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Descriptive Finding

High life expectancy and reversed socio-economic gradients of elderly people in Mexico and Costa Rica

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Descriptive Finding

High life expectancy and reversed socioeconomic gradients of elderly people in Mexico and Costa Rica

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Abstract

BACKGROUND
Some existing estimates suggest, controversially, that life expectancy at age 60 (LE60) of Latin American males is exceptionally high. Knowledge of adult mortality in Latin America is often based on unreliable statistics or indirect demographic methods.

OBJECTIVES
This study aims to gather direct estimates of mortality at older ages in two Latin American countries (Mexico and Costa Rica) using recent longitudinal surveys and to determine the socioeconomic status (SES) gradients for LE60.

METHODS
Data were collected from independent panels of approximately 7,000 older adults followed over more than a decade – the MHAS and CRELES surveys. The age-specific death rates were modeled with Gompertz regression, and thousands of life tables were simulated to estimate LE60 and its confidence interval.

RESULTS
LE60 estimates obtained from MHAS and CRELES are similar to those obtained from traditional statistics, confirming the exceptionally high LE60 of men in the two countries. The expected gradients of higher LE60 with higher SES are not present, especially among males, who even show reverse gradients (some exaggerated by data issues).

CONCLUSIONS
Vital statistics correctly estimate elderly mortality in Mexico and Costa Rica. The higher-than-expected LE60 among Latin American males in general, and particularly among low-SES individuals, seems to be real; their determinants should be thoroughly investigated.

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CONTRIBUTION
This study shows with hard, reliable data, independent of traditional statistics, that elderly males in tropical Latin America enjoy an exceptionally high life expectancy and that SES gradients are absent or even reverse.

1. Introduction

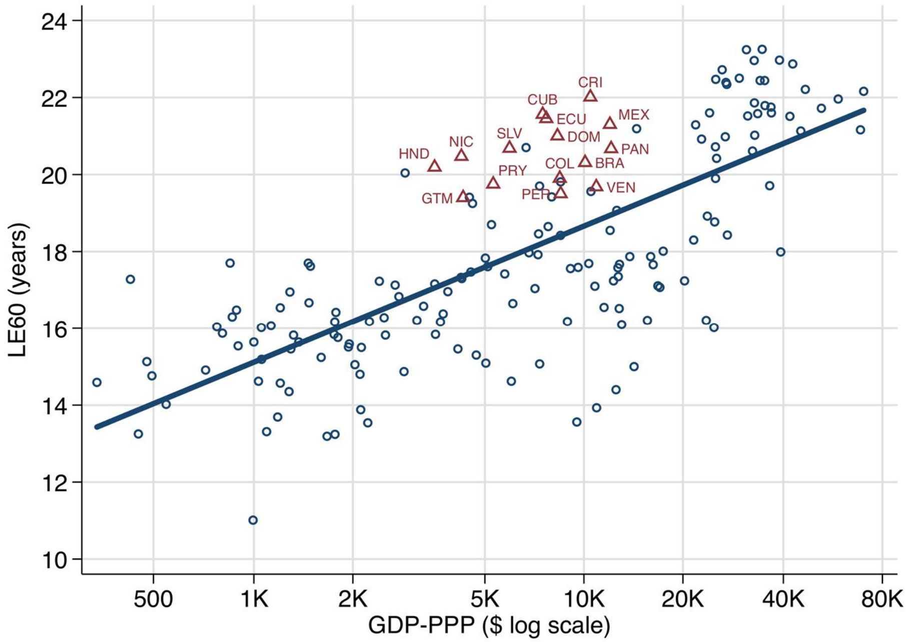
In each cohort of Latin Americans, 84% of life table deaths occur after age 60 (UNPD 2015). Despite this preponderance, estimates of old-age mortality in Latin America are controversial, often based on unreliable statistics or indirect demographic methods. Only five countries[2] have vital statistics that are considered adequate to allow valid estimates of mortality (CELADE 2010); only Chile is included in the Human Mortality Database of populations with complete data (HMD 2017). In most Latin American countries, adult mortality estimates are based on indirect demographic methods using questionable assumptions (Hill, Choi, and Timæus 2005).

A peculiarity of Latin America is that elderly males show better-than-expected life expectancy given the level of development of the countries. Figure 1 shows the life expectancy of males at age 60 (LE60-M) (UNPD 2015) in relation to the per capita gross domestic product parity purchasing power (GDP-PPP) (World Bank 2013) in 170 countries across the world. As expected, countries with higher GDP show higher LE60-M. Strikingly, all tropical Latin American countries are above the regression line that best fit the data, which means that these countries have a higher-than-expected LE60-M.[3] Costa Rica, Cuba, Ecuador, and Mexico, with a GDP-PPP per capita of about $10,000, show LE60-M of approximately 22 years, which would normally agree with economies of about $70,000.

Although the exceptionally low Latin American mortality at older ages has been documented (UNPD 1982), it has been dismissed as a result of faulty data, particularly age-misreporting in censuses (Coale and Kisker 1986; Dechter and Preston 1991; Preston, Elo, and Stewart 1999). Recent evidence, however, suggests that health at old ages in Latin America may be as good as in the United States (Payne 2015).

[2] Argentina, Chile, Costa Rica, Cuba, and Uruguay.
[3] An analogous figure (provided as supplemental material to this article) with child mortality instead of GDP on the x-axis shows that LE60-M is also higher than expected in tropical Latin American countries given their child mortality levels.

Figure 1: Life expectancy of males aged 60 years by GDP-PPP. World's countries circa 2010



BRA=Brazil, COL=Colombia, CRI=Costa Rica, CUB=Cuba, DOM=Dominican Republic, ECU=Ecuador, SLV=El Salvador, GTM=Guatemala, HND=Honduras, MEX=Mexico, NIC=Nicaragua, PAN=Panama, PRY=Paraguay, PER=Peru, VEN=Venezuela.

Latin America has the highest income distribution inequality in the world (Ravallion 2014). If mortality were determined exclusively by income, the region should also show extreme social inequalities in life expectancy. Indeed, Behm and collaborators documented extreme socioeconomic inequalities in child mortality in the 1970s (Behm 1980). In Guatemala, for example, the children of uneducated mothers died at a rate four times higher than that for the children of mothers with ten or more years of education (Chackiel and Plaut 1996). It has often been assumed that similar inequalities occur in adult mortality, although the statistical evidence supporting this assumption is exiguous. For example, in a book on adult mortality in Latin America that compiles 18 papers, not a single item of hard data shows socioeconomic status (SES) inequalities (Timaeus, Chackiel, and Ruzicka 1996). Only in Chile and Argentina has it been documented that low-educated or low-income adults tend to die at higher rates (Sandoval and Turra 2015; Peláez and Acosta 2011; Rofman 1994). By contrast, studies of Hispanics in the United States and of adult Costa Ricans have questioned the existence of SES gradients in adult mortality, especially at older ages (Rosero-Bixby and Dow 2016; Turra and Goldman 2007; Lariscy, Hummer, and Hayward 2015).

This report, based on longitudinal surveys in Mexico and Costa Rica, has the double purpose of (1) directly and independently determining adult mortality in those countries and to assess the validity of existing estimates and (2) documenting the SES gradients for mortality as a first step toward understanding its determinants.

Both Mexico and Costa Rica are middle-income economies with large income distribution inequality (Gini index of 0.5 (Underwood 2014)). While 70% of Mexicans had health insurance in 2008 (Gómez-Dantés et al. 2011), 85% of Costa Rica had it according to the 2011 census.

2. Methods

This report uses existing databases from two independently conducted longitudinal surveys: (1) the Mexican Health and Aging Study (MHAS 2004; Wong et al. 2015) and (2) the mother sample of the Costa Rican Study of Longevity and Healthy Aging (CRELES) (Rosero-Bixby and Dow 2009).

MHAS is a representative panel of the older Mexican population initiated in 2001 with follow-up waves in 2003 and 2012. Its micro-databases are publicly available on the project's website (MHAS 2012). For comparability purposes, ages younger than 55 and older than 99 as well as interviewed spouses were excluded. The analytical sample size used here is 6,700 individuals (Table 1). Relatives and neighbors provided information on the date of death for 87% of the deceased participants; 4% of the missing dates were randomly imputed for 2001–2003 and 9% for 2003–2012. The sample includes 4% of the deaths recovered from the MHAS data files of no-interviews. The analytical panel has an attrition rate of 7% that clearly increases with SES. Dropouts were censored at the date of the last contact. A sensitivity analysis to attrition-mortality scenarios is provided as supplementary material. The observation time started on January 1, 2002, several months after the baseline interviews, and stopped on the date of the 2012 interview.

Table 1: Sample sizes and attrition rate by gender, age, and SES groups.

Groups	Persons		Person-years		Deaths		% attrition	
	Mexico	Costa Rica	Mexico	Costa Rica	Mexico	Costa Rica	Mexico	Costa Rica
Total	6,748	7,629	57,995	59,147	2,049	3,290	6.9	1.5
Gender								
Male	2,908	3,620	24,541	27,742	969	1,651	6.7	1.1
Female	3,840	4,009	33,454	31,405	1,080	1,639	7.0	1.9
Baseline age								
55–74	5,508	4,076	49,829	39,402	1,275	975	6.9	0.7
75–99	1,240	3,553	8,166	19,745	774	2,315	6.9	2.4
Observed age								
55–74			39,853	28,521	768	509		
75–99			18,142	30,626	1,281	2,781		
Baseline residence								
<100,000 inhab.	2,825	3,488	25,103	27,226	864	1,486	4.0	1.4
100,000+ inhab.	3,923	4,141	32,892	31,921	1,185	1,804	8.9	1.6
Education								
None	2,017	1,500	16,858	10,767	738	724	5.1	1.9
Primary	3,566	4,979	31,186	38,705	1,059	2,152	6.0	1.5
Secondary	833	712	7,196	5,954	184	266	11.3	0.8
Post-secondary	332	438	2,755	3,722	68	148	15.4	1.4
Wealth tercile								
Low	1,948	2,957	16,710	22,479	672	1,332	5.1	1.4
Medium	2,409	2,162	20,510	17,129	771	911	6.4	1.7
High	2,391	2,510	20,775	19,539	606	1,047	8.8	1.5

The CRELES panel is a national sample of residents aged 55 or more drawn from 2000 census files linked to the death registry (details in Rosero-Bixby, Brenes, and Collado 2004). After excluding foreigners (3%) and centenarians the analytical sample size is 7,200. In addition to the follow-up in the death registry, the survival of individuals was verified using the voting lists for the presidential elections of 2002, 2006, 2010, and 2014, resulting in an attrition rate of 1.5% of non-death individuals who disappeared from the voting lists. These lost individuals were excluded from observation on the closing date of the voting registry in which they first disappeared. Observation started on January 1, 2001 (six months after the census) and stopped on December 31, 2011. A nested subsample of 3,000 individuals was contacted in person in three waves of visits mostly in 2005, 2007, and 2009. In waves 2 and 3, relatives or neighbors reported 566 deaths in this subsample. Only five of these deaths (<1%) were missing in the death registry follow-up, suggesting that the Costa Rican registry is essentially complete.

SES groups were defined with three indicators at baseline: (1) educational attainment (no formal education, some elementary, some secondary, and postsecondary education); (2) tercile of household wealth (measured by the count of eight household assets: tap water inside the house, toilet, television, refrigerator, washer, telephone, hot water, and car); and (3) whether the place of residence is a city of more than 100,000 inhabitants. People in cities usually enjoy better economic opportunities and services (clean water, electricity, transportation, banking, health care, and so on) than in rural areas, and thus they are considered of a higher SES. Table 1 shows the analytical sample sizes of the 40 groups defined with these variables.

Age in each observation segment was established from the date of birth (DoB) in months. DoB in CRELES was taken from the linked birth registry, which makes it error-free. Participants in MHAS reported their DoB in the 2001 wave. An assessment of the accuracy of DoB in MHAS, based on confirmatory reports during the 2012 wave, is included as supplementary material. Only 13% of MHAS participants changed their reported birth year; 8% changed their five-year bracket.

A two-parameter Gompertz function (Pollard 1991) was estimated for each SES group using hazard regression (Hosmer and Lemeshow 1999). The LE60 and its 95% confidence interval (95% CI) were estimated for each group using the Gompertz parameters (and their standard errors) to generate 1,000 sets of death rates, and the corresponding life tables with Monte Carlo simulation. The median value of LE60 in 1,000 simulations is taken as the point indicator of mortality in a group along with the 2.5 and 97.5 percentiles as estimates of the 95% CI.[4]

The national estimates of LE60 in this report are compared to estimates[5] from the following other sources:

- Vital statistics: deaths in the last intercensus period and, as rates denominator, the population average of the census of 2000 and 2010 in Mexico and of 2000 and 2011 in Costa Rica (Palloni, Pinto, and Beltrán-Sánchez 2014).
- Official estimates: the age-specific death rates from 2000–2010 used by the *Consejo Nacional de Población* (CONAPO 2012) in the population projections of Mexico and the average of the Costa Rican death rates of 2000–2005 and 2005–2010 in the life tables by the Pension Superintendent (SUPEN) (CCP 2014).
- LAMBdA project: death rates in the life tables estimated by the project "Latin American Mortality Database" (LAMBdA), Mexico 2000–2010 and Costa Rica 2000–2011 (Palloni, Pinto, and Beltrán-Sánchez 2014).

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[4] Supplementary material includes a STATA data file with the microdata used to estimate death rates and the hazard regression models. Table S1 shows the two Gompertz parameters for each of the 40 groups and their standard errors as well as the corresponding LE60 estimate and its 95% CI, along with estimates of life expectancy for ages 55 and 65.

[5] To avoid discrepancies due to differences in the method used by each source to compute LE60, this indicator was re-estimated with the set of age-specific death rates in ages 55–99 years for each source modeled with a Gompertz function to obtain smoothed rates for ages 55–114 years and the corresponding life table.

- GBD: average of the death rates reported for 2000 and 2010 by the project "Global Burden of Disease" (GBD) (IHME 2015).
- UNPD: Average of death rates of 2000–2005 and 2005–2010 in (UNPD 2015).

3. Results

The resulting LE60 for males (21.2 years in Mexico and 21.9 years in Costa Rica) is essentially the same as those from vital statistics considering the 95% CI (Table 2). Among women, the MHAS estimate (23.4 years) and its 95% CI is slightly higher than that from the Mexican vital statistics, whereas the CRELES estimate (24.4 years) is slightly lower. The UNPD estimates for these two countries, as well as the official life tables of Costa Rica, also yield estimates similar to those of MHAS and CRELES. The official mortality estimate for Mexico found in the CONAPO seems slightly up-biased (down-biased LE60).

Table 2: Comparing estimates of life expectancy at age 60

Country, period, and source	Males		Females	
Mexico 2000–2010				
MHAS 2002–2011	21.2	(20.5–21.8)	23.4	(22.8–24.0)
Vital statistics	20.4		22.4	
Official CONAPO	19.9		22.1	
LAMBdA	18.0		19.6	
GBD	21.8		24.7	
UNPD	20.8		22.6	
Costa Rica 2000–2010				
CRELES 2002–2012	21.9	(21.5–22.2)	24.3	(23.9–24.8)
Vital statistics	21.8		24.8	
Official SUPEN	21.8		24.4	
LAMBdA	19.3		21.4	
GBD	20.7		24.0	
UNPD	21.5		24.2	

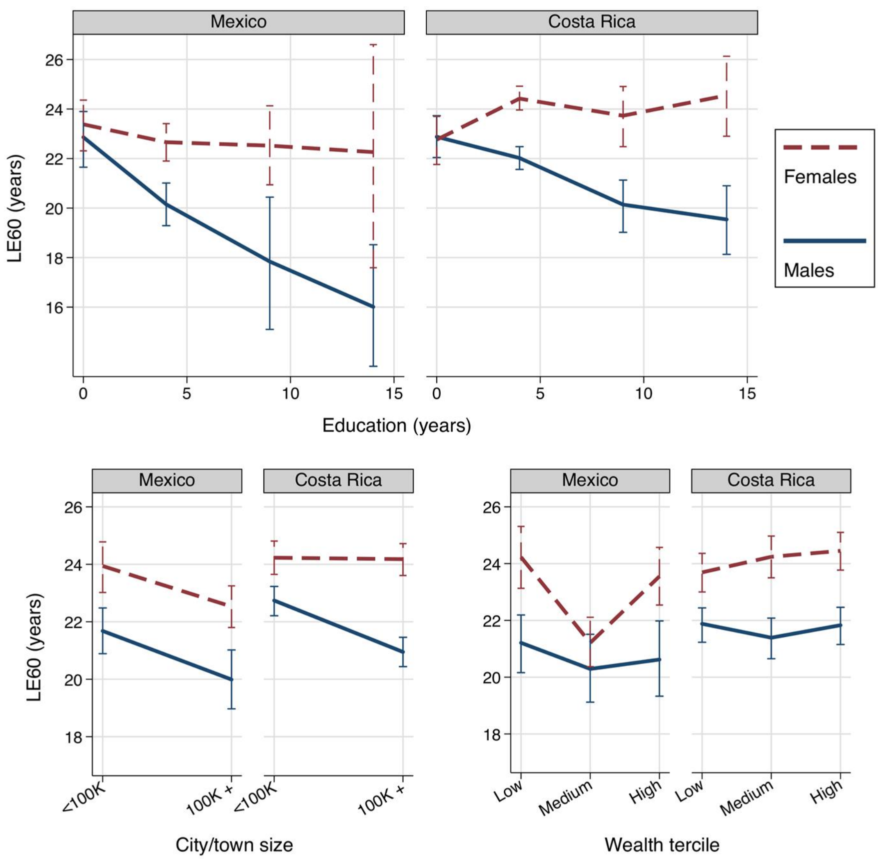
In parenthesis the 95% confidence interval.

Estimates from the multicountry projects LAMBdA and GBD tend to be out of range. LAMBdA yields substantially higher mortality (lower LE60) in the two countries. For example, LE60 of Mexican males is just 18.0 years according to LAMBdA. The LE60 GBD estimate is too high for Mexico and too low for Costa Rica.[6]

[6] A more detailed comparison of the age-specific death rates (instead of the summary LE60) is shown in Figure S2, included as supplementary material.

Figure 2 shows the resulting SES gradients in LE60. Strikingly, the expected gradients of higher LE60 with better SES do not show up in Figure 2, except among Costa Rican women. There are no significant differences in LE60 by education among Mexican women. Males in the two countries clearly show declining LE60 with increased education – a reverse gradient. Mexicans with postsecondary education, for example, have just 16.0 years (13.6–18.5 CI) of LE60 compared to 22.9 years (21.7–23.9 CI) for those with no education.

Figure 2: Life expectancy at age 60 (LE60) by gender and SES groups. Mexico and Costa Rica



Residents in large cities tend to have lower LE60, with the exception of Costa Rican women. For example, LE60 among Mexican males residing in cities larger than 100,000 inhabitants is 20.0 years compared to 21.7 years for people living in small towns or rural areas.

The stratification by three groups (terciles) of household wealth does not yield gradients, negative or positive, in LE60.

4. Discussion

Panels of approximately 7,000 older adults followed over more than a decade in Mexico and Costa Rica yielded direct and independent estimates of adult mortality that allow an assessment of existing estimates. Two results are apparent: (1) LE60 from these two panels is similar to the raw estimates from vital statistics in the two countries, and (2) SES gradients are lacking; moreover, some ‘reverse inequality’ shows up among males, with LE60 declining with increasing education or in large cities.

The lack of SES gradients challenges the assumption that SES-based inequality of mortality at older ages is similar to the inequalities documented for child mortality in Latin America (Behm 1980) or those observed among adults in developed countries (Mackenbach et al. 2008). Earlier Costa Rican studies had noted this lack of SES gradients among elderly Costa Ricans (Rosero-Bixby and Dow 2009; Rosero-Bixby and Dow 2016) as well as among the Hispanic population (which has a large Mexican component) in the United States (Turra and Goldman 2007; Lariscy, Hummer, and Hayward 2015). Consistent with these results, an analysis of cardiovascular risk factors (obesity, smoking, hypertension, and diabetes) with data from CRELES and MHAS found a weak or null association between the prevalence of these factors and education, particularly in rural areas, where reverse gradients even occur (Hummer et al. 2014). Another study using partial data from CRELES and MHAS found functional health levels comparable to the United States (Payne 2015).

The paradoxically high life expectancy of older Latin American males could very well be an expression of another paradox unveiled in this study: low-SES adults do not endure lower life expectancy.

Additional research is needed to determine the origin of these paradoxes. Part of the explanation could be the relatively low prevalence of obesity among older males in the region, particularly in rural areas. For example, the prevalence of obesity (BMI $\leq$ 30 kg/m^2) among elderly males in Costa Rica is 20%, compared to 38% in the United States (Rosero-Bixby and Dow 2016).

A different approach from the explanation that focuses on a risk factor would be explanations that focus on past survival to very high mortality rates in childhood and the corresponding selection of the fittest, which would have resulted in cohorts of older adults with gene mutations that are protective against some diseases. Examples of promising studies that take this approach are those of polymorphisms in the enzymes ACP1 (Gloria-Bottini et al. 2010) and G6PD (Manganelli et al. 2013) that protect against both cardiovascular diseases and some types of cancer. The key to these polymorphisms is that they are gender specific and more prevalent among malaria survivors, which would explain the concentration of exceptional longevity only in males from tropical countries. The survival-selection argument has been used to explain the black/white crossover in old-age mortality in the United States (Manton, Poss, and Wing 1979).

A third explanation is faulty data: age-misreporting and attrition-caused biases from excluding healthy out-migrants or individuals who were lost because of death. As mentioned before, age-misreporting does not exist in the CRELES data. Age errors in MHAS, assessed from comparing DoB reports in waves of 2001 and 2012, are lower than errors documented in census data (Preston, Elo, and Stewart 1999). Corrections of age errors in MHAS reduce little the LE60 estimates and essentially do not change SES gradients. Attrition of healthier out-migrants could be exaggerating some of the reverse SES gradients found especially in Mexico. In an extreme scenario of zero-mortality of dropouts, the contrast between education groups would cut by half in Mexican males. Attrition of high-mortality participants may be up-biasing LE60 estimates only in a few decimal points. Sensitivity analysis of these potential errors is included as supplementary material.

Strengths of estimates in this report are that rates were computed using information from the same source for the numerator (deaths) and denominator (population), which may be crucial in studying SES gradients, and the similarity of the results from two independent surveys. The estimates in this report also have the advantage that they did not require assumptions about population dynamics as those required by indirect methods. Notably, the estimates excluded the approximately six-month period immediately following the baseline contact, thus avoiding the possibility that ill individuals close to death were omitted from the sample.

A weakness of the estimates in this report is the noise from sampling errors that necessitate smoothing out the age-specific rates, which was performed with a Gompertz function. It must be noted, however, that this function is reputed to be a very good fit in the age range studied (Bongaarts and Feeney 2002).

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