Call Me Maybe: An examination of noncoverage error in Mexican cell-phone surveys
Ilse Paniagua
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Abstract

This study examines non-coverage bias associated with using a cell-phone mode of data collection compared to a face-to-face interview. A random sample of 2010 census records for the Mexican states of Jalisco and Puebla are treated as the true population value, while households that indicated that at least one member of their household owned a cell-phone are used as a subset that could have been contacted using a cell-phone mode of data collection. The difference between census records and the cell-phone subset is calculated for 50 survey variables to estimate noncoverage bias. After using ratio-raking adjustments, five survey estimates still have an absolute bias that is greater than five percentage points: owning a refrigerator, owning a washing machine, owning a car or van, having drainage inside the household property, and having access to all three available public services (electricity, drainage, and piped water).

Introduction

Data collection in low and middle-income countries has typically been conducted using face-to-face interviews (FTF). Historically, this has been due to a lack of address-based frames for mail surveys, as well as lower ownership rates of landlines and cell-phones (Dabelen et al, 2016). To provide information for policymakers and analysts, a number of large-scale household surveys are conducted in almost all developing countries on a regular basis (Dabelen et al, 2016).

However, FTF data collections are costly and difficult to conduct in remote and conflict areas. Further, designing and implementing FTF surveys can often take months to deliver results to decision-makers and may fail to meet urgent data needs. Given the proliferation of cell-phones and growing network coverage in developing countries, cell-phone data collection has the potential to provide high-quality, high-frequency, and low-cost survey data on living conditions and perceptions of populations in developing countries (Schuster and Brito, 2011).

There are over 7 billion mobile cellular subscriptions worldwide (Sanou, 2015). Globally, mobile broadband penetration reached 47 percent in 2015, a 12 fold increase since 2007 (Sanou, 2015). In Mexico, the percentage of households that report at least one household member owning a cellphone jumped from 55 in 2005 to 83 percent in 2018 (Latinobarometro).

There is a growing literature that explores the possibility of leveraging cell-phones to collect data at random or from panels of respondents in developing countries. A 2011 World Bank experiment in Guatemala found that average interview costs decreased by 71 percent when switching from a FTF to a cell-phone survey (Schuster and Brito, 2011). A study of the feasibility of cell-phone surveys in four low-income countries (Afghanistan, Ethiopia, Mozambique, and Zimbabwe) found that cell-phone samples in countries with high mobile penetrations can closely resemble the demographics of the actual population after using ratio-raking weighting adjustments on sample data (Leo et al. 2015).

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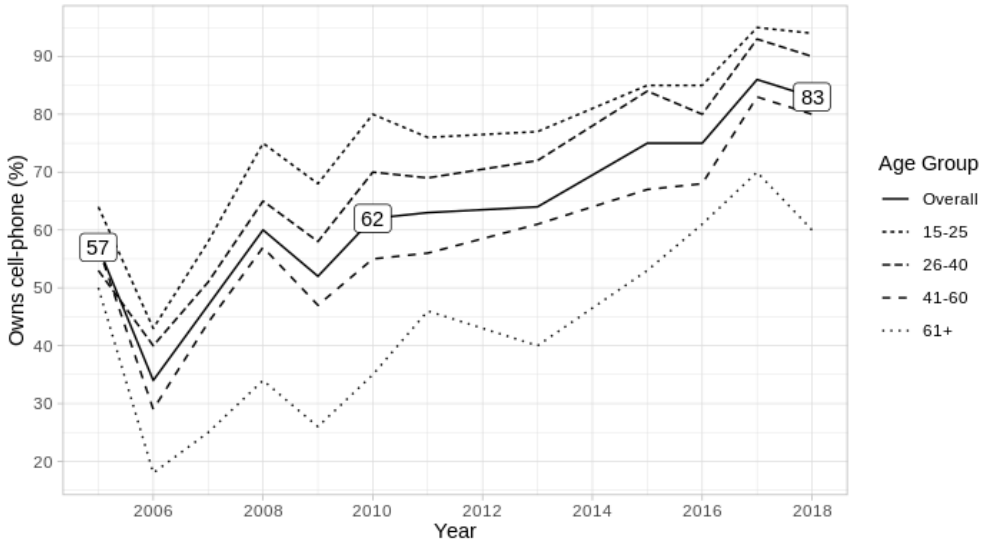
Studies comparing data quality from cell-phones and FTF interviews in developing countries have found mixed results. An experiment on high-frequency phone surveys for African microentreprises found that data patterns from weekly cell-phone surveys were comparable to monthly FTF interviews (Garlick et al. 2016). On the other hand, a 2015 World Bank experiment in Peru and Honduras found that Short Message Service (SMS) and Interactive Voice Recognition (IVR) modes were statistically different from answers to the same questions in FTF interviews (Ballivian et al, 2015).

Despite previous contributions to the issue of cost, measurement error, and coverage in select countries, there exist little to no studies that have quantified noncoverage bias associated with switching from a FTF to a cell-phone mode of data collection in Latin America. In other words, there is a gap in the literature that explores how groups of the population may be systematically excluded from a cell-phone survey, and how not having these units affects survey estimates. Studies of noncoverage bias in developed countries show that survey estimates may be biased if there is a strong correlation between households that have a telephone and the survey estimates of interest (Blumberg et al 2016; Lee et al. 2010; Link et al. 2007). Similar efforts in developing countries can help practitioners make informed decisions about the tradeoffs between cost and bias for various data collection methods.

This study attempts to fill this gap by examining noncoverage bias in Mexico. This country was chosen because it has a relatively high household cell-phone coverage rate (83 percent in 2018, according to the Latinobarometro), as well as publicly-available census microdata. Cell-phone ownership for the Latinobarometro and the Mexican census is defined as at least one household member owning a cell-phone. According to Latinobarometro survey results from 2005 to 2018, Mexican household cell-phone ownership is closely related to the household head's age (see Figure 1). A similar relationship between cell-phone ownership and age has been found in other countries.

Figure 1: Household cell-phone ownership 2005-2018, by age group



Source: Latinobarometro

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for households at the national level, according to the 2010 Census. Similarly, according to the 2010 census only about 20 percent of households have access to a refrigerator and 7 percent have access to the Internet at the national level, while this number is about 82 percent and about 21 percent in both Jalisco and Puebla, respectively. Therefore, inference from this analysis should be limited to these two states. Further generalizations to similar Mexican states should be done with caution.

The census has a variety of questions related to asset ownership, education, health insurance, indigenous status, and others. Because bias is determined for each survey estimate, this study is able to evaluate if some questions are more or less affected by the choice of mode.

Table 1 presents the fifty survey estimates that are analyzed in this study, grouped by estimate characteristics.

Table 1. Survey Estimates, by common characteristic

Characteristics	Measure	Analysis-Level	Estimate
Sex	Male	Individual	Proportion
Number of children	Number of live children born of women aged 18-130	Individual	Mean
Age	0 to 17; 18-29; 30-44; 45-64; 65 and up	Individual	Proportion
Education	Can read and write; currently attends school	Individual	Proportion
Highest Level of Education	Less than primary, primary, secondary, high school, more than high school	Individual	Proportion
Health insurance	IMSS*; ISSSTE**; private health insurance; no health insurance	Individual	Proportion
Indigenous Status	Speaks indigenous language	Individual	Proportion
Public Services	Access to electricity; access to piped water; access to drainage; access to all three	Household	Household
Age of household head	0 to 17; 18-29; 30-44; 45-64; 65 and up	Household	Proportion
Number of rooms	1 room; 2 rooms; 3 or more rooms	Household	Proportion
Number of bedrooms	1 bedroom; 2 bedrooms; 3 or more bedrooms	Household	Proportion
Asset Ownership	Toilet; radio; television; refrigerator; washing machine; car or van; computer; landline; cell-phone; Internet	Household	Proportion

*Calculated by this author
**Mexican Institute for Social Security (IMSS) health insurance

*** Mexican Civil Service Social Security and Services Institute (ISSSTE) health insurance

Table 2 presents the sample sizes available for Jalisco and Puebla. Standard errors for each household or individual estimate are computed according to the sample size available, respectively.

Table 2. Sample sizes, by state and type

State	Type		Sample Size
Jalisco	Population	Households	143,090
Jalisco	Population	Individuals	561,243
Jalisco	Cell-Phone Subset	Households	91,646
Jalisco	Cell-Phone Subset	Individuals	362,540
Puebla	Population	Households	143,090
Puebla	Population	Individuals	561,309
Puebla	Cell-Phone Subset	Households	91,631
Puebla	Cell-Phone Subset	Individuals	363,192

Analysis

Unweighted Estimates

I first calculate state-level population proportions and standard errors for each survey estimate for Jalisco and Puebla. Some estimates give information about the entire household, such as asset ownership and household structure materials. Other estimates are calculated for each member of the household, such as gender, education status, and healthcare coverage. Standard errors are provided to reflect the fact that not all census records for a given state are available in the public microdata.

Then, I calculate the same estimates only for households that have a cell-phone. These differences can be thought of as noncoverage bias that would have occurred if the survey would have been conducted via cell-phone rather than FTF (assuming that there are no systematic differences in response rate between groups). I provide the standard error of the difference between the “true” population value and the cell-phone subset using un-pooled variance. I conduct a Z-test to determine if the difference between the cell-phone subset and the census microdata is statistically significant.

Adjusted Estimates

The next portion of the analysis explores if noncoverage bias could potentially be reduced using an iterative proportional fitting algorithm, or ratio-raking weighting. Ratio raking weights the individual survey responses so that the marginal proportions of the sample match the population.

The effect of weighting is variable-specific, meaning that bias reduction depends on the relationship between the variables used for weighting and individual survey estimates.

I adjust the sample based on state-specific population distributions for education, age, household wealth, and speaking an indigenous language. Age, education, and socioeconomic status are included based on previous literature showing that younger, more educated, and wealthier respondents are more likely to own a cell-phone (Leo et al., 2015). Speaking an indigenous language, which can be thought of as a proxy for indigenous status, was incorporated based on large observed differences between the "true" population value and unweighted cell-phone subset estimates.

While age, education, and indigenous status are included in the census microdata, a direct measure of income is not available. To estimate a household's wealth, previous studies have created a wealth index utilizing a principal component analysis of household assets and consumption (Leo et al., 2015; Demographic Health Surveys). Principal component analysis involves replacing many correlated variables with a set of uncorrelated "principal components" that explain a large portion of the selected variables' variance. Rare assets with a high variance can be used as a proxy for higher wealth, whereas commonplace items with low variance would indicate a lower wealth status.

After taking the first principal component, the scores are ranked on a continuous scale and subdivided into five equal parts. It should be noted that under this technique, it is the first principal component and *not* the number of households that is divided into five equal parts. Therefore, the wealth index indicates which percentage of the population belongs to each wealth quintile. The five wealth quintiles add to 100 percent.

To create a wealth index for this study, I take the first principal component of the available household assets (toilet, radio, television, refrigerator, washing machine, car or van, computer, landline, cell-phone, Internet). I employ the variance covariance decomposition technique and a varimax rotation.

Raking variables include age category (0-17, 18-29, 30-44, 45 to 64, 65 and up), highest level of education (less than primary, primary, secondary, high school, more than high school), the household's wealth factor index, and speaking an indigenous language. I collapse the fourth and fifth wealth quintiles because fewer than 5 percent of the sample belonged to the fifth quintile, based on guidelines suggested by DeBell and Krosnick (2009).

For each state, I calculate survey weights using the anesrake package in R using the algorithm developed by DeBell and Krosnick (2009) for the American National Election Survey. The maximum value for weights was set at five. The raking algorithm for Jalisco converged after 34 iterations, while the algorithm for Puebla converged after 37 iterations. The design effect associated with the inclusion of ratio-raking weights is 1.131 for Jalisco and 1.134 for Puebla.

Results

Table 3 shows population, cell-phone estimates, unadjusted bias, adjusted cell-phone estimates, and adjusted bias for the 50 survey estimates of interest. Unadjusted bias is calculated by subtracting estimates from the cell-phone subset from the population census records. Adjusted bias subtracts the weighted cell-phone subset from the population census records. With the exception of birth rate, all presented estimates are percentages. Unadjusted and adjusted bias represent percentage point differences.

Fourteen out of the fifty survey estimates of interest had an unadjusted absolute bias greater than five percentage points, all of which are significant at the 0.01 level. After ratio-raking adjustments, only five survey estimates had an unadjusted absolute bias greater than five percentage points. Given the large sample sizes available in this study, many more estimates had bias levels below five percentage points that were statistically significant at the 0.05 and 0.01 levels. Variance increased about 13 percent in both states as a result of weighting adjustments.

Weighting was successful at eliminating bias primarily for the variables that were used for raking (age, education, wealth index, and speaking an indigenous language). Variables that had an absolute bias of greater or equal to five percentage points after weighting adjustments include owning a refrigerator, owning a washing machine, owning a car or van, having drainage inside the household property, and having all public services (electricity, drainage, and piped water).

However, in some cases bias *increased* as a result of weighting. The survey estimate of household ownership of having a car or van, which previously had an absolute bias of less than three percent, increased to over 7 and 8 percent after weighting adjustments in Jalisco and Puebla, respectively. This demonstrates the unintended consequences of applying survey weights when a particular survey estimate is weakly correlated with the variables used for adjustment.

Table 3. Unadjusted and Adjusted Bias for Survey Estimates

Measure	Population Estimate, % (SE)		Cell-Phone Estimate, % (SE)		Unadjusted Bias, (SE)		Cell-Phone Adjusted Estimate, % (SE)		Adjusted Bias, (SE)	
	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla
Male	48.83 (0.07)	48.72 (0.07)	48.65 (0.08)	48.54 (0.08)	-0.18 (0.21)	-0.19 (0.21)	48.34 (0.09)	48.49 (0.09)	-0.48 (0.21) **	-0.23 (0.21)
Number of children	2.34 (0.01)	2.33 (0.01)	2.03 (0.01)	2.02 (0.01)	-0.31 (0.01) ***	-0.31 (0.01) ***	2.22 (0.01)	2.21 (0.01)	-0.12 (0.01) ***	-0.12 (0.01) ***
Age										
0-17	35.46 (0.06)	35.4 (0.06)	34.82 (0.08)	34.8 (0.08)	-0.64 (0.2) ***	-0.6 (0.2) ***	35.46 (0.08)	35.4 (0.08)	0 (0.2)	0 (0.2)
18-29	20.68 (0.05)	20.7 (0.05)	21.75 (0.07)	21.84 (0.07)	1.07 (0.17) ***	1.14 (0.17) ***	20.68 (0.07)	20.7 (0.07)	0 (0.17)	0 (0.17)
30-44	21.41 (0.06)	21.37 (0.06)	23.02 (0.07)	22.99 (0.07)	1.61 (0.18) ***	1.63 (0.18) ***	21.41 (0.07)	21.37 (0.07)	0 (0.17)	0 (0.17)
45-64	16.21 (0.05)	16.23 (0.05)	16.18 (0.06)	16.08 (0.06)	-0.03 (0.16)	-0.14 (0.16)	16.21 (0.06)	16.23 (0.06)	0 (0.16)	0 (0.16)
65+	6.24 (0.03)	6.3 (0.03)	4.23 (0.03)	4.28 (0.03)	-2.01 (0.1) ***	-2.02 (0.1) ***	6.24 (0.04)	6.3 (0.04)	0 (0.1)	0 (0.1)
Age of Household Head										
0-17	0.12 (0)	0.1 (0)	0.11 (0.01)	0.1 (0.01)	-0.01 (0.01)	-0.01 (0.01)	0.12 (0.01)	0.1 (0.01)	0 (0.01)	0 (0.01)
18-29	10.9 (0.04)	10.92 (0.04)	11.05 (0.05)	11.1 (0.05)	0.16 (0.13)	0.18 (0.13) *	10.97 (0.05)	10.55 (0.05)	0.08 (0.13)	-0.37 (0.13) ***
30-44	38.85 (0.07)	38.69 (0.07)	41.41 (0.08)	41.29 (0.08)	2.56 (0.21)	2.6 (0.21)	41.27 (0.08)	41.44 (0.08)	2.42 (0.21)	2.75 (0.21)

Measure	Population Estimate, % (SE)		Cell-Phone Estimate, % (SE)		Unadjusted Bias, (SE)		Cell-Phone Adjusted Estimate, % (SE)		Adjusted Bias, (SE)	
	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla
					***	***			***	***
45-64	37.26 (0.06)	37.33 (0.07)	37.88 (0.08)	37.77 (0.08)	0.61 (0.2)	0.45 (0.2)	36.85 (0.08)	36.82 (0.08)	-0.41 (0.2)	-0.5 (0.2)
					***	**			**	***
65+	12.88 (0.05)	12.96 (0.05)	9.55 (0.05)	9.74 (0.05)	-3.32 (0.14)	-3.22 (0.14)	10.79 (0.05)	11.08 (0.05)	-2.09 (0.14)	-1.88 (0.14)
					***	***			***	***
Number of rooms										
One	5.84 (0.03)	5.78 (0.03)	4.21 (0.03)	4.07 (0.03)	-1.63 (0.09)	-1.71 (0.09)	4.89 (0.04)	4.52 (0.04)	-0.95 (0.1)	-1.26 (0.09)
					***	***			***	***
Two	15.52 (0.05)	15.73 (0.05)	11.46 (0.05)	11.81 (0.05)	-4.06 (0.15)	-3.93 (0.15)	12.92 (0.06)	13.03 (0.06)	-2.6 (0.15)	-2.71 (0.15)
					***	***			***	***
Three or more	78.64 (0.06)	78.49 (0.06)	84.33 (0.06)	84.12 (0.06)	5.68 (0.17)	5.64 (0.17)	82.19 (0.07)	82.46 (0.07)	3.55 (0.17)	3.97 (0.17)
					***	***			***	***
Number of bedrooms										
One	27.55 (0.06)	27.77 (0.06)	22 (0.07)	22.17 (0.07)	-5.54 (0.18)	-5.59 (0.18)	23.69 (0.07)	23.52 (0.07)	-3.85 (0.19)	-4.25 (0.19)
					***	***			***	**
Two	40.86 (0.07)	40.64 (0.07)	41.7 (0.08)	41.5 (0.08)	0.84 (0.21)	0.86 (0.21)	42.3 (0.09)	42.06 (0.09)	1.44 (0.21)	1.42 (0.21)
					***	***			***	***
Three or more	31.59 (0.06)	31.59 (0.06)	36.3 (0.08)	36.33 (0.08)	4.71 (0.2)	4.74 (0.2)	34 (0.08)	34.43 (0.08)	2.41 (0.2)	2.83 (0.2)
					***	***			***	***
Education										
Can read and write	90.56 (0.04)	90.49 (0.04)	94.21 (0.04)	94.2 (0.04)	3.65 (0.11)	3.71 (0.12)	90.19 (0.05)	92.24 (0.05)	-0.36 (0.12)	1.75 (0.12)
					***	***			***	***
Is student	30.86 (0.06)	30.79 (0.06)	32.24 (0.08)	32.04 (0.08)	1.39 (0.2)	1.25 (0.2)	31.96 (0.08)	34.17 (0.08)	1.1 (0.2)	3.38 (0.2)

Measure	Population Estimate, % (SE)		Cell-Phone Estimate, % (SE)		Unadjusted Bias, (SE)		Cell-Phone Adjusted Estimate, % (SE)		Adjusted Bias, (SE)	
	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla
					***	***			***	***
Highest Level: Less than primary	14.29 (0.05)	14.37 (0.05)	11.34 (0.05)	11.39 (0.05)	-2.96 (0.14) ***	-2.98 (0.14) ***	14.29 (0.07)	14.4 (0.06)	0 (0.16)	0.03 (0.15)
Highest Level: Primary	35.59 (0.07)	35.43 (0.07)	30.48 (0.08)	30.35 (0.08)	-5.11 (0.2) ***	-5.08 (0.2) ***	35.59 (0.08)	35.51 (0.08)	0 (0.2)	0.07 (0.2)
Highest Level: Secondary	24.71 (0.06)	24.85 (0.06)	25.9 (0.08)	26.1 (0.08)	1.19 (0.18) ***	1.25 (0.18) ***	24.71 (0.07)	24.9 (0.07)	0 (0.18)	0.05 (0.18)
Highest Level: High school	14.31 (0.05)	14.18 (0.05)	17.21 (0.06)	17.09 (0.06)	2.91 (0.15) ***	2.92 (0.15) ***	14.30 (0.06)	14 (0.06)	-0.62 (0.15)	-0.18 (0.15)
Highest Level: More than high school	11.1 (0.04)	11.16 (0.04)	15.07 (0.06)	15.06 (0.06)	3.97 (0.14) ***	3.9 (0.14) ***	11.09 (0.05)	11.19 (0.05)	-0.67 (0.13)	0.02 (0.13)
Health Insurance										
IMSS	31.55 (0.06)	31.57 (0.06)	38.54 (0.08)	38.59 (0.08)	6.99 (0.2) ***	7.02 (0.2) ***	36.48 (0.08)	36.84 (0.08)	4.93 (0.2) ***	5.27 (0.2) ***
ISSTE	0.75 (0.01)	0.77 (0.01)	0.97 (0.02)	1.01 (0.02)	0.21 (0.04) ***	0.24 (0.04) ***	0.85 (0.02)	0.91 (0.02)	0.1 (0.04) ***	0.14 (0.04) ***
Private insurance	23.31 (0.06)	23.55 (0.06)	17.66 (0.06)	18.05 (0.06)	-5.65 (0.17) ***	-5.5 (0.17) ***	19.86 (0.07)	19.98 (0.07)	-3.45 (0.18) ***	-3.57 (0.18) ***
No insurance	33.89 (0.06)	33.65 (0.06)	31.12 (0.08)	30.68 (0.08)	-2.77 (0.2) ***	-2.97 (0.2) ***	32.65 (0.08)	31.8 (0.08)	-1.24 (0.2) ***	-1.85 (0.2) ***
Asset Ownership										
Radio	80.52	80.47	86.04	86.03	5.53	5.56	84.93	85.11	4.41	4.65

Measure	Population Estimate, % (SE)		Cell-Phone Estimate, % (SE)		Unadjusted Bias, (SE)		Cell-Phone Adjusted Estimate, % (SE)		Adjusted Bias, (SE)	
	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla
	(0.05)	(0.05)	(0.06)	(0.06)	(0.16) ***	(0.16) ***	(0.06)	(0.06)	(0.16) ***	(0.16) ***
Television	93.72 (0.03)	93.66 (0.03)	98.36 (0.02)	98.37 (0.02)	4.64 (0.09) ***	4.71 (0.09) ***	97.69 (0.03)	97.84 (0.03)	3.97 (0.09) ***	4.18 (0.09) ***
Refrigerator	82.87 (0.05)	82.61 (0.05)	91.9 (0.05)	91.73 (0.05)	9.03 (0.15) ***	9.13 (0.15) ***	89.88 (0.05)	90 (0.05)	7.02 (0.15) ***	7.39 (0.15) ***
Washing Machine	68.32 (0.06)	68.21 (0.06)	80.12 (0.07)	79.92 (0.07)	11.8 (0.19) ***	11.71 (0.19) ***	76.64 (0.07)	76.95 (0.07)	8.32 (0.19) ***	8.74 (0.19) ***
Car or Van	61.03 (0.17)	60.6 (0.16)	58.26 (0.1)	58.31 (0.1)	-2.77 (0.21) ***	-2.29 (0.21) ***	52.56 (0.09)	53.17 (0.1)	-8.47 (0.21) ***	-7.43 (0.21) ***
Computer	29.79 (0.06)	29.66 (0.06)	41.49 (0.08)	41.34 (0.08)	11.7 (0.2) ***	11.68 (0.2) ***	34.31 (0.08)	34.45 (0.08)	4.53 (0.2) ***	4.79 (0.2) ***
Landline	43.5 (0.07)	43.45 (0.07)	49.46 (0.08)	49.4 (0.08)	5.95 (0.21) ***	5.95 (0.21) ***	43.03 (0.09)	43.52 (0.09)	-0.47 (0.21) **	0.08 (0.21)
Toilet	95.85 (0.03)	95.77 (0.03)	98.38 (0.02)	98.3 (0.02)	2.53 (0.07) ***	2.53 (0.07) ***	97.93 (0.02)	97.87 (0.02)	2.08 (0.08) ***	2.1 (0.08) ***
Internet	21.34 (0.06)	21.39 (0.06)	30.35 (0.08)	30.45 (0.08)	9.01 (0.18) ***	9.06 (0.18) ***	21.62 (0.07)	21.69 (0.07)	0.28 (0.17) *	0.3 (0.17) *
Wealth Index										
Quintile 1	62.2 (0.07)	62.2 (0.07)	55.72 (0.08)	55.83 (0.08)	-6.48 (0.21)	-6.37 (0.21)	62.2 (0.08)	62.2 (0.08)	0 (0.21)	0 (0.21)

Measure	Population Estimate, % (SE)		Cell-Phone Estimate, % (SE)		Unadjusted Bias, (SE)		Cell-Phone Adjusted Estimate, % (SE)		Adjusted Bias, (SE)	
	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla
					***	***				
Quintile 2	15.97 (0.05)	15.92 (0.05)	13.51 (0.06)	13.34 (0.06)	-2.45 (0.15) ***	-2.58 (0.15) ***	15.97 (0.06)	15.92 (0.06)	0 (0.15)	0 (0.15)
Quintile 3	2.43 (0.02)	2.39 (0.02)	3.1 (0.03)	3.03 (0.03)	0.66 (0.07) ***	0.64 (0.07) ***	2.43 (0.03)	2.39 (0.03)	0 (0.07)	0 (0.06)
Quintile 4	19.34 (0.05)	19.42 (0.05)	27.59 (0.07)	27.72 (0.07)	8.25 (0.18) ***	8.3 (0.18) ***	19.34 (0.07)	19.43 (0.07)	0.01 (0.17)	0.01 (0.17)
Quintile 5	0.06 (0)	0.06 (0)	0.08 (0)	0.08 (0)	0.02 (0.01) *	0.02 (0.01) *	0.05 (0)	0.05 (0)	-0.01 (0.01)	-0.01 (0.01)
Type of Flooring										
Dirt floors	6.64 (0.03)	6.6 (0.03)	3.22 (0.03)	3.2 (0.03)	-3.42 (0.09) ***	-3.4 (0.09) ***	4.05 (0.03)	3.85 (0.03)	-2.59 (0.1) ***	-2.75 (0.1) ***
Non-dirt floors	91.54 (0.04)	91.65 (0.04)	96.43 (0.03)	96.46 (0.03)	4.88 (0.1) ***	4.82 (0.1) ***	95.63 (0.04)	95.85 (0.03)	4.09 (0.11) ***	4.2 (0.11) ***
Public Services										
Has electricity	98.29 (0.02)	98.19 (0.02)	99.51 (0.01)	99.5 (0.01)	1.22 (0.05) ***	1.31 (0.05) ***	99.47 (0.01)	99.48 (0.01)	1.18 (0.05) ***	1.29 (0.05) ***
Has drainage	88.38 (0.04)	88.41 (0.04)	95.69 (0.03)	95.56 (0.03)	7.31 (0.12) ***	7.15 (0.12) ***	94.34 (0.04)	94.4 (0.04)	5.96 (0.12) ***	5.99 (0.12) ***
Has piped water	86.34 (0.05)	86.39 (0.05)	92.36 (0.04)	92.32 (0.04)	6.02 (0.13) ***	5.92 (0.13) ***	91.04 (0.05)	91.28 (0.05)	4.7 (0.14) ***	4.89 (0.14) ***
Has electricity,	80.36 (0.05)	80.35 (0.05)	89.51 (0.05)	89.39 (0.05)	9.15 (0.16)	9.04 (0.16)	87.39 (0.06)	87.63 (0.06)	7.03 (0.16)	7.28 (0.16)

Measure	Population Estimate, % (SE)		Cell-Phone Estimate, % (SE)		Unadjusted Bias, (SE)		Cell-Phone Adjusted Estimate, % (SE)		Adjusted Bias, (SE)	
	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla	Jalisco	Puebla
drainage, and piped water					***	***			***	***
Indigenous Status										
Speaks indigenous language	6.71 (0.03)	6.64 (0.03)	2.58 (0.03)	2.55 (0.03)	-4.13 (0.09) ***	-4.09 (0.09) ***	6.71 (0.04)	6.64 (0.04)	0 (0.11)	0 (0.11)

Note: Significance stars have been added at the 0.10 (*), 0.05 (**), and 0.01 (***) alpha levels.

Discussion

Consistent with previous literature, households with a cell-phone are younger, more educated, and have fewer children. Cell-phone ownership is also tied to socioeconomic status, with a higher proportion of the population in wealth quintiles three to five. Households with a cell-phone are also more likely to have a landline, a computer, and an Internet connection.

It is not clear why weighting was not successful at sufficiently reducing bias for owning a refrigerator, owning a washing machine, owning a car or van, having drainage inside the household property, and having all public services (electricity, drainage, and piped water). While adjusted bias remained above five percent for these variables, bias levels decreased by two to three percentage points from unadjusted bias (with the exception of owning a car or van, which had an increase in bias after weighting). Therefore, there is evidence that important differences remain between population estimates and households with a cell-phone after weighting adjustments.

A limitation of this study is the limited geographic constraint to two Mexican states and that, at the time of this writing, the data used for analysis is 10 years old. In 2010, between 60 to 65 percent of Mexican households had at least one member that owned a cell-phone. In 2018, this number was over 80 percent, according to the Latinobarometer. Future studies can replicate these methods using 2020 Census microdata to provide an updated analysis of noncoverage error associated with cell-phone surveys.

References

Ballivian, Amparo, Joâo Pedro Azevedo, William Durbin, Jesus Rios, Johanna Godoy, Christina Borisova, and Sabine Mireille Ntsama. 2013. “Listening to LAC: Using Mobile Phones for High Frequency Data Collection.” Final report (February), WorldBank, Washington,DC.

Dabalen. Mobile Phone Panel Surveys in Developing Countries: A Practical Guide for Microdata Collection. Unspecified, 2016.

DeBell, M. and J.A. Krosnick. (2009). Computing Weights for American National Election Study Survey Data, ANES Technical Report Series, No. nes012427. Available from: ftp://ftp.electionstudies.org/ftp/nes/bibliography/documents/nes012427.pdf

Garlick, Rob, Kate Orkin, and Simon Quinn. 2015. “Call Me Maybe: Experimental Evidence on Using Mobile Phones to Survey African Microenterprises.” Working paper, Centre for Economic Policy Research and U.K. Department for International Development, London.

Latinobarometer: Mexico 1995-2018 [dataset]. Latinobarometer Corporation [producer], Santiago, Chile. Accessed January 30, 2020

Leo, Ben, et al. “Do Mobile Phone Surveys Work in Poor Countries? - Working Paper 398.” *Center For Global Development*, 7 Apr. 2015, www.cgdev.org/publication/do-mobile-phone-surveys-work-poor-countries-working-paper-398.

Lee, S., Brick, J.M., Brown, E.R. and Grant, D. (2010), Growing Cell□Phone Population and Noncoverage Bias in Traditional Random Digit Dial Telephone Health Surveys. Health Services Research, 45: 1121-1139. doi:10.1111/j.1475-6773.2010.01120.x

Lynn, Peter, and Olena Kaminska. 2013. “The Impact of Mobile Phones on Survey Measurement Error.” Public Opinion Quarterly 77 (2): 586–605.

Michael W. Link, Michael P. Battaglia, Martin R. Frankel, Larry Osborn, Ali H. Mokdad, Reaching the U.S. Cell Phone Generation: Comparison of Cell Phone Survey Results with an Ongoing Landline Telephone Survey, *Public Opinion Quarterly*, Volume 71, Issue 5, 2007, Pages 814–839, https://doi.org/10.1093/poq/nfm051

Sanou. ICT Facts and Figures: The World in 2015, 2015, www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf.

Stephen J. Blumberg, Julian V. Luke, Marcie L. Cynamon, “Telephone Coverage and Health Survey Estimates: Evaluating the Need for Concern About Wireless Substitution”, American Journal of Public Health 96, no. 5 (May 1, 2006): pp. 926-931.

Schuster, Christian, and Carlos Perez Brito. *Cutting Costs, Boosting Quality and Collecting Data Real-Time –Lessons from a Cell Phone-Based Beneficiary Survey to Strengthen Guatemala’s Conditional Cash Transfer Program*, Feb. 2011, siteresources.worldbank.org/INTLAC/Resources/257803-1269390034020/EnBreve_166_Web.pdf.

Stephen J. Blumberg, Julian V. Luke, “Reevaluating the Need for Concern Regarding Noncoverage Bias in Landline Surveys”, American Journal of Public Health 99, no. 10 (October 1, 2009): pp. 1806-1810.

The DHS Program - Wealth-Index-Construction, www.dhsprogram.com/topics/wealth-index/Wealth-Index-Construction.cfm.