

Recent Trends in Coverage of the Mexican-Born Population of the United States: Results From Applying Multiple Methods Across Time

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Abstract The accuracy of counts of U.S. racial/ethnic and immigrant groups depends on the coverage of the foreign-born in official data. Because Mexicans constitute by far the largest single national-origin group among the foreign-born in the United States, we compile new evidence about the coverage of the Mexican-born population in the 2000 census and 2001–2010 American Community Survey (ACS) using three techniques: a death registration, a birth registration, and a net migration method. For the late 1990s and first half of the 2000–2010 decade, results indicate that coverage error was somewhat higher than currently assumed but had substantially declined by the latter half of the 2000–2010 decade. Additionally, we find evidence that U.S. census and ACS data miss substantial numbers of children of Mexican immigrants, as well as people who are most likely to be unauthorized: namely, working-aged Mexican immigrants (ages 15–64), especially males. The findings highlight the heterogeneity of the Mexican foreign-born population and the ways in which migration dynamics may affect population coverage.

Keywords Enumeration error · Coverage error · Mexican foreign-born

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Introduction

Governmental agencies often rely on official U.S. statistics regarding the sizes of racial and ethnic groups to administer public policies (Anderson and Fienberg 1999). Because knowing how thoroughly these kinds of groups are covered in censuses and surveys is crucial, this article develops estimates of coverage error for one especially important group: the U.S. Mexican-born population. We focus on the Mexican-born population because no other single origin group so dominates U.S. immigration, with Mexicans now accounting for 32.1 % of all U.S. immigrant newcomers since 1990 (21.4 % of new legal permanent residents (LPRs) and 58.0 % of unauthorized immigrants) (Passel et al. 2012; U.S. Department of Homeland Security 2012). As a result, the 12 million Mexican-born persons estimated to be living in the United States by 2010 constituted 29.3 % of the entire U.S. foreign-born population, as well as 10 % of all Mexicans living either in Mexico or anywhere else in the world (Instituto Nacional de Estadística Geografía e Informática (INEGI) 2013). No other nation has so overwhelmed decadal migration in-flows since Ireland was responsible for 41.9 % of new arrivals from 1830 to 1850 (U.S. Department of Homeland Security 2012). Mexicans also constitute a substantial majority of unauthorized immigrants in the United States (Passel et al. 2012). Owing to their marginality, this group carries more potential than any other for *not* being covered in official data.

Coverage error is the difference between the number of people expected to be enumerated for a designated geographic unit or group and the number actually enumerated in the census or represented in the survey. Broadly defined, such error arises when people are missed by the census or survey, people are counted more than once, population survey weights are incorrect, or people are counted but misclassified (e.g., when the foreign-born are erroneously recorded as U.S.-born). In evaluating coverage for the 2010 census, the Census Bureau used two approaches to gauge the expected size of the U.S. population. One involved demographic analysis, an historical accounting technique that in 2010 combined data on Medicare enrollments for the population aged 65 and older and data on births, deaths, and estimates of net international migration for the population aged 0–64 to estimate the expected population (Devine et al. 2012). The other approach involved dual-system estimation, which uses information from independent post-enumeration surveys and statistical models to calculate the expected population (Mule 2012). Coverage rates can be expressed in relative terms as the percentage enumerated of the expected total. When the expected and the enumerated totals are the same, as was the case with the results from demographic analysis in 2010 (Mule 2012), the figure can be 100.0 %. When an enumerated total falls below the expected number, the coverage rate subtracted from 100 is sometimes called the “net undercount” rate.

Although political controversies concerning adjusting population totals for coverage error have receded since the mid-1990s, coverage error in censuses and surveys remains an essential element in estimating the size of certain subgroups, especially residual estimates of foreign-born unauthorized migrants (Carriquiry and Majmundar 2013; Hanson 2006; Hill 1985; Judson and Swanson 2011; Van Hook and Bean 1998a). Importantly, we do *not* seek to estimate the coverage of *unauthorized* Mexican migrants. Instead, we concentrate on the entire Mexican-born population of the United States. The reason is simply that unauthorized migrants are not identified in

any of the data sources necessary for residual estimation, including the census, the American Community Survey (ACS), the Current Population Survey (CPS), and vital statistics data. As a consequence, prior efforts to assess unauthorized undercount have been plagued by reliance on different and often local data sources. Hanson (2006:867) noted the following about estimates up to the early 2000s: “Since different authors [often] use different post-enumeration surveys as the basis for selecting undercount rates, there is little consensus in the literature about what has happened to undercount rates over time, other than [their] exhibiting a downward trend.”

The approach taken here is to estimate the undercount of the entire Mexican-born population and its recent changes using multiple methods applied to several official data sources collected in both the United States and Mexico across five-year intervals since 1995. At the end of this article, we include a discussion of the implications of the research findings for unauthorized undercount rates among Mexicans. Overall, Mexican-born coverage may have shifted over the past 15 years for several reasons. The economic and public policy conditions driving migration to the United States have fluctuated considerably over this period. Examples include the economic booms of the late 1990s and mid-2000s that brought unprecedented increases in the numbers of unauthorized Mexican migrants coming to the country. Also, the out-sized economic downturn starting in late 2007 (the Great Recession) coincided with the virtual cessation of net migration from Mexico (Holzer and Hlavac [forthcoming](#); Passel and Cohn 2009), and increased legislative and enforcement initiatives—some designed to foster “self-deportation”—may have encouraged some to return to Mexico or to move “underground” (Lofstrom et al. 2011; National Research Council 2011). Next to nothing, however, is known about the implications of these changes for coverage error of the Mexican-born.

Past Research

Higher rates of coverage error may typify the U.S. Mexican-born population compared with others. Roughly one-half are unauthorized, and they are disproportionately characterized by high residential mobility as well as complex family and living arrangements (Boehm 2012; Glick 2010; Glick et al. 1997), illicit entry and fear of detection (Chavez 2012; Hernández-León 2008; Massey and Sanchez 2010; Spener 2009), and sociopolitical and socioeconomic marginality (Bean et al. 2011, [forthcoming](#)). The group is thus less likely to be included in censuses or surveys (Judson and Swanson 2011; Swanson et al. 2004). Most research, however, has concentrated on unauthorized undercount. Owing to space constraints, we highlight here only a few general results from this research, looking at data from the 1980s, 1990s, and more recently to gain perspective on apparent trend-line levels. Because no studies during this period examine the Mexican-born per se, we roughly extrapolate from the results of these studies the minimum coverage error levels they imply about Mexican-born persons.

Studies from the 1980s implied rates of undercount for unauthorized Mexicans of approximately 50 % (Heer and Passel 1987; Muller and Espenshade 1985; Passel 1985; Passel and Robinson 1988). Other evidence has implied a slightly lower range of estimates, falling roughly between 30 % and 40 %, although occasionally as high as 45 % (Bean et al. 1983; Borjas et al. 1991; Passel 1985; Passel and Robinson 1988).

Given that about 45 % of the Mexican-born population was unauthorized in 1980 (1.13 unauthorized of 2.53 million Mexican-born; Van Hook and Bean 1998a), these estimates imply a minimum range of 16 % to 23 % undercount for the entire Mexican-born population in 1980.¹ In the case of the 1990 census, several studies based on a variety of methods found that the rate of undercount for the unauthorized immigrant population was somewhat lower than in 1980, falling to the range of 15 % to 30 % (Corona Vazquez 1991; de la Puente 1992; U.S. General Accounting Office 1993). Van Hook and Bean (1998b), in work commissioned for the Mexico/U.S. Binational Migration Study, used a death registration method, which suggested that the rate of undercount for the unauthorized population probably fell within the range of 15 % to 25 % and likely was no higher than 35 %. Given that about 31 % of the Mexican-born population was unauthorized in 1990 (2.1 million unauthorized out of 6.7 million Mexican-born) (Van Hook and Bean 1998a), these estimates suggest a minimum range of about 7 % to 14 % coverage error for the entire Mexican-born population in 1990—values somewhat lower than those circa 1980.

In the case of the 2000 census and the ACSs conducted during the 2000s, the U.S. Census Bureau and others have conducted analyses of coverage error for major racial and ethnic groups (Devine et al. 2012; Mule 2012); the results for Hispanics imply that Mexicans are likely to have a higher undercount rate than other groups (see also Chen et al. 2010; Elliott and Little 2005). However, only two studies to our knowledge have explicitly evaluated national-level coverage error among *Mexican-born* persons for this time period. One study conducted by Hill and Wong (2005), using a similar approach as Corona Vazquez (1991) and the U.S. General Accounting Office (1993) (i.e., the net migration method), yielded estimates implying that Mexican-born undercount in the 2000 U.S. census data was probably higher than zero but perhaps no higher than 20 %. In another study, Genoni et al. (2012) used Mexican data and compared the number of Mexicans who migrated to the United States between 2002 and 2005 with the corresponding number in the ACS; they found coverage error rates of about 30 %.

The present research makes three contributions to the coverage literature. First, we produce estimates of coverage error among the Mexican-born based on analyses of data for three time intervals: 1995 to 2000, 2000 to 2005, and 2005 to 2010. We thus extend prior estimates into the 2000 decade. This is crucial given that the two previous national-level empirical assessments of coverage error for the Mexican-born have examined migration within a single time interval. As mentioned earlier, much has changed during the 2000–2010 decade that could have altered the coverage of this population. Second, we use three methods to estimate coverage error in the Mexican-born population: (1) a death registration method, (2) a birth registration method, and (3) a net migration method. Each uses different data and has unique strengths and weaknesses. Using multiple methods provides a certain measure of cross-validation for the results obtained. Third, our approach entails the possibility of drawing inferences about relative levels of coverage error among unauthorized Mexican immigrants, given that coverage error of unauthorized immigrants is likely to be higher than both

¹ In general, coverage error, r , is a function of the size and coverage error of its subgroups: $r = 1 - \{1/[p_1 / (1 - r_1) + p_2 / (1 - r_2)]\}$, where p_1 and p_2 are the proportions, and r_1 and r_2 are coverage error rates for subgroups 1 and 2. If coverage error is 0 % among legally resident Mexicans and 30 % among the unauthorized, and 45 % are unauthorized, then the minimum coverage error for all Mexican-born = $.16 = 1 - \{1 / [.45 / (1 - .30) + .55]\}$.

authorized immigrants and Hispanics as a whole—for whom the coverage error rate in the 2010 census was estimated at 1.5 % (Mule 2012). We return to this issue in the conclusion.

Methodology

Each of the three methods for assessing coverage error estimates an expected value of the size of the Mexican-born population based on non-U.S. census data sources, $E[P]$, and compares this quantity with the population either enumerated in the census or estimated in the ACS, P . Coverage error, r , is then estimated as a percentage difference of the two: $r = (E[P] - P) / E[P] \times 100$. Because there is often uncertainty about the value of $E[P]$, we estimate a plausible range of values for $E[P]$ that correspond with a plausible range of assumptions about its key inputs. This allows us to assess whether the difference between $E[P]$ and P is larger than could be explained by plausible alternative assumptions.

The *death registration method* uses the number of Mexican immigrant deaths observed in U.S. vital statistics and age-specific death rates for the Mexican-born to estimate how large the population must be for it to generate the observed number of deaths, $E[P]$. Originally described by Bogue (1950), the death registration method has been used in the past to evaluate the number of unauthorized immigrants (Robinson 1980) and coverage error of the foreign-born (Borjas et al. 1991; Van Hook and Bean 1998b), but to our knowledge this method has not yet been applied to 2000 census or ACS data.

Estimation

Age-specific death rates for the Mexican-born (${}_nM_x$) are calculated by dividing the number of deaths (${}_nD_x$) by the population at risk. If age-specific death rates are known from an independent data source or borrowed from another population, then it is possible (as we do here) to rearrange the terms and estimate the *expected* population based on the number of deaths for the Mexican-born:

$$E[{}_nP_x] = {}_nD_x / {}_nM_x.$$

Coverage error for the Mexican-born population is then estimated as:

$${}_nr_x = (E[{}_nP_x] - {}_nP_x) / E[{}_nP_x],$$

where ${}_nP_x$ is the enumerated population aged x to $x + n$.

We describe our data sources in Table 1. Of note, we selected the 2007 mortality rates for Hispanics produced by Arias (2010) for ${}_nM_x$. We considered other sources, such as mortality rates estimated for Hispanic Social Security recipients (Elo et al. 2004) and Arias et al. (2010) estimates based on older survey data. We selected the Arias (2010) estimates because they are up to date, span all age groups, include unauthorized immigrants (unlike samples of Social Security recipients), include adjustments for age misreporting and Hispanic origin misreporting, and model mortality for those aged 80 and older using the Brass relational method because of a lack of appropriate data in this age range. Arias' (2010) estimates do not adjust for selective

Table 1 Data sources

Method	Terms	Data Sources
Death Registration	$E[\mu P_x] = \mu D_x / \mu M_x$ and $\mu r_x = (E[\mu P_x] - \mu P_x) / E[\mu P_x]$ μP_x U.S. deaths to Mexican-born persons, age x to $x + n$ μM_x U.S. age- and sex-specific mortality rates for Hispanics, age x to $x + n$ μP_x Enumerated Mexican-born population, age x to $x + n$	1995–2008 multiple cause-of-death files (NCHS 2010) 2007 Hispanic life table (Arias 2010), adjusted for Mexican-born (Esebach et al. 2006) 1995–1999 March Current Population Survey; 2000 5 % IPUMS; 2001–2008 ACS (Ruggles et al. 2010) ^a
Birth Registration	$E[P_{a,t}] = B_{t-a} - {}_aD_0 - {}_aE_0$ and $r_{a,t} = (E[P_{a,t}] - P_{a,t}) / E[P_{a,t}]$ B_{t-a} U.S. Births to Mexican-born mothers, year $t - a$ ${}_aD_0$ Deaths to birth cohorts between birth and age a ${}_aE_0$ Net emigration from United States to Mexico between birth and age a $P_{a,t}$ Enumerated children of Mexican-born mothers age a , year t	1991–2004 NCHS Natality files (NCHS 2009) 2007 Hispanic life table (Arias 2010) 2000, 2005, and 2010 Mexican censuses (Ruggles et al. 2010) 2001–2008 ACS; 2001–2008 March CPS (Ruggles et al. 2010)
Net Migration	$N_{Mx} = P'_{Mx} - P^{t,NM}_{Mx}$ and $N_{US} = P'_{US} - P^{t,NM}_{US}$ ${}_5P^{t,NM}_x = ({}_5S_{x, t-5})({}_5S_{x, t+5})$ ${}_5P^{t,NM}_0 = (B)({}_5S_{0, 0-4})$ $E[P'_{US}] = P^{t,NM}_{US} + N_{Mx}$ and $r = (E[P'_{US}] - P'_{US}) / E[P'_{US}]$ P'_{Mx} Mexican-born population enumerated in Mexico, year t P'_{US} Mexican-born population enumerated in United States, year t	1995, 2000, 2005, and 2010 Mexican census data (INEGI 2010) March CPS averaged across 1994, 1995, and 1996; 2000 5 % IPUMS; 2005 and 2010 ACS (Ruggles et al. 2010)

Table 1 (continued)

Method	Terms	Terms	Data Sources
	B	Mexican Births between censuses	U.S. Census Bureau's International Data Base (2012), based on fertility rates produced by INEGI (1999)
	${}_5S_{x, x+5}$	Five-year survival in Mexico	Mortality rates for Mexico, 1995–2010 (United Nations 2012)
		Five-year survival in the United States	2007 Hispanic life table (Arias 2010), adjusted for foreign-born (Eschbach et al. 2006)

Note: Please see the text for details.

^aPublic-use files of the ACS (e.g., as distributed by IPUMS) have been found to produce distorted single-year-of-age patterns for the population aged 65 and older compared with the 100 % restricted ACS files (Alexander et al. 2010). We therefore produced alternative coverage error estimates while using estimates of ${}_n P_x$ generated from the restricted-use ACS (special cross-tabulations of the Mexican-born population by age and sex were provided to us by the U.S. Census Bureau), and we obtained nearly identical coverage error estimates; results are available upon request.

emigration (i.e., “salmon bias” Palloni and Arias 2004), but that is actually preferable because the method requires mortality rates for the population remaining in the United States, even if that population is selected positively on health. The Arias (2010) estimates pertain to all Hispanics rather than the group we focus on, the Mexican-born. To adjust, we multiplied the Arias (2010) death rates by mortality ratios (Hispanic foreign-born/Hispanic) reported by Eschbach et al. (2006).²

Uncertainty

The strength of the death registration method is that virtually all deaths in the United States are registered, and classification as Mexican-origin among the foreign-born appears to be consistent with reporting in surveys (Arias et al. 2010). Nevertheless, the method is vulnerable to other sources of error.

First, even if mortality rates are stable and known, the number of deaths observed each year fluctuates randomly, especially for numerically small groups. We therefore smoothed the estimates by combining annual death data across years (1995–1999, 2000–2004, and 2005–2008) so that the coverage error estimates pertain to multiple years rather than a single point in time. Additionally, although we estimated $E[P]$ for detailed age groups (0, 1–4, 5–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–74, 75–84, and 85+), we collapsed them (0–14, 15–24, 25–44, 45–64, 65+) when we compared $E[P]$ with P .

Second, the level and age pattern of mortality among the Mexican-born relative to the U.S.-born remains uncertain (Palloni and Arias 2004). Of special concern for us is that we adjusted the Arias (2010) estimates with foreign-born/U.S.-born mortality ratios (Eschbach et al. 2006), and these ratios were estimated from a sample and are subject to sampling error. We therefore present two additional sets of coverage error estimates in which we alternatively assume that the Eschbach mortality ratios are (1) two standard errors below their mean and (2) two standard errors above their mean.

The birth registration method estimates the expected population of U.S.-born children ages 0–9 with Mexican-born mothers, $E[P]$, based on birth records. Others have used variations of the birth registration data to project school enrollments in local areas (Morrison 2000) and to estimate the expected number of U.S.-born Hispanic children in the 2010 Census (Devine et al. 2012). Because most young children live with their mothers, and because parents (not children) fill out census forms, the resulting assessment reflects coverage error for Mexican-born mothers with young U.S.-born children. This turns out to be the majority of Mexican-born women ages 20–44: in 2010, 58 % had a child younger than age 10; and of these, 96 % had at least one U.S.-born child. Nevertheless, it is important to keep in mind that the birth registration estimates pertain to *U.S.-born* children of Mexican-born mothers, while the estimates derived from the other two methods pertain to Mexican-born children, a group that is likely to have higher coverage error.

² Eschbach et al. (2006) reported Californian mortality rates for Hispanics by nativity. We used these rates to convert mortality rates for all Hispanics to mortality rates for the Hispanic foreign-born as follows: $M_{x, \text{foreign-born}} = M_{x, \text{Hispanics}} / [p + (1 - p) / r]$, where $M_{x, \text{Hispanics}}$ is the age-specific mortality rate for Hispanics estimated by Arias (2010), p = the proportion foreign-born among the Hispanic population age x , and r = the ratio of foreign-born to native-born mortality rates, provided by Eschbach et al. (2006).

Estimation

The expected number of U.S.-born children of Mexican-born mothers age a in year t , $E[P_{a,t}]$, is equal to births in year $t - a$ (B_{t-a})³ minus deaths (${}_aD_0$) and net emigration (${}_aE_0$) between birth and age a .

$$E[P_{a,t}] = B_{t-a} - {}_aD_0 - {}_aE_0.$$

Coverage error is then:

$$r_{a,t} = (E[P_{a,t}] - P_{a,t}) / E[P_{a,t}],$$

where $P_{a,t}$ is the census or ACS enumerated number. To increase precision, we combined ages 0–4 and 5–9. We present single-year estimates as well as averaged estimates across years (2001–2004, 2005–2009), similar to the death registration estimates. See Table 1 for a description of our data sources. Of special interest, we estimated net emigration between birth and age a as the number of U.S.-born children age a reported in the 2000, 2005, and 2010 Mexican census data (interpolated to obtain estimates for intercensal years). Birth data on children of Mexican-born mothers are available only through 2004 (National Center for Health Statistics 2009), so we could not estimate the expected number of children aged 0–4 after 2004.

Uncertainty

The strength of the birth registration method is that its largest component—the number of births—is not subject to coverage or sampling error. The National Center for Health Statistics (2009) estimated that more than 99 % of all births occurring in the United States are registered on official certificates. The large number of births and relatively small adjustments to these numbers (i.e., deaths and emigrants) mean that the estimates are less sensitive to random fluctuations than the death registration method.

Nevertheless, we evaluated the sensitivity of birth registration estimates to (1) coverage error in the Mexican census (which affects our estimates of the number of emigrants ($E_{a,t}$)), and (2) inconsistencies in the classification of children of Mexican-born mothers in birth records versus census/ACS data. Space limitations prevent us from describing the tests in detail (available upon request), but suffice it to note that we inflated all estimates of the number of U.S.-born children living in Mexico upward according to estimates of coverage error implied by the International Data Base (IDB) estimates of the Mexican population (for more detail, see section on the net migration method). Second, to assess the possibility of classification error, we compared the birth registration results with groups (all Mexican-origin children) and data sources (the CPS) that are less prone to classification error. Finally, we directly examined the consistency of maternal place-of-birth reporting between birth certificates and surveys using the Early Childhood Longitudinal Sample (ECLS-B), finding that only 6 % more women were classified as foreign-born on birth certificates than in the ECLS-B. We thus provided alternative estimates of coverage error while assuming that the number of

³ Children age a at last birthday in year t were actually born in two different years ($t - a$ and $t - a - 1$), so we averaged births across both years.

children of Mexican-born mothers in birth certificate data is overclassified relative to the ACS by as much as 6 %.

The *net migration method* involves two major steps. Step 1 is to estimate the number of net migrants moving from Mexico to the United States based on demographic components of change (i.e., after accounting for natural increase, the intercensal change in population is mostly due to net migration): first, on the basis of Mexican data; and second, using U.S. data. Step 2 calculates the expected Mexican-born living in the United States, $E[P]$, by substituting the Mexican-based estimate of net migration in the components-of-change equation for the United States. As with the other two methods, $r = (E[P] - P) / E[P]$.

Because of its emphasis on net migration during the previous five years, this approach is most sensitive to the coverage of the recently arrived Mexican-born population who moved to the United States in the five years prior to the census or ACS being evaluated (Hill and Wong 2005; U.S. General Accounting Office 1993). Importantly, this method *does not* rely on information on duration of residence based on the “year-of-arrival” question. This is helpful given concerns over the ambiguity surrounding responses to this question in U.S. census data (Ellis and Wright 1998; Redstone and Massey 2004), particularly in the case of Mexicans, whose migration tends to be more circular than that of other immigrant groups.

Estimation, Step 1

With some modifications, we followed the methodology outlined by Hill and Wong (2005) to estimate net migration during the 1995–2000, 2000–2005, and 2005–2010 periods, which correspond with intercensal periods in Mexico. The Mexican population in the Mexican census in year t (P^t) equals the population five years earlier (P^{t-5}) projected forward (accounting only for natural increase, $P^{t,NI}$) plus net international migration (N). Net migration is thus the enumerated minus the projected population:

$$N = P^t - P^{t,NI}$$

We estimated $P^{t,NI}$ with the cohort-component projection method (Preston et al. 2001). For all but the youngest and oldest age intervals,

$${}_5P_x^{t,NI} = ({}_5P_{x-5}^{t-5})({}_5S_{x,x+5}),$$

where ${}_5S_{x,x+5}$ is the proportion of those ages $x - 5$ to x who survive five years to age x to $x + 5$ (${}_5L_{x+5} / {}_5L_x$). For the youngest age group, 0–4,

$${}_5P_0^{t,NI} = B_5 S_{b,0-4},$$

where B is the number of births occurring in the years between censuses, and ${}_5S_{b,0-4}$ is the proportion of births surviving to the 0–4 age group (${}_5L_0 / 5 \times l_0$). Finally, for the oldest age group, 80+,

$$P_{80+}^{t,NI} = ({}_5P_{75}^{t-5})({}_5S_{75,80}) + (P_{80}^{t-5})({}_5S_{80+,85+}),$$

where ${}_5S_{75, 80} = {}_5L_{80} / {}_5L_{75}$, and ${}_5S_{80+, 85+} = T_{85} / T_{80}$.⁴ As noted earlier, we used these equations to estimate net migration from Mexico to the United States first on the basis of Mexican data, and second, using U.S. data (see Table 1 for data sources). We divided the net migration estimates by the exact number of years between censuses or surveys to obtain comparable estimates of *annual* net migration, and adjusted the Mexican-based estimate to account for the fact that most (but not all) Mexican emigrants go to the United States (about 97 % of men and 93 % of women) (Hill and Wong 2005).

Uncertainty in Step 1

One source of uncertainty is that the estimates are sensitive to stochastic errors in their underlying components. The estimates were made for five-year age groups, but we pooled them (0–14, 15–24, 25–44, and 45–64) to yield more stable estimates. Because so few migrants are aged 65 or older, we could not use the net migration method to estimate coverage error for persons aged 65 and older.

Additionally, if coverage error in Mexico increased between censuses and was unaccounted for, undercounted groups would be erroneously classified as net migrants (Hill 1985). Although the level of coverage error in Mexican census data is not well known,⁵ we were able to locate one set of estimates. The U.S. Census Bureau's IDB program produces population estimates for Mexico based on the 1980 census population (adjusted for coverage error at that time) and subsequent births, deaths, and estimates of net international migration. When compared with the enumerated populations in the Mexican census, the IDB estimates imply coverage error levels of 1.9 % in 1995, 2.7 % in 2000, 2.8 % in 2005, and 1.4 % in 2010. We therefore made two sets of estimates while assuming that (1) coverage error in Mexico was 2 % for all years, and (2) coverage error followed the patterns estimated by the IDB. To adjust, we calculated the number of people assumed to be missing in all Mexican censuses and distributed them according to the age and sex pattern of coverage error observed in the U.S. population (U.S. Census Bureau 2003) prior to estimating net migration in Step 1. We used the U.S. age-sex pattern because this information was not available for Mexico.

Estimation, Step 2

In Step 2, we converted the two net annual migration estimates (based on Mexican versus U.S. data) into estimates of coverage error for all Mexican-born. The

⁴ One complication is that the time between Mexican censuses is never exactly five years, so five-year cohorts cannot be followed neatly across censuses. The 1995, 2000, 2005, and 2010 Mexican censuses were conducted in November 1995, February 2000, October 2005, and February 2010, respectively. For intercensal periods longer than five years, we adjusted the survival ratios to account for both longer exposure and differential mortality risk across three age categories, and we allocated the survivors proportionately across the next two older age intervals. For intercensal periods shorter than five years, we adjusted the survival ratios to account for the shorter and differential exposure to mortality risk across two age categories, and we allocated the survivors proportionately across the same and next older age intervals.

⁵ Hill and Wong (2005) provided alternative estimates of net migration while varying assumptions of coverage error in Mexican census data, but they did not provide an independent assessment of coverage error in Mexico.

U.S.-resident Mexican-born population in year t can be expressed as the population five years earlier ($t - 5$) projected forward to year t (accounting only for natural increase) plus net migration, where net migration is based on U.S. census data:

$$P^t_{US} = P^{t,NI}_{US} + N_{US}.$$

However, an expected population estimate can be obtained by substituting the U.S.-based estimate of net migration with the Mexican-based estimate:

$$E[P^t_{US}] = P^{t,NI}_{US} + N_{Mx}.$$

The estimated coverage error rate is then:

$$r = (E[P^t_{US}] - P^t_{US}) / E[P^t_{US}].$$

Unlike the death and birth registration methods, which produce estimates of coverage error averaged across multiple years, we used the net migration method to estimate r for three time points: 2000, 2005, and 2010.

Uncertainty in Step 2

As described earlier, Step 2 of the net migration method does not account for coverage error of earlier arrivals. Taking 2005 as an example, $P^{05,NI}_{US}$ is the enumerated 2000 population, P^{00} , survived forward five years, and the methods described earlier assume no error in the 2000 enumeration. We therefore built in three alternative coverage error adjustments into the earlier estimate: (1) 10 % (borrowing from DHS assumptions for all unauthorized); (2) lower-bound estimates based on the death registration method (males: 22 % in 1995, 16 % in 2000, 9 % in 2005; females: 9 % in 1995, 6 % in 2000, 3 % in 2005); and (3) upper-bound death registration estimates (males: 34 % in 1995, 29 % in 2000, 24 % in 2005; females: 29 % in 1995, 27 % in 2000, 24 % in 2005). As before, we added back in those assumed to be missing and distributed them according to the age and sex pattern of coverage error observed in the U.S. population (U.S. Census Bureau 2003).

Results

Death Registration Method

We first present illustrative findings for each approach starting with the death registration method for 2000–2004 (Table 2). The first column lists the average annual number of recorded U.S. deaths of Mexican-born persons in the years 2000–2004 (D_x). Taking men aged 15–24 as an example, an annual average of 1,604 deaths occurred in the 2000–2004 period. Given the range of estimated death rates for the Mexican-born population, between 1,348 and 1,503 thousand person-years lived in that period would have been necessary to produce that many deaths. However, a smaller number (1,077 thousand) was represented in the 2000–2004 census/ACS data, implying a coverage error rate of 20 % to 28 %.

Table 2 Coverage error of Mexican-born for 2000–2004, based on death registration method

Age	D_x Mexican- born Deaths	$E[P]$ Population (1,000s), Given Mortality			P ACS Estimate (1,000s)	r Coverage Error, Given Mortality		
		Arias ^a	Arias, Low ^b	Arias, High ^c		Arias ^a	Arias, Low ^b	Arias, High ^c
Female	12,037	5,102	5,844	4,554	4,430	13	24	3
0–14	106	703	1,077	482	419	40	61	13
15–24	258	879	1,011	773	751	15	26	3
25–44	1,143	2,316	2,492	2,156	2,203	5	12	–2
45–64	2,512	898	942	851	819	9	13	4
65+	8,018	306	322	293	238	22	26	19
Male	16,935	6,488	7,163	6,011	5,449	16	24	9
0–14	134	779	1,209	529	450	42	63	15
15–24	1,604	1,421	1,503	1,348	1,077	24	28	20
25–44	3,897	3,085	3,195	2,980	2,858	7	11	4
45–64	4,112	978	1,021	940	880	10	14	6
65+	7,188	224	236	214	184	18	22	14

Note: Death and population estimates are averaged across five years (2000–2004).

^a Hispanic life table (Arias 2010), adjusted for Mexican-born.

^b Hispanic life table (Arias 2010), adjusted for Mexican-born (foreign-born to U.S.-born mortality ratio is 2 standard errors below the mean).

^c Hispanic life table (Arias 2010), adjusted for Mexican-born (foreign-born to U.S.-born mortality ratio is 2 standard errors above the mean).

We repeated these calculations for three time periods (1995–1999, 2000–2004, and 2005–2009) and present the results in Table 3 by sex and broad age groupings. We focus on the medium estimates (labeled Arias), but refer to the “low” and “high” variants when discussing uncertainty. Most striking is the decline in coverage error over the period examined. For Mexican-born persons of all ages, it declined from 24 % in 1995–1999 to 15 % in 2000–2004 and then to 4 % in 2005–2009. Remarkably, coverage error declined for nearly all age and sex groupings, although the timing and degree of change in coverage varied. Apart from this trend, strong age patterns are evident. The estimates for children (0–14), young adults (15–24), and the elderly (65+) tended to be higher than older adults aged 25–64. In fact, the negative coverage error rates for men and women ages 25–64 imply a small overcount in the late 2000s. On the other hand, coverage error among children and young adults (aged 15–24) remained high even in the latter half of the 2000s (e.g., ranging 11 % to 32 % for women aged 15–24 and 20 % to 28 % for men aged 15–24), although the estimates for children range widely (e.g., 7 % to 55 % for girls in the latter half of the 2000s). This uncertainty stems from the wide confidence intervals of the Eschbach et al. (2006) estimates of U.S.-born/foreign-born mortality ratios for children. Finally, the results suggest gender differences conditional on period. Women aged 15–64 tended to have

lower coverage error rates than men in 1995–1999; but in the 2000s, male coverage error rates declined more precipitously, falling to roughly the same level estimated for women in the final period.

Birth Registration Method

We illustrate the birth registration method for 2004 in Table 4. For example, children who were age 6 in 2004 were born in 1997 or 1998. This cohort started with 312,000 births, but an estimated 2,000 died, and 25,000 moved to Mexico, leaving 285,000 expected to be living in the United States in 2004. Only 232,000 were counted in the ACS—a difference of 53,000, or an undercount of 19 %.

We summarize the results for 2001–2009 in Table 5. Unlike the death registration estimates, the results suggest consistently high levels of coverage error among children of Mexican-born mothers throughout the 2000s. Among children aged 0–4, the rate averaged 25.1 % in the early 2000s; for children aged 5–9, it was 16.3 % in the early 2000s and 19.1 % in the latter half of the 2000s (Panel B, ACS-based results). By comparison, the range of coverage error rate for children of non-Mexican-origin

Table 3 Coverage error estimates among Mexican-born while varying assumptions about mortality, 1995–2008, death registration method

Mortality Assumptions:	1995–1999			2000–2004			2005–2008		
	Arias ^a	Arias, Low ^b	Arias, High ^c	Arias ^a	Arias, Low ^b	Arias, High ^c	Arias ^a	Arias, Low ^b	Arias, High ^c
All Mexican-born	24	32	17	15	24	6	4	13	–4
Female	19	29	9	13	24	3	5	16	–5
0–14	43	62	18	40	61	13	34	55	7
15–64	15	22	7	8	15	0	1	9	–7
15–24	26	35	16	15	26	3	22	32	11
25–44	11	17	4	5	12	–2	–6	1	–14
45–64	12	17	8	9	13	4	–2	3	–7
65+	21	25	17	22	26	19	12	17	8
Male	28	34	22	16	24	9	4	11	–3
0–14	46	65	21	42	63	15	23	48	–9
15–64	25	28	22	12	16	9	2	6	–2
15–24	35	38	31	24	28	20	24	28	20
25–44	24	27	21	7	11	4	–6	–3	–10
45–64	13	16	9	10	14	6	0	4	–4
65+	13	18	9	18	22	14	1	6	–3

^a Hispanic life table (Arias 2010), adjusted for Mexican-born.

^b Hispanic life table (Arias 2010), adjusted for Mexican-born (foreign-born to U.S.-born mortality ratio is 2 standard errors below the mean).

^c Hispanic life table (Arias 2010), adjusted for Mexican-born (foreign-born to U.S.-born mortality ratio is 2 standard errors above the mean).

Table 4 Expected number (1,000s) and coverage error of children of Mexican-born mothers in the United States in 2004, birth registration method

Age in 2004	Years of Birth	<i>B</i> Births	<i>D</i> Deaths	<i>E</i> Net Emigration	$E[P]$ $= B - D -$		<i>r</i> %	
					<i>E</i> Expected Population	<i>P</i> 2004 ACS		
0	2003–2004	433	2	16	415	273	142	34
1	2002–2003	417	2	27	387	270	117	30
2	2001–2002	402	2	29	371	274	97	26
3	2000–2001	383	2	31	349	282	67	19
4	1999–2000	353	2	32	319	268	51	16
5	1998–1999	326	2	26	298	235	63	21
6	1997–1998	312	2	25	285	232	53	19
7	1996–1997	308	2	24	282	237	45	16
8	1995–1996	301	2	20	279	236	43	15
9	1994–1995	294	2	20	271	223	48	18
0–4	1999–2004	1,989	12	135	1,842	1,367	475	26
5–9	1994–1999	1,540	11	115	1,415	1,162	253	18
0–9	1994–2004	3,529	22	249	3,257	2,530	728	22

Notes: Births are the number of births in the United States to Mexican-born mothers, averaged across possible birth years. Deaths are based on survival ratios in the Hispanic life table developed by Arias (2010). Net emigration is based on the percentage of U.S.-born children of Mexican-born mothers in the 2005 Mexican census, which are then applied to 2004 population estimates.

mothers was much lower (0.4 % to 1.8 %, depending on age and period),⁶ which suggests that the high coverage-error pattern we observe is much more prominent among Mexican-origin children than non-Hispanic children in the ACS.

The ACS does not include a direct question on maternal place of birth, so identifying children of Mexican-born mothers in the ACS is complex, requiring us to match children with their coresidential mothers.⁷ However, the results suggest that children of Mexican-born mothers are probably underrepresented in the ACS rather than simply misclassified. First, coverage error for all Mexican-origin children was substantial (10.7 % to 14.2 %, as shown in Panel B), even though the calculations for all Mexican-origin children do not require us to identify children by their mother's place of birth or to match children with their mothers. Second, coverage error for children of Mexican-born mothers was only a little lower for the CPS (which includes a direct question on maternal place of birth) than the ACS. For example, among children aged

⁶ One might expect the coverage error rate to be even closer to zero among this group. However, we did not factor in emigration to countries other than Mexico, which could account for some of the discrepancy between the expected and ACS estimated numbers. Additionally, these results are consistent with recent research suggesting growing levels of coverage error among young U.S. children of all racial and ethnic groups, possibly because of time constraints of parents with young children and young children's increasingly complex living arrangements (O'Hare 2013).

⁷ We used the mother-child identifiers provided by Integrated Public Use Microdata Series (IPUMS) (Ruggles et al. 2010).

Table 5 Coverage error estimates for children ages 0–9, 2001–2009, birth registration method

	Children of Mexican-born Mothers		Mexican-Origin Children		Children of Non-Mexican Mothers	
	Age 0–4	Age 5–9	Age 0–4	Age 5–9	Age 0–4	Age 5–9
Panel A. Estimated Coverage Error in ACS by Year						
2001	24.6	17.6	15.0	10.9	1.6	0.6
2002	25.4	14.8	15.8	10.5	0.2	0.4
2003	24.7	14.8	12.5	10.0	0.5	0.7
2004	25.8	17.9	13.6	11.2	-0.7	1.2
2005	—	20.3	—	13.8	—	2.3
2006	—	17.9	—	12.0	—	1.5
2007	—	17.2	—	13.0	—	1.4
2008	—	19.5	—	9.0	—	2.4
2009	—	20.4	—	8.2	—	1.3
Panel B. Estimated Coverage Error for ACS Versus CPS						
ACS						
2001–2004	25.1	16.3	14.2	10.7	0.4	0.7
2005–2009	—	19.1	—	11.2	—	1.8
CPS						
2001–2004	18.8	15.4	9.1	8.3	1.2	0.9
2005–2009	—	17.3	—	10.9	—	1.8
Panel C. Estimated Coverage Error for ACS After Adjusting for Discrepancy Between Birth Certificate and ACS Classification of Mother's Place of Birth						
If number classified as children of Mexican-born mothers on birth certificates is:						
3 % more than ACS						
2001–2004	22.6	13.5	11.5	7.8	0.4	0.7
2005–2009	—	16.0	—	9.1	—	1.8
6 % more than ACS						
2001–2004	20.0	10.5	8.5	4.7	1.0	1.2
2005–2009	—	13.1	—	6.1	—	2.3

0–4, it was 25.1 % in the ACS and 18.8 % in the CPS in the early 2000s. This suggests that classification error may account for a small portion, but certainly not all, of the apparent coverage error in the ACS. Third, when we adjusted for a possible discrepancy in reporting on maternal place of birth on surveys versus birth certificates (by reducing the number of births to Mexican-born mothers in birth certificates by as much as 6 %), the coverage error estimates remained substantial (20 % for ages 0–4 in early 2000s; 10.5 % and 13.1 % for ages 5–9 in the early 2000s and late 2000s, respectively).

Net Migration Method

Finally, we turn to the net migration results, which emphasize coverage among newly arrived immigrants. We illustrate results from this approach in Table 6 for male net

Table 6 Estimates of net migration from Mexico to the United States based on Mexican and U.S. data sources, males 2000–2005 (all estimates in 1000s)

Age	Net Migration Based on Mexican Data				Net Migration Based on U.S. Data				Difference in Annual Net Migration (Mexico – U.S.)	
	Population		Projected 2005 Population	Net Migration	Annual Net Migration	Population		Projected 2005 Population		Net Migration
	2000	2005				1990	2005			
0–4	5,529	5,415	5,788	–373	65	90	63	12	53	
5–9	5,868	5,591	5,605	–14	2	163	170	85	16	
10–14	5,569	5,749	5,820	–71	12	230	220	158	12	
15–19	4,975	5,096	5,579	–483	84	420	370	225	27	
20–24	4,331	4,355	5,001	–645	112	709	701	405	55	
25–29	4,006	3,988	4,352	–365	63	788	924	687	44	
30–34	3,513	3,927	3,989	–61	11	724	899	778	23	
35–39	3,120	3,525	3,510	15	–3	606	791	724	13	
40–44	2,569	2,978	3,099	–121	21	447	641	608	6	
45–49	2,026	2,510	2,557	–47	8	313	451	452	–1	
50–54	1,701	2,051	2,008	43	–7	207	315	316	–1	
55–59	1,287	1,570	1,646	–75	13	135	211	209	3	
60–64	1,094	1,301	1,233	68	–12	89	132	135	–2	
65–69	808	967	998	–31	5	61	91	87	4	
70–74	607	737	711	25	–4	42	59	56	1	
75–79	421	504	495	9	–1	29	42	36	1	
80+	443	645	578	67	–12	30	40	40	–12	
Total	47,868	50,909	52,969	–2,060	358	5,082	6,121	5,001	1,120	210

migration from Mexico to the United States between 2000 and 2005 (i.e., Step 1 of the net migration method). The left side of the table displays the estimates of annual net migration based on Mexican data, and the right side reflects estimates based on U.S. data. Positive-signed estimates of annual net migration indicate net flows from Mexico to the United States, and negative-signed estimates indicate the reverse. The direction varies by age, with more return migration to Mexico among older adults (perhaps for retirement) and, to a lesser degree, among children ages 5–9 (perhaps to attend school in Mexico; Rendall and Torr 2008). On balance, net migration flows from Mexico to the United States. More important for evaluating coverage error, annual net migration totals 358,000 when we use Mexican data but only 210,000 when we use U.S. data, a difference of 148,000 (41 % of the Mexican-based estimate). Estimates of annual net migration for all groups and periods are reported in Table 10 in the Appendix.

Table 7 illustrates how we convert these estimates into coverage error estimates (i.e., Step 2 of the net migration method). For men ages 15–24, for example, this group would have declined from 1,129,000 in 2000 to 630,000 in 2005 in the absence of migration (“Survivors to 2005”). The 2005 ACS estimated 1,071,000, or 441,000 more than projected—a difference that we attribute to net migration from Mexico to the United States. However, if we substitute the U.S.-based estimate of net migration with the Mexico-based estimate of net migration (1,045,000), the 2005 population estimate would be higher: between 1,701,000 and 1,748,000, depending on level of coverage error built into the original 2000 census estimate. Comparing these new estimates with the number in the 2005 ACS suggests levels of coverage error between 37 % and 39 %.

We repeated the calculations shown in Tables 6 and 7 for both males and females for the 1995–2000, 2000–2005, and 2005–2010 periods. Shown in the top panel of Table 8, when we assumed no change in coverage error in Mexico and only 10 % coverage error in the previous census or ACS (columns 1, 4, and 7), coverage error for the Mexican-born aged 15–64 would be about 8 % in 2000, 15 % in 2005, and –6 % (a small overcount) in 2010. However, if coverage error in Mexico followed the pattern assumed by the Census Bureau IDB (lower panel), coverage error in the United States would be slightly lower in 2000 (1 %) and 2005 (14 %) but higher in 2010 (6 %). Additionally, if coverage error in the earlier census or ACS were as high as our death registration estimates suggest (columns labeled “DR low rate” and “DR high rate”), the foreign-born coverage error estimates would tend to be higher, ranging from 6 % to 15 % in 2000, 15 % to 24 % in 2005, and 2 % to 16 % in 2010. Similar to the results from the death registration method, we see higher rates for children in all time periods, men versus women (particularly in 2000), and young adults aged 15–24 (particularly in 2005); and declines in coverage error between 2005 and 2010. In 2010, the results even suggest a substantial overcount (i.e., negative rates) for adults aged 45–64. The reason for the overcount is that the Mexican-based estimates of net migration suggest substantial return migration for this group, and the U.S.-based estimates suggest a small inflow into the United States.

Summary and Conclusions

This research has applied multiple methods to different kinds of data at multiple recent time intervals to calculate plausible ranges of coverage error for the Mexican

Table 7 Components of change, alternative estimates of net migration, and coverage error, Mexican-born males, 2005 (estimates in 1,000s)

Age	Components of Change, U.S. Data				Net Migrants			$E[P] = P^{05,NI} + N_{MX}$ if Coverage Error for Pre-2000 Arrivals Is:			r Coverage Error, if Coverage Error for Pre-2000 Arrivals Is:		
	2000 Population P^{00}	Projected to 2005 $P^{05,NI}$	Net Migrants N_{US}	2005 Population $P^{05} = P^{05,NI} + N_{US}$	Based on Mexican Data, ^a N_{MX}			10 %	DR Low Rate ^b	DR High Rate ^c	10 %	DR Low Rate ^b	DR High Rate ^c
0-14	483	242	210	452	425	711	736	793	36	39	43		
15-24	1,129	630	441	1,071	1,045	1,701	1,716	1,748	37	38	39		
25-44	2,565	2,798	457	3,255	493	3,628	3,831	4,270	10	15	24		
45-64	744	1,112	-2	1,110	10	1,211	1,264	1,379	8	12	19		

^a Assumes 2 % coverage error in Mexican censuses, all years.

^b Death registration lower-bound coverage error estimates (males: 22 % in 1995, 16 % in 2000, 9 % in 2005; females: 9 % in 1995, 6 % in 2000, 3 % in 2005).

^c Death registration upper-bound coverage error estimates (males: 34 % in 1995, 29 % in 2000, 24 % in 2005; females: 29 % in 1995, 27 % in 2000, 24 % in 2005).

Table 8 Coverage error estimates for Mexican-born by age and sex, 2000, 2005, and 2010, based on net migration method

	2000			2005			2010		
	10 %	DR Low Rate ^a	DR High Rate ^b	10 %	DR Low Rate ^a	DR High Rate ^b	10 %	DR Low Rate ^a	DR High Rate ^b
Error for Earlier Arrivals									
No Change in Mexican Coverage Error ^c									
All Mexican-born	8	12	20	15	16	25	-6	-10	7
Children 0-14	—	—	—	34	35	43	35	32	42
Women, 15-64	11	10	20	17	15	25	-6	-13	6
15-24	1	1	7	25	24	29	-6	-10	2
25-44	16	16	26	16	13	25	4	-3	15
45-64	3	3	15	11	9	20	-32	-42	-17
Men, 15-64	20	26	30	17	20	27	-1	-2	11
15-24	27	27	28	37	38	39	4	4	7
25-44	18	25	31	10	15	24	4	3	18
45-64	18	24	29	8	12	19	-20	-22	-6
International Data Base's Assumptions of Mexican Coverage Error ^d									
All Mexican-born	1	6	15	14	15	24	6	2	16
Children 0-14	—	—	—	29	29	39	54	52	58
Women, 15-64	7	6	17	16	14	25	1	-5	12
15-24	-3	-3	4	26	25	30	3	-1	9
25-44	13	12	23	15	13	25	10	4	20
45-64	-2	-3	11	10	8	19	-22	-29	-8
Men, 15-64	17	23	28	16	20	26	7	6	17
15-24	26	27	28	38	38	39	8	8	11
25-44	14	22	28	9	14	23	12	11	24
45-64	11	18	25	7	11	18	-7	-8	5

Note: A dash indicates a negative population base (during this period, net migration from Mexico to the United States was negative for children); no percentage error was estimated.

^a Death registration lower-bound coverage error estimates (males: 22 % in 1995, 16 % in 2000, 9 % in 2005; females: 9 % in 1995, 6 % in 2000, 3 % in 2005).

^b Death registration upper-bound coverage error estimates (males: 34 % in 1995, 29% in 2000, 24% in 2005; females: 29% in 1995, 27% in 2000, 24% in 2005).

^c 2 % in all years.

^d 1.9 % in 1995; 2.7 % in 2000; 2.8 % in 2005; 1.4 % in 2010.

foreign-born population in the United States. Table 9 summarizes the results. The top panel presents estimates averaged across all plausible ranges by broad age groupings (0-14, 15-24, 25-44, 45-64, and 65+) and by sex. The lower panel presents minimum and maximum coverage error levels for major age and sex groupings (children aged 0-14, men aged 15-64, women aged 15-64, men aged 65+, and women aged 65+). In general, we give more weight to estimates and methods with narrower ranges. For example, the range for children in the early 2000s is narrower when based on the birth

Table 9 Coverage error estimates for Mexican-born by age and sex, by estimation method

	Birth Registration Method		Death Registration Method			Net Migration Method		
	2001–2004	2005–2009	1995–1999	2000–2004	2005–2008	2000	2005	2010
Panel A. Coverage Error Estimate (average of plausible ranges)								
All Mexican-born	—	—	24	15	5	10	18	3
Children (0–9/0–14) ^a	21	22	37	33	22	—	35	46
Women 15–64	—	—	15	8	1	12	19	–1
15–24	—	—	26	14	22	1	27	0
25–44	—	—	11	5	–6	18	18	8
45–64	—	—	12	9	–2	4	13	–25
Men 15–64	—	—	25	12	2	24	21	6
15–24	—	—	35	24	24	27	38	7
25–44	—	—	24	7	–6	23	16	12
45–64	—	—	13	10	0	21	13	–10
Women 65+	—	—	21	22	12	—	—	—
Men 65+	—	—	13	18	2	—	—	—
Panel B. Plausible Ranges of Coverage Error Estimates								
All Mexican-born								
Low	—	—	17	6	–4	1	14	–10
High	—	—	32	24	13	20	25	16
Children (0–9/0–14) ^a								
Low	15	17	17	12	–3	—	29	32
High	21	22	63	62	52	—	43	58
Women 15–64								
Low	—	—	7	0	–7	6	14	–13
High	—	—	22	15	9	20	25	12
Men 15–64								
Low	—	—	22	9	–2	17	16	–2
High	—	—	28	16	6	30	27	17
Women 65+								
Low	—	—	17	19	8	—	—	—
High	—	—	25	26	17	—	—	—
Men 65+								
Low	—	—	9	14	–3	—	—	—
High	—	—	18	22	6	—	—	—

^a The birth registration method produces estimates only for children age 0–9, whereas the death registration method produces estimates for children 0–14.

registration method (15 % to 21 %) than the death registration method (17 % to 63 %), so we give more credence to the birth registration estimates.

We draw three major conclusions. First, coverage error tends to be relatively high for the Mexican-born population during the late 1990s and early 2000s. The average death

registration estimates for all Mexican-born is 24 % in 1995–1999 and 15 % in 2000, and the average net migration estimates are 10 % and 18 % for 2000 and 2005, respectively. The plausible range of these estimates suggests some uncertainty (e.g., with the net migration estimate for 2000 ranging from 1 % to 20 %, and the death registration estimate for 2005–2008 ranging from 6 % to 24 %). However, the narrowest ranges suggest that coverage error was at least 17 % in 2000 and at least 14 % in 2005 for all Mexican-born, and it may be as high as 32 % in 2000 and 25 % in 2005. If coverage error were indeed at least 15 % among all Mexican-born, this suggests that coverage error for the Mexican unauthorized population—which composed roughly one-half of the enumerated population in the early 2000s—was probably higher than 15 % and may have been as high as 26 % (i.e., based on the equation in footnote 3).

Second, the age and sex patterns further suggest that coverage error among unauthorized Mexican immigrants is probably higher than that for the entire Mexican-born population. Coverage error appears to be higher among the groups among whom unauthorized status is known to be more prevalent, such as: (1) Mexican-born children (based on the death registration and net migration methods, which averaged 33 % and 35 %, respectively, in the early 2000s) compared with the U.S.-born children of Mexican-born mothers (based on the birth registration method, which averaged 21 % in the early 2000s); (2) men compared with women (e.g., in the late 1990s, average coverage error for men aged 15–64 was 24 % to 25 %, depending on method, compared with 12 % to 15 % among women); and (3) Mexican-born children and young adults aged 15–24 (which ranged from 14 % to 38 % in the early 2000s depending on age, gender, and method) compared with older working-age adults aged 45–64 (which ranged from 9 % to 13 % in the same year). The moderately high coverage error among immigrants aged 65+ (ranging from 13 % to 22 % in the late 1990s and early 2000s) is somewhat surprising, however, given that fewer are likely to be unauthorized immigrants and that they are likely to have lived in the United States for a long time. Additionally, we found high error among children of Mexican immigrants, ranging about 15 % to 22 %, according to the most precise method (birth registration). These findings are consistent with assessments of the 1990 census showing high coverage error among minority children (West and Robinson 1999) and with new evidence of increasing coverage error among young children over the last several decades, particularly among Latinos and blacks (O’Hare 2013).

A third major conclusion is that coverage error appears to have declined substantially during the 2000s. This trend appears in estimates based on both the death registration and net migration methods. By the latter part of the decade, coverage error rates for the entire Mexican-born population are estimated to be close to 5 % or less. During the 2000s, estimates based on the net migration method dropped the most, particularly among young adult women and men (both saw declines of nearly 30 percentage points) and also older working-age adults (45–64), who actually appear to be overcounted in 2010. In contrast, children (when evaluated by all three methods) and young adults (when evaluated by the death registration method) showed little to no evidence of declines in coverage error throughout the 2000 decade. Because the net

migration method is especially sensitive to coverage among recent temporary labor migrants whereas the birth and death methods capture mostly those who are permanently settled (i.e., unauthorized families), this pattern suggests that the declines in coverage error were largely driven by reductions in the number of hard-to-count temporary labor migrants as well as by the tendency for the ACS to overcount older immigrants.

What might account for these patterns and trends? During the late 1990s and early 2000s, high coverage-error estimates make sense. The high-tech and hyper-construction-based nature of the U.S. economy during this time attracted unskilled Mexican labor to carry out this work (Bean et al. 2012). For example, between 1992 and 2006, the number of persons employed in construction grew by 67 % from 4.6 million to 7.7 million persons (U.S. Bureau of Labor Statistics 2012). This pattern spread throughout much of the country during the 1990s (Leach and Bean 2008). The growth and new locations of unauthorized migrants may have raised the potential for undercoverage of the foreign-born, particularly given that recent immigrants often live in highly complex households with relatives for a period of time until they become better established (Glick et al. 1997; Van Hook and Glick 2007). The greater residential mobility, household complexity, and more fluid living arrangements among Mexican immigrants decrease the chances they were listed accurately in household rosters for censuses and surveys.

Additionally, increases in DHS enforcement activities in the late 1990s and early 2000s made migrants more fearful (Boehm 2012; Massey and Pren 2012; Massey and Sanchez 2010), thus probably reducing the likelihood that the unauthorized participated or provided accurate responses to immigration-related questions in censuses or surveys. Starting in 1994, the United States began pouring additional resources into enforcement in an effort to limit unauthorized land entries at the southwestern border with Mexico, with the number of Border Patrol agents rising from 4,000 in 1994 to more than 17,000 by 2008 (Haddal 2010). This has had the effect of making illegal border crossings more difficult and costly (with the price of hiring a “coyote” to shepherd entry increasing threefold) (Hernández-León 2008; Roberts et al. 2010; Spener 2009). It also increased the likelihood of migrants staying longer (Massey et al. 2002). In addition, the George W. Bush administration mandated a dramatic rise in Immigration and Customs Enforcement (ICE) raids in the country, starting around 2005–2006. At the same time (and perhaps because of the increase in border enforcement), the migration of Mexican unauthorized women and children (i.e., entire families: if not initially, then eventually) appears to have risen (Hernández-León 2008). Together, the increased risk of deportation, the heightened costs of reentering the United States if deported, and the fear of family separation increased the risks of unauthorized immigration, probably also making migrants less willing to respond to official surveys.

What then explains the decline in coverage error in the late 2000s? One possibility relates to the U.S. economic downturn and the collapse of the U.S. housing market in 2008, together with the associated reductions in demand for lower-skilled labor from Mexico. A recent report by the Pew Hispanic Center documented how net Mexican migration flows declined during this period, even

leading to likely reversals in the flow (Passel et al. 2012). These trends seem likely to have led to reductions in coverage error. Declines in the temporary labor migrant population are likely to diminish coverage error for the overall Mexican-born population because of reductions in the hard-to-count portion of the population: namely, unauthorized temporary labor migrants. The fact that evidence for decline in coverage error among young adults occurs *primarily* for the net migration method accords with this possibility.

A second contributing factor relates to how the Census Bureau produces population estimates for the Mexican-born population. Starting in the early 2000s, the ACS has been used as the principal source of demographic data on this group. The ACS is designed to replace the decennial census long form and provide intercensal population estimates, but it may not adequately capture trends in the size of the foreign-born population, especially during periods of sudden demographic change. A key reason why is that the ACS sampling weights are designed to sum to population totals by age, sex, race, Hispanic ethnicity, and geography, which in turn are based on the population estimates series (U.S. Census Bureau 2010). Thus, the degree to which the foreign-born are represented in the ACS depends at least partially on the accuracy of the population estimates series. The problem is that the population estimates assess growth in the foreign-born population (including a large portion of Hispanics) by examining change in the foreign-born in the ACS compared with the previous year's ACS total. Thus, past distortions in the ACS are built into current estimates. When the Mexican-born population declined in the late 2000s and some people returned to Mexico (including those possibly nearing retirement), the population estimates series would not have picked up this phenomenon as quickly and therefore overestimated the numbers of such immigrants. This could help explain the high overcount rates observed among adults aged 45–64.

Finally, like all indirect estimation methods, the methods we used to assess coverage error have limitations. Most importantly, they depend on a number of assumptions. For example, the death registration method assumes that the age-specific death rates we use are accurate; the birth registration method rests on the assumption that children of Mexican-born mothers who emigrated from the United States are mostly captured in the Mexican census; and the net migration method assumes a given historical pattern for coverage error in Mexico. In some sense, each of these methods—if taken in isolation—might be considered unreliable. However, each rests on *different* data and assumptions. This is a major strength of this study. The three methods we used produce roughly consistent results despite their reliance on different data and assumptions, and the consistency across the methods offers evidence of the robustness of the findings.

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Appendix

Table 10 Annual net migration estimates for Mexican-born by age and sex (1,000s), based on Mexican data, U.S. data, and difference

	1995–2000			2000–2005			2005–2010		
	Mexican Data	U.S. Data	Diff.	Mexican Data	U.S. Data	Diff.	Mexican Data	U.S. Data	Diff.
No Change in Mexican Coverage Error ^a									
All	503	477	25	572	375	197	-116	234	-350
Children 0–14	-38	105	-143	140	75	65	100	47	53
Female, 15+	188	155	32	223	126	97	-22	115	-137
15–24	77	81	-4	94	52	42	26	41	-15
25–44	117	75	43	120	74	46	26	60	-34
45–64	-6	0	-6	9	-1	10	-75	13	-88
65+	7	-1	8	7	-1	8	-25	11	-35
Male, 15+	379	221	158	290	168	122	-76	50	-126
15–24	210	133	77	196	83	113	76	73	3
25–44	153	90	62	92	86	7	-66	-14	-52
45–64	17	-2	19	2	0	2	-86	-8	-78
65+	-3	-9	6	0	3	-3	-36	4	-40
IDB Assumptions of Mexican Coverage Error ^b									
All	364	477	-113	541	375	166	154	234	-80
Children 0–14	-91	105	-196	122	75	48	183	47	137
Female, 15+	156	155	1	219	126	94	47	115	-68
15–24	71	81	-10	96	52	44	38	41	-3
25–44	98	75	24	117	74	42	65	60	4
45–64	-14	0	-13	7	-1	8	-56	13	-69
65+	5	-1	6	7	-1	8	-20	11	-31
Male, 15+	332	221	111	282	168	114	25	50	-26
15–24	206	133	73	199	83	116	85	73	12
25–44	122	90	32	84	86	-1	-6	-14	8
45–64	4	-2	6	-1	0	-1	-54	-8	-46
65+	-6	-9	3	-1	3	-3	-28	4	-32

^a 2 % in all years.

^b 1.9 % in 1995; 2.7 % in 2000; 2.8 % in 2005; and 1.4 % in 2010 (International Data Base assumptions).

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