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Descriptive Finding

Alternative estimates of the centenarian population in Argentina for census years 2001, 2010, and 2022

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Descriptive Finding

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Abstract

BACKGROUND
The rise in human longevity has brought increased academic attention to centenarians, a rare population group often subject to age misreporting.

OBJECTIVE
This paper compares the census counts of centenarians in Argentina in 2001, 2010, and 2022 with estimates derived from indirect demographic methods and alternative data sources.

METHODS
For the indirect estimation of the centenarians in 2001 and 2010 we use two methods: (1) an r-variable technique based on data from the censuses and life tables, with a battery of sensitivity analyses performed, and (2) a cohort reconstruction based on data from the vital registration system. For the estimation of centenarians in 2022, we use the COVID-19 vaccination database.

RESULTS
The indirect estimates of the centenarian population are similar to the censuses of 2001, 2010 and 2022.

CONTRIBUTION
The centenarian population counted in the censuses of 2001, 2010, and 2022 is quite reliable, although a slight overestimation cannot be ruled out. This pattern contrasts with that of Brazil, where centenarian overcounts are more substantial, despite both countries being geographically close and sharing broadly similar socioeconomic conditions. This underscores the importance of national context in shaping the quality of demographic data at very old ages.

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1. Introduction

The study of centenarians has gained increasing relevance in demographic research, driven by the global rise in human longevity and the growing number of individuals reaching extreme old ages. While much of the academic literature on centenarians centers on analyzing old-age mortality patterns and the upper limits of human longevity (Alvarez et al. 2021; Barbi et al. 2018; Kannisto 1994; Maier, Jeune, and Vaupel 2021; Ouellette et al. 2021; Robine and Vaupel 2002; Saito, Ishii, and Robine 2021; Vaupel and Jeune 1994), centenarians can also serve as a sensitive indicator of data quality. Because centenarians are exceptionally rare, even small errors in enumeration or age reporting can lead to large distortions. In this sense, the number of centenarians recorded in a census provides a valuable benchmark for assessing the accuracy and reliability of population data at advanced ages.

Centenarians can be viewed as a sensitive indicator of data quality. Because they represent the extreme upper tail of the age distribution, their presence in a population is highly subject to error in data collection and reporting. In contexts where birth registration was historically incomplete or age documentation is weak, the elderly tend to be overreported, often reflecting age exaggeration (Del Popolo 2000; Gomes and Turra 2009; Grushka 1996; Turra et al. 2023). For this reason, studying the centenarian population offers an indirect but powerful lens through which to evaluate the quality of censuses. While such issues are often more visible in low- and middle-income countries, they are not exclusive to these contexts. Overcounts of centenarians have also been documented in more developed economies, including Canada (Bourbeau and Lebel 2000), the United States (Meyer 2012), and Australia (Wilson and Terblanche 2018).

Argentina presents an interesting case for examining the quality of extreme age reporting. Its earliest census records show signs of age exaggeration: The 1869 census reported one centenarian per 7,450 inhabitants (Otero 2020), a proportion nearly twice as high as in the 2010 census and comparable to levels in 2022. Over the past decades, however, Argentina has made significant progress in developing its statistical and civil registration systems. Its national vital registration system is among the most complete in Latin America (Del Popolo and Bay 2021), and census-taking operations have become more standardized and professionalized. These improvements suggest that extreme age misreporting should have diminished in recent decades, yet little formal analysis has assessed this.

In Argentina, the censuses counted 1,900 centenarians in 2001, 3,500 in 2010, and 6,300 centenarians in 2022. In every year, around 80% are women, and the remaining 20% are men. The National Institute of Statistics and Census (INDEC) corrected these numbers very little in the population estimates for 2010 (INDEC 2013a).

Beyond national censuses, the United Nations World Population Prospects (WPP) has been a primary data source for estimating Argentina's centenarian population over recent decades. However, a longitudinal comparison of WPP revisions reveals significant inconsistencies: Centenarian estimates increased between the 2019 and 2022 editions, only to decrease in the 2024 revision (see Table 1). While an exhaustive analysis of these variations is beyond the scope of this study, such discrepancies underscore the urgent need for a more robust understanding of centenarian population trends in Argentina.

Table 1: Centenarians in Argentina in 2001, 2010 and 2022, censuses and UN WPP

	2001			2010			2022		
	Men	**Women**	**Total**	**Men**	**Women**	**Total**	**Men**	**Women**	**Total**
Census	347	1,508	1,855	784	2,700	3,484	1,409	4,884	6,293
WPP 2019	192	691	883	374	1,573	1,947			
WPP 2022	321	1,217	1,538	854	2,674	3,528			
WPP 2024	251	956	1,207	668	2,751	3,419	1,519	6,160	7,679

Source: Elaborated by the authors based on the population censuses of Argentina (INDEC) and United Nations (2019, 2022, 2024).

Understanding discrepancies in centenarian counts is crucial for several reasons. Population data by age and sex serve as the basis for calculating mortality rates, which are in turn used to construct life tables. Overestimated populations can lead to underestimated mortality and inflated life expectancies. These distortions affect actuarial calculations for pensions, annuities, and life insurance, and they also weaken the foundation for evidence-based health and social policies aimed at the elderly population.

How have centenarian counts improved in recent censuses? While it is evident that the overenumeration seen in the 1869 census has diminished, can the centenarian figures from the most recent censuses be considered reliable? This is a crucial research question, particularly given that neighboring countries like Brazil have experienced significant overcounts of centenarians (Gomes and Turra 2009; Nepomuceno and Turra 2020).

In this context, the present study contributes to the demographic literature by evaluating the enumeration of centenarians in Argentina's 2001, 2010, and 2022 censuses. By comparing official census counts with alternative indirect demographic estimates, we assess the plausibility of the reported figures and provide evidence on the quality of Argentina's census data at extreme ages.

2. Methods and data

2.1 r-variable

The first indirect method we use consists of an r-variable technique. We use this method to estimate the centenarians in 2001 and 2010, but not in 2022.

The discretized formula (Preston, Heuveline, and Guillot 2001) used to indirectly estimate centenarians is the following:

$$ {}_5N_x^* = {}_5N_y^* \, e^{-5\sum_{a=y}^{x-5} {}_5\bar{r}_a - 2.5\, {}_5\bar{r}_x} \, \frac{{}_5L_x^*}{{}_5L_y^*}, \tag{1} $$

where ${}_5N_x^* = \sqrt{{}_5N_x(t_1)\, {}_5N_x(t_2)}$ and ${}_5L_x^* = \sqrt{{}_5L_x(t_1)\, {}_5L_x(t_2)}$.

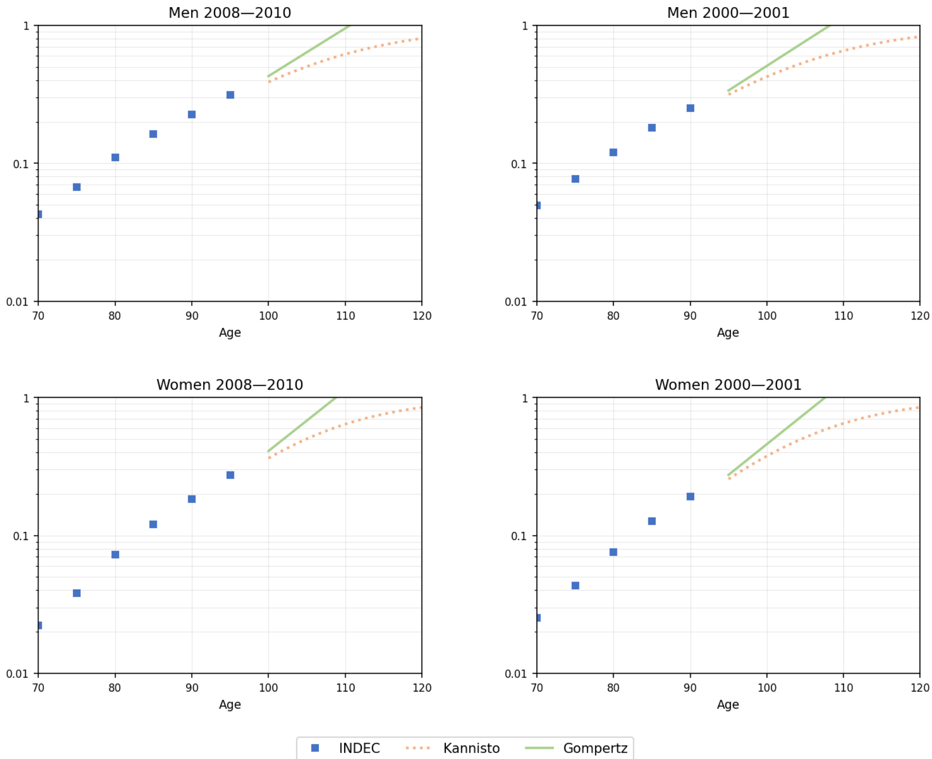
We will use this equation to estimate the population aged $[100, 105)$ based on the population aged $[50, 55)$ in the same year, then $[105, 110)$, $[110, 115)$, and $[115, 120)$, assuming no survivors beyond 120 years.

To apply the r-variable method, we use three inputs:

1. Population count for the base age group $[50, 55)$, taken from Argentina's 2001 and 2010 censuses.
2. Age-specific growth rates, calculated from population data in two adjacent census rounds: 1991 and 2010 for estimates in 2001, and 2001 and 2022 for estimates in 2010. A single age-specific growth rate for those over 90 years will be calculated since age-reporting issues are more prevalent at older ages.
3. Survivorship ratios, derived from life tables constructed for each census round, obtained from INDEC (2005) and INDEC (2013b). These tables end with an open age interval of $[95, \omega)$ for 2001 and $[100, \omega)$ for 2010. Since we needed survivorship ratios for more advanced ages, we extended the life tables using the Kannisto model (see Figure 1). For the 2001 estimates, the model was fitted using observed mortality data for ages 70 to 90; for the 2010 estimates, the fitting range was extended to ages 70 to 95. The fitted curves were then used to extrapolate survivorship ratios up to age 120.

It is important to note that the 2022 and 2010 censuses collected both age and date of birth, while the 2001 census recorded only age.

Figure 1: Extended m_x with different mortality models



Source: Elaborated by the authors.

We select the age group $[50, 55)$ as the base population because it represents a middle-aged adult group, minimizing several potential sources of bias. First, undercounts of young children are a well-documented issue in censuses worldwide (O'Hare 2015). Second, Argentinian adolescents and young adults are more likely to die from external causes, which can introduce additional uncertainty into our estimates (Santoro 2020). Third, age overstatement becomes increasingly common after age 60 (Del Popolo 2000). Fourth, international migration is more prevalent below 50 (Canales 2009; International Organization for Migration (IOM) 2024). Nonetheless, we provide sensitivity estimates using alternative base age groups and find that deviations from the main results are minimal.

2.2 Extinct cohorts

The second method we use for 2001 and 2010 is the extinct cohorts method (Vincent 1951), which involves summing the deaths of a cohort from a certain age (in this case, 100) until no members of that cohort remain alive.

To implement this method, we use death counts by age and year from the Dirección de Estadísticas e Información de la Salud (DEIS) under Argentina's Ministry of Health. The data contain individual counts of deaths by completed age and calendar year from 2001 through 2022.

Regarding coverage errors in vital statistics, Argentina has had an almost complete system for many years, although its quality might fluctuate from decade to decade (Jaspers 1994; Palloni and Pinto-Aguirre 2010). More recent evaluations confirm this high reliability: The estimated omission of deaths in Argentina between 1995 and 2015 was less than 3%, placing the country among the top four in the region, together with Chile, Cuba, and Uruguay (Del Popolo and Bay 2021).

2.3 COVID-19 vaccination database

For the 2022 census round we indirectly estimate centenarians using the COVID-19 vaccination database Ministerio de Salud de la Nación (2021), which records each vaccine dose since January 2021, including personal ID, age, sex, residence, and dose type. Every vaccine administered had to be registered.

To receive the vaccine, individuals presented their ID card with date of birth. As noted by Turra et al. (2023), this helps reduce errors from memory recall, proxy reporting, or low literacy. Age misreporting can still occur from late birth registrations, but these errors usually lower reported ages, meaning some centenarians may not appear as such. This reinforces that estimates from this source should be viewed as a lower bound since they include only those correctly recorded and who chose to vaccinate.

The campaign was free and widely publicized but voluntary, so some centenarians may have opted out. In the database, the group "≥ 100" includes 11,019 records in 2021, 4,010 in 2022, and 858 in 2023 (all doses). First-dose records peak in March 2021 with over 1,000, then decline until late 2022, leveling off just under 6,000. Given this pattern and the focus on the oldest first, we restrict to January–December 2021 and unique IDs. Assuming uniform mortality, estimates are taken as of July 1, 2021. For 68 cases (1.2%) without sex, we apportion proportionally to men and women.

3. Results

Table 2 presents the census counts and three indirect estimates of the centenarian population: the r-variable method, cohort reconstruction, and the COVID-19 vaccination database.

Table 2: Census counts and indirect estimates of centenarians in Argentina, years 2001, 2010, and 2022, by sex

	Men			Women			Total		
	2001	2010	2022	2001	2010	2022	2001	2010	2022
Census	347	784	1,409	1,508	2,700	4,884	1,855	3,484	6,293
r-variable	325	735		1,701	3,166		2,026	3,901	
Cohort reconstruction	303	602		1,256	2,541		1,559	3,143	
COVID-19 vaccination database			1,294			4,364			5,658

Source: Elaborated by the authors.

Overall, the results from the indirect methods show a high degree of consistency with the census figures.

For the years 2001 and 2010, the r-variable method consistently produces higher estimates than the cohort reconstruction technique. This divergence is a noteworthy pattern in our results and may reflect underreporting of deaths in the vital statistics system, overreporting of age in the censuses, or a combination of both. With the available data and methods, we are not in a position to determine which explanation is more likely. It is also worth noting that, in both 2001 and 2010, the r-variable method yields higher estimates than the census for women, while producing slightly lower estimates for men.

For the year 2022, the estimates derived from the COVID-19 vaccination database are broadly aligned with the census figures but are consistently lower. This difference is expected, given that COVID-19 vaccination was voluntary and coverage – although high – was not universal. The fact that the gap remains relatively small supports the plausibility of the 2022 census figures for the centenarian population.

We do not consider the COVID-19 vaccination database to be a gold standard. To assess the quality of this data source, we compared population counts for age groups other than centenarians – specifically 70–79, 80–89, and 90–99 – to those reported in the 2022 census. As shown in Table 3, the vaccination database yields population estimates that are remarkably close to the official census figures across all age groups and for both sexes. The COVID-19 counts are consistently slightly lower, as expected given that vaccination was voluntary and not all individuals were registered. This small and systematic undercount supports the idea that the database has high coverage and internal consistency. These findings give us confidence in using the COVID-19 vaccination data as a reliable basis for indirect estimation of centenarians.

Table 3: Census counts and indirect estimates of population from the COVID-19 vaccination database for other age groups

	Men		Women	
Age group	COVID-19 DB	2022 Census	COVID-19 DB	2022 Census
70–79	1,042,160	1,052,938	1,367,649	1,410,247
80–89	360,585	366,414	652,107	667,401
90–99	48,396	60,015	140,225	158,592

Source: Elaborated by the authors.

4. Sensitivity analysis for r-variable estimates

The sensitivity analyses discussed in this subsection have been previously detailed in Battocchio (2023), available for a more comprehensive explanation.

As results depend on the base population, the specific growth rates, and the survivorship ratios, we will compare alternative estimates under different assumptions to assess their sensitivity.

For the base population age group, we chose different age groups, ranging from $[55, 60)$ to $[85, 90)$. For the specific growth rates, we (1) smoothed them by applying a linear fit, and (2) calculated them on 10-year age groups.

For these two inputs, the sensitivity estimates are similar to the baseline. For the survivorship ratios, we took two alternative approaches: (1) extrapolating the mortality tables using the Gompertz formula, which assumes an exponential increase in the force of mortality, instead of the Kannisto formula, and (2) using the model life tables (MLTs) from United Nations (2011), specifically the Latino and general models based on life expectancy at age 50.

The extrapolation with Gompertz is, except in the case of males in 2010, the one that penalizes the centenarian estimation the most. The values are 33% lower in 2001, and a little over 10% lower in 2010, for both sexes, when compared to the baseline Kannisto extrapolation. These values are closer to those obtained from the reconstruction of extinct cohorts. Even so, the estimates with Gompertz remain higher than the estimates in the 2019 WPP (Table 4).

Table 4: Sensitivity estimates of the *r*-variable method

	Men				Women				Total			
	2001		2010		2001		2010		2001		2010	
Base population age group												
55–59	300	(–8%)	746	(2%)	1,565	(–8%)	3,215	(2%)	1,865	(–8%)	3,961	(2%)
60–64	295	(–9%)	750	(2%)	1,552	(–9%)	3,232	(2%)	1,847	(–9%)	3,982	(2%)
65–69	300	(–8%)	724	(–1%)	1,549	(–9%)	3,107	(–2%)	1,849	(–9%)	3,831	(–2%)
70–74	328	(1%)	718	(–2%)	1,695	(0%)	3,090	(–2%)	2,023	(0%)	3,808	(–2%)
75–79	330	(2%)	758	(3%)	1,651	(–3%)	3,215	(2%)	1,981	(–2%)	3,973	(2%)
80–84	309	(–5%)	803	(9%)	1,550	(–9%)	3,467	(9%)	1,859	(–8%)	4,270	(9%)
85–89	330	(2%)	822	(12%)	1,636	(–4%)	3,454	(9%)	1,966	(–3%)	4,277	(10%)
Age-specific growth rates												
Linear fit	334	(3%)	796	(8%)	1,830	(8%)	3,480	(10%)	2,164	(7%)	4,276	(10%)
Ten-year age groups	284	(–13%)	662	(–10%)	1,442	(–15%)	2,857	(–10%)	1,726	(–15%)	3,519	(–10%)
Survivorship ratios												
INDEC+Gompertz	217	(–33%)	653	(–11%)	1,137	(–33%)	2,747	(–13%)	1,354	(–33%)	3,400	(–13%)
Latino MLT	355	(9%)	486	(–34%)	2,037	(20%)	3,391	(7%)	2,392	(18%)	3,877	(–1%)
General MLT	365	(12%)	457	(–38%)	2,065	(21%)	3,605	(14%)	2,430	(20%)	4,602	(4%)
Baseline	325		735		1,701		3,166		2,026		3,901	

Source: Elaborated by the authors.
Notes: The percentages in parentheses represent the percent difference with respect to *r*-variable baseline results in Table 2. MLT = model life table.

The use of different survivorship ratios produces significantly different estimates of centenarians. The differences observed in the sensitivity analysis primarily stem from the fact that the mortality patterns embedded in the MLTs do not align closely with Argentina's actual old-age mortality. To better understand these discrepancies, we computed e_{80} and e_{100} for all life tables used, the WPP, and a log-quad model we fitted (Wilmoth et al. 2012). For e_{100} in 2008–10, our baseline estimates using the Kannisto extrapolation are 2.3 years for males and 2.4 years for females – well within the plausible range of 2.0–2.6 for males and 2.1–2.9 for females. These values fall between the official INDEC life tables (which are 0.3–0.4 years higher), the WPP estimates (slightly higher), and the extinct cohort method (somewhat lower). In contrast, the log-quad model yields estimates below 2.0, which appear too low to be viable alternatives. We obtained similar results for e_{80}.

Selecting an appropriate MLT is inherently difficult since the r-variable estimates are highly sensitive to the assumed mortality pattern. Models that diverge substantially from Argentina's old-age mortality can generate implausible results – for instance, the log-quad model yields zero male centenarians in 2001 and 2010. To address this, we relied on life tables whose e_{80} and e_{100} values are closest to those obtained with the Kannisto extrapolation. These baseline estimates are also supported by the close agreement with the extinct cohort approach.

5. Conclusions and discussion

Census counts of centenarians in Argentina align closely with estimates from indirect methods and alternative data sources. Sensitivity analyses suggest the results are robust to changes in age grouping and growth rate smoothing but more sensitive to the choice of survivorship ratios. Model life tables tend to yield higher estimates, while the Gompertz-based approach produces lower ones, closer to cohort reconstructions. Overall, census figures appear relatively reliable, with possible overenumeration likely below 20%, a modest level compared to other countries.

The accuracy of Argentina's census records presents a stark contrast to the demographic patterns observed in Brazil, where Nepomuceno and Turra (2020) and Gomes and Turra (2009) identify centenarian overenumeration exceeding indirect estimates tenfold. This discrepancy in the Brazilian context is primarily attributed to historical gaps in universal birth registration, which induce significant age misreporting among the oldest-old population (Turra et al. 2023). Conversely, the Argentine case aligns more closely with the high data quality standards of Costa Rica, where robust recordkeeping has validated survival rates among nonagenarians (Rosero-Bixby 2008). These findings indicate that Argentina's census data provide a plausible representation of its centenarian population, offering a reliable empirical foundation for further demographic research.

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