the association between MPO and sociodemographic background characteristics (women, aged 15–49)



Survey	Age 20-24	Age 25-29	Age 30-34	Age 35-39	Age 40-44	Age 45-49	At least primary education	Household Size 5-9	Household Size >9	Marrid or cohabiting	Access to electricity	Capital region	Rural residence
Burundi 2016	4.00	5.98	6.74	5.96	5.05	4.12	5.54	1.00	1.05	0.95	3.25	1.19	0.39
Ethiopia 2016	1.55	1.63	1.35	0.89	0.85	0.80	7.02	0.75	0.79	0.69	2.60	3.57	0.35
Malawi 2015	2.76	4.12	4.77	5.30	4.65	4.48	4.04	0.85	0.87	0.97	3.22	0.87	0.46
Papua New Guinea 2017	1.92	1.87	1.81	2.05	2.24	2.09	4.86	0.87	0.84	0.73	2.57	0.80	0.44
Sierra Leone 2019	4.04	6.23	7.46	8.76	7.51	7.13	3.99	0.86	0.89	0.75	1.94	1.31	0.32
Uganda 2016	4.92	8.14	9.75	11.23	11.19	10.65	3.89	0.65	0.56	0.67	2.91	1.30	0.45
Liberia 2019	2.63	4.31	5.87	5.60	5.16	6.11	3.84	0.74	0.77	0.67	1.91	1.48	0.38
Rwanda 2019	6.35	7.14	7.92	9.39	8.81	7.47	2.62	1.03	1.05	0.48	2.81	1.61	0.53
Benin 2017	4.99	6.95	7.87	9.45	9.37	8.78	3.08	0.81	0.60	0.82	2.86	1.39	0.63
Angola 2015	2.42	3.68	4.56	5.23	3.92	5.00	5.05	0.84	0.90	0.65	2.09	1.54	0.36
Tanzania 2015	4.38	6.04	6.95	8.11	7.77	7.03	2.74	0.82	0.60	0.77	2.84	1.91	0.46
Zambia 2018	3.69	5.49	7.85	9.43	8.93	7.92	4.40	0.93	0.95	0.68	2.72	1.38	0.46
Nigeria 2018	3.60	5.28	5.62	6.81	6.67	6.74	4.80	0.66	0.45	0.72	2.42	1.10	0.47
Haiti 2016	4.23	6.95	7.07	7.36	7.27	5.03	4.92	0.74	0.76	0.68	1.88	0.83	0.74
Mali 2018	1.97	2.17	2.30	1.88	1.97	2.04	2.67	0.68	0.56	0.79	1.79	1.98	0.47
Cameroon 2018	4.35	5.97	6.50	7.96	6.69	7.59	3.46	0.74	0.56	0.78	3.72	1.50	0.49
Timor-Leste 2016	3.28	3.29	3.27	2.50	1.83	1.23	3.28	0.76	0.58	0.95	1.35	1.11	0.64
Senegal 2017	4.19	4.21	4.57	4.31	4.49	4.01	2.60	0.71	0.56	1.20	2.41	2.35	0.71
Zimbabwe 2015	3.15	4.97	6.51	7.02	6.67	8.33	2.60	0.77	0.82	0.84	2.24	0.95	0.58
Nepal 2016	3.75	3.97	4.24	2.24	1.57	1.13	4.01	0.45	0.32	1.86	2.08	0.85	0.78
Gambia 2019	4.29	5.56	5.69	5.04	6.49	5.52	2.44	0.85	0.77	1.21	1.76	1.08	0.62
Mauritania 2020	3.05	3.26	3.20	3.41	2.96	2.49	2.05	0.64	0.42	1.56	2.03	0.91	0.64
Cambodia 2021	1.87	1.78	1.40	1.16	0.72	0.53	3.74	0.80	0.62	0.82	2.28	2.79	0.56
Gabon 2019	5.59	7.15	10.39	11.03	10.55	12.65	3.56	0.61	0.45	0.94	2.90	0.96	0.56
South Africa 2016	3.58	7.38	6.32	5.61	4.68	8.60	4.26	0.58	0.54	0.90	1.65	2.12	1.13

3.2 Adult mortality among siblings of mobile phone owners versus total sample

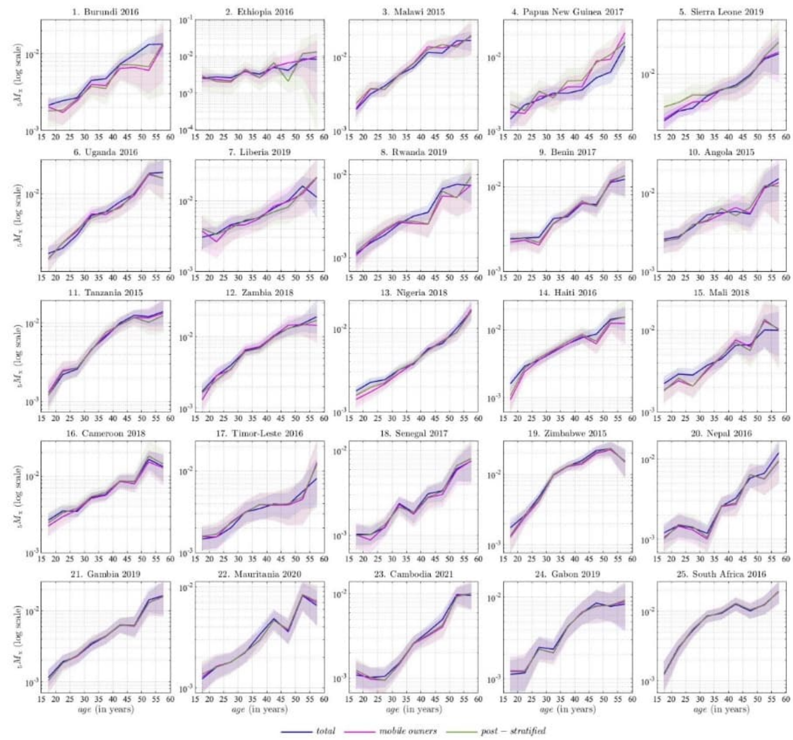
Age-specific mortality rates from the entire sample and those derived from the subsample of owners are shown in Figure 1. As one would expect, adult mortality rapidly increases with age.

Figure 1 also shows that differences between the estimates derived from the entire sample and from the subsample of owners are relatively small. This is more formally evaluated in Figure 3, which shows the bootstrap distribution of the ratio of the probability ${}_{45}q_{15}$ computed from owners relative to the entire population. A ratio of 1 means there is no difference between the two estimates and that sample selection bias is negligible.

From Figure 2 we also note that adult mortality estimates derived from the subsample of owners are comparable to those for the entire sample of female respondents, with statistically significant differences in only 5 out of the 25 surveys (Burundi, Papua New Guinea, Rwanda, Haiti, and Zimbabwe). In Papua New Guinea, the ${}_{45}q_{15}$ estimate using data from owners is biased upwards; in the other four countries, the estimates are lower than in the entire sample. Downwards bias in the probability of dying in adulthood was most pronounced in Burundi (0.80; 95% CI: 0.65–0.96), which is where MPO was the lowest.

In the remaining 19 countries, the ratio of $_{45}q_{15}$ is never greater than 1.1 or smaller than 0.9 and does not reach statistical significance.

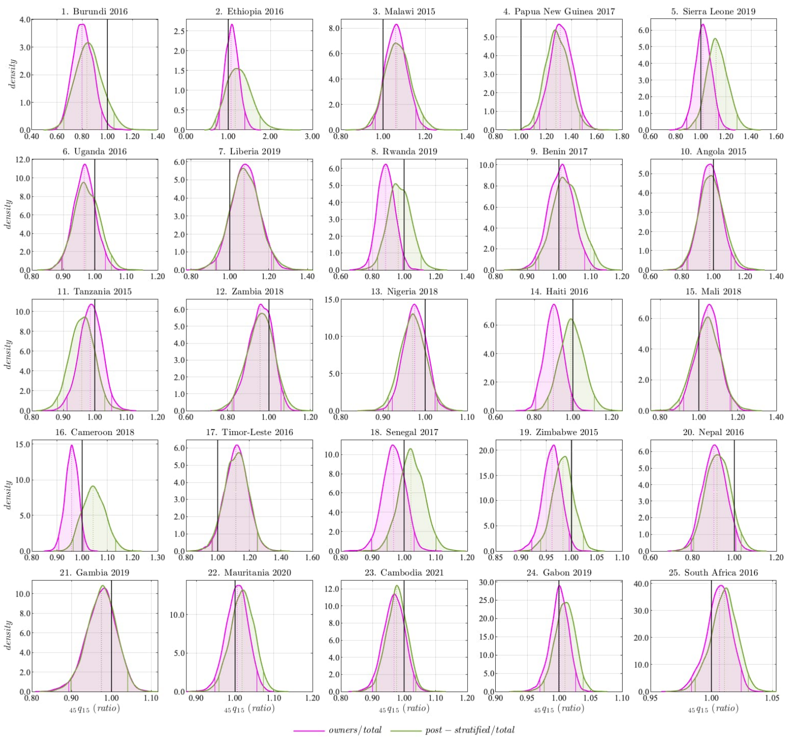
Figure 1: Age-specific mortality rates from SSH: All women of reproductive age versus mobile phone owners, by country (25 DHS)



Notes: This figure illustrates the age-specific mortality rates across 25 surveys, with the 95% CIs. It presents three distinct estimates: in blue, the age-specific mortality rates obtained from the total sample of female respondents; in pink, the age-specific mortality rates obtained from SSH reports of mobile phone owners, and in green the age-specific mortality rates obtained from reports of mobile phone owners after post-stratification weighting

The second observation from Figure 2 is that adult mortality estimates after post-stratification weighting are generally close to the unweighted estimates. However, in the four DHS where the estimates based on owners are biased downwards (Burundi, Rwanda, Haiti, Zimbabwe), post-stratification does lead to an upward adjustment that renders the difference insignificant. Even in these cases, the point-estimates are still well below the full population sample estimates. In four countries (Sierra Leone, Tanzania, Cameroon, Senegal), the ratio of ${}_{45}q_{15}$ after post-stratification weighting is further removed from 1 than the estimate before post-stratification weighting, but it is not statistically different from the total population estimate.

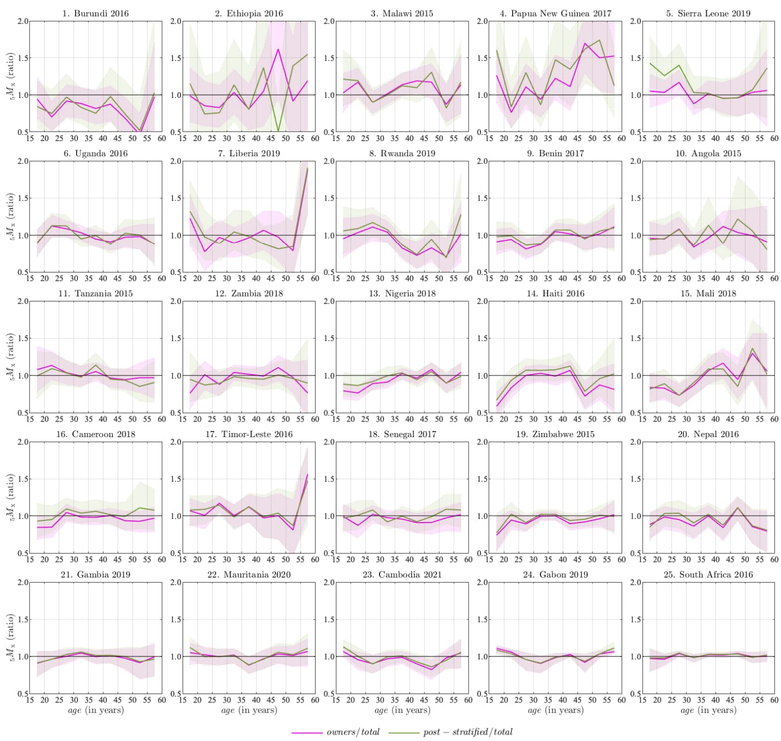
Figure 2: Ratio of ${}_{45}q_{15}$ derived from reports of mobile phone owners relative to the total sample: Before (pink) and after (green) post-stratification weighting, by country (25 DHS surveys)



Notes: This figure illustrates the bootstrap distributions of the ratio of ${}_{45}q_{15}$ derived from reports of MPOs relative to the total sample (with markers for the median and the 95% CI). The distributions in pink only make use of the DHS survey weights; the distributions in green also incorporate the post-stratification weights.

Figure 3 summarizes age-specific mortality rate ratios. Because countries are arranged by female MPO prevalence, this illustration shows that estimates tend to stabilize as MPO prevalence increases, as expected. In countries where MPO prevalence is lower the ratios are more erratic, and that is particularly the case below age 25 and above age 45. In some instances, post-stratification weighting produces a correction in the expected direction (e.g., Senegal and Zimbabwe), but in several other countries the correction induced by the post-stratification weights is erratic (e.g., Ethiopia and Sierra Leone). Uncertainty bounds around estimates are also higher at younger and older ages, which is related to the lower effective sample size for estimating mortality (i.e., number of person-years in siblings aged less than 25 or above age 45, as reported by respondents aged 15–49).

Figure 3: Ratio of age-specific mortality rates ($_nM_x$) among mobile phone owners relative to the total sample before and after post stratification, by country (25 DHS surveys)



Notes: This figure illustrates the ratio of $_nM_x$ derived from reports from owners relative to the total sample (median with bootstrap 95% CIs). The distributions in pink only make use of the DHS survey weights; the distributions in green also incorporate the post-stratification weights. Plots arranged by the level of women's MPO reported in the DHS (lowest in the top left corner to highest in the bottom right).

4. Discussion

Mobile phone surveys are increasingly considered as an alternative to classical face-to-face data collection in LMICs. They are particularly appealing in situations where timely data are needed and in-person data collection is restricted or considered too costly. However, MPO is unequally distributed and this may introduce sample selection bias (Sánchez-Páez et al. 2023). In this study we evaluated bias in adult mortality estimates from SSH by comparing estimates from a subsample of owners to a general population sample. To that end, we used data from 25 DHS in LMICs that included information on MPO and collected SSH.

In many of the countries included, MPO among women remains low, and in four the ownership prevalence was below 40%. The higher prevalence of MPO among men compared to women is pertinent for mortality measurement, given that most SSH are administered to women. Further, our results suggest a clear social gradient, with higher ownership rates among better-educated women living in smaller, wealthier, and urban households. These associations are often most pronounced in countries with relatively low mobile phone penetration rates.

Because the sociodemographic background characteristics that correlate with MPO are also predictors of mortality, the mortality estimates derived from a sample of owners could be biased. However, we do not find much support for that assertion in our results.

MPO-associated selection bias in summary indices of adult mortality (e.g., ${}_{45}q_{15}$) from SSH are generally modest, and exceeded 10% in only 5 out of the 25 countries that were included in this study. In one of these countries (Papua New Guinea), adult mortality was even higher in the data derived from the subsample of owners. In the countries where bias was statistically significant, this was usually alleviated – and no longer statistically significant – after post-stratification weighting using the sociodemographic attributes of the respondent. However, these corrections were small and fall short of recovering the point estimate for the general population sample. In some instances the weighting correction even deteriorated the estimates.

The assessment of MPO-associated selection bias in adult mortality estimates from SSH is therefore quite different from the one observed for under-5 mortality from birth histories (Sánchez-Páez et al. 2023). We hypothesize that this is due to the greater correlation between mother’s background characteristics and her children’s mortality risks compared to the association between the respondent’s attributes and the mortality risk of her adult siblings. This not only reduces selection bias, but also implies that corrections for this bias via post-stratification weighting on the respondent’s background characteristics will be less effective.

The age-disaggregated estimates further indicate that the largest differences between estimates from owners and the general population sample are observed at both ends of the age spectrum, where the statistical uncertainty is greatest and MPO is lower. Summary indices of adult mortality derived from mobile phone surveys will therefore be less prone to bias when restricted to mid-adulthood (e.g., $_{30}q_{20}$). This conclusion adds to the more general observation that SSH data for older adults are less reliable due to errors in the reporting of ages and ages at death (Helleringer et al. 2014).

To the best of our knowledge, this is the first study to investigate the potential selection bias in adult mortality estimates from SSH collected in a sample of mobile phone owners. Our study is limited in that MPO was used as a proxy for reaching people in a mobile phone survey, but this does not address other characteristics of mobile phone interviews with possible repercussions for data quality and the ensuing estimates. Non-response and reporting errors are common in face-to-face surveys, and they may be exacerbated in MPS (Helleringer et al. 2023).

In conclusion, our study demonstrates that sample selection bias in adult mortality estimates from SSH in a sample of owners is likely to be limited, and probably negligible in populations with high mobile phone penetration rates. Where bias exists, however, post-stratification weighting using the respondents' sociodemographic characteristics may be less effective. Our findings complement an earlier study on MPO-related selection bias in under-5 mortality and fertility estimates. Together, these emphasize that both sample selection bias and the utility of post-stratification weighting methods will depend on the specific demographic indicator that is being studied.

5. Acknowledgements

Ethics approval: This study is based on publicly available and anonymized secondary data sources only. The study protocol was reviewed by the Ethics Committee of the London School of Hygiene and Tropical Medicine (reference: 26393/RR/24486).
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Availability of data and materials: Code and instructions to reproduce the results are available from the MPselection GitHub repository (Ahmed and Romero-Prieto 2024).

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Annex: Numerical version of Figure 2

Table A-1: Ratio of $_{45}q_{15}$ (both sexes) derived from reports of mobile phone owners relative to the total sample, before and after post-stratification weighting, by country (25 DHS surveys)

Survey	45q15 per 1000			Observed (Owners/total)			Post-stratified (Owners/total)		
	median	95% CI		median	95% CI		median	95% CI	
Burundi 2016	260.09	238.13	282.79	**0.80**	**0.65**	**0.96**	0.82	0.65	1.03
Ethiopia 2016	184.27	157.81	214.95	1.07	0.79	1.39	1.20	0.75	1.75
Malawi 2015	325.36	302.69	349.92	1.06	0.96	1.16	1.04	0.93	1.16
Papua N Guinea 2017	190.26	166.14	216.21	**1.31**	**1.15**	**1.48**	**1.24**	**1.06**	**1.42**
Sierra Leone 2019	302.95	269.25	340.86	1.02	0.89	1.14	1.14	0.97	1.32
Uganda 2016	305.53	284.97	327.32	0.97	0.90	1.03	0.97	0.89	1.05
Liberia 2019	287.94	256.30	323.69	1.08	0.93	1.21	1.07	0.92	1.23
Rwanda 2019	163.26	145.78	182.33	**0.88**	**0.78**	**0.99**	0.98	0.84	1.13
Benin 2017	229.59	206.49	255.75	1.01	0.93	1.08	1.04	0.94	1.13
Angola 2015	255.06	217.22	292.99	0.97	0.84	1.11	0.99	0.84	1.16
Tanzania 2015	279.54	255.47	303.27	0.99	0.91	1.05	0.96	0.88	1.03
Zambia 2018	329.87	294.85	378.51	0.96	0.83	1.06	0.96	0.83	1.08
Nigeria 2018	229.19	213.01	245.71	0.98	0.92	1.02	0.97	0.91	1.03
Haiti 2016	277.30	249.35	307.83	**0.90**	**0.81**	**0.99**	1.00	0.88	1.12
Mali 2018	220.15	190.67	256.03	1.04	0.92	1.16	1.04	0.91	1.17
Cameroon 2018	287.33	262.35	314.98	0.96	0.91	1.01	1.03	0.95	1.13
Timor-Leste 2016	153.19	128.40	180.13	1.11	0.97	1.25	1.10	0.95	1.24
Senegal 2017	129.08	112.77	148.82	0.97	0.90	1.03	1.03	0.95	1.11
Zimbabwe 2015	418.58	391.36	446.29	**0.96**	**0.92**	**1.00**	0.99	0.94	1.03
Nepal	162.78	140.12	186.50	0.90	0.79	1.01	0.90	0.79	1.01
Gambia 2019	245.15	207.91	286.58	0.97	0.89	1.04	0.97	0.90	1.04
Mauritania 2020	154.52	137.98	171.86	1.01	0.95	1.06	1.02	0.96	1.08
Cambodia 2021	161.92	143.86	179.82	0.97	0.90	1.03	0.98	0.91	1.04
Gabon 2019	191.78	160.40	225.98	1.00	0.97	1.03	1.01	0.98	1.04
South Africa 2016	337.16	306.98	369.36	1.01	0.98	1.02	1.01	0.99	1.03