ABOUT MORTALITY DATA FOR CHILE

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"Mas que mejorar la suerte del pueblo, el primer paso es conocerlo a fondo y, por desgracia, carecemos de datos estadísticos." Andrés Bello, 1835 Founder of the University of Chile in 1843¹.

Translation: "More than improving the situation of the [Chilean] people, the first step is to know it in detail; unfortunately, we lack statistical data [for this purpose]."

GENERAL

The collection of official demographic statistics for Chile started with the census of 1835. There was an earlier census in 1813 that has figures regarding the national population, but coverage was incomplete (INE, 2003). The second census attempt started in 1831, but was not finished until 1835 and it triggered the creation of the Office of Statistics (Oficina de Estadística) in 1843 (Kappes, 1993). It was later known as the Central Office of Statistics (Oficina Central de Estadística), General Direction of Statistics (Dirección General de Estadística), Direction of Statistics and Census (Dirección de Estadísticas y Censos), and since 1970, as the Instituto Nacional de Estatística (INE). Since its establishment, this institution has been responsible for collecting census and vital statistics data. Its first task was the third official census collection in 1843. After the 1854 census, it was declared by law that censuses would occur at 10 year intervals in 1865, 1875, 1885 and 1895 (INE, 2003). The next census was delayed two years until 1907 because of the devastating 1906 earthquake. Later, Chile conformed with the recommendations of the IVth International Conference of Statistics that censuses would occur at the end of each decade (although that practice was interrupted in 1950): 1920, 1930, 1940, 1952, 1960 and 1970.

The most recent censuses were conducted in 1982, 1992, 2002, 2012, and 2017. However, the 2012 census was flawed by a large undercount. The Director of INE ended up resigning after irregularities in the census were discovered, and he was accused of manipulating the figures (Bonnefoy, 2013). An external review commission was appointed to review the process. They concluded that at least 9.3% of the population was not counted and the undercount exceeded 20% in one-fifth of the municipalities (Bravo et al., 2013). The commission recommended against using the 2012 census for official population estimates (Bravo et al., 2013). Consequently, INE decided to discard the results from that census. Chile held another abbreviated census in 2017.

¹ http://en.wikipedia.org/wiki/Andres Bello

In Chile, vital statistics data, which complemented the information provided by the censuses, were first published in 1860 with the first edition of the *Statistical Yearbook of the Republic of Chile* (Anuario Estadístico de la República de Chile). This information was published on a regular basis until 1937, and much of the data was also published in smaller collections since 1911, among them *Demography* (Kappes, 1993). This latter publication has also had the title *Demography and Social Welfare* (Demografía y Asistencia Social), *Demographic Yearbook* (Anuario de Demografía), *Yearbook of Vital Statistics* (Anuario de Estadísticas Vitales), and more recently, *Vital Statistics Yearly Report* (Estadísticas Vitales Informe Anual). The registration of vital events and the preparation, collection, and publication of these data is currently carried out by three institutions that constitute the System of Vital Statistics (Sistema de Estadísticas Vitales). Those three institutions are the Civil and Identification Register Service (Servicio de Registro Civil e Identificación), the Ministry of Health (Ministerio de Salud), and the INE (INE, 2003).

The mortality series for Chile included in the Human Mortality Database (HMD) covers the period since 1992. This initial series was selected after assessment of the developments in birth, death, and population counts during the second half of the twentieth century. Parts of this evaluation are included in the present document. The main reasons for restricting the HMD series to the period since 1992 are: 1) 1992 was the first census with less than 3% age misreporting; 2) it is only in the last decade of the twentieth century that the percentage of delayed birth registration is 5.4% or lower; and 3) finally, during this period, at least 90% of deaths were certified by a physician. On the page for Chile in the HMD, the section labeled "Input data" includes all of the raw data on population, births and deaths for the second half of the twentieth century that we discuss here.

Source of Data

For the HMD, we use death counts disseminated via the Departemento de Estadísticas e Informatión de Salud (DEIS), Ministerio de Salud, Gobierno de Chile website (http://www.deis.cl/bases-de-datos-defunciones/). For recent years, birth counts were obtained from the INE's online archives (https://www.ine.cl/estadisticas/sociales/demografia-y-vitales/nacimientos-matrimonios-y-defunciones). Sex-specific annual birth counts prior to 2008 were obtained from annual vital statistic publications. Monthly birth counts prior to 2012 were obtained from the Human Fertility Database, who extracted the original data from annual vital statistics publications or from the data archives maintained by the Ministerio de Salud. The census counts were obtained from published tables (1992) or downloaded from INE's online archives (2002 & 2017, see Appendix 1 for more details.)

Specific Episodes in Chile's Demographic History in the second half of the twentieth century

Between the 1950s and 1970s, relative to its overall population, Chile did not experience any large scale wave of immigrants, and net migration was mainly negative but minor. Data from the UN suggests low levels of negative net migration (-0.4% to -0.3%) during 1950-1975, after which net migration increased slowly to near zero in

1990-95 and reached +0.2% during 2010-15 (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

Currently, the largest number of immigrants comes from neighboring countries. Among these migrants, INE (2005) estimated that a large proportion later returned to their country of origin. INE estimated that 857,781 Chileans were living abroad in 2005, 50.1% of whom were in Argentina, 13.3% in the United States and 4.9% in Sweden (INE, 2005). The report *Chileans Living Abroad* (INE, 2005) notes that economic and family reasons were the main impetus for the emigration. The period of 1970-75 was an exception; political turmoil within Chile caused an increase in political emigration as well as an increase in the number of deaths.

TERRITORIAL COVERAGE

During the period covered by the HMD, the national territory of Chile is bordered by Peru to the north, Bolivia and Argentina to the east, the South Pole, and the Pacific Ocean to the west (INE, 2003). This also includes Easter Island (Isla de Pascua) and Isla Sala y Gomez. The region of Tacna, which belonged to Chile from 1880 until 1929, is not included in the HMD mortality series.

DEATH COUNT DATA

Coverage and Completeness

Death data cover the *de facto* population. In the second half of the twentieth century, the collection of deaths is of good quality (INE-CEPAL, 2004), and after World War II, the first evidence of mortality decline in Chile was observed in the period 1965 to 1970, together with a strong decline in fertility. This reduction in mortality was interrupted during the years of political turmoil, but after 1975 the declining trend continued. By 1975, infant mortality had reached very low levels comparable to those in developed nations (INE, 1999; INE-CEPAL, 2004). Medical certification of deaths is required by law in Chile; in the 1980s, over 90% of deaths were certified by physicians, and by 2003 this figure had reached 99%. Finally, as another measure of the quality of death registration system, ill-defined conditions were indicated as the cause of death for only 3% of registered deaths in 2003 (Núñez and Icaza, 2006).

As reported to the United Nations Statistical Division (2017) by the Chilean National Statistics Office, completeness of death registration for Chile was 90% or greater in 2012. The Global Burden of Diseases (GBD) study (Wang et al., 2017, see Figure 1) estimated that completeness of death registration in Chile was 95% or higher during 1990-2014. The Latin American Mortality Database (LAMBdA) Team estimated that relative completeness (i.e., the completeness of death registration relative to population counts) was 96% for the intercensal interval 1952-60, but improved to 98% for the period centered at 2006 based on the census in 2002 (Beltrán-Sánchez et al., 2019, see Table 3.4).

Specific Details

Annual death counts since 1990 are available from DEIS by sex, age, and year of birth (i.e., Lexis triangle). Prior to 2002, there are many inconsistencies between age

and birth cohort as well as missing information for the year of birth. For example, in 1992, age and cohort was inconsistent for more than 1% of deaths and year of birth was missing for another 0.3%. Since 2002, fewer than 0.2% of annual deaths exhibit inconsistencies between age and birth cohort or missing data for year of birth. Thus, we use death counts by single year of age (1x1) for 1992-2001 and deaths by Lexis triangle since 2002.

POPULATION COUNT DATA

Coverage and Completeness

All Chilean censuses represent the *de facto* population. The country has a long history of censuses, but data quality has varied over time (Goyer and Draaijer, 1983). INE calculated that the Census of 1940 was underenumerated by 4% and published only adjusted results with no documentation for the adjustment method. Table 1 presents an indicator of age heaping on any terminal digit (i.e., Myer's Index) for the subsequent five censuses. Myer's Index ranges from 0 to 90, where 0 indicates no age heaping.

Whipple's Index shows the excess or deficit of people at ages ending in 0 or 5. When this index is applied to Chilean data it suggests that the 1960 Census was of high quality (Goyer and Draaijer, 1983), yet Myer's Index indicates that age is reported incorrectly for more than 10% of the population (Table 1). The 1970 census showed little improvement in Myer's index and worsening of Whipple's Index. During the last three decades of the twentieth century, data quality improved substantially.

Table 1. Myer's Index for the Chilean censuses from 1952 to 2002.

CENSUS	Total	Males	Females
1952	15.3	12.9	17.6
1960	12.9	11.0	14.6
1970	10.3	9.4	11.2
1982	4.0	3.3	4.7
1992	2.6	2.4	2.9
2002	2.5	2.5	2.6

Source: INE-CEPAL. 2004

In Figure 1, we plotted the total population based on the 1992, 2002, and 2017 censuses against the official population estimates. The latter are higher than the former; the biggest differential is for men in 2017, where the official population estimate as of June 30, 2017 is 5.5% higher than the April 19, 2017 census count. The total census count in 2017 is roughly on par with the official population estimate five years earlier.

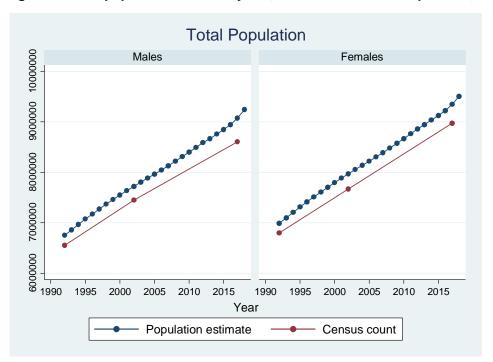


Figure 1. Total population of Chile by sex, Census vs. Official Population, 1992-2017

When we examined the ratio of population estimates to census counts by age. we found that the biggest relative discrepancies were above age 80 in 1992 (Figure 2) and 2002 (Figure 3) and at ages 100 and older in 2017 (Figure 4). However, at those oldest ages, the official population estimates are much *lower* than the census counts, perhaps because of age exaggeration in the census. The age structure of adjustment appears to differ across the three censuses. In 1992, the official population estimates above age 70 appear to have been adjusted downwards compared with the census counts. In 2002, the official population estimates were adjusted downwards compared with the census counts only above age 80. By 2017, the downward adjustment compared with the census counts was only above age 100. At younger ages, there does not appear to be a consistent census undercount below age 60 in 1992. Yet, the discrepancies between the (adjusted) population estimates and census counts in 2002 suggest a notable undercount at young ages. By 2017, there appears to be a consistent undercount at most ages below 70. Although the 1992 and 2002 census show evidence of age heaping, the 2017 census appears less affected by age heaping. Altogether, these results suggest that the quality of the census may have improved over time. The problems at working ages may reflect the inability of the statistical system to accurately reflect processes related to internal and international migration.

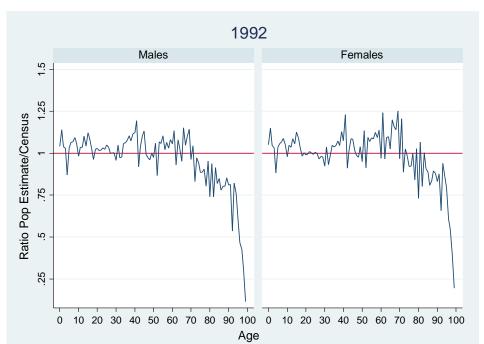
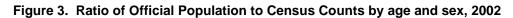
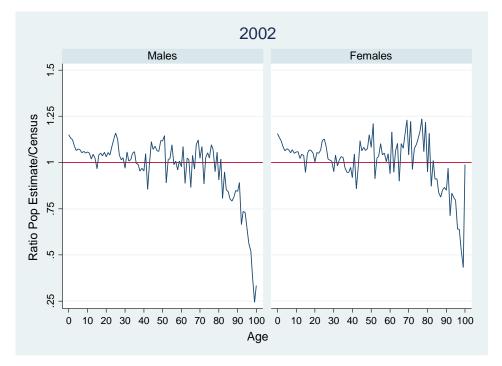


Figure 2. Ratio of Official Population to Census Counts by age and sex, 1992





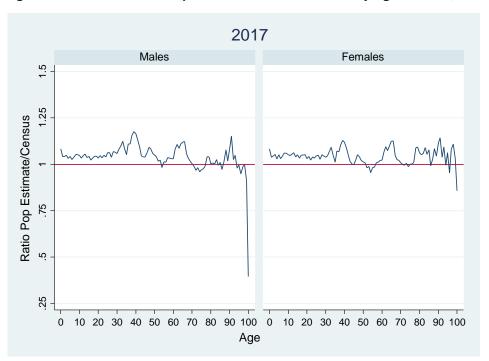


Figure 4. Ratio of Official Population to Census Counts by age and sex, 2017

When we plot the official population estimates against the census counts below age 70, we can see that in 1992 (Figure 5) the former are generally higher than the latter except at age 5 and ages ending in 10, suggesting age heaping in the census.

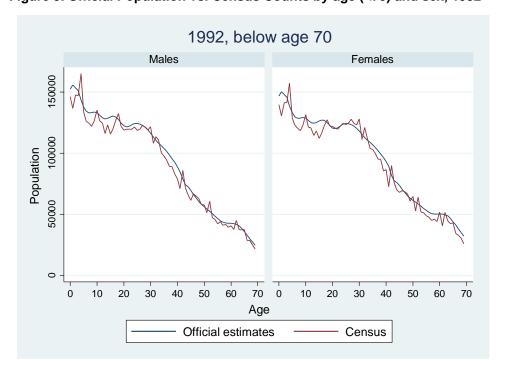


Figure 5. Official Population vs. Census Counts by age (<70) and sex, 1992

As we understand it from the documentation (INE, 2018), INE begins with the population in 1992 and then uses annual data on fertility, mortality, and migration by sex and age to recursively derive the population estimates for each year. However, it is unclear to us how the estimates for the 1992 population were derived. The documentation indicates that the 1992 population is based on CELADE's calculations using data beginning in 1950, along with old projections.

If the official population estimates are closer to the true population than the census counts but death counts are under-registered, then estimates of life expectancy using unadjusted death counts in the numerator but official population estimates in the denominator will be upwardly biased (i.e., mortality rates will be under-estimated). Therefore, we use the census counts (rather than the official population estimates) and produce our own intercensal estimates using the HMD methods protocol. The resulting HMD estimates of life expectancy are generally similar to those published by INE (2000, 2016) and the UN (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

Although using census counts is probably the best possible alternative, there are several disadvantages:

- 1) We may not be able to extend the Chilean mortality series for more than a few years, after which we will have to wait for the next census.
- 2) The population at working ages may be underestimated, but it is unlikely to have a substantial influence on mortality.
- 3) The last intercensal period is unusually long (15 years), which may negatively affect the quality of intercensal population estimates.
- 4) Data by single year of age should be used with caution.

BIRTH COUNT DATA

Coverage and Completeness

In general, the data are considered to be of good quality, although there are some problems. As reported to the United Nations Statistical Division (2017) by the Chilean National Statistics Office, completeness of birth registration for Chile was 90% or greater in 2012.

Statistics on births have been a concern for INE, not because of unregistered births, but because of delayed registration. INE has elaborated a system called "inscripciones tardias" to fix this problem, by updating official counts with births registered up to seven years after the birth (INE, 2004). The percentage of births with delayed registration declined from 5.1% in 1992 to 0.7% in 2006 to 0.3% in 2010 (INE, 2015, 2019). It is thought that many infant deaths occurring before a birth certificate is issued are registered as fetal deaths (INE-CEPAL, 2004).

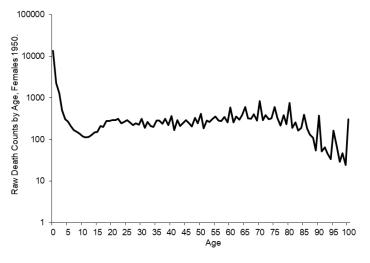
DATA QUALITY ISSUES

These data should be used with caution because of data quality issues (e.g., age heaping in the census counts, possible under-estimation of old-age mortality, census undercounts at younger and working ages).

Age Heaping

- Prior to 1990, the raw death counts exhibited patterns of age heaping at ages 40, 50, ..., 90 (see Figure 6). By 1990, the age heaping had largely disappeared.
- ❖ The census counts prior to 1992 showed considerable age heaping at ages 30, 40, ..., 80 (see Figure 7). By the 1992 census, age heaping was greatly attenuated.
- Correspondingly, the death rates prior to 1990 show notable age heaping at older ages (see Figure 8), which is one of the reasons why we restricted the mortality series for Chile to the period since 1992 (see "GENERAL" section above for more details).
- ❖ As noted above, there is still some age heaping in the 1992 and 2002 census counts.

Figure 6. Raw Death Counts by Age. Females, 1950 and 1990



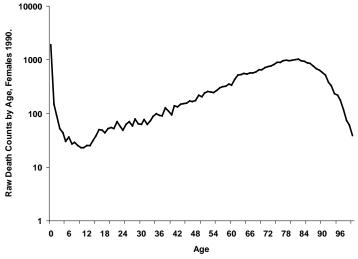
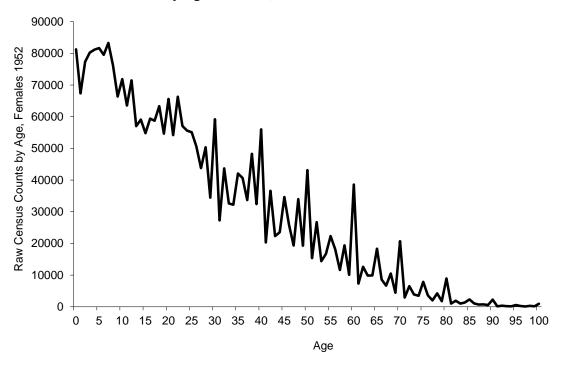


Figure 7. Raw Census Counts by Age. Females, 1952 and 1992



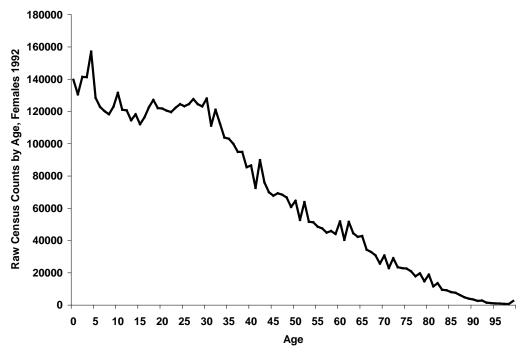
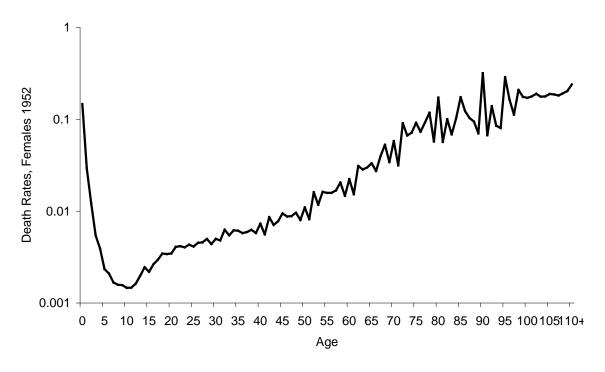
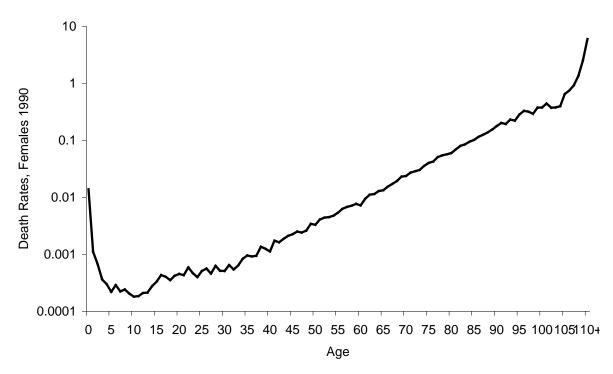


Figure 8. Estimated Death Rates by Age, Females, 1952 and 1990.





Possible under-estimation of old-age mortality

As noted above, comparison of the census counts with the (adjusted) official population estimates suggest that the census overestimated the population at the oldest ages (see Figures 2-4). However, above age 80 we recalculate population estimates using the extinct cohort or survivor ratio method, which avoids some of these problems of apparent age exaggeration in the census.

If we had used the official population estimates rather than the census counts, our estimates of e₈₀ for the period 1992-2002 would have been similar (e.g., 8.7 years in 2002 using the official population estimates versus 8.6 years using the census counts), but the estimates of e₈₀ after 2002 would have been even higher. For example, our current estimate for e₈₀ in 2017 (among both sexes combined) is 8.8 years; if we had used the official population estimates, the corresponding estimate would have been 9.9 years. This is similar to the difference in the estimates of e₀ (79.8 in 2017 when using the census counts versus 80.8 when using the official population estimates). Thus, we conclude that the differences are driven primarily by younger ages (i.e., in 2017, the official population estimates at younger ages were higher than the census counts; because the denominators are bigger for the former than the latter, they yield lower mortality rates and higher estimates of life expectancy).

It is still possible that we are underestimating mortality at older ages, but the problem would have been much worse if we had used the (adjusted) official population estimates in place of the census counts.

Census undercounts at younger and working ages

As noted above, there is evidence that the 2002 census may have undercounted the population at young ages, especially below age 20 (see Figure 3) and that the 2017 census undercounted the population at most ages below 70 (see Figure 4). Consequently, it is possible that we have overestimated the mortality rates at younger ages (because the denominators are too small).

REVISION NOTES

Changes with the December 2017 revision:

Life tables: All life tables have been recalculated using a modified methods protocol. The revised protocol (Version 6) includes two changes: 1) a more precise way to calculate a0, the mean age at death for children dying during the first year of life and 2) the use of birth-by-month data (where and when available) to more accurately estimate population exposures. These changes have been implemented simultaneously for ALL HMD series/countries. For more details about these changes, see the revised Methods Protocol (at http://v6.mortality.org/Public/Docs/MethodsProtocol.pdf), particularly section 7.1 on Period life tables and section 6 and Appendix E, on death rates. The life tables calculated under the prior methods (Version 5) remain available at v5.mortality.org but will not be further updated in the future.

Changes with the October 2020 revision:

Raw Data: We added death and birth counts for 2008-2017. Death counts for 1992-2007 were updated (deaths since 2002 are now available by Lexis triangle; all death counts are available to the maximum age attained; there is no longer an open age interval). We added the 2017 census counts and are no longer using the official population estimates. Thus, we revised all previous population estimates.

ACKNOWLEDGEMENTS

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APPENDIX 1:

DESCRIPTION OF ORIGINAL DATA USED FOR HMD CALCULATIONS

DEATHS

Period Type of Data		Age Grouping	RefCode(s)†
1992-	Annual number of deaths (de facto population) by sex and single	0,1,,max, unk	19
2001	year of age (1x1) ^a		
2002-	Annual number of deaths (de facto population) by sex, single year	0,1,,max, unk	19
2017	of age, and birth cohort (Lexis triangles)		

[†] The reference code is used in the raw data files (Input Database) to link data with sources. unk = deaths of unknown age

POPULATION

Period	Type of Data	Age Grouping	RefCode(s)†
1992	Census counts (de facto population) as of April 22th, by sex and	0, 1,, 99+	25
	single year of age to 99+.		
2002	Census counts (de facto) as of April 24th, by sex and single year of	0, 1,, 107,	26
	age to 108+.	108+	
2017	Census counts (de facto) as of April 19th, by sex and single year of	0, 1,, 107,	27
	age to 100+.	100+	

[†] The reference code is used in the raw data files (Input Database) to link data with sources. unk=population of unknown age

BIRTHS BY SEX

	Period	Type of Data	RefCode(s) [†]
ĺ	1907-2017	Live birth counts for the <i>de facto</i> population by sex and calendar year	1-9

[†] The reference code is used in the raw data files (Input Database) to link data with sources.

BIRTHS BY MONTH

Period	Type of Data	RefCode(s) [†]
1947-2017	Live birth counts for the <i>de facto</i> population by month and calendar year	32-36

[†] The reference code is used in the raw data files (Input Database) to link data with sources.

^a Deaths counts for 1990-2001 are available by Lexis triangle, but we do not use the information regarding year of birth because of there are many deaths for which the year of birth is missing or there are inconsistencies between age, date of birth, and date of death (see "Death Count Data, Specific Details").

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APPENDIX 2:

ADDITIONAL DATA INCLUDED IN THE INPUT DATA

DEATHS

Period	Type of Data	Age Grouping	RefCode(s)†
1943- 1953	Annual number of deaths (<i>de facto</i> population) by sex and single year of age up to age 99 and open age interval 100+ (1x1)	0,1,,100+, unk	10, 11, 12
1954	Annual number of deaths (<i>de facto</i> population) by sex and single year of age up to age 104 and open age interval 105+ (1x1)	0,1,,105+, unk	12
1955	Annual number of deaths (<i>de facto</i> population) by sex and 5-year age groups (5x1)	0-4,5-9,,95-99, 100+, unk	13
1956- 1961	Annual number of deaths (<i>de facto</i> population) by sex and single year of age up to age 104 and open age interval 105+ (1x1)	0,1,,105+, unk	14
1962	Annual number of deaths (<i>de facto</i> population) by sex and 5-year age groups (5x1)	0-4, 5-9,,95-99, 100+, unk	15
1963- 1989	Annual number of deaths (<i>de facto</i> population) by sex and single year of age up to age 104 and open age interval 105+ (1x1)	0,1,,105+, unk	16, 17, 18
1990- 1991	Annual number of deaths (<i>de facto</i> population) by sex and single year of age (1x1)	0,1,,max	19

[†] The reference code is used in the raw data files (Input Database) to link data with sources. unk=deaths of unknown age

POPULATION

Period	Type of Data	Age Grouping	RefCode(s)†
1940	Census counts (de facto population) as of November 28th, by	0, 1,, 100,	20
	sex and single year of age to 101.	101+	
1952	Census counts (de facto population) as of April 24th, by sex and	0, 1,, 99,	21
	single year of age to 100.	100+, unk	
1960	Census counts (de facto population) as of November 29th, by	0, 1,, 99, 100+	22
	sex and single year of age to 100.		
1970	Census counts (de facto population) as of April 22th, by sex and	0, 1,, 84, 85+	23
	single year of age to 85.		
1982	Census counts (de facto population) as of April 21th, by sex and	0, 1,, 99+	24
	single year of age to 99.		
1992-	Official population estimates as of June 30th, by sex and single	0, 1,, 99, 100+	50
2018	year of age to 100+.		

[†] The reference code is used in the raw data files (Input Database) to link data with sources.