National Population Estimates and Projections 1950 - 2100

METHODOLOGY DOCUMENT

San José, Costa Rica
MARCH 2026

INSTITUTO NACIONAL DE ESTADÍSTICA Y CENSOS

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Development:
Process for the development of statistical outputs of the Demographic Statistics Unit

Technical Advisory:
Central American Population Center, University of Costa Rica
Latin American and Caribbean Demographic Center, Economic Commission for Latin America and the Caribbean

Design and Layout:
Graphic Production Process

304.6 Costa Rica. Instituto Nacional de Estadística y Censos
C837e National population estimates and projections 1950 – 2100 : methodology document [recurso electrónico] / Instituto Nacional de Estadística y Censos. – San José, Costa Rica : INEC, 2026.
1 recurso en línea (62 páginas).

Título original: Estimaciones y proyecciones nacionales de población 1950-2010: documento metodológico.

ISBN: 978-9930-641-10-1

1. Población. 2. Proyección demográfica. 3. Metodología. 4. Costa Rica.

Clarification note: Original publication: 2024 (Spanish version). English version published in 2026.

Presentation

This document provides a synthesis of the process involved in defining the base population for updating population estimates and projections 1950 - 2100, as well as the methodology developed for projecting each component of demographic change, namely mortality, fertility and migration, and finally the process for obtaining population estimates and projections by sex and age.

This is the result of a process of demographic reconciliation that covered the period 1950 - 2022, involving the analysis and evaluation of different sources of demographic data, including vital statistics, censuses, household surveys and various administrative records. Also, a projection methodology was also implemented to best align with the country's demographic dynamics.

In order to carry out the process of demographic reconciliation and defining the projection methodology, we received the valuable technical support of the Central American Population Center of the University of Costa Rica, CCP-UCR, through its experts M. Sc. Jorge Barquero Barquero, the Center's director, and Gilbert Brenes Camacho, PhD. In addition, we were accompanied in this process by Helena Cruz Castanheira, PhD, Population Officer, and Guiomar Bay, PhD, expert consultant, of the Latin American and Caribbean Demographic Center, CELADE-ECLAC. Financial support was also provided by the United Nations Population Fund. These institutions are considered strategic partners of INEC, since, over the years, they have offered their unconditional collaboration for the strengthening of our staff's technical abilities in demographic analysis and the development of relevant and quality official statistics.

INEC extends its sincerest gratitude to these entities, and to all the institutions of the National Statistical System (SEN) that collaborated by providing their databases for the development of this important product for the country.

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President
Directing Council

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Symbols and Acronyms

Symbols

(-)	a) in a box: indicates the amount is null or zero. b) between years (2005 - 2022): indicates the whole period, including the first year and the last year. c) preceding a number: indicates deficit or decrease.
(.)	Used to indicate decimals.
( )	Used to indicate thousands.
(fx)	Specific fertility rates.
(mx)	Specific mortality rates.

Acronyms and initialisms

CELADE	Latin American and Caribbean Demographic Center
CCP	Central American Population Center
DGME	General Directorate of Migration and Alien Affairs
PEP	Population estimates and projections
INEC	National Institute of Statistics and Census
MEP	Ministry of Public Education
NSS	National Statistical System
TFR	Total fertility rate
TSE	Supreme Electoral Tribunal
DSU	Demographic Statistics Unit
UNFPA	United Nations Population Fund

1. Introduction

The timely availability of socio-demographic data related to various groups and sectors that make up the population, according to their age and sex, is becoming increasingly relevant. This information turns out to an input for public policy planning and management.

The interrelationship between demographic, economic, social and environmental variables is well-known, as well as the fact that population, in its diversity, is not only a resource-demanding entity, but also a productive resource in itself and an active agent of sustainable development.

In this sense, having information to identify and characterize population and its future evolution becomes an opportunity for different entities, both governmental and private sector, to develop not only actions aimed at meeting their specific needs, but also actions aimed at taking advantage of this potential in order to facilitate inclusive and sustainable development processes that guarantee the full enjoyment of human rights for the entire population.

The impossibility of conducting continuous census surveys to meet these information requirements, due to the enormous technical, logistical and financial efforts that this entails, leads to the use of population projections as a feasible and effective alternative to estimate the population's future behavior.

This statistical product is based on the implementation of demographic, statistical and mathematical models that feed on information from administrative records, censuses and available surveys. Therefore, its calculation implies the design and development of a complete and recent diagnosis of demographic evolution, the selection of an appropriate model, not only from the reliability of calculations, but also from the availability of the inputs required to make assumptions about the future evolution of the components of demographic change.

Given the relevance of this statistical output and in compliance with the provisions of Law No. 9694, section 34, paragraph A, which establishes as INEC's competence the development of population statistics, such as population estimates and projections, vital statistics, among others, the INEC is carrying out a project called "Development of population estimates and projections and their monitoring". This project is focused on creating institutional abilities for the institution, specifically the Demographic Statistics Unit, to assume the development of this important product, establishing a methodology that fits the country's reality, that is robust and comparable, and that allows not only its preparation, but also its continuous monitoring and updating.

This document describes the main conceptual, methodological and technical aspects applied in the preparation of population estimates and projections. The first section describes the process that involved the estimation of the 2022 base population, its different stages and the reconstruction of the population in the past for the 1950 - 2022 period, which involved a significant process for the evaluation and reconciliation of sources of demographic information.

The second section describes the methodology used to project each of the components of demographic change, mortality, fertility and migration, as well as the procedure to obtain the projection of the population by sex and age for the 2023 - 2100 period.

Additionally, this document includes links to access the products derived from this process, such as those tabulated with the estimated and projected population, as well as some demographic indicators of interest.

2. Definition of Terms

K-means cluster analysis for functional data: consists of dividing a sample of n data $\{x_1,...,x_n\}$ into a certain number of groups. The criterion used to make groups is to try to have similar data in the same group and different data integrated into different groups. One of the procedures used to form these groups is the k-means method, which uses a non-hierarchical classification to group a dataset into k groups using the mean of such groups. (Ruiz, 2017, p. 8).

This grouping technique can be applied to functional data, which are those defined as continuous functions, rather than discrete points and can therefore be represented as a curve or function, usually in a time span. (Baragilly, Gabr, & Willis, 2021, p. 47).

Demographic reconciliation: set of demographic procedures through which the following processes are carried out: a) evaluating the coverage of each of the available population censuses; b) correcting sex and age distributions of censuses or other records that respond to differential omissions or poor declaration of age; c) reconciling the demographic dynamics at least for an inter-census period, seeking consistency of the available demographic data sources; and d) establishing a base population for the projection. (Rincón, 1982, p. 3).

It should be noted that a reconciliation process is not intended to reach an exact truth, but rather to achieve a diagnosis in which all the elements involved in determining an outcome are compatible with each other. (Rincón, 1982, pag. 4).

Lexis diagram: is used to represent demographic phenomena over time and facilitate the interpretation of several rates and other demographic indicators. It was introduced by the German statistician Wilhem Lexis in his book “Introduction to the Theory of Population Statistics”, written in 1875. The horizontal axis represents time t, and the vertical axis represents age x, from the moment of birth, although other variables could also be included, such as the duration of marriage or participation in any economic activity. If the two axes are measured on the same scale, each individual in a population is represented by a 45 degrees line on each of the axes, starting from age x equal to zero, and time of birth in t. As time passes, the point moves along the lifeline, which stops when the person dies. The horizontal lines of the diagram represent anniversaries or birthdays and the vertical lines represent the passage from one calendar year to another. (Ortega, 1987, p. 7-8)

Balancing equation: is a basic demographic formula used to estimate the total change of a population between two given dates, or to estimate any unknown component of population movement from other known components. The balancing equation covers all components of population movement: births, deaths, immigration and emigration. (Haupt & Kane, 1986, p. 56).

Logistic function: is the function that includes the theoretical values of the maximum and minimum population growth; that is, with this function, the assumption is made that with a maximum value (higher level) and a minimum value (lower level) of the logistic growth pattern, population can be projected. In other words, after a certain time, the population gradually stops growing until an upper limit is reached. On the contrary, after a certain time, the population will not be able to reduce from a lower limit. (Román, Navarrete, & Barreto, 2023)

Relative fertility method: a method that derives the foreign female population of childbearing age from the estimated fertility rates (fx), which are the result of applying the relative fertility observed in the census (ratio of the average live births of foreign women among this same indicator for Costa Rican women) to the fertility rates of Costa Rican women (fx).

Product-ratio method for coherent projections: coherent projections are called those that seek to model the relationship between the demographic rates of women and men. In the product/ratio method in functional data analysis, the functions that make up the geometric mean of the smoothed demographic rates of the groups (product) and the ratio of the rates of each group among the geometric mean are estimated.

Cycle methodology: a cycle is defined as a sequence of two movements, entry-departure or departure-entry. In this methodology, depending on the migratory category to be measured, the time- distance between the last movement and the cut-off date is analyzed, in which case if the distance between the last entry to the country and the cut-off date is equal to or greater than six months, the person is classified as a resident. On the other hand, if the distance between the last departure and the cut-off date is equal to or greater than six months, the person is classified as an emigrant.

3. Demographic reconciliation 1950 - 2022

3.1 Estimation of the preliminary base population

The preliminary base population is the population estimated as of June 30, 2022 and is based on a demographic methodology, which is supported on different data sources, mainly those from administrative records, such as the electoral register, the births master file[1/], the deaths master file [2/], the birth and death databases prepared by INEC, the entries and departures base of the General Directorate of Migration and Alien Affairs (DGME), school enrollment records of the Ministry of Public Education (MEP), and information from population censuses and household surveys.

This estimation was carried out in stages and through the application of the balancing equation. In a first stage, the national population was estimated, later, the population coming from another country, and finally, the emigrant population, in order to obtain the resident population in the country as of June 30, 2022.

Each one of these stages is explained below.

3.1.1 Estimation of the national population

The estimation of the national population was carried out in two sub-stages. First, an estimation of the population under 20 years old, and second an estimation of the population aged 20 years and over.

National population under 20 years old

This estimate was made by reconstructing births cohorts of population under 20 years old as of June 30, 2022, to which the mortality experienced during this period was applied. For this purpose, the INEC's births and deaths bases, corrected by late registration, were used.

For the correction of late registration, the following procedure was implemented:

1. A cross-referencing of the variables year of occurrence and year of registration (which corresponds to the year in which the death was declared) was performed.
2. Events in which the year of registration is greater than the year of occurrence correspond to late registration.
3. In order to estimate the proportion of the total events that are recorded late, a reference of ten years was taken, that is, the events recorded in the same year of occurrence and in the previous 9 years were selected.

1/ Database grouping all the births historically registered in the country.
2/ Database grouping all the deaths historically registered in the country.

4. When cross-referencing these two variables and presenting them in the form of a matrix, as shown in Box 3.1, which corresponds to a summary of the 1990 - 2000 period, it can be observed that by vertically adding it results in the number of events recorded in each year, regardless of their year of occurrence. On the other hand, if the horizontal sum is made, the events that occurred in one year are obtained, regardless of the year of registration. Finally, if the sum is made diagonally, the events occurred and recorded in the same year are obtained, that is, the timely record.

5. When analyzing this matrix, it is evident that the number of events that are registered one, two, three years and more, after occurring, decreased over time.

6. The implemented procedure assumes that, with certain adjustments, the number of events actually occurring for a certain year can be satisfactorily approximated by adding up all the events occurring in that year recorded in a given period, for example, 10 years (horizontal sum in Box 3.1).

BOX 3.1

Costa Rica. Total births by year of registration, by year of birth, 1990 - 2000

Year of birth	Births occurred	Year of registration										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total	**874 531**	**81 939**	**81 110**	**80 164**	**79 714**	**80 391**	**80 306**	**79 203**	**78 018**	**76 982**	**78 526**	**78 178**
Before 1990	6 513	3 645	1 283	701	302	241	158	105	64	14	-	-
1990	82 013	78 294	3 109	220	94	83	67	68	36	23	19	-
1991	79 491	-	76 718	2 159	175	174	66	47	54	35	30	33
1992	79 935	-	-	77 084	2 164	239	147	64	73	54	66	44
1993	79 471	-	-	-	76 979	1 938	185	112	95	56	55	51
1994	79 956	-	-	-	-	77 716	1 778	147	119	67	47	82
1995	80 078	-	-	-	-	-	77 905	1 762	170	87	77	77
1996	79 041	-	-	-	-	-	-	76 898	1 789	152	115	87
1997	77 539	-	-	-	-	-	-	-	75 618	1 646	160	115
1998	76 221	-	-	-	-	-	-	-	-	74 848	1 178	195
1999	78 216	-	-	-	-	-	-	-	-	-	76 779	1 437
2000	76 057	-	-	-	-	-	-	-	-	-	-	76 057

Source: INEC-Costa Rica. Vital statistics, 1990 - 2000.

7. The main limitation of this method is that for the most recent years the established series will always be incomplete, so we proceeded to estimate the ratio of events recorded late with respect to the timely registration, for each category, that is, one year late, two years late, three years late and so on up to 9 years late. This ratio is called $R_{z,i}$.

The registration ratio $R_{z,i}$ is defined as follows:

$$R_{z,i} = \frac{B_{z,i}}{B_{z,0}}$$

Where:

$B_{z,i}$: births occurring in year z registered i years later

$B_{z,0}$: births occurring in year z registered in the same year

8. Box 3.2 shows the $R_{z,i}$ obtained for the period 1975 - 2019. As can be seen, for the years 2011 - 2019, the series of ratios are incomplete and, therefore, these should be estimated based on the data observed in previous years.

BOX 3.2

Costa Rica. Values of $R_{z,i}$ ratios among registered births one, two, three and up to nine years later and births registered in the same year, 1975 - 2018

Year of birth	$R_{z,i}$								
	1	2	3	4	5	6	7	8	9
1975	0,0558	0,0041	0,0028	0,0017	0,0018	0,0026	0,0015	0,0008	0,0006
1976	0,0448	0,0062	0,0020	0,0019	0,0018	0,0014	0,0008	0,0007	0,0008
1977	0,0512	0,0033	0,0021	0,0020	0,0013	0,0010	0,0007	0,0007	0,0007
1978	0,0445	0,0034	0,0019	0,0014	0,0011	0,0008	0,0007	0,0008	0,0005
1979	0,0451	0,0035	0,0018	0,0013	0,0007	0,0008	0,0007	0,0005	0,0005
1980	0,0523	0,0031	0,0012	0,0009	0,0007	0,0007	0,0006	0,0004	0,0006
1981	0,0497	0,0023	0,0012	0,0010	0,0007	0,0007	0,0008	0,0008	0,0003
1982	0,0450	0,0023	0,0015	0,0011	0,0008	0,0008	0,0006	0,0005	0,0012
1983	0,0471	0,0024	0,0014	0,0009	0,0009	0,0008	0,0006	0,0015	0,0006
1984	0,0565	0,0029	0,0012	0,0011	0,0012	0,0009	0,0020	0,0012	0,0005
1985	0,0506	0,0027	0,0016	0,0012	0,0010	0,0020	0,0011	0,0005	0,0004
1986	0,0453	0,0024	0,0014	0,0007	0,0021	0,0013	0,0008	0,0006	0,0004
1987	0,0372	0,0029	0,0014	0,0019	0,0014	0,0006	0,0007	0,0005	0,0004
1988	0,0370	0,0021	0,0023	0,0016	0,0008	0,0007	0,0006	0,0005	0,0003
1989	0,0386	0,0039	0,0018	0,0008	0,0006	0,0006	0,0004	0,0005	0,0002
1990	0,0397	0,0028	0,0012	0,0011	0,0009	0,0009	0,0005	0,0003	0,0002
1991	0,0281	0,0023	0,0023	0,0009	0,0006	0,0007	0,0009	0,0004	0,0004
1992	0,0281	0,0031	0,0019	0,0008	0,0090	0,0007	0,0005	0,0006	0,0007
1993	0,0252	0,0024	0,0015	0,0012	0,0070	0,0070	0,0070	0,0070	0,0008
1994	0,0229	0,0019	0,0015	0,0009	0,0060	0,0110	0,0090	0,0060	0,0070
1995	0,0226	0,0022	0,0011	0,0010	0,0010	0,0013	0,0090	0,0100	0,0080
1996	0,0233	0,0020	0,0015	0,0011	0,0015	0,0009	0,0010	0,0080	0,0050
1997	0,0218	0,0021	0,0015	0,0014	0,0011	0,0013	0,0009	0,0050	0,0050
1998	0,0157	0,0026	0,0019	0,0011	0,0014	0,0013	0,0006	0,0050	0,0030
1999	0,0187	0,0026	0,0012	0,0012	0,0013	0,0010	0,0006	0,0040	0,0030
2000	0,0212	0,0021	0,0018	0,0015	0,0010	0,0008	0,0004	0,0030	0,0020
2001	0,0196	0,0036	0,0019	0,0012	0,0010	0,0008	0,0004	0,0030	0,0030
2002	0,0174	0,0024	0,0016	0,0015	0,0006	0,0005	0,0003	0,0020	0,0020
2003	0,0163	0,0022	0,0020	0,0005	0,0004	0,0004	0,0004	0,0003	0,0004
2004	0,0119	0,0025	0,0010	0,0006	0,0006	0,0004	0,0004	0,0006	0,0004
2005	0,0108	0,0014	0,0009	0,0007	0,0004	0,0005	0,0005	0,0004	0,0003

continues

Continues from Box 3.2

Year of birth	$R_{z,i}$								
	1	2	3	4	5	6	7	8	9
2006	0,0093	0,0012	0,0007	0,0005	0,0005	0,0008	0,0005	0,0003	0,0005
2007	0,0079	0,0012	0,0006	0,0004	0,0006	0,0006	0,0003	0,0003	0,0004
2008	0,0063	0,0009	0,0005	0,0006	0,0006	0,0006	0,0005	0,0003	0,0001
2009	0,0060	0,0006	0,0008	0,0006	0,0004	0,0003	0,0002	0,0001	0,0001
2010	0,0065	0,0009	0,0008	0,0004	0,0005	0,0005	0,0001	0,0001	0,0002
2011	0,0063	0,0008	0,0005	0,0005	0,0004	0,0001	0,0001	0,0001	
2012	0,0063	0,0007	0,0006	0,0004	0,0001	0,0001	0,0000		
2013	0,0050	0,0007	0,0005	0,0002	0,0001	0,0001			
2014	0,0052	0,0005	0,0003	0,0002	0,0001				
2015	0,0041	0,0004	0,0002	0,0002					
2016	0,0039	0,0002	0,0002						
2017	0,0044	0,0004							
2018	0,0054								

Source: INEC-Costa Rica. Vital statistics, 1975 - 2019.

9. To this end, an harmonic mean of the last three years is applied with observed data, as shown in Box 3.3. The above considers two main assumptions. The first, that there is a parallelism in the values of $R_{z,i}$ over time, and all converge toward a very small value; and the second, that the trend of the late record decreasing will maintain.

BOX 3.3

Costa Rica. Values of $R_{z,i}$ ratios among registered births one, two, three and up to nine years later and births registered in the same year, 2008 - 2019

Year of birth	$R_{z,i}$								
	1	2	3	4	5	6	7	8	9
2008	0,0063	0,0009	0,0005	0,0006	0,0006	0,0006	0,0005	0,0003	0,0001
2009	0,0060	0,0006	0,0008	0,0006	0,0004	0,0003	0,0002	0,0001	0,0001
2010	0,0065	0,0009	0,0008	0,0004	0,0005	0,0005	0,0001	0,0001	0,0002
2011	0,0063	0,0008	0,0005	0,0005	0,0004	0,0001	0,0001	0,0001	0,0001
2012	0,0063	0,0007	0,0006	0,0004	0,0001	0,0001	0,0000	0,0001	0,0001
2013	0,0050	0,0007	0,0005	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001
2014	0,0052	0,0005	0,0003	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001
2015	0,0041	0,0004	0,0002	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001
2016	0,0039	0,0002	0,0002	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001
2017	0,0044	0,0004	0,0002	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001
2018	0,0054	0,0003	0,0002	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001
2019	0,0045	0,0003	0,0002	0,0002	0,0001	0,0001	0,0000	0,0001	0,0001

Source: Box 3.2

10. In order to estimate the number of events that would be recorded late, this ratio is multiplied by the total events with timely registration, that is, occurred and recorded in the same year, as shown in Box 3.4.

BOX 3.4

Costa Rica. Observed and projected births, 2008 - 2019

Year of birth	Registered in the same year	Late registration									Total number of births ocurred
		1	2	3	4	5	6	7	8	9	
2008	74 284	465	66	34	43	42	45	35	21	5	75 040
2009	74 224	449	42	61	48	30	25	17	9	7	74 912
2010	70 212	456	63	58	28	35	34	7	7	11	70 911
2011	72 758	457	55	40	33	26	6	6	5	7	73 393
2012	72 503	455	53	41	32	7	6	1	7	8	73 113
2013	69 756	350	48	38	11	9	7	2	6	8	70 235
2014	71 181	371	37	19	14	9	6	2	6	7	71 652
2015	71 175	292	25	14	11	8	6	1	6	8	71 547
2016	69 479	272	17	13	12	9	6	2	6	8	69 823
2017	68 450	300	29	14	12	8	6	2	6	7	68 834
2018	68 069	365	22	13	11	8	6	2	6	7	68 510
2019	63 834	286	20	13	11	8	6	2	5	7	64 191

11. Finally, in order to obtain the corrected events for each year, the total number of events occurred (last column of Box 3.4) is taken.

Once the data on births and deaths were corrected, a Lexis diagram was prepared, which estimated the population aged 0 to 19 years as of January 1, 2022 and as of January 1, 2023.

To reconstruct this population as of January 1, 2022 using the Lexis diagram, births from the 2002 - 2021 period and deaths of children under 20 years old for the same period were used. In the case of the population as of January 1, 2023, births and deaths of children under 20 years old from 2003 - 2022 were used.

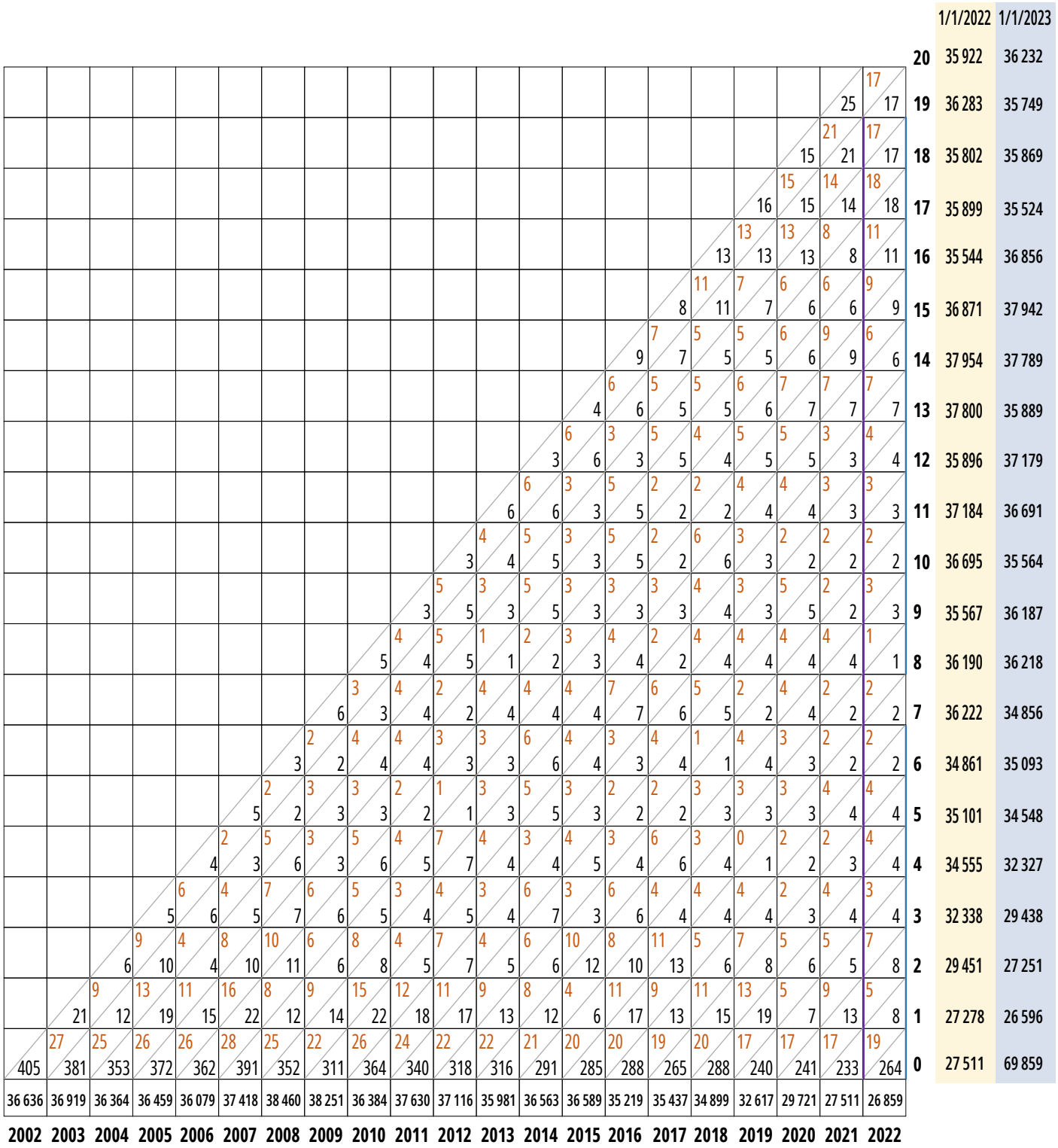
Preston separation factors (Preston, Heuveline, & Guillot, 2001) were used to obtain the proportion of deaths per year for each birth cohort.

Preston separation factor for children under 1 year old	
Men	
M_0 >/ = a 0,107:	0.33
M_0 < = a 0,107:	0.045 + 2.684 * M_0
Women	
M_0 >/ = a 0.107:	0.35
M_0 < = a 0.107:	0.053 + 2.800 * M_0

For the population aged 1 - 4 years old, Glover separation factors were used (Ortega, 1987, p. 31).

Glover separation factors				
x...	1	2	3	4...
f_x...	0.41	0.47	0.48	0.48

FIGURE 3.1
Costa Rica. Lexis diagram for population reconstruction of men under 20 years old as of January 1, 2022 and 2023



Source: prepared by the author.

A reconstruction of the population for men and a reconstruction for women were prepared and the total was obtained by adding.

In order to obtain the mid-term population (June 30, 2022), the exponential growth formula was used.

$$P_f = P_i * e^{rt}$$

Where:

P_f : population under 20 years old as of January 1, 2023

P_i : population under 20 years old as of January 1, 2022

r : growth rate between both periods

t : period to which it is necessary to move population, which in this case is mid-year.

To apply this formula, first r had to be calculated, which is obtained by clearing the same formula:

$$r = \log \frac{P_f}{P_i} / t$$

This estimation resulted in a population of 1 353 234 nationals under the age of 20, of which 689 591 are men and 663 644 are women.

National population aged 20 and over

This population was estimated on the basis of the electoral roll, which was adjusted by matching, by ID number, with the deaths master file. It should be noted that only one case was identified, that is, one person whose death was in the deaths master file, but was active in the electoral roll. This case was eliminated from the estimate. Finding only one event with these characteristics is an indicator of the quality of this record.

Finally, to obtain the total national population, the population aged 0 to 19 and 20 years old and over were added. The estimated national population was 4 715 600 persons.

3.1.2 Estimation of the foreign population

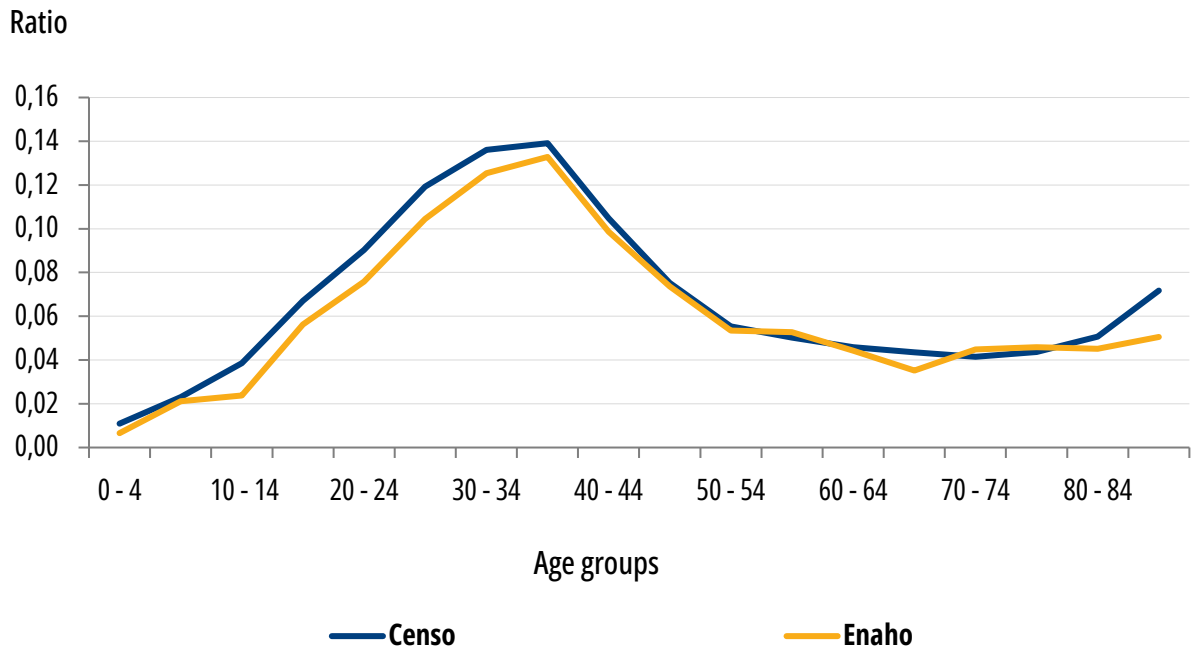
The foreign population was estimated in two stages, first the Nicaraguan population was estimated, because it is the largest in the country, and then the rest of the foreign population.

Nicaraguan population

First, the ratio of Nicaraguan population and Costa Rican population for each age and sex was obtained, both the one observed in the 2011 census and in the 2022[3/] census. These ratios obtained from the censuses were evaluated with the ratios derived from the information provided by the 2011 and 2022 National Household Surveys. As can be seen in Charts 1 and 2, the structures by sex and age are consistent between the 2011 census and ENAHO 2011. In the case of 2022, despite the coverage problems of the 2022 census, when comparing the structures with those of ENAHO 2022, these are also consistent.

CHART 3.1

Costa Rica. Population ratio of Nicaraguan and Costa Rican men, 2011

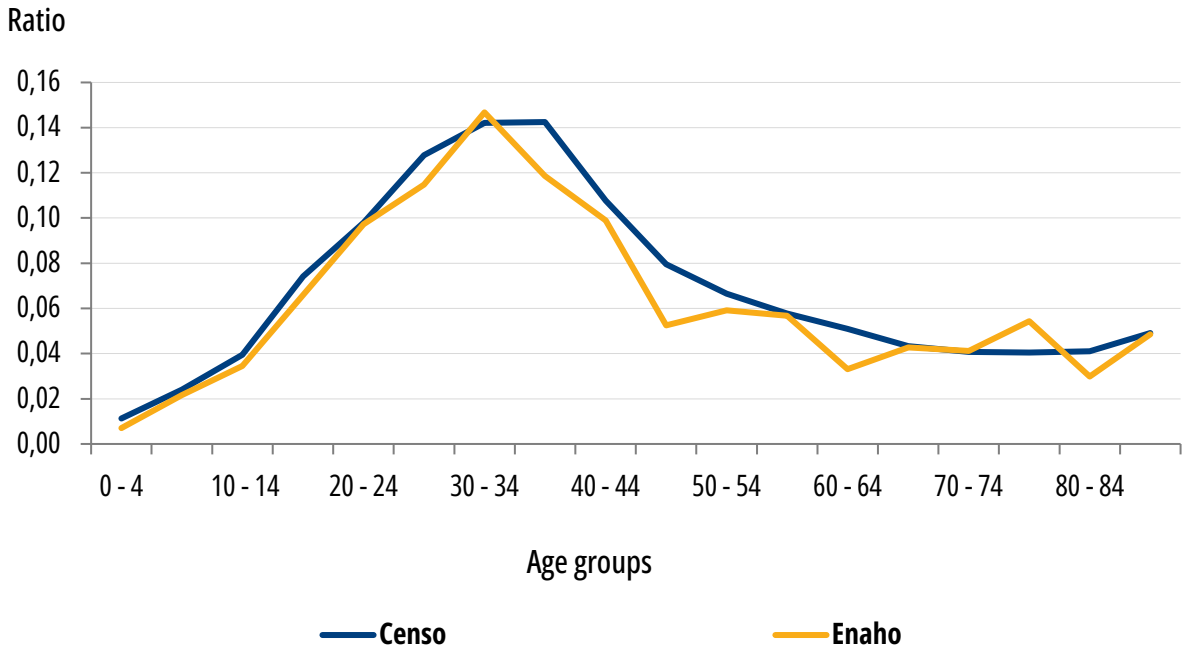


Source: INEC-Costa Rica. National Population Census 2011 and National Household Survey 2011.

3/ This estimate corresponds to a variation of the method used by Dr. Brenes in 2013 to estimate the foreign population, which was based on the relative fertility method, which derives the foreign female population of childbearing age from the estimated fertility rates (f_{xi}), which are the result of applying the relative fertility observed in the census, (ratio of the average of live children born to foreign women among this same indicator for Costa Rican women) to the fertility rates of Costa Rican women (f_x), to estimate the fertility rate of foreign women. Thus, once the rate is obtained with the births from foreign mothers, the formula is cleared from f_x to obtain the female population. The male population is obtained by applying the sex ratio of the mortality tables. This method was not used since in recent years it overestimated the underaged population of childbearing age, since the fertility rate of young women experienced a considerable decline in recent years.

CHART 3.2

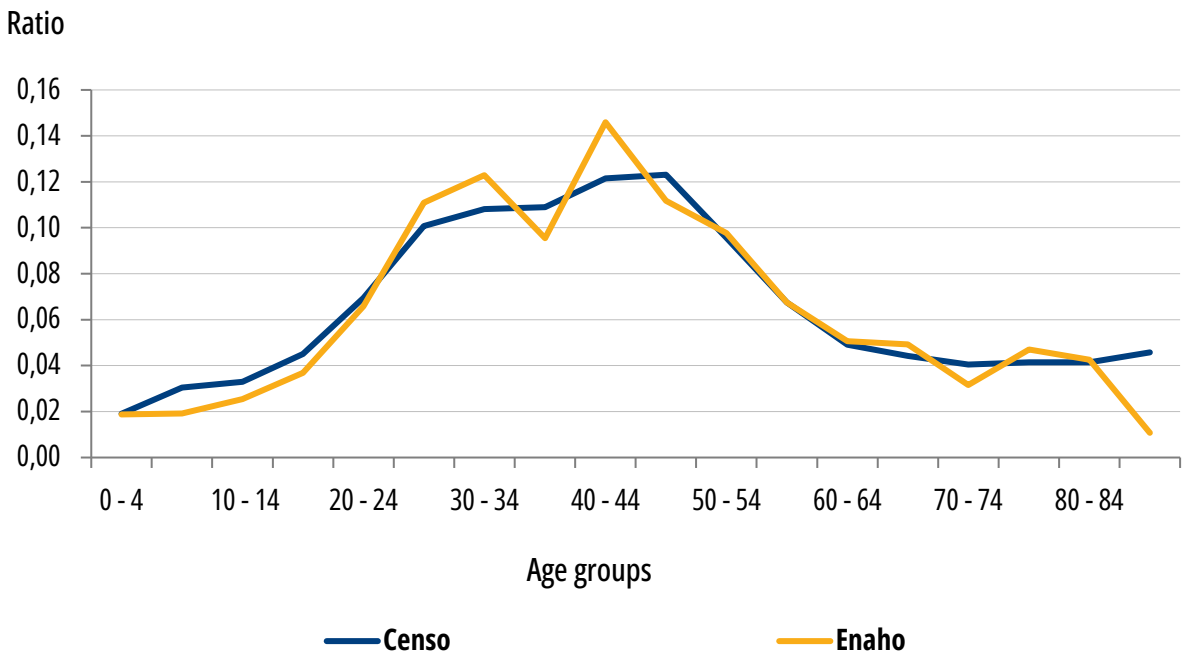
Costa Rica. Population ratio of Nicaraguan and Costa Rican women, 2011



Source: INEC-Costa Rica. National Population Census 2011 and National Household Survey 2011.

CHART 3.3

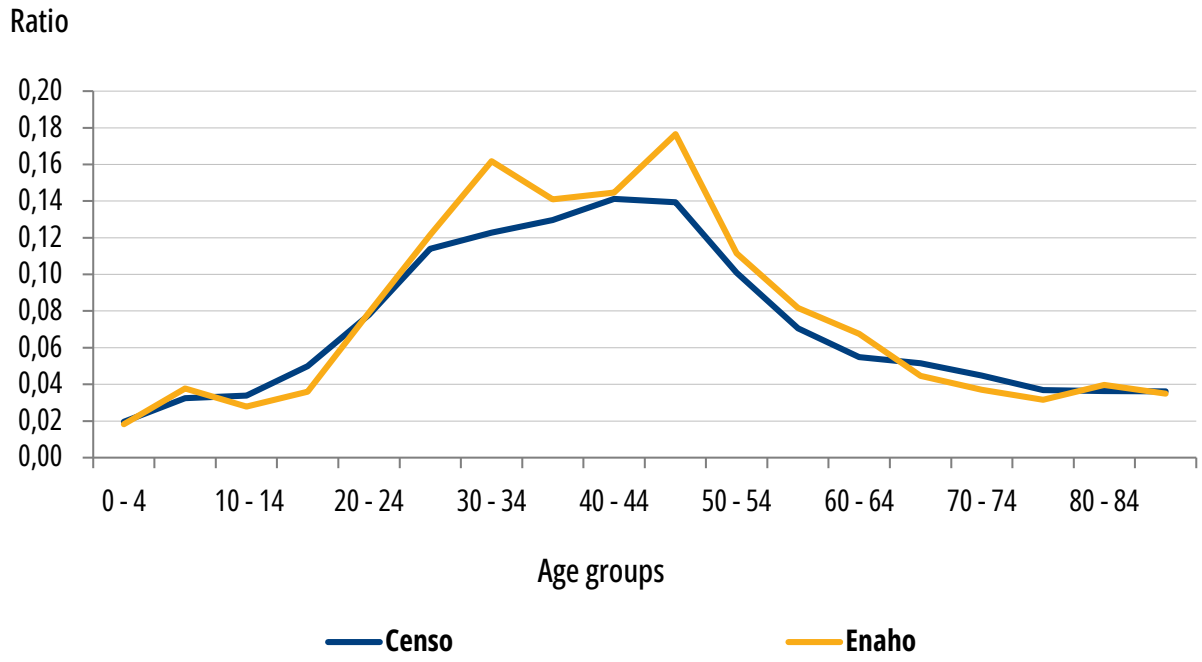
Costa Rica. Population ratio of Nicaraguan and Costa Rican men, 2022



Source: INEC-Costa Rica. National Population Census 2022 and National Household Survey 2022.

CHART 3.4

Costa Rica. Population ratio of Nicaraguan and Costa Rican women, 2022



Source: INEC-Costa Rica. National Population Census 2022 and National Household Survey 2022.

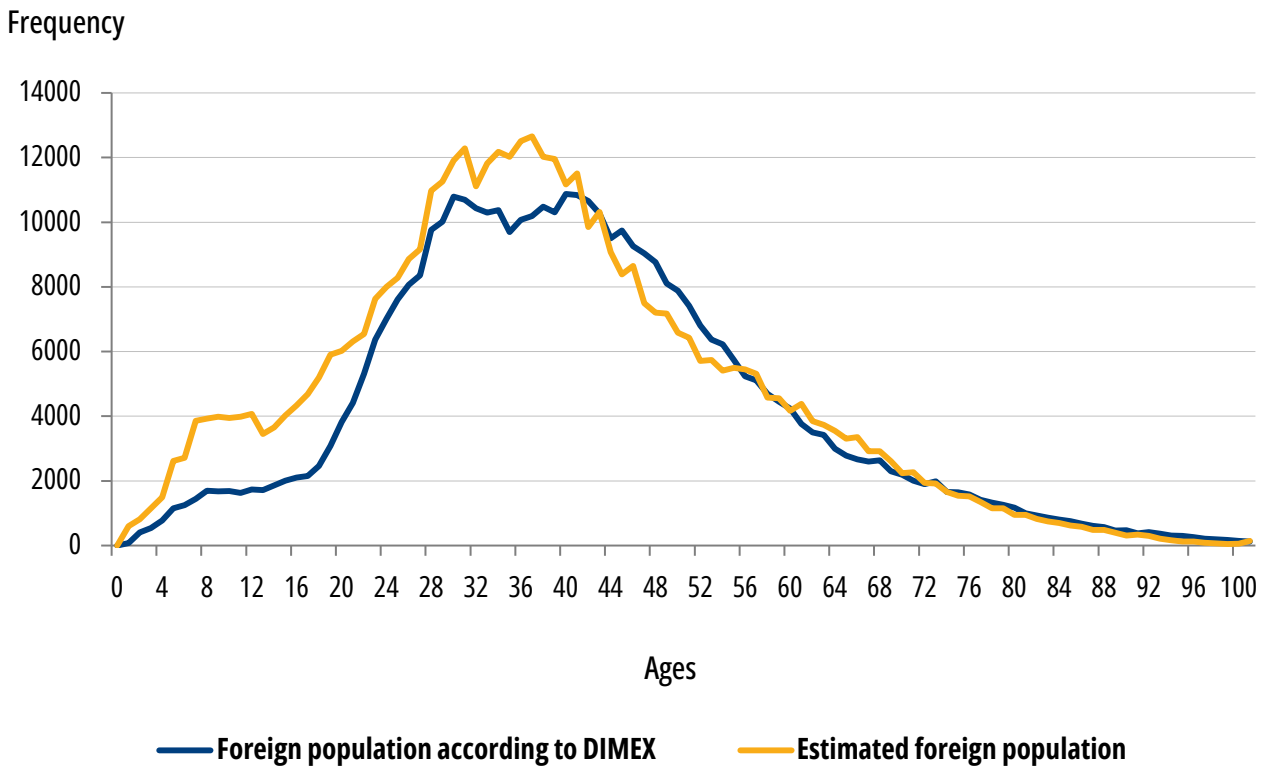
Both sets of ratios were averaged for each age and sex, then the specific average obtained for each age and sex was multiplied by the corresponding national population, thus obtaining the total Nicaraguan population. The same procedure was carried out with the ratio of foreign population from other countries to obtain the total population.

In order to validate this estimate, a comparison was made with the foreign population registered in the DIMEX[4/] database.

Chart 3.5 shows the age distribution of the foreign population recorded in the DIMEX databases and the estimated population. First, the population registered in the DIMEX database is observed to be smaller than the estimate, as is expected, since not all foreigners carry out the process to obtain this identification. In addition, it shows that this population is slightly older. This is also expected, since it is possible that some time elapses between the time of entry to the country and the completion of the process to obtain the identity document.

4/ Identity document for foreigners.

CHART 3.5
Costa Rica. Total foreign population estimated by sources of information, 2022



Source: prepared by the author with data from the General Directorate of Migration and Alien Affairs.

Subsequently, a validation of the estimation of foreign school-age population was carried out with the data of the foreign population of this same age registered with the school enrollment bases of the MEP.

BOX 3.5
Costa Rica. School aged population registered with the Educational System and estimated school aged population, 2022

Cycle	Students in the Educational System		Estimated school aged population	
	Nationals	Foreigners	Nationals	Foreigners
Pre-school	129 814	5 177	133 721	4 225
Cycle I and II	432 195	23 739	423 181	17 490
Cycle III and diversified education	385 256	18 084	431 535	25 347

Source: Ministry of Public Education, students enrolled in the Costa Rican Educational System, 2015 - 2022 and Educational Centers Roll, 2022.

As evidenced in Box 3.5, when comparing the foreign population registered with the MEP and that derived from the estimate, in the group of 4 to 12 years old, corresponding to preschool, and cycles I and II, the estimate is lower than this population. Therefore, an adjustment was decided using the ratios of foreigners for each Costa Rican person derived from the MEP information.

In addition, it is observed that, for the 7 to 12 age group (corresponding to cycles I and II), the Costa Rican population registered with the MEP is larger than the estimated population, so a 2.3 percent adjustment was applied.

The following box shows the result of this adjustment.

BOX 3.6

Costa Rica. School aged population registered with the Educational System and estimated adjusted school aged population, 2022

Cycle	Students in the Educational System		Estimated adjusted school aged population	
	Nationals	Foreigners	Nationals	Foreigners
Pre-school	129 814	5 177	133 721	5 333
Cycle I and II	432 195	23 739	432 491	23 756
Cycle III and diversified education	385 256	18 084	431 535	25 347

Source: Ministry of Public Education, students enrolled in the Costa Rican Educational System, 2015 - 2022 and Educational Centers Roll, 2022.

Finally, a total foreign population of 474 192 persons (9.3%) was obtained, 232 865 men and 241 327 women.

3.1.3 Estimation of the Costa Rican emigrant population

Costa Rican emigrant population over 20 years old

To estimate the Costa Rican emigrant population, the DGME entry and departure base was used. Using the cycles methodology [5/], only coherent cycles were taken, i.e. those where the last movement was a departure within 6 months[6/] or more as compared to June 30, 2022, which is the cut-off date.

5/ A cycle is defined as a sequence of two movements, for example: entry-departure or departure-entry.
6/ Regarding the cut-off date, which is June 30, 2022.

An important aspect to note is that the number of departures was limited to three, in order to filter cases of persons who, having many movements, appear to be international tourists or entrepreneurs, rather than emigrants.

To this methodology were added single movement cycles (departure) which had to have been performed six months or more since the cut-off date.

The departures of persons over 100 years old were prorated, as well as cases with no date of birth.

Once filtered the cases that met the above criteria, a data cleaning was carried out in two phases:

1. Review of duplicate records by exact match of identity number, full name and date of birth.
2. Manual review of duplicates by approximate match of identity number, first name, last name and date of birth.

In the first phase, the duplicate registration or records per person were discarded according to the exact match in the identity card number, and secondly, the records in which there was a coincidence in the full name and date of birth were identified and excluded, respectively. It should be noted that, at this stage, a link was made with the deaths master file to rule out cases in which it would be determined that this person is no longer alive and, applying a similar procedure to the above, records with exact matches in the identity number and full name were excluded. Once this procedure was performed, the preliminary number of Costa Rican emigrants was obtained.

Taking into account that a characteristic of the electoral roll is its updating every 10 years, it was accepted the assumption that Costa Ricans who left the country before 2013 were not on the electoral roll as of June 30, 2022. Therefore, this estimate considered only Costa Rican emigrants from January 1, 2013 to June 30, 2022 (cut-off date).

Since the entry and departures base had allegedly duplicate records, which were not captured due to exact matching of identity card and name, the second phase of the data cleansing process was carried out, which consisted of a review of each entry and departure base record resulting from the previous phase with the data of the national electoral roll (consultation system) and voting roll abroad.

In cases where allegedly repeated records were found, that is, those with high matching in some digits of the identity number, in the first name, last name or date of birth, we proceeded to review the TSE consultation system to determine the correct registration in the entries and departures base. Although the presence of the record on the electoral roll may mean that the person is residing in the country, as the record is updated every 10 years, the entries and departures information was taken as valid, since it has been more recently updated (monthly).

Once the case was identified, if there was missing or incorrect information (identity card number, first name, last name and date of birth) in the entry and departure base, it was corrected according to the TSE information. Also, through this consultation, records of deceased persons were identified, which were excluded from the estimate of emigrants.

In parallel, a validation was carried out with the voting register abroad[7/] to determine coincident cases according to the above mentioned identification variables. In the event of a coincidence, the emigrant status was confirmed.

Costa Rican emigrant population under 20 years old

Since the entry and departure bases at the date of this estimate did not include data on minors, an estimate was made using a ratio of emigrant population over the Costa Rican resident population, derived from the 2022 census, since the 2011 census did not have the information by sex and age of emigrants.

To evaluate the 2022 census ratio, the same ratio was estimated, but with the data of emigrants over the age of 20 and the Costa Rican resident population. This estimate was compared with that of the census and the difference was calculated, that is, how much the census underestimated this ratio.

Finally, to estimate the minor emigrant population, the average emigrants/residents ratio of ages 20 - 24 from entries and departures was used to adjust the censuses ratio, as it is the closest group.

The total estimated emigrant population was 93 807 persons, 45 460 men and 48 347 women.

3.1.4 2022 base population

To obtain the total population residing in the country as of June 30, 2022, the balancing equation was applied, using the following formula:

Total population = national population + foreign population - emigrant population

As shown in Box 3.7, the estimated final population as of June 30, 2022 was 5 104 907. Some demographic indicators of this population are shown in Box 3.8.

7/ As of June 30, 2022, the voting register abroad registered 56 435 persons. It should be noted that not all persons register with the consulates of their country of residence with the intention to vote, therefore this register is considered to underestimate the national emigrant population.

BOX 3.7

Costa Rica. Base population by sex, according to age groups, June 30, 2022

Age groups	Total	Men	Women
Total	**5 104 907**	**2 551 111**	**2 553 795**
0 - 4	295 847	150 089	145 758
5 - 9	370 903	189 005	181 898
10 - 14	381 344	194 822	186 522
15 - 19	379 566	193 035	186 530
20 - 24	402 987	204 702	198 285
25 - 29	430 713	218 436	212 277
30 - 34	438 093	221 784	216 309
35 - 39	422 038	211 652	210 386
40 - 44	362 403	180 383	182 019
45 - 49	298 133	148 283	149 849
50 - 54	282 885	139 821	143 065
55 - 59	279 225	137 583	141 643
60 - 64	240 932	117 996	122 936
65 - 69	187 588	90 918	96 670
70 - 74	132 102	62 891	69 211
75 - 79	90 181	42 238	47 944
80 - 84	57 215	25 963	31 253
85 - 89	32 503	13 642	18 861
90 - 94	15 165	5 964	9 201
95 - 99	4 554	1 720	2 834
100 years old or	529	185	344

Source: INEC-Costa Rica. National population estimates and projections 1950-2100, July 2024.

BOX 3.8

Costa Rica. Main demographic indicators of the base population, 2022

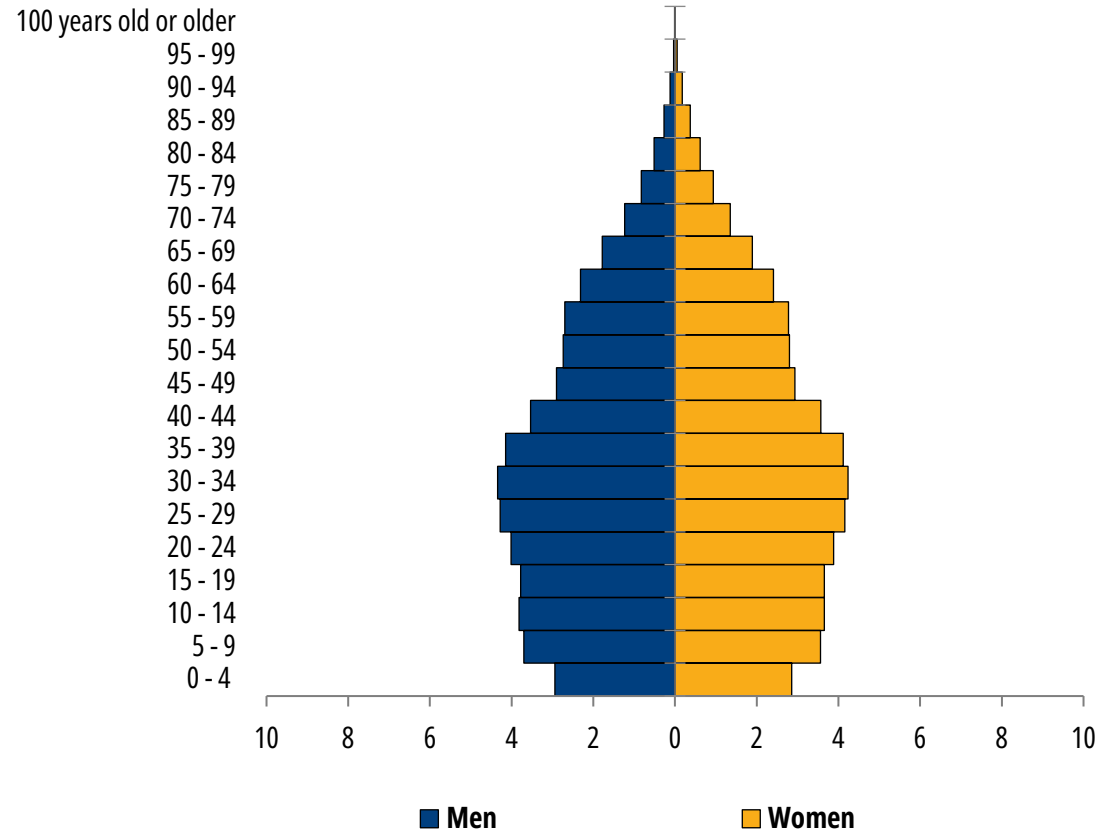
Demographic indicators	
Male/female ratio (male/female every per cent)	99,9
Demographic dependency ratio [(<15 +65 y+)/(15-64) per cent]	44,3
Aging index (65+/<15 per cent)	49,6
Aging index (85+/<15 per cent)	5,0
Average age	34,8
Median age	33,0

Source: INEC-Costa Rica. National Population Estimates and Projections 1950 - 2100, July 2024.

The following chart shows the estimated base population pyramid.

CHART 3.6

Costa Rica. Percentage distribution of population by sex and age groups, June 30, 2022



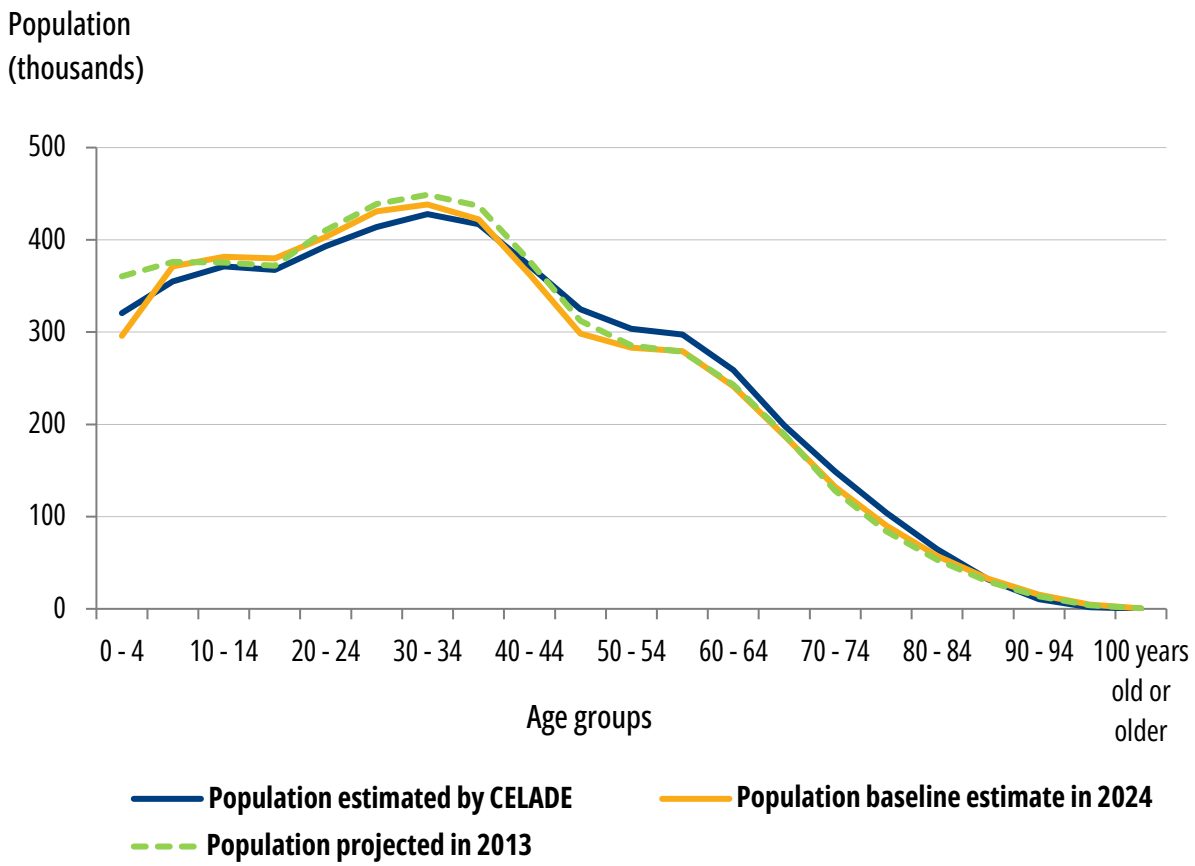
Source: Box 3.7

In order to validate this population, we compared, in terms of structure by sex and age, the 2022 population derived from estimates and projections made by CELADE and current projections. As shown in the following chart, the total base population and by sex reproduces the structure of the current projections and those of CELADE. In the case of men, the current projection estimates more population at ages 20 to 44. It should be noted that the base population shows the impact of the decline in fertility in the first two age groups, which the current projections do not reproduce, since the decline in fertility was sharper than expected.

The following charts show the estimated base population and the current projected population (calculated in 2013) as of June 30, 2022, for the total, men and women, respectively.

CHART 3.7

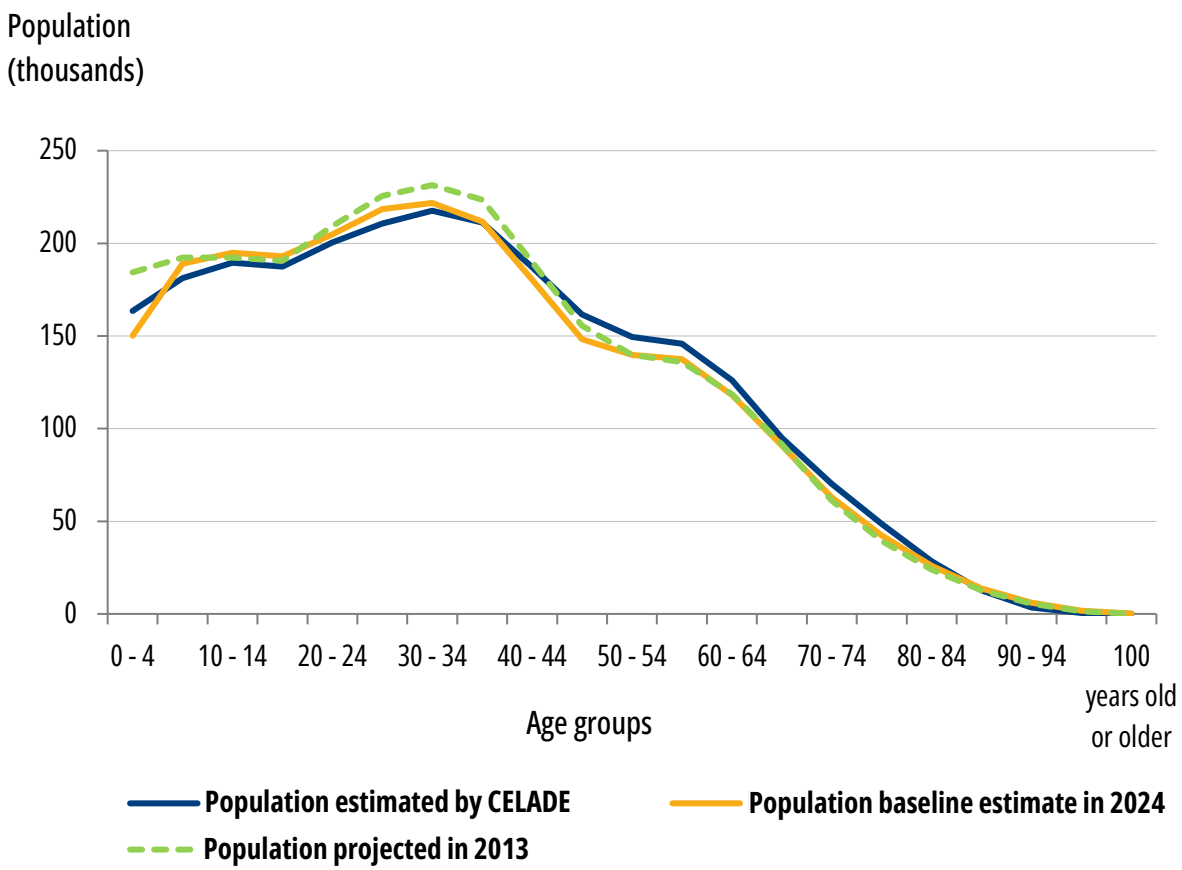
Costa Rica. Total estimated and projected population by source of information, June 30, 2022



Source: CELADE-ECLAC. ECLACSTAT statistical databases and publications, demographic and social indicators;
INEC-Costa Rica. National population estimates and projections, March 2013 and national population estimates and projectior 1950 - 2100, July 2024.

CHART 3.8

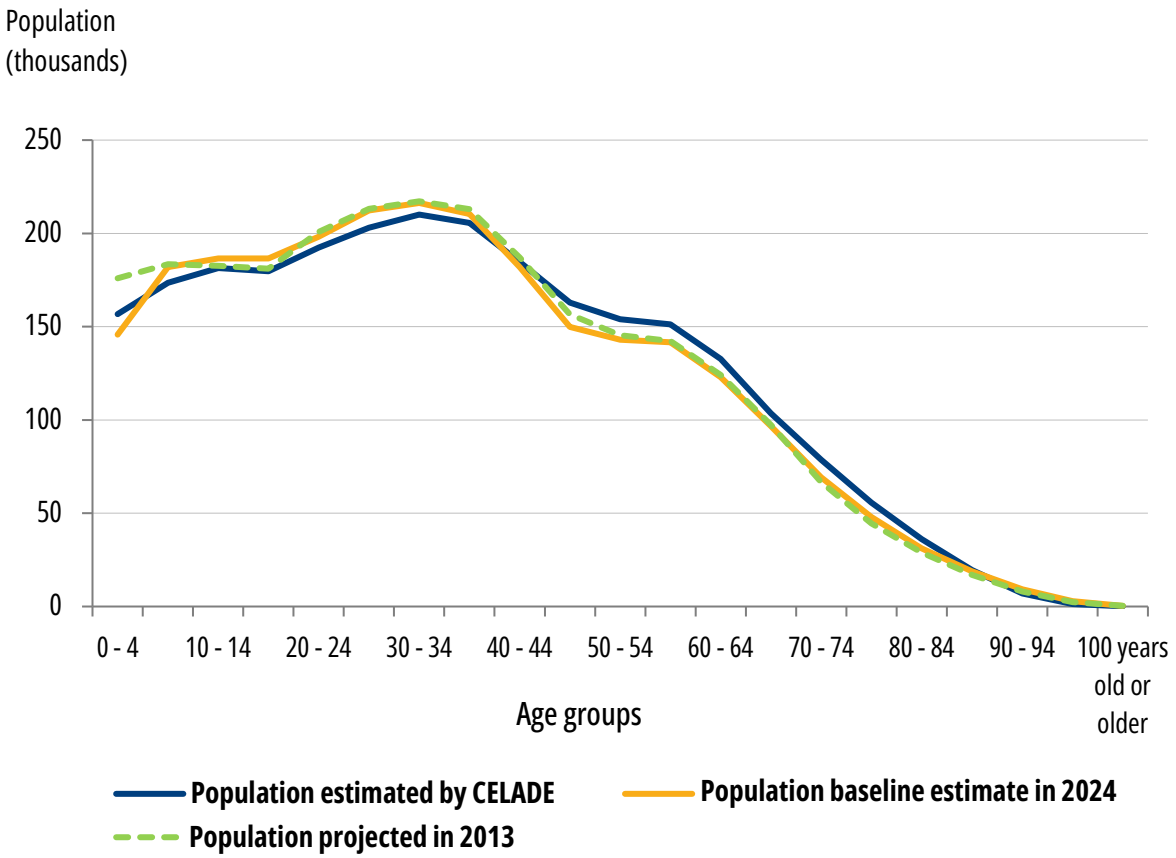
Costa Rica. Estimated and projected men population by source of information, June 30 2022



Source: CELADE-ECLAC. ECLACSTAT statistical databases and publications, demographic and social indicators; INEC-Costa Rica. National population estimates and projections, March 2013 and national population estimates and projections 1950 - 2100, July 2024.

CHART 3.9

Costa Rica. Estimated and projected women population by source of information, June 30 2022



Source: CELADE-ECLAC. ECLACSTAT statistical databases and publications, demographic and social indicators; INEC-Costa Rica. National population estimates and projections, March 2013 and national population estimates and projections 1950 - 2100, July 2024.

When analyzing the ratios by sex, as shown in Box 3.9, there is a greater similarity with CELADE projections up to age 60 and over. This indicator shows a behavior closer to what is expected theoretically, that is, some ratios by sex close to 100, which decrease in older ages due to a greater survival of women, although in the CELADE projections the gap between sexes is wider and wider in the older ages.

BOX 3.9

Costa Rica. Sex ratio of total estimated and projected population, June 30, 2022

Age groups	Population sex ratio		
	Estimated by CELADE	Estimated base in 2024	Proyected in 2013
Total	**100,0**	**99,9**	**101,4**
0 - 4	104,3	103,0	104,8
5 - 9	104,4	103,9	104,8
10 - 14	104,5	104,5	105,3
15 - 19	104,3	103,5	105,2
20 - 24	104,3	103,2	104,2
25 - 29	103,7	102,9	105,9
30 - 34	103,6	102,5	106,5
35 - 39	102,7	100,6	104,9
40 - 44	101,3	99,1	101,5
45 - 49	99,2	99,0	99,4
50 - 54	97,1	97,7	96,1
55 - 59	96,5	97,1	95,5
60 - 64	95,0	96,0	95,5
65 - 69	91,8	94,0	94,0
70 - 74	89,2	90,9	91,9
75 - 79	87,1	88,1	88,3
80 - 84	78,7	83,1	82,6
85 - 89	64,6	72,3	74,9
90 - 94	50,3	64,8	68,3
95 - 99	38,7	60,7	58,6
100 years old or old	30,3	53,9	48,8

Source: CELADE-ECLAC. ECLACSTAT statistical databases and publications, demographic and social indicators; INEC-Costa Rica. National population estimates and projections, March 2013 and national estimates and projections 1950 - 2100, July 2024.

Subsequently, a reconciliation was carried out with different data sources that would allow the population to be reconstructed for the estimation period 1950 - 2022, as discussed below.

3.2 Reconstruction of the national population 1950 - 2022

To estimate the population for the 1950 - 2021 period, a reconstruction process was carried out, starting from the 2022 base population. Therefore, a retroprojection was made, that is, the population is taken to the past by applying the balancing equation, reproducing the cohorts that gave origin to such base population.

To carry out this process, the base population was taken to January 1, 2022, in order to be able to apply annual deaths and net migratory balances. To the base population, deaths occurred from January to June, corrected by late registration [8/] were added, and half of the annual net migratory balance was subtracted, assuming a homogeneous distribution.

Once the population as of January 1, 2022 was obtained by age and sex, the cohorts were reconstructed using the following formula:

$$P_{(x-1)\ y-1} = P_{(x)\ y} + (D\theta_{(x-1)\ y} + D\alpha_{(x)\ y}) - SNM_{(x)\ y}$$

Where:

$P_{(x-1)\ y-1}$: population aged x-1 in year y-1

$P_{(x)\ y}$: population aged x in year y

$D\theta_{(x-1)\ y}$: age x-1 deaths occurred during the year and belonging to the previous cohort.

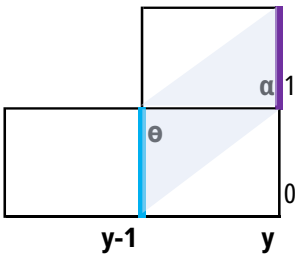
$D\alpha_{(x)\ y}$: period to which it is necessary to move population, which in this case is mid-year.

To determine the proportion of deaths that correspond to each cohort, Preston separation factors for children under one year old, Glover separation factors for ages 1 to 4, and a 0.5 separation factor from age 5 and above were used.

Figure 3.2 exemplifies the application, in the Lexis diagram, of deaths separation factors to obtain the proportion corresponding to each cohort (light blue shade) that allows to obtain the population of 0 years in year y-1 (right vertical light blue line) from the 1 year old population in year y (right vertical purple line). These deaths correspond to the parentheses section of the formula described in the preceding paragraph.

8/ Since the correction for late registration was carried out on an annual basis, the monthly structure of observed deaths was applied, by sex and age.

FIGURE 3.2
Costa Rica. Application of cohort deaths in the Lexis diagram, 2024



Source: prepared by the author.

The net migratory balances used in the retroprojection are those estimated by the United Nations in the 2022 update of the World Population Prospect, decreased by 30%, a percentage required for the estimated population to be consistent in structure and magnitude with the population of the available censuses.

Population estimates are published as of June 30 each year, so the estimated population for the 1950 - 2021 period was brought to June 30, applying an average by cohort, using the following formula:

$$P_{(x)(30/06/y-1)} = P_{(x+1)(01/01/y)} + P_{(x)(01/01/y-1)} / 2$$

Where:

$P_{(x)(30/06/y-1)}$: population aged x as of June 30 of year y-1.

$P_{(x+1)(01/01/y)}$: population aged x+1 as of January 1 of year y.

$P_{(x+1)(01/01/y)}$: population aged x as of January 1 of year y.

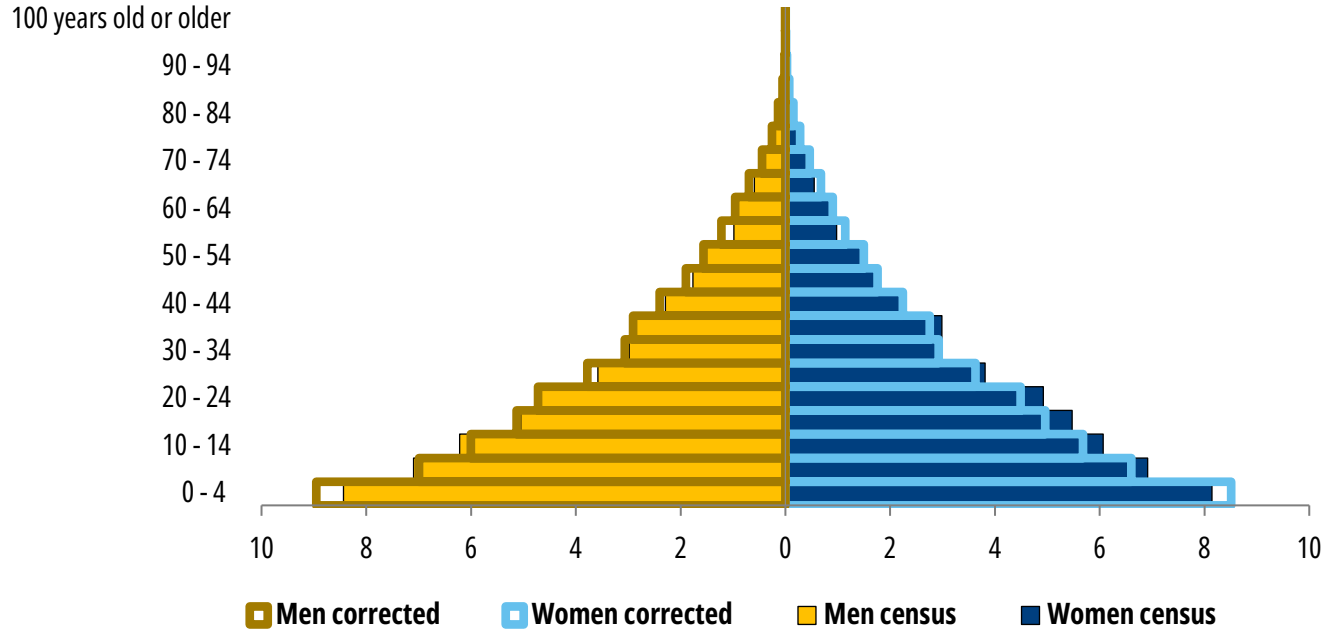
Since the population aged 100 and over showed an irregular behavior, an adjustment was made by averaging ages 98, 99 and 100 to obtain the population aged 100 and over.

As part of the process of reconciliation of demographic sources, the estimated population for the years 1950, 1963, 1973, 1984, 2000 and 2011 was compared with the population registered for those years. For 2022, the comparison was made with the estimate published in July 2023.

The following charts show the population pyramids of the above mentioned years and that the estimated population, resulting from the 1950 - 2022 demographic reconciliation, reproduces the sex and age structure of the registered populations (1950, 1963, 1973, 1984, 2000 and 2011) and the 2022 population estimate, but as expected, with higher values.

CHART 3.10

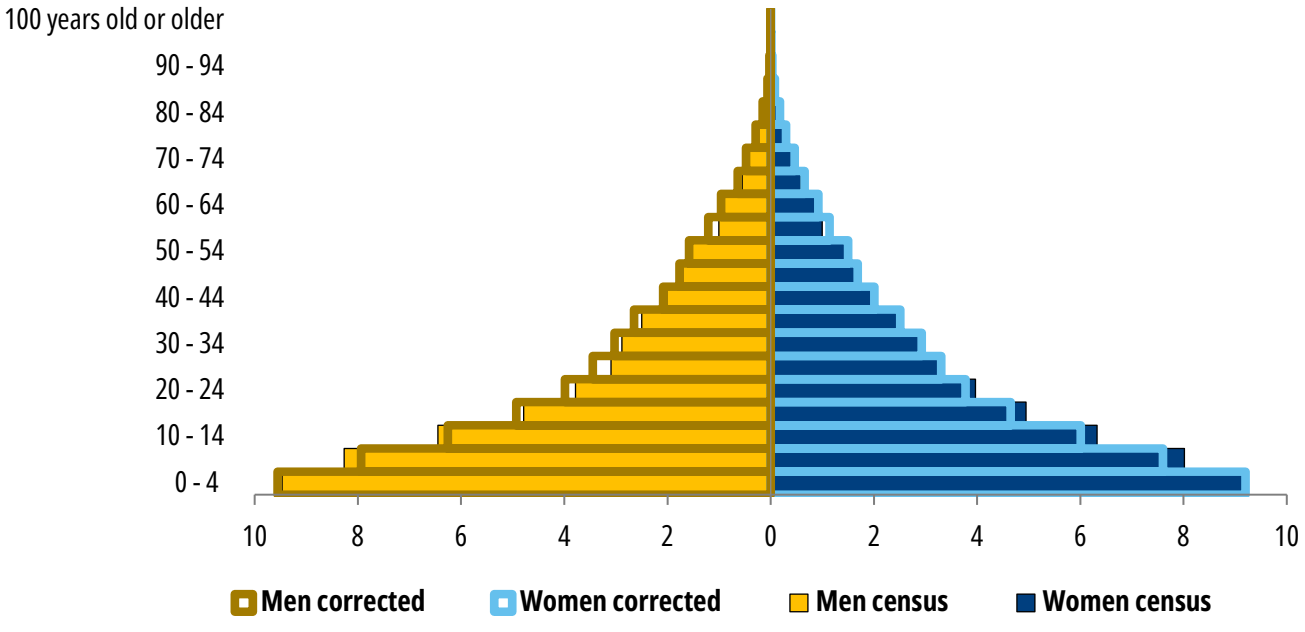
Costa Rica. Percentage distribution of population by sex and age groups, 1950



Source: INEC-Costa Rica. National Population Census 1950 and National Population Estimates and Projections 1950 - 2100, July 2024

CHART 3.11

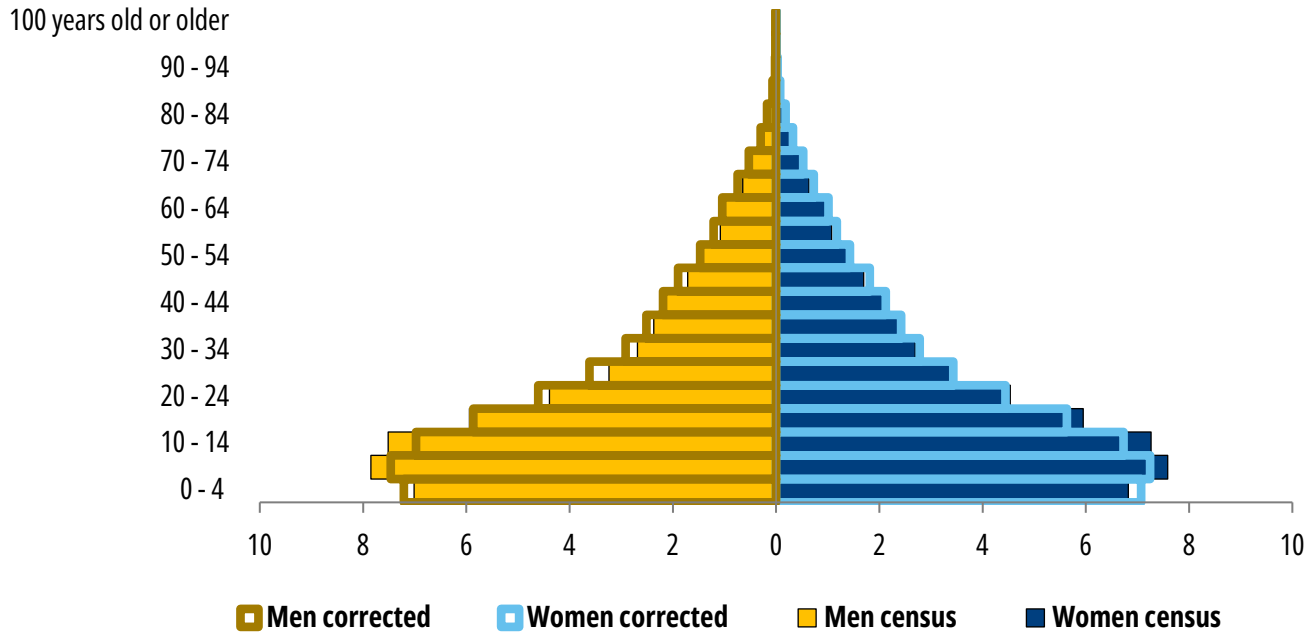
Costa Rica. Percentage distribution of population by sex and age groups, 1963



Source: INEC-Costa Rica. National Population Census 1963 and National Population Estimates and Projections 1950 - 2100, July 2024

CHART 3.12

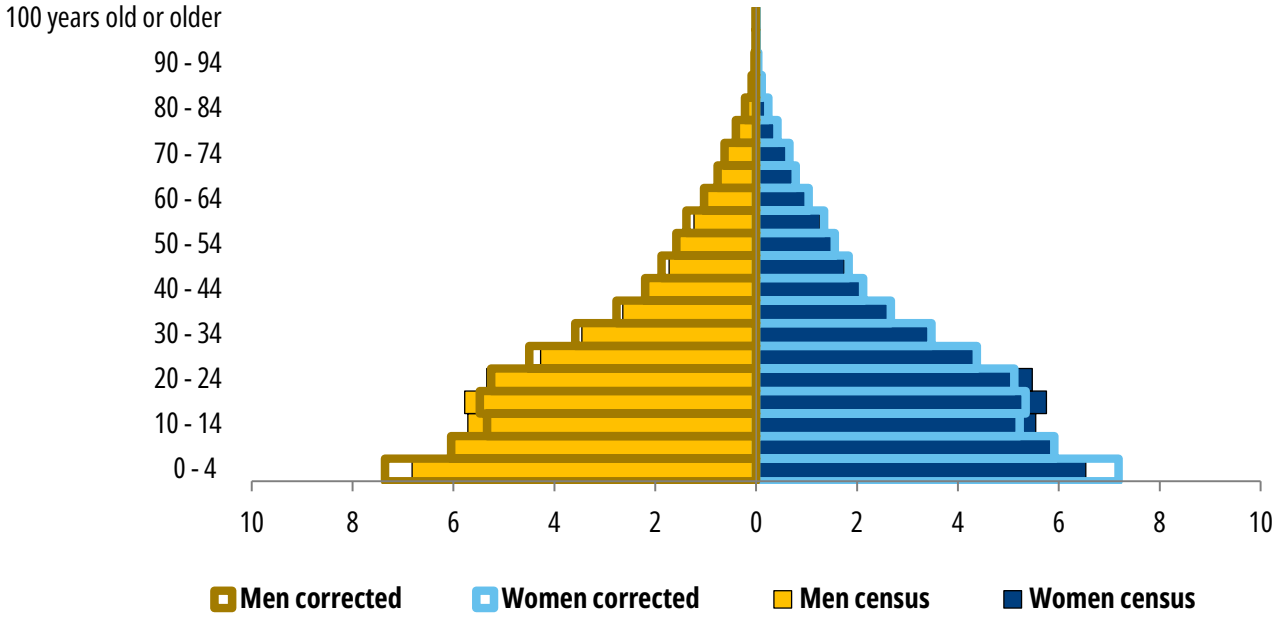
Costa Rica. Percentage distribution of population by sex and age groups, 1973



Source: INEC-Costa Rica. National Population Census 1973 and National Population Estimates and Projections 1950 - 2100, July 2024

CHART 3.13

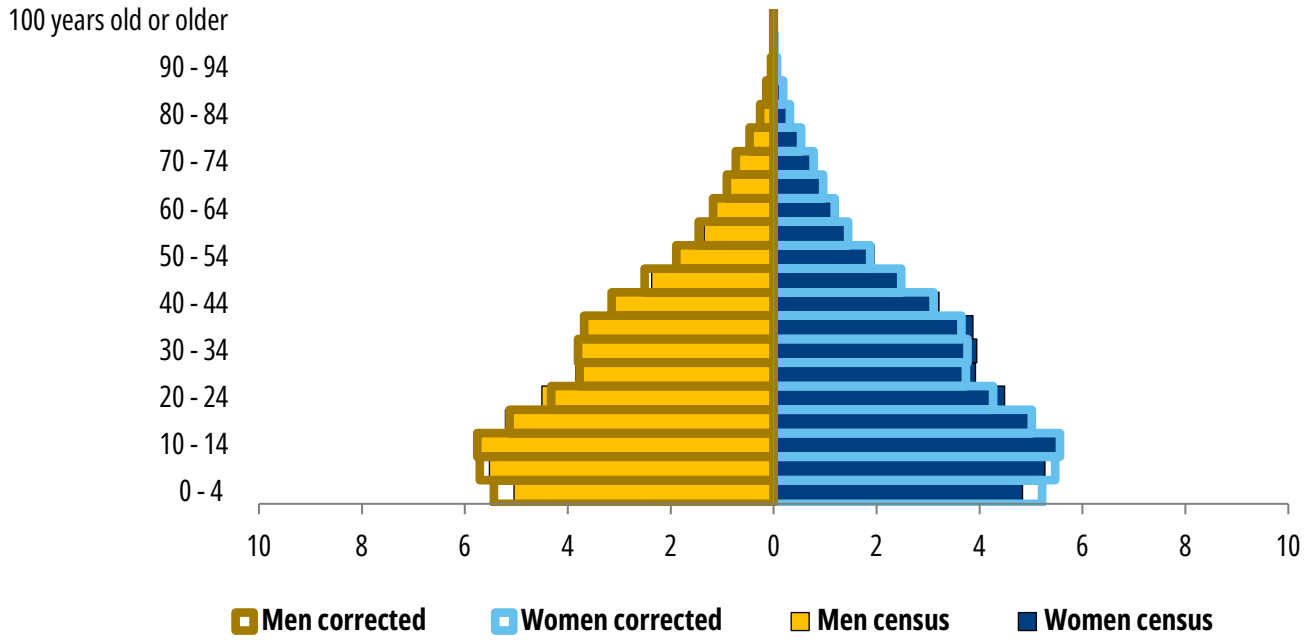
Costa Rica. Percentage distribution of population by sex and age groups, 1984



Source: INEC-Costa Rica. National Population Census 1984 and National Population Estimates and Projections 1950 - 2100, July 2024

CHART 3.14

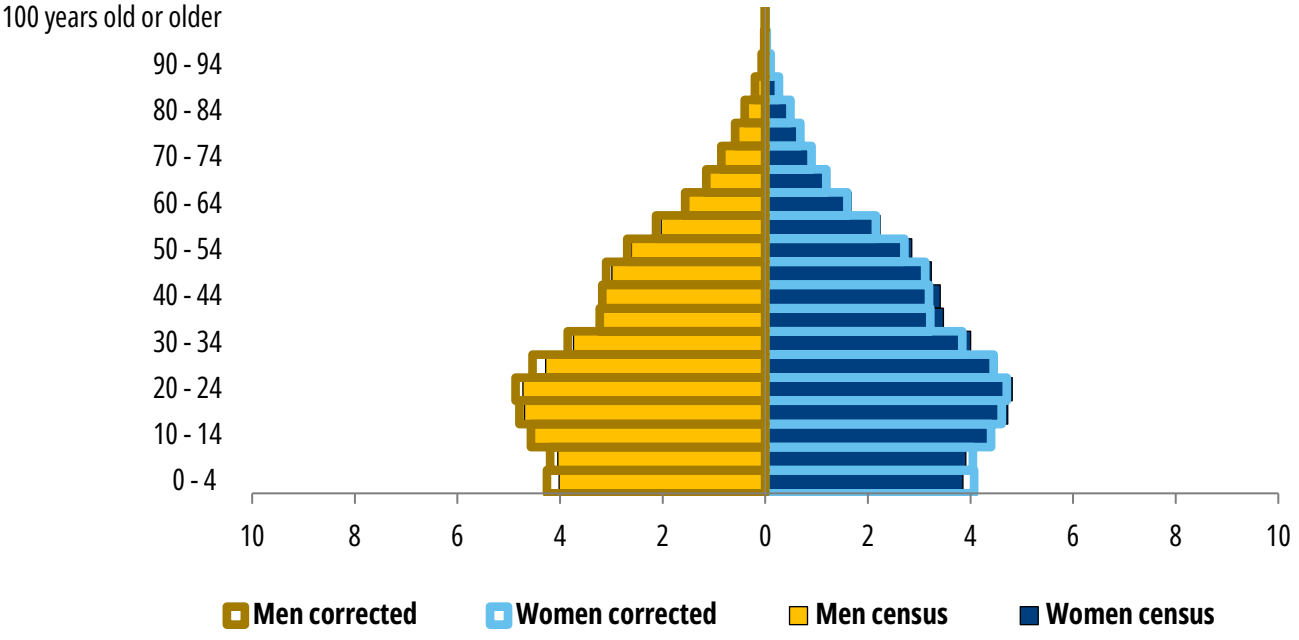
Costa Rica. Percentage distribution of population by sex and age groups, 2000



Source: INEC-Costa Rica. National Population Census 2000 and National Population Estimates and Projections 1950 - 2100, July 2024

CHART 3.15

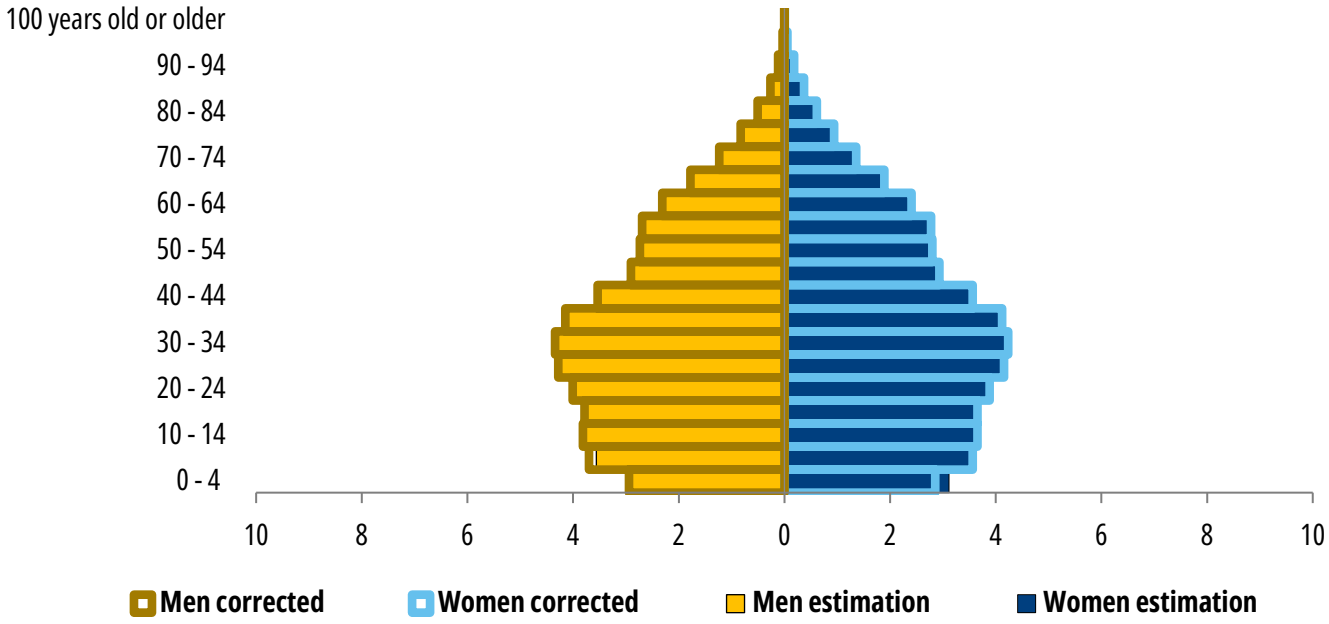
Costa Rica. Percentage distribution of population by sex and age groups, 2011



Source: INEC-Costa Rica. National Population Census 2011 and National Population Estimates and Projections 1950 - 2100, July 2024

CHART 3.16

Costa Rica. Percentage distribution of population by sex and age groups, 2022



Source: INEC-Costa Rica. Population and Housing Estimation 2022, July 2023 and National Population Estimates and Projections 1950 - 2100, July 2024.

Box 3.10 compares the total population to census omissions in the light of updated populations, being the 1973 and 2000 censuses those with the smallest omissions and men are consistently the most omitted population.

BOX 3.10

Costa Rica. Registered population, estimated population and census omissions by sex, 1950 -

Year	Registered population			Estimated population			Omission		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
1950	804 262	401 557	402 705	891 998	456 776	435 222	9,8	12,1	7,5
1963	1 336 274	668 957	667 317	1 421 207	725 589	695 618	6,0	7,8	4,1
1973	1 871 930	938 598	933 332	1 905 236	967 989	937 248	1,7	3,0	0,4
1984	2 416 809	1 208 216	1 208 593	2 574 604	1 301 230	1 273 374	6,1	7,1	5,1
2000	3 810 179	1 902 614	1 907 565	3 883 765	1 956 235	1 927 530	1,9	2,7	1,0
2011	4 301 712	2 106 063	2 195 649	4 594 347	2 306 818	2 287 528	6,4	8,7	4,0
2022[a/]	5 044 197	2 511 843	2 532 354	5 104 907	2 551 111	2 553 795	NA	NA	NA

a/ Corresponds to the population estimate, therefore, the census omission calculation does not apply.

Source: INEC-Costa Rica, National Population Censuses 1950, 1963, 1973, 1984, 2000, 2011, Population and Housing Estimation 2022, July 2023 and national population estimates and projections 1950 - 2100, July 2024.

Box 3.11 shows the estimated population by sex for the 1950 - 2022 period.

BOX 3.11

Costa Rica. Total estimated population by sex, 1950 -2022

Year	Total	Men	Women
1950	891 998	456 776	435 222
1951	922 064	472 153	449 911
1952	954 143	488 555	465 588
1953	987 649	505 689	481 960
1954	1 024 013	524 289	499 724
1955	1 062 762	543 939	518 822
1956	1 102 417	563 989	538 428
1957	1 143 400	584 815	558 585
1958	1 184 637	605 729	578 908
1959	1 229 683	628 582	601 101
1960	1 275 730	652 077	623 652
1961	1 325 024	676 879	648 145
1962	1 372 861	701 131	671 730
1963	1 421 207	725 589	695 618
1964	1 470 440	750 176	720 264
1965	1 519 911	775 211	744 700
1966	1 570 152	800 427	769 724
1967	1 620 701	825 880	794 821
1968	1 669 795	850 674	819 121
1969	1 716 554	873 774	842 780
1970	1 763 144	897 169	865 975
1971	1 810 655	920 725	889 930
1972	1 857 740	944 206	913 534
1973	1 905 236	967 989	937 248
1974	1 953 549	991 996	961 554
1975	2 002 834	1 016 610	986 224
1976	2 052 553	1 041 310	1 011 243
1977	2 107 444	1 068 613	1 038 831
1978	2 164 958	1 097 202	1 067 757
1979	2 227 176	1 127 927	1 099 249
1980	2 292 937	1 160 605	1 132 332
1981	2 361 542	1 194 678	1 166 864
1982	2 431 913	1 229 879	1 202 034
1983	2 502 133	1 265 059	1 237 073
1984	2 574 604	1 301 230	1 273 374
1985	2 654 969	1 341 467	1 313 502

continues

Continues from Box 3.11

Year	Total	Men	Women
1986	2 737 002	1 382 713	1 354 289
1987	2 817 494	1 422 862	1 394 632
1988	2 895 804	1 462 285	1 433 519
1989	2 978 329	1 503 453	1 474 876
1990	3 063 102	1 546 118	1 516 984
1991	3 146 668	1 588 401	1 558 267
1992	3 230 836	1 630 503	1 600 333
1993	3 315 886	1 673 022	1 642 864
1994	3 399 345	1 714 835	1 684 510
1995	3 485 671	1 757 864	1 727 807
1996	3 568 079	1 799 074	1 769 005
1997	3 651 695	1 840 753	1 810 942
1998	3 730 516	1 879 764	1 850 751
1999	3 808 357	1 918 737	1 889 619
2000	3 883 765	1 956 235	1 927 530
2001	3 957 540	1 992 741	1 964 799
2002	4 024 389	2 025 974	1 998 415
2003	4 090 807	2 058 724	2 032 083
2004	4 156 143	2 090 916	2 065 226
2005	4 219 913	2 122 287	2 097 626
2006	4 283 349	2 153 437	2 129 912
2007	4 347 672	2 185 173	2 162 499
2008	4 411 867	2 216 864	2 195 003
2009	4 472 706	2 246 763	2 225 944
2010	4 532 029	2 276 118	2 255 911
2011	4 594 347	2 306 818	2 287 528
2012	4 654 485	2 336 466	2 318 019
2013	4 713 092	2 365 253	2 347 839
2014	4 771 778	2 393 935	2 377 843
2015	4 828 520	2 421 303	2 407 217
2016	4 882 723	2 447 602	2 435 121
2017	4 933 519	2 472 250	2 461 269
2018	4 981 349	2 495 215	2 486 134
2019	5 020 970	2 513 828	2 507 142
2020	5 051 379	2 527 425	2 523 954
2021	5 077 667	2 538 898	2 538 769
2022	5 104 907	2 551 111	2 553 795

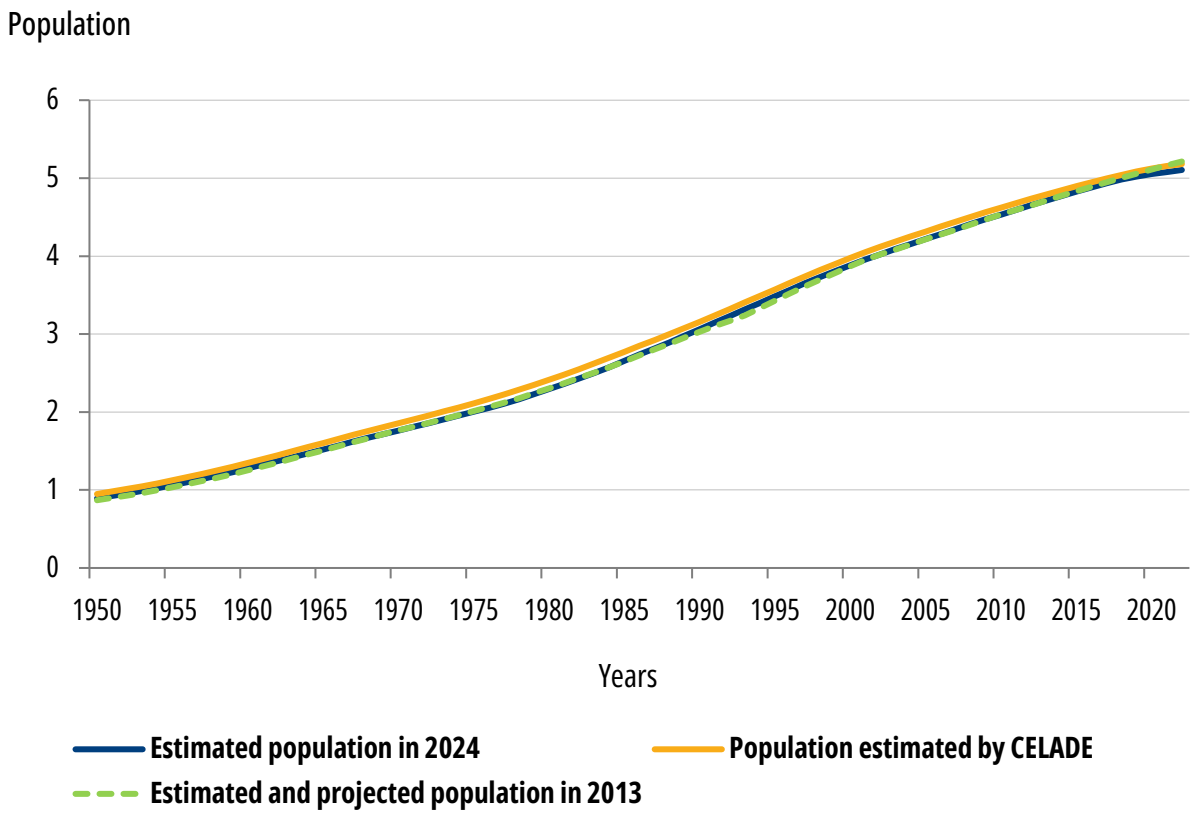
Source: INEC-Costa Rica. National population estimates and projectior 1950-2100, July 2024.

Chart 3.17 shows the estimated population for the 1950 - 2022 period and its comparison with the estimates made by CELADE and the estimates and projections made in 2013. It is seen that for most of the period, the population estimated by CELADE is higher than the estimated and current population. Also, for the 1990 - 1998 period, the new estimate estimates a slightly higher population than the current estimates.

CHART 3.17

Costa Rica. Total estimated population, 1950 - 2022

(Millions)



Source: CELADE-ECLAC. ECLACSTAT statistical databases and publications, demographic and social indicators;
INEC-Costa Rica. National population estimates and projections, March 2013 and national population estimates and projections 1950 - 2100, July 2024.

To know the results details you can consult the following link https://inec.cr/busqueda?searchtext=proyecciones&formats=application%252Fvnd.ms-excel%252Capplication%252Fvnd.openxmlformats-officedocument.spreadsheetml.sheet&thematics=91%252C646

4. 2023 - 2100 population projection process

The projection process, as its name implies, consists in projecting the future behavior of the components of demographic change (fertility, mortality and migration) and their impact on the population, both in size and structure by sex and age. For this update, the national population projection covers the 2023 - 2100 period.

The following sources of information were used in the development of population projections:

- Base population by sex and simple ages, estimated in paragraph 1.
- Vital statistics (fertility and mortality).
- Current national population projections 2011 - 2100 (INEC and CPC, 2013).
- Human Fertility Database (Max Planck Institute for Demographic Research and Vienna Institute of Demography, 2023).

4.1 Mortality projection

In calculating the mortality rates for the 1950 - 1969 period, deaths figures estimated by Dr. Héctor Pérez Brignoli and used in the current estimates published in 2013 were used. On the other hand, for the 1970 - 2019 period, the deaths recorded in Costa Rica during these years were used, corrected by late registration. The populations generated from the estimation process described above were used as rates denominator.

Once the mortality rates were obtained, we proceeded to apply the Gompertz model to the rates of ages 85 years and over. Finally, to prevent fluctuations in rates, at all ages, a smoothing was applied using the monotonic regression splines (msplines) method (Wood, 1994).

The Lee Carter model (Lee, 1992) was used to project specific mortality rates by sex and age. This model is based on the basic premise of a linear relationship between the logarithm of specific mortality rates m(x,t) and two explanatory factors: age interval (x) and time (t). The Lee Carter model is expressed in the following equation:

$$ln(m_{x,t}) = a_x + k_t b_x + \epsilon_{x,t}$$

Where:

x : age

t : time (typically one year)

a_x : variation across ages of average rates over time

b_x : relative mortality of the rate at each age with respect to the average rate

k_t : average variation over time in mortality rates

$\epsilon_{x,t}$: model error component

The 1950 - 2019 rates series were used to estimate the parameters of the Lee Carter model since the 2020 - 2022 rates are affected by the COVID-19 pandemic. This exclusion is based on an analysis conducted by Dr. Brenes Camacho for four European countries that experienced Russian flu (1889 - 1890) and Spanish flu (1918 - 1920) pandemics and that did not participate in World War I (Denmark, Switzerland, Norway and Sweden) and therefore did not have excess mortality due to the war.

This analysis showed that life expectancy regains its trend between three to five years after the onset of each pandemics (see Annex I). The decision to exclude rates for the 2020 - 2022 period is consistent with methodological decisions recommended by the United Nations Population Division (United Nations Department of Economic and Social Affairs, 2022).

The parameters of the Lee-Carter model were estimated using the "lca" function of the R demography package (Hyndman R., 2023). The Booth, Maindonald and Smith (2002) method included in this function was used for selecting the parameters estimation base years, as it better captures the moderate growth of life expectancy at birth in Costa Rica that has been experienced since 1980.

When executing the "lca" function, the algorithm selected rates starting from 1980 for women and 1982 for men.

4.2 Fertility projection

Costa Rica has experienced an accelerated decline in fertility over the past decade. According to official INEC figures, the total fertility rate (TFR) for 2020 was 1.41 children per woman. Some TFR projection models were tested (see Annex III), including the one programmed by the UED based on the coherent projection method found in the R demography package (Hyndman R., 2023), as well as the double exponential model (Knudsen, McNown & Rogers, 1993).

Both models were not considered relevant, as they yielded values beyond expectations. In the first case, the model generated higher rates than those observed in 2022, which is unlikely in a context of continuous decline in fertility. The second projected lower values to one child per woman, which is also unlikely, given that very few societies in the world have such low fertility levels.

Therefore, in order to establish a methodology that would contribute to the best projection of the TFR, it was decided to analyze the behavior of this indicator according to the information published by the Human Fertility Database (Max Planck Institute for Demographic Research and Vienna Institute of Demography, 2023), which collects information from 39 countries around the world.

With this analysis, countries that fulfilled the following criteria (eminently empirical) were selected:

a. Availability of quality data.

b. At least 30 years after reaching an total fertility rate of about 1.5 children per woman (Costa Rica reached it in 2020).

Based on these criteria, nine countries were selected: Austria, Belgium, Bulgaria, Denmark, West Germany (with 1990 pre-reunification limits), Italy, Japan, the Netherlands and Spain.

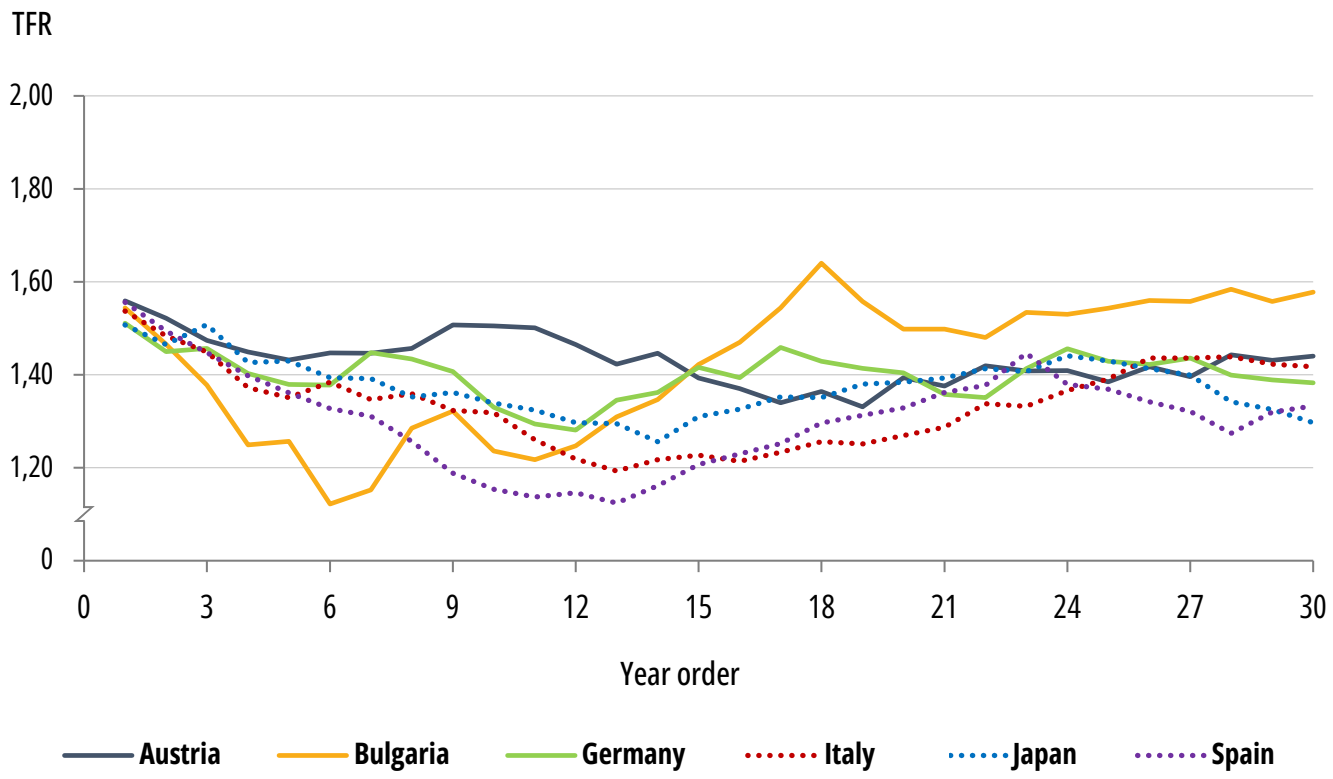
A matrix with a series of thirty TFRs for each country was developed with the information from these countries. Each series was considered a functional data, and a K-means cluster analysis for functional data procedure was executed with the "fdakmeans" function of the fdacluster package (Stamm, 2023).

Two clusters were chosen, and each series was smoothed with local regression with a 30% parameter ("lowess30"). Smoothing was necessary to have an average curve with the lowest degree of random variations ("white noise"). The two resulting clusters comprise the following countries: Austria, Bulgaria, West Germany (equivalent to pre-reunification limits), Italy, Japan and Spain in cluster 1, and Belgium, Denmark and the Netherlands in cluster 2.

The following charts show the behavior of the TFR for each cluster.

CHART 4.1

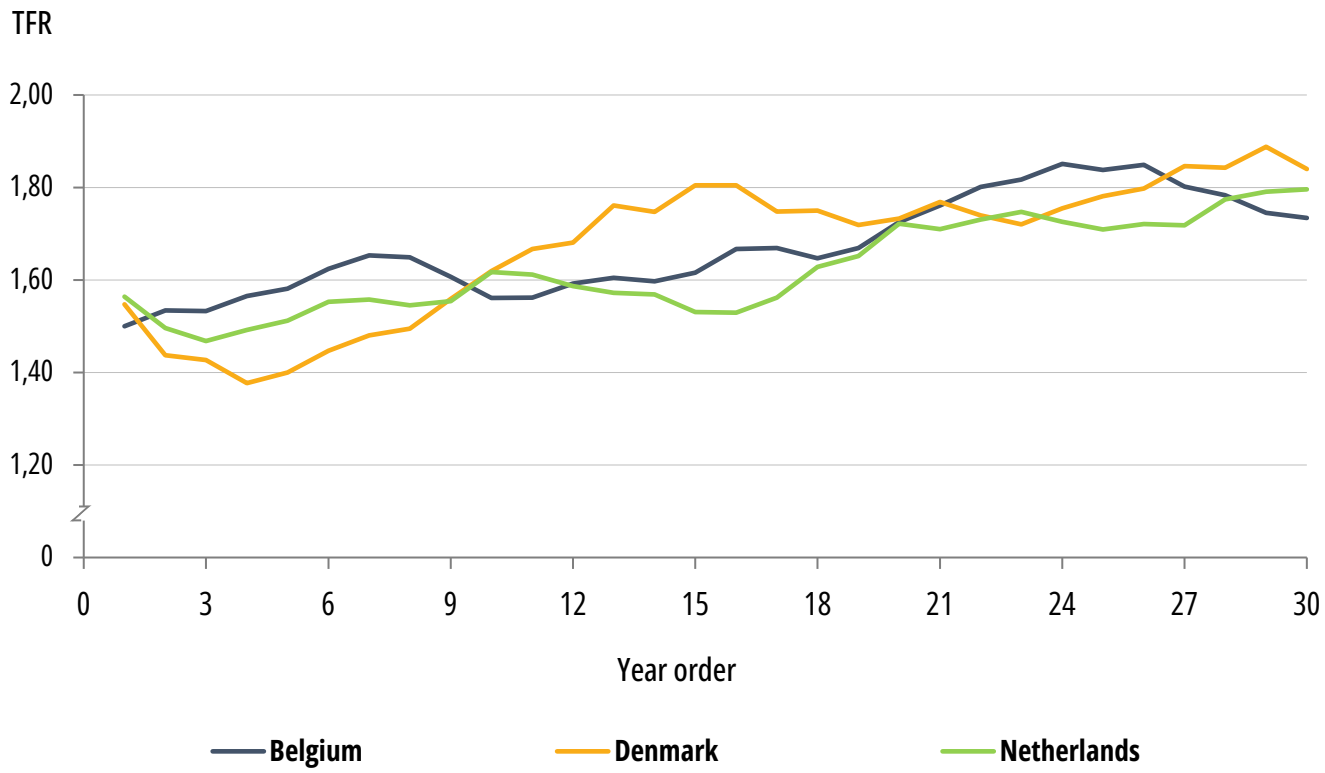
Total fertility rate (TFR) of countries in cluster 1, 2023



Source: Human Fertility Database (Max Planck Institute for Demographic Research and Vienna Institute of Demography, 2023).

CHART 4.2

Total fertility rate (TFR) of countries in cluster 2, 2023



Source: Human Fertility Database (Max Planck Institute for Demographic Research and Vienna Institute of Demography, 2023).

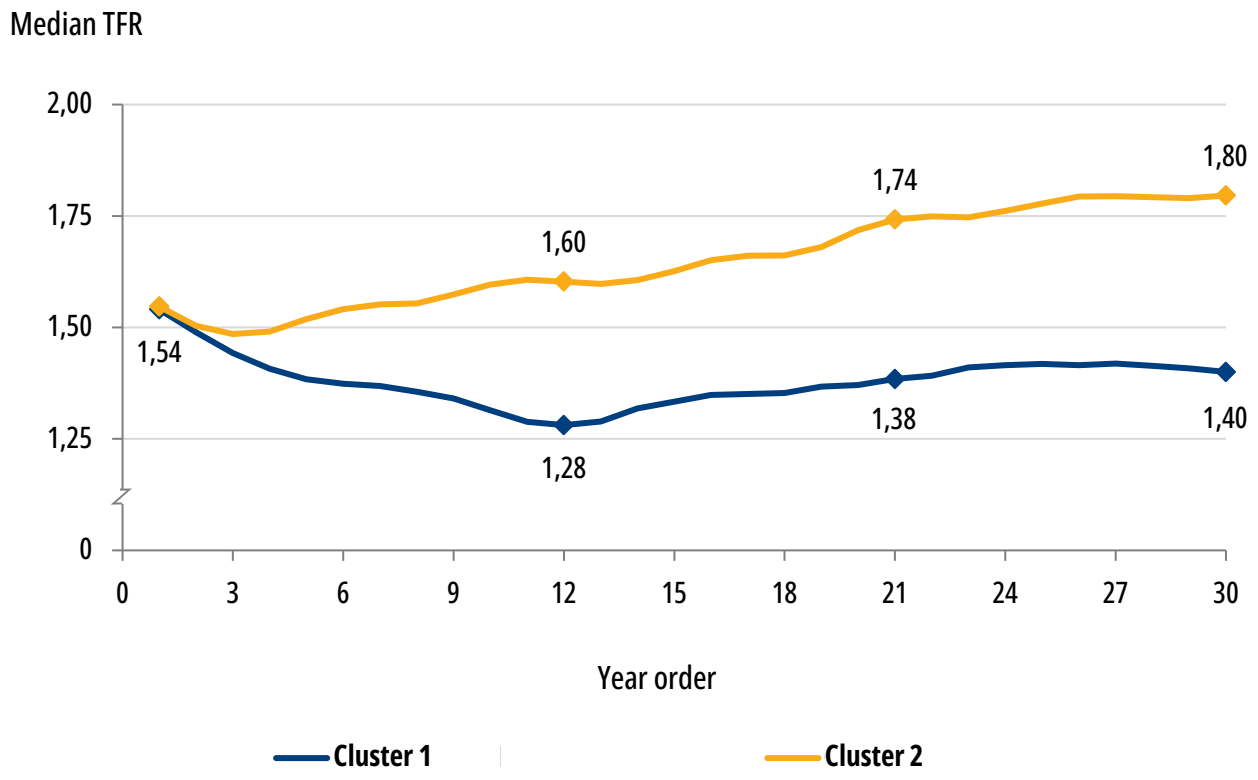
Subsequently, the median TFR between countries was calculated for each group. Cluster 1 is characterized by a downward curve that reaches a level of 1.2 children per woman and then grows slowly to a maximum of 1.45 children per woman.

By contrast, the average TFR of cluster 2 decreases to a level of 1.4 children per woman, then grows to levels between 1.7 and 1.8 children per woman.

The following chart shows the median TFR for each cluster.

CHART 4.3

Median total fertility rate (TFR) for each cluster of countries, 2022



Source: prepared by the author with data from the Human Fertility Database (Max Planck Institute for Demographic Research Vienna Institute of Demography, 2023).

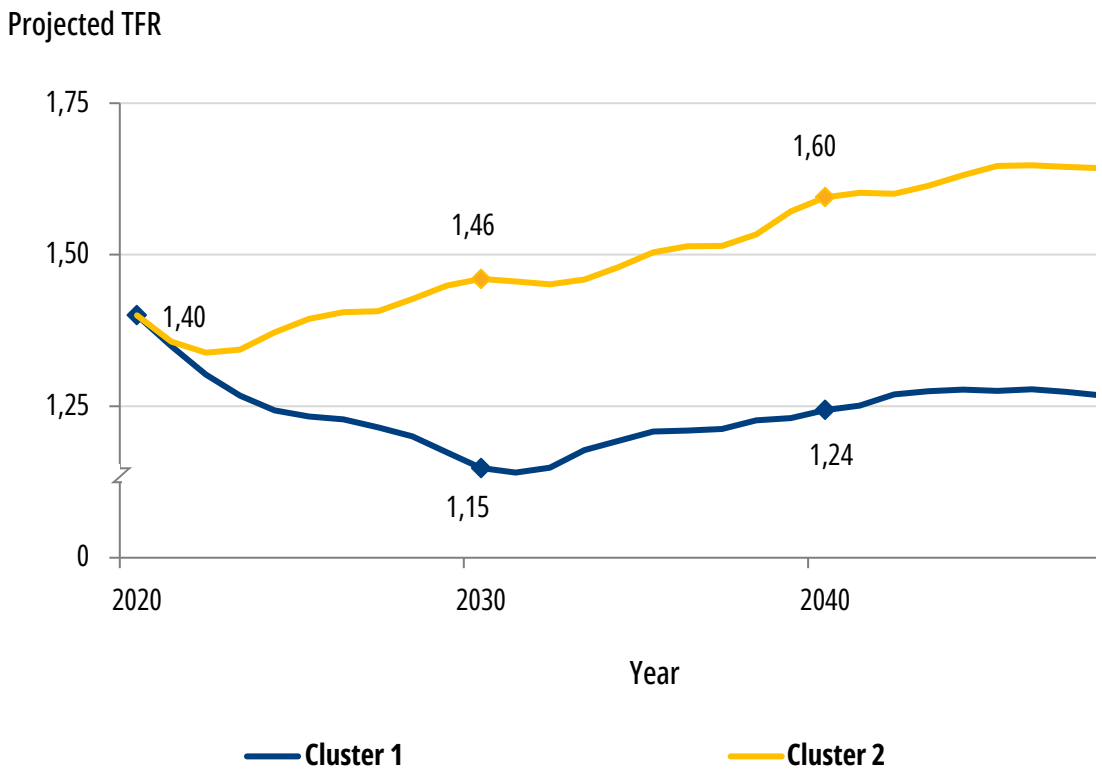
Then, the difference between the first year in which cluster 1 reached a value of 1.5 and the second year was calculated; and thus continuously until the third year of the series.

In order to obtain the projected TFR for Costa Rica, the difference between year one and year two of cluster 1 was added to 2020 TFR (1.45), thus obtaining the 2021 projected TFR. To the new 2021 TFR, the difference between year two and year three of cluster 1 was added to obtain the 2022 projected TFR, and so on.

The following chart shows the TFR projection for Costa Rica.

CHART 4.4

Costa Rica. Two scenarios of projected total fertility rate (TFR), 2020 - 2049



Source: prepared by the author.

Once the projected TFR was calculated, to obtain its structure by age (specific fertility rates) the model structure M13 was used, which was suggested by CELADE's projections expert Helena Cruz as a result of the analysis of a series of 21 models of relative fertility structures.

Therefore, the age-smoothed structure of Costa Rica's 2020 fertility rates was calculated and linearly interpolated between 2020 and 2050 to calculate the relative structure for each year of said period. From 2050, specific rates remain constant until 2100.

4.3 Migration projection

Initially, a functional data analysis model was used for projecting net migratory balances, in particular the product/ratio method for "coherent" projections (Hyndman, Booth & Yasmeen, 2011). Coherent projections are called those that seek to model the relationship between the demographic rates of women and men. In the product/ratio method in functional data analysis, the functions that make up the geometric mean of the softened demographic rates of the groups (product) and the ratio of the rates of each group among the geometric mean are estimated. To these indicator time series, the main components analysis and a time series model are applied to each function: non-stationary ARIMA models for the product model, and ARFIMA models for the rate ratio model.

After obtaining the results of such projections, a simulation is performed and the median of the simulated data is calculated to obtain the projection of the net migratory balances by sex and age. However, this model yielded atypical results in the estimation period, therefore a projection using a logistic model was decided.

To carry out the projection of the net migratory balances through the logistics function, a modification of the "Logistic" template of the Census Bureau, provided by CELADE, was used, through which a projection was made for each sex and then the total net balances were obtained by adding.

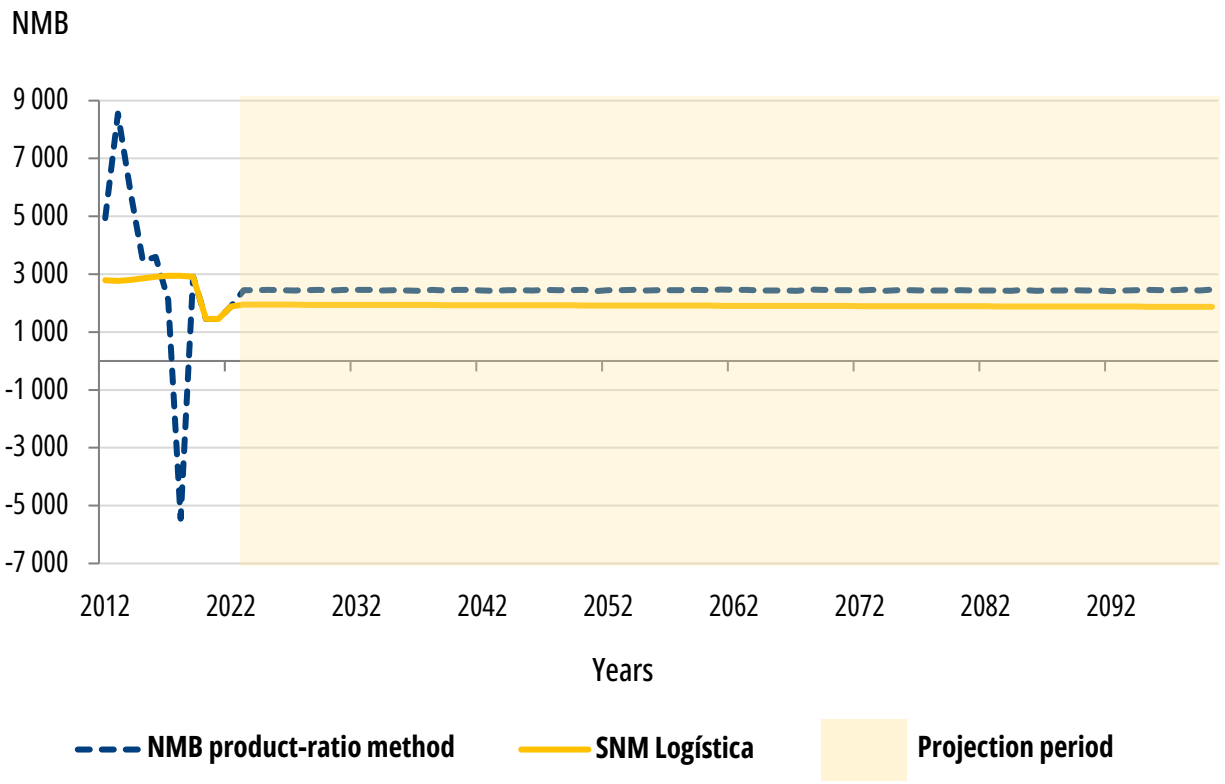
To adjust the projection model, the value of 6 300 was included as higher asymptote, since this was the highest value experienced in the 1990s, the period of greater immigration to the country as a consequence of the post-war political and economic crisis in Nicaragua, and a value of 500 was included as lower asymptote.

The observed data of the last decade of the estimates (2012 - 2022) were included as pivots, since it is the most recent period, and for the projection years 2030, 2050, 2060, 2075, 2085 and 2100, values close to 1 000 were defined. In addition, as in the projection of mortality the years 2020 and 2021 are excluded as pivots, since these years had an atypical behavior due to the closure of borders and the restrictions due to the COVID-19 pandemic.

The following chart shows the evolution of the projected net migratory balances (lines within the shaded area) both of the product/ratio method, which corresponds to the dashed line, and of the logistics method, which corresponds to the continuous line. The above predicted values by the product/ratio method for the 2023 - 2025 period are highlighted, in which a decline is estimated, while the logistic method, which was the one selected, estimates a more stable behavior with values close to 2 000 persons, with a slight tendency to decrease.

CHART 4.5

Costa Rica. Estimated and projected net migratory balance (NMB), 2012 - 2100



Source: INEC-Costa Rica. National population estimates and projections 1950-2100, July 2024.

4.4 Population projection

With the estimates and projections of the components of demographic change, the population is projected by sex and simple ages. The projection period is 2023 - 2100.

In 2011, all components of demographic change were projected using models that quantified projection variability (or uncertainty) using the Lee Carter method for mortality, and the coherent projections of functional data method for fertility and migration. Therefore, in 2011, the pop.sim function of the demography package (Hyndman, 2023) was used to project population.

Given the limitations of the method of coherent projections of functional data to address the fertility behavior experienced in the country in the recent past, the population was projected using the equations proposed by Preston, Heuveline and Guillot (2001, p. 128).

The Preston, Heuveline and Guillot (2001) formulas refer to female population, but can be generalized for male population using the theoretical ratio of male births of 105/205, which are detailed below.

Where:

${}_kI_x^F(t,t+k)$: net female migration balance aged between x and x + k between time t and t + k

${}_kN_x^F(t+k)$: female population aged between x and x + k in time t + k

${}_kB_x^F(t,t+k)$: female births of mothers aged between x and x + k between time t and t + 5

${}_kL_x^F$: number of years person lived between ages x and x + k in the life table

Therefore:

$$ {}_kN_x^F(t,t+k) = \left({}_kN_{x-k}^F(t) + \frac{{}_kI_{x-k}^F(t,t+k)}{2} \right) * \frac{{}_kL_x^F}{{}_kL_{x-k}^F} + \frac{{}_kI_x^F\ (t,t+k)}{2} $$

$$ {}_kB_x^F(t,t+k) = k * \frac{100}{205} * \frac{{}_kN_x^F\ (t) + \frac{{}_kI_x^F\ (t,t+k)}{2} + {}_kN_x^F\ (t+k)}{2} $$

These formulas were programmed in R, and were used to project the population from 2023 to 2100 using the 2022 base population.

Box 4.1 shows the estimated projected population by sex for the 2023 - 2100 period.

BOX 4.1

Costa Rica. Total projected population by sex, 2023 - 2100

Year	Total	Men	Women
2023	5 135 912	2 565 812	2 570 099
2024	5 164 860	2 579 443	2 585 417
2025	5 191 823	2 592 027	2 599 796
2026	5 217 295	2 603 800	2 613 495
2027	5 241 449	2 614 868	2 626 581
2028	5 263 912	2 625 025	2 638 887
2029	5 284 616	2 634 257	2 650 359
2030	5 303 115	2 642 336	2 660 780
2031	5 319 393	2 649 242	2 670 151
2032	5 334 186	2 655 358	2 678 828
2033	5 348 122	2 661 007	2 687 116
2034	5 361 936	2 666 570	2 695 365
2035	5 375 045	2 671 746	2 703 299
2036	5 387 338	2 676 499	2 710 840
2037	5 398 339	2 680 580	2 717 759
2038	5 407 991	2 683 957	2 724 034
2039	5 416 650	2 686 818	2 729 832
2040	5 423 898	2 688 960	2 734 938
2041	5 429 961	2 690 506	2 739 455
2042	5 434 572	2 691 324	2 743 248
2043	5 438 002	2 691 564	2 746 438
2044	5 439 639	2 690 916	2 748 723
2045	5 439 395	2 689 320	2 750 075
2046	5 436 984	2 686 659	2 750 326
2047	5 432 644	2 683 035	2 749 608
2048	5 426 003	2 678 281	2 747 722
2049	5 417 124	2 672 417	2 744 707
2050	5 405 872	2 665 406	2 740 467
2051	5 392 558	2 657 380	2 735 178
2052	5 377 383	2 648 432	2 728 951
2053	5 360 302	2 638 568	2 721 734
2054	5 341 473	2 627 851	2 713 622
2055	5 320 909	2 616 293	2 704 616
2056	5 298 746	2 603 988	2 694 758
2057	5 275 220	2 591 018	2 684 203
2058	5 250 375	2 577 395	2 672 981
2059	5 224 385	2 563 216	2 661 169
2060	5 197 035	2 548 406	2 648 629
2061	5 168 664	2 533 100	2 635 564

continues

Continues from Box 4.1

Year	Total	Men	Women
2062	5 139 136	2 517 274	2 621 862
2063	5 108 897	2 501 058	2 607 838
2064	5 077 770	2 484 419	2 593 351
2065	5 045 723	2 467 350	2 578 373
2066	5 012 864	2 449 853	2 563 011
2067	4 979 155	2 431 968	2 547 187
2068	4 944 649	2 413 671	2 530 978
2069	4 909 478	2 395 014	2 514 464
2070	4 873 540	2 376 014	2 497 527
2071	4 836 677	2 356 537	2 480 140
2072	4 798 722	2 336 577	2 462 145
2073	4 759 774	2 316 130	2 443 644
2074	4 719 722	2 295 170	2 424 553
2075	4 678 480	2 273 697	2 404 783
2076	4 636 074	2 251 703	2 384 370
2077	4 592 463	2 229 201	2 363 263
2078	4 547 153	2 206 011	2 341 142
2079	4 500 526	2 182 303	2 318 223
2080	4 452 580	2 158 093	2 294 487
2081	4 403 630	2 133 475	2 270 154
2082	4 353 695	2 108 491	2 245 204
2083	4 303 053	2 083 207	2 219 846
2084	4 251 961	2 057 760	2 194 201
2085	4 199 923	2 032 011	2 167 912
2086	4 146 465	2 005 763	2 140 702
2087	4 092 829	1 979 480	2 113 350
2088	4 039 568	1 953 409	2 086 159
2089	3 986 729	1 927 492	2 059 236
2090	3 933 503	1 901 533	2 031 971
2091	3 880 518	1 875 665	2 004 854
2092	3 828 213	1 850 097	1 978 116
2093	3 776 120	1 824 747	1 951 373
2094	3 724 253	1 799 547	1 924 706
2095	3 672 867	1 774 587	1 898 280
2096	3 621 475	1 749 741	1 871 735
2097	3 571 163	1 725 334	1 845 829
2098	3 521 000	1 701 089	1 819 911
2099	3 471 795	1 677 294	1 794 502
2100	3 422 780	1 653 569	1 769 212

Source: INEC-Costa Rica. National Population Estimates and Projections 1950 - 2100, July 2024.

To know the results details you can consult the following link https://inec.cr/busqueda?searchtext=proyecciones&formats=application%252Fvnd.ms-excel%252Capplication%252Fvnd.openxmlformats-officedocument.spreadsheetml.sheet&thematics=91%252C646

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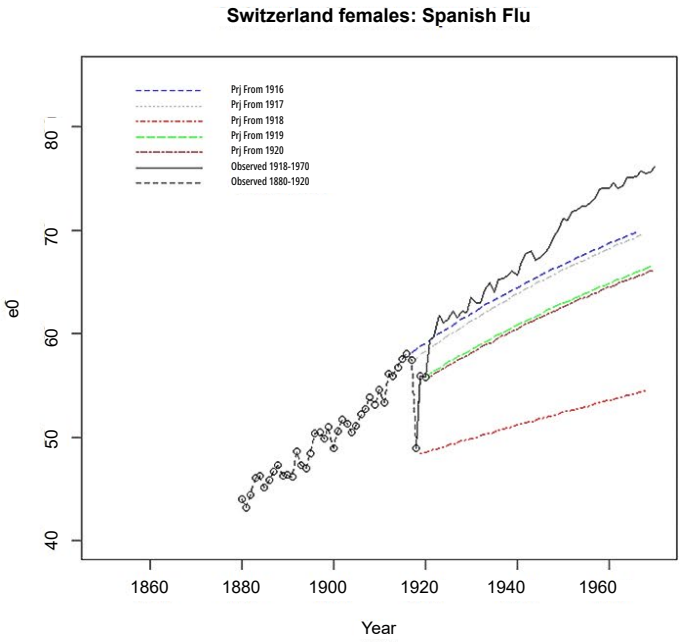
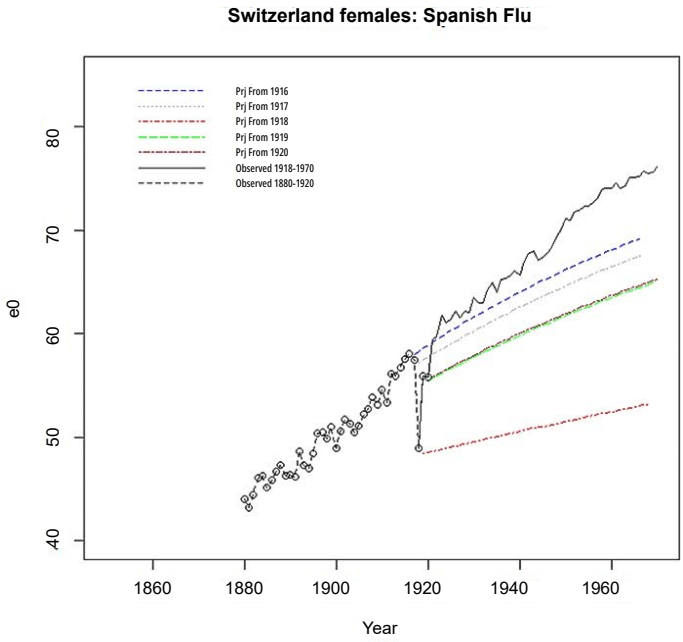
Annex

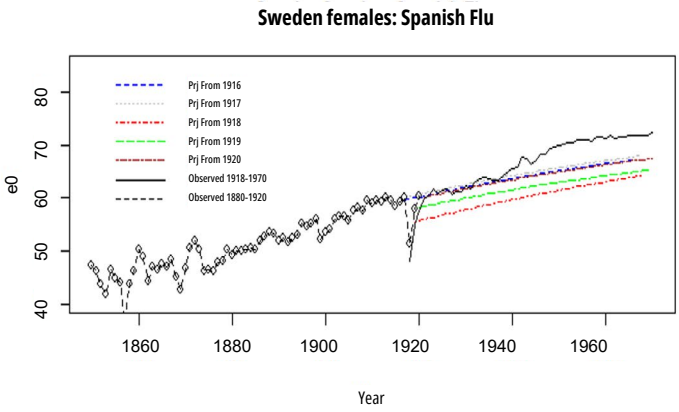
Projection of historical mortality in several European countries after two health crises (Russian flu 1889 - 1890 and Spanish flu 1918 - 1920), with the Lee-Carter model, without adjustment (right column) and with the adjustment of the Booth-Maindonald-Smith method (left column).

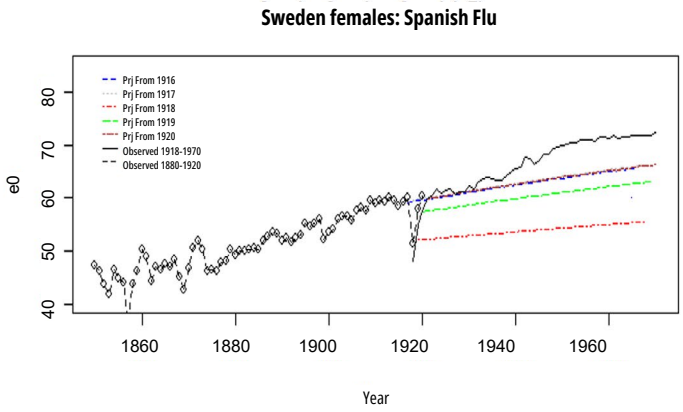
Switzerland. Life expectancy at birth of women after the Spanish flu

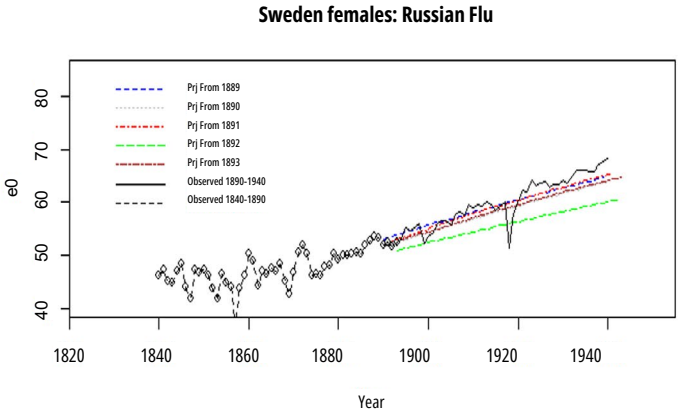


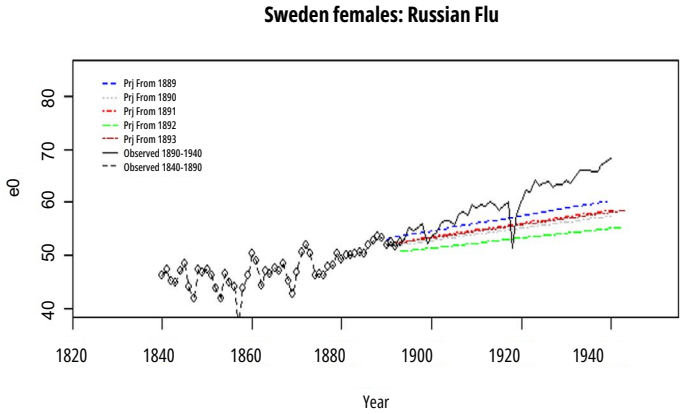


Sweden. Life expectancy at birth of women after the Spanish flu and the Russian flu

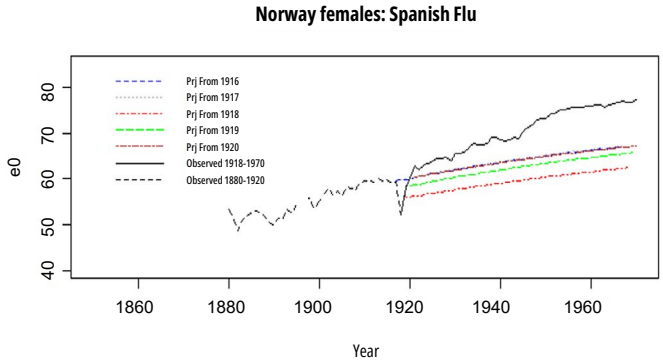


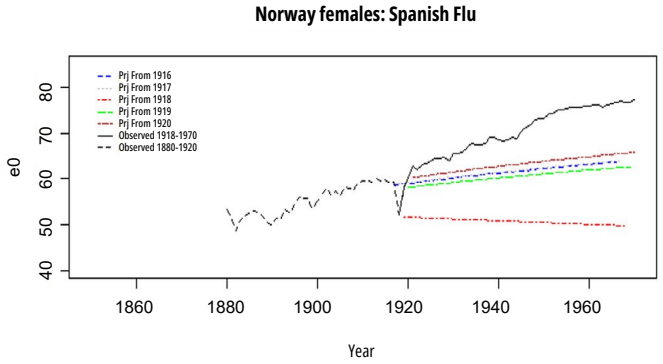


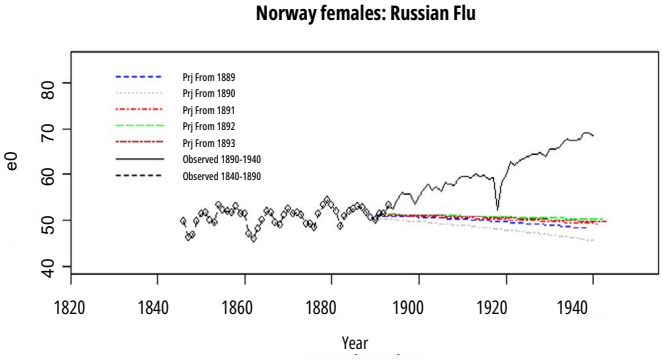


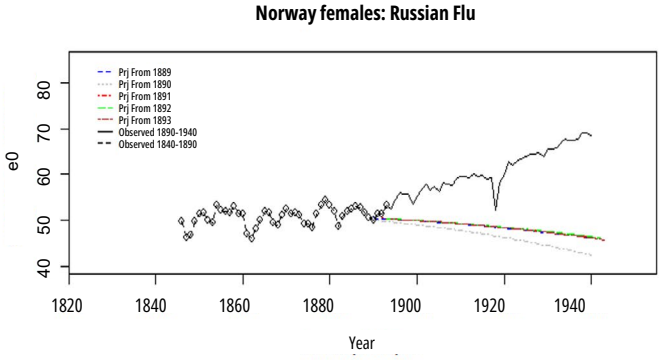


Norway. Life expectancy at birth of women after the Spanish flu and the Russian flu

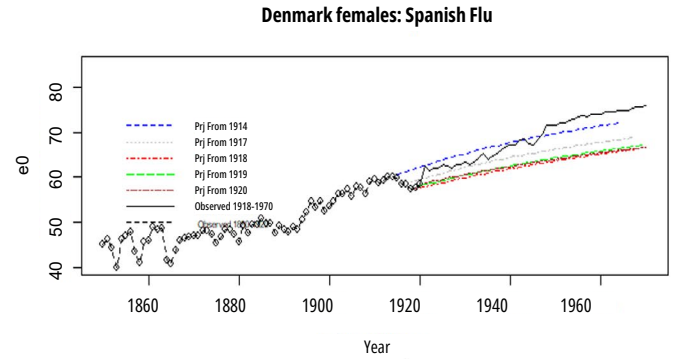


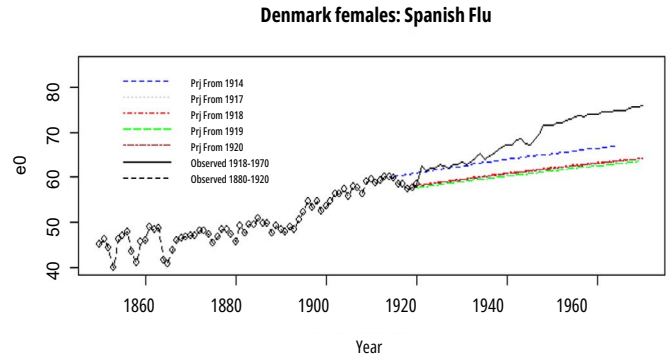


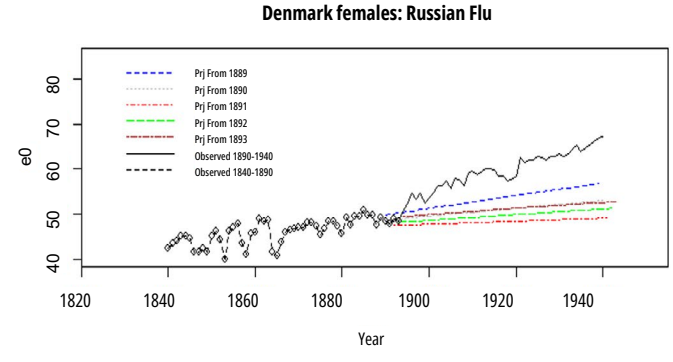


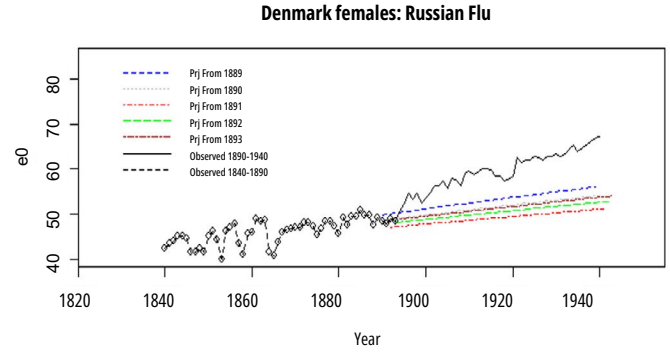


Denmark. Life expectancy at birth of women after the Spanish flu and the Russian flu

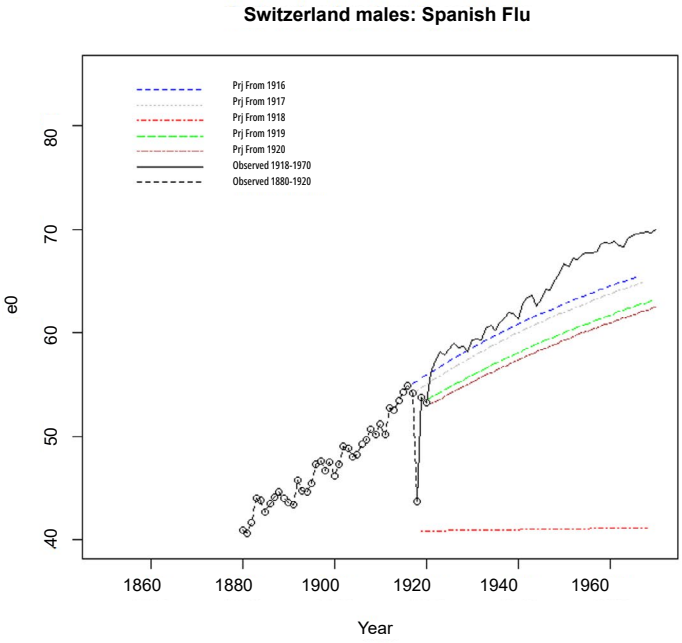


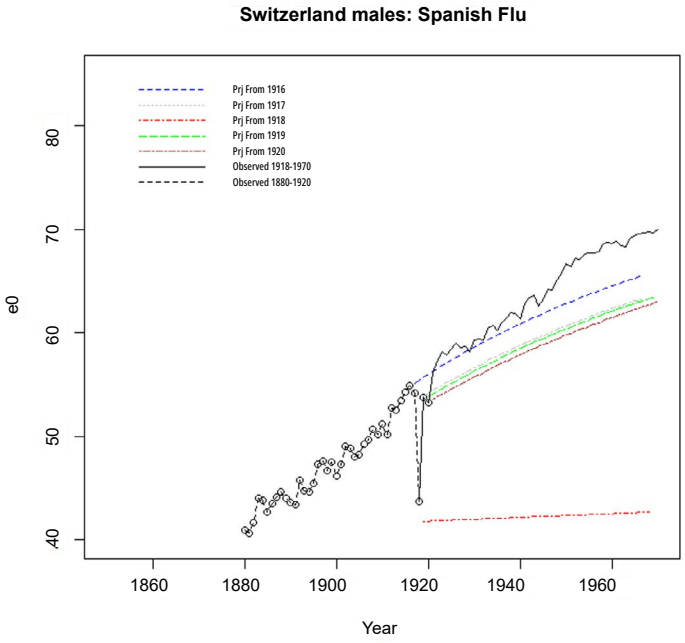




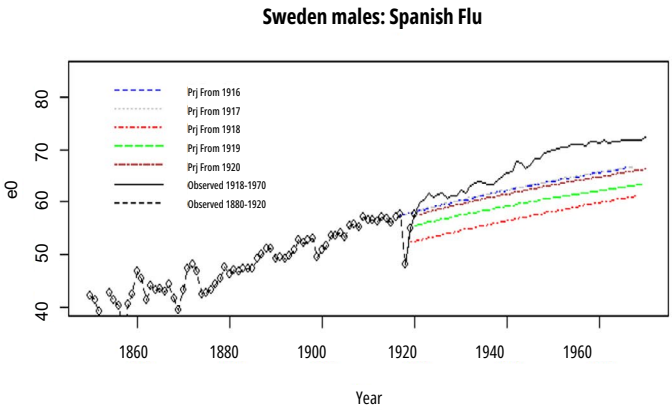


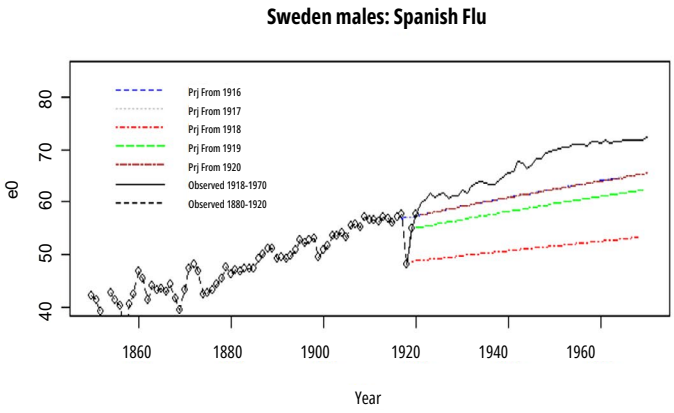
Switzerland. Life expectancy at birth of men after the Spanish flu

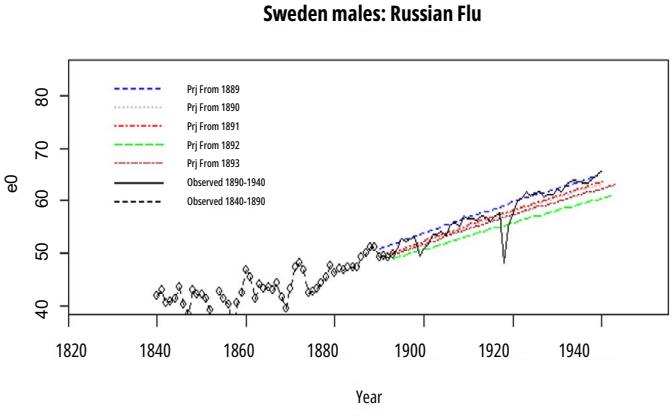


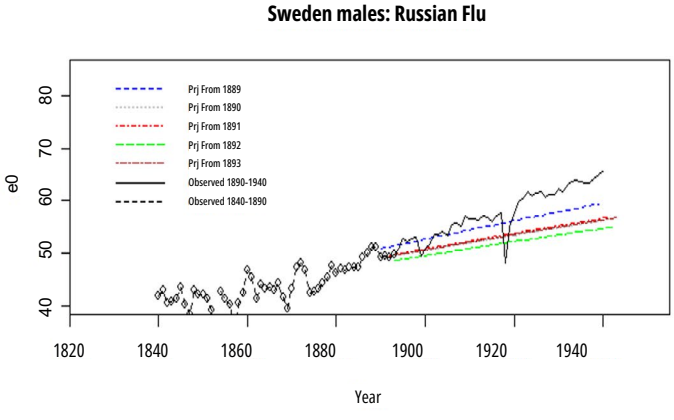


Sweden. Life expectancy at birth of men after the Spanish flu and the Russian flu

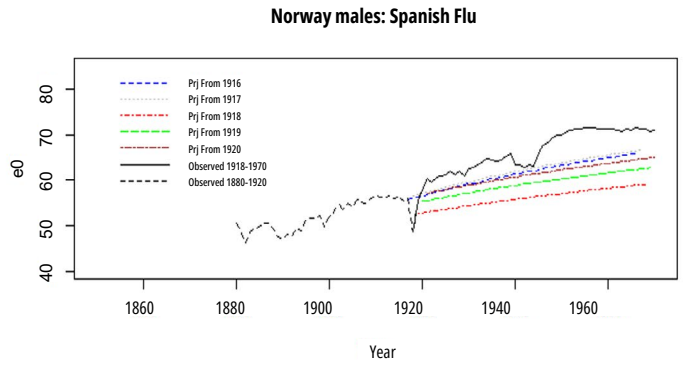


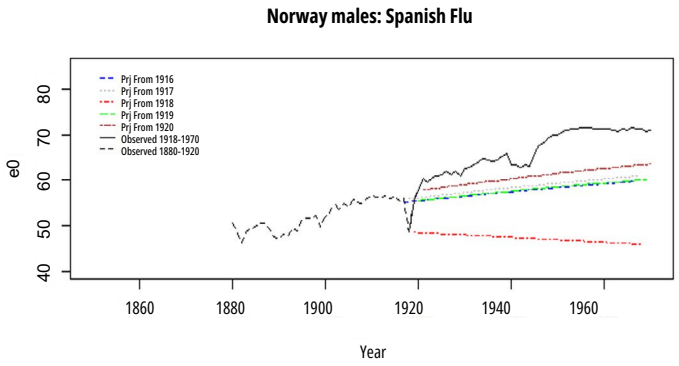


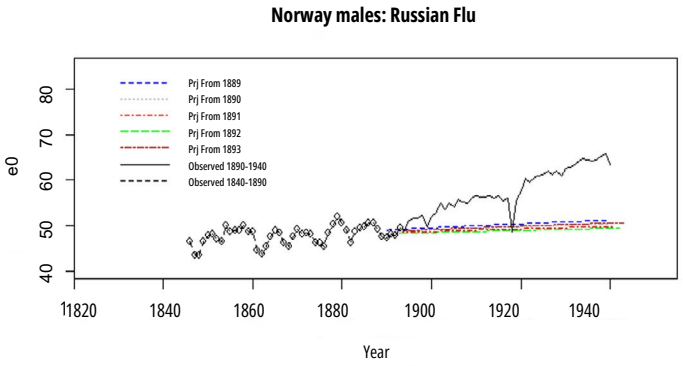


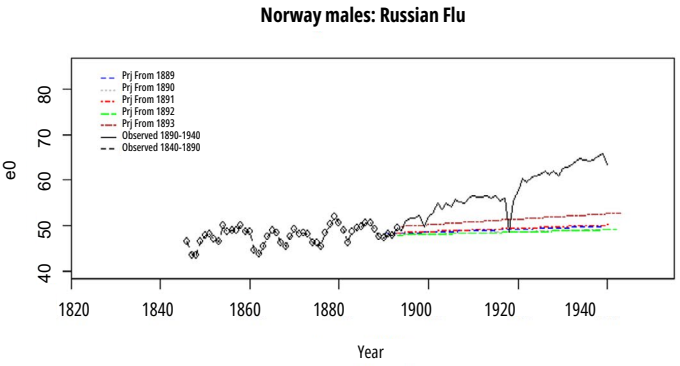


Norway. Life expectancy at birth of men after the Spanish flu and the Russian flu

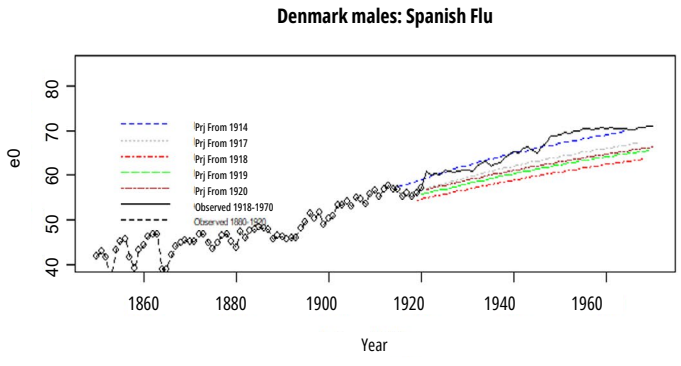


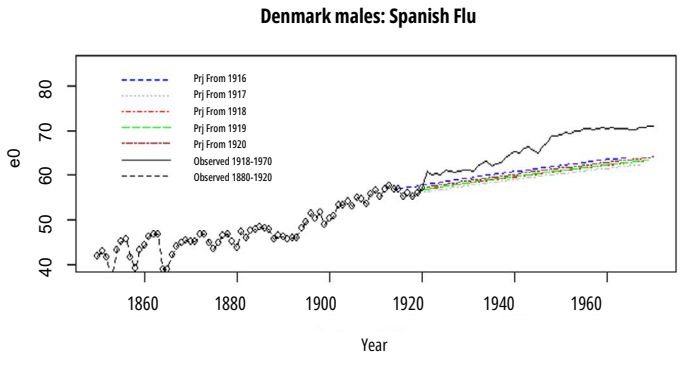


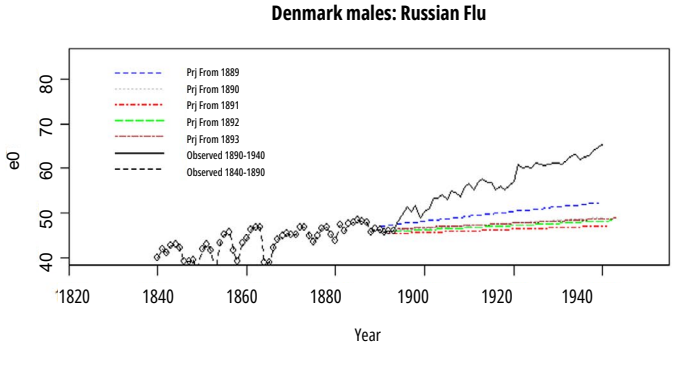


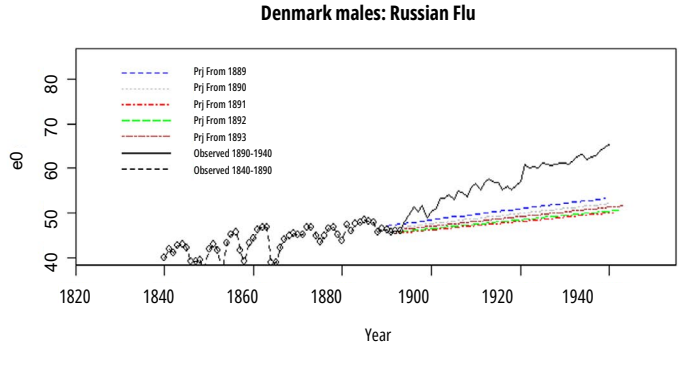


Denmark. Life expectancy at birth of men after the Spanish flu and the Russian flu









INEC, de la rotonda de La Bandera 450 metros oeste, sobre calle Los Negritos,
edificio Ana Lorena, Mercedes de Montes de Oca, Costa Rica.
Correo electrónico solicitud.datos@inec.go.cr Apartado 10163-1000 San José, C. R.
Teléfonos: (+506) 25-27-11-44, 25-27-11-45, 25-27-11-46, 25-27-11-47 y 25-27-11-24.