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Comparing the loss of life expectancy at birth during the 2020 and 1918 pandemics in six European countries

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Abstract

The COVID-19 pandemic that reached Europe in 2020 has often been compared to the Spanish flu pandemic of 1918. In this article, we compare the two pandemics in terms of their respective impacts on the loss of life expectancy at birth in six European countries (France, Italy, the Netherlands, Spain, Sweden, Switzerland) by estimating life expectancy in 2020 using Eurostat data. We found that the loss of life expectancy at birth was up to 20 times larger between 1917 and 1918 than between 2019 and 2020. A decomposition of these losses clearly shows that in all six countries, the main contributors were older age groups in 2020 and younger age groups in 1918. These observations are consistent with evidence indicating that most COVID-19 fatalities were among the elderly, while a majority of Spanish flu fatalities were among the young.

Keywords: all-cause mortality; COVID-19; Europe; life expectancy decomposition; period life expectancy; Spanish flu

1 Introduction

The COVID-19 pandemic that reached Europe in 2020 is considered by many to be the health event that had the greatest impact on all-cause mortality since the Spanish flu of 1918 (e.g. Morens et al., 2021). As of early 2021, several studies had been published that attempted to estimate the loss of life expectancy in 2020 in various countries around the world (e.g. Aburto et al., 2021a; Andrasafay and Goldman, 2021; Heuveline and Tzen, 2021; Locatelli and Rousson, 2021). For example, Locatelli and Rousson (2021) estimated that in Switzerland, life expectancy at birth

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declined between 2019 and 2020 by 5.3 months for women and by 9.7 months for men. Although losses of this magnitude had not previously been observed since 1962 for women and since 1944 for men, the authors of the Swiss study noted that the Spanish flu pandemic had a far greater impact, with life expectancy decreasing between 1917 and 1918 by more than eight years for women and by more than 10 years for men. In the following analysis, we will further compare levels of all-cause mortality between the two pandemics in six European countries. Our approach is to compare the loss of life expectancy at birth in 2020 and in 1918, and to decompose the losses into the contributions of different age groups, following the method used in United Nations (1982, 1985), as reported in Ponnapalli (2005).

2 Data

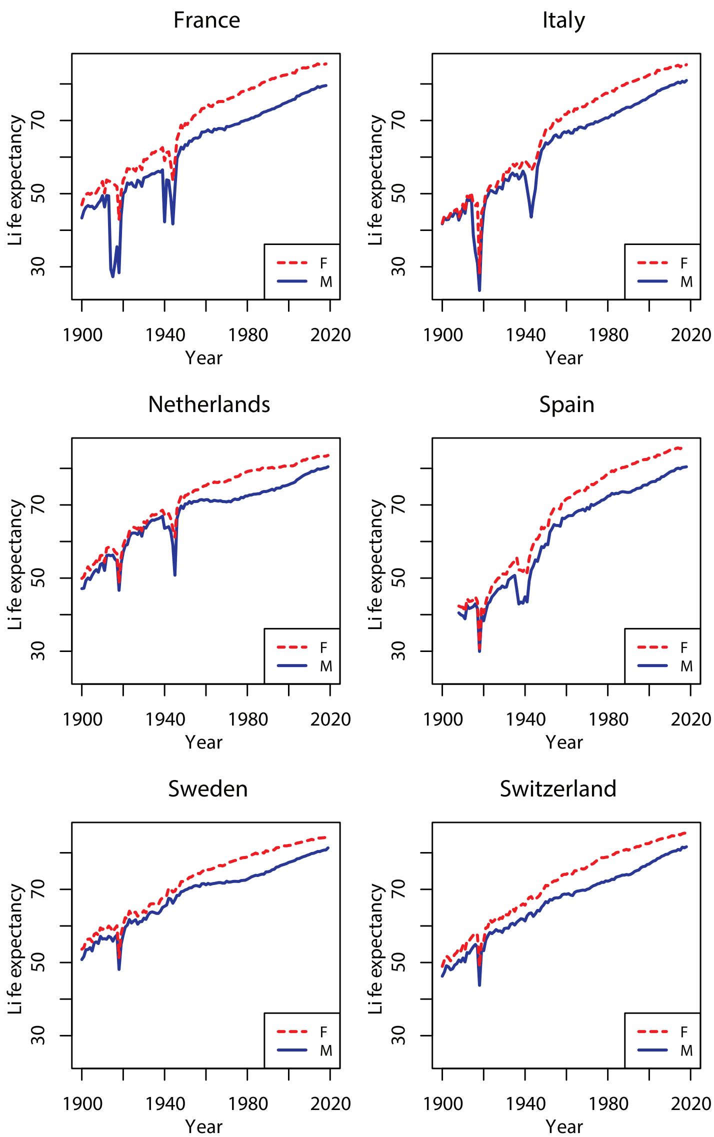
The countries included in this study were chosen primarily on the basis of available data. Period life tables for 1917 and 1918 were taken from the Human Mortality Database (HMD, https://www.mortality.org/). As these data were not available for all European countries, we had to exclude a number of countries, including Austria, Belgium, Germany, Greece, Ireland, Luxembourg, Portugal, the United Kingdom and the Eastern European countries. We also excluded countries that experienced (almost) no loss of life expectancy in 2020, such as Denmark, Finland, Iceland and Norway (Aburto et al., 2021b). This left us with six countries – namely France, Italy, the Netherlands, Spain, Sweden and Switzerland – that were all affected (to varying degrees) by the two pandemics, as seen below.

Figure 1 displays estimates from the HMD of life expectancies at birth for women and men in these six countries from 1900 (1908 for Spain) to 2018 (2019 for the Netherlands and Sweden). The figure shows that there was a dramatic drop in life expectancy in 1918, and thus during the largest wave of the Spanish flu, both in countries that were actively participating in the First World War (France and Italy) and in countries that were not directly involved (the Netherlands, Spain, Sweden and Switzerland). Note that during the First World War, special methods for obtaining estimates of death and population numbers were used to include the military population in France and in Italy (see the HMD country-specific documentation).

For these six countries, the number of deaths (from all causes) for the years 2010–2020 and the population size on January 1 for the years 2010–2021 by age and sex (with a last open age group of 100+) were obtained from the Eurostat website (https://ec.europa.eu/eurostat/fr/web/main/data/database, last accessed on April 29, 2022).[1] Age- and sex-specific mortality rates in each year were calculated by dividing the number of deaths in that year by the average of the population size of the corresponding year for a given age and sex.

[1] Population size on January 1, 2021 is still provisional in France.

Figure 1:
Life expectancy at birth between 1900 (1908 for Spain) and 2018 (2019 for the Netherlands and Sweden) for women (F) and men (M) in six European countries



Source: Human Mortality Database, University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at https://www.mortality.org.

3 Methods

For a given country and sex, the probabilities l_x^y of surviving to age x for each year y ($y = 2010, \ldots, 2020$) were obtained using a piecewise exponential model (Friedman, 1982) until the age of 110. This was done by letting $l_0^y = 1$ and calculating (for $x = 1, \ldots, 110$):

$$l_x^y = \exp\left(-\sum_{t=0}^{x-1} m_t^y\right).$$

In this formula, m_x^y denotes the mortality rate at age x for year y obtained above using Eurostat data, assumed to be constant in the last open age group (100+). Life expectancy e_x^y at age x in year y was estimated using the l_x^y by means of classical mortality table calculations. This was done by calculating (for $x = 0, \ldots, 109$):

$$e_x^y = \frac{\sum_{t=x}^{109}(l_t^y + l_{t+1}^y)/2}{l_x^y}.$$

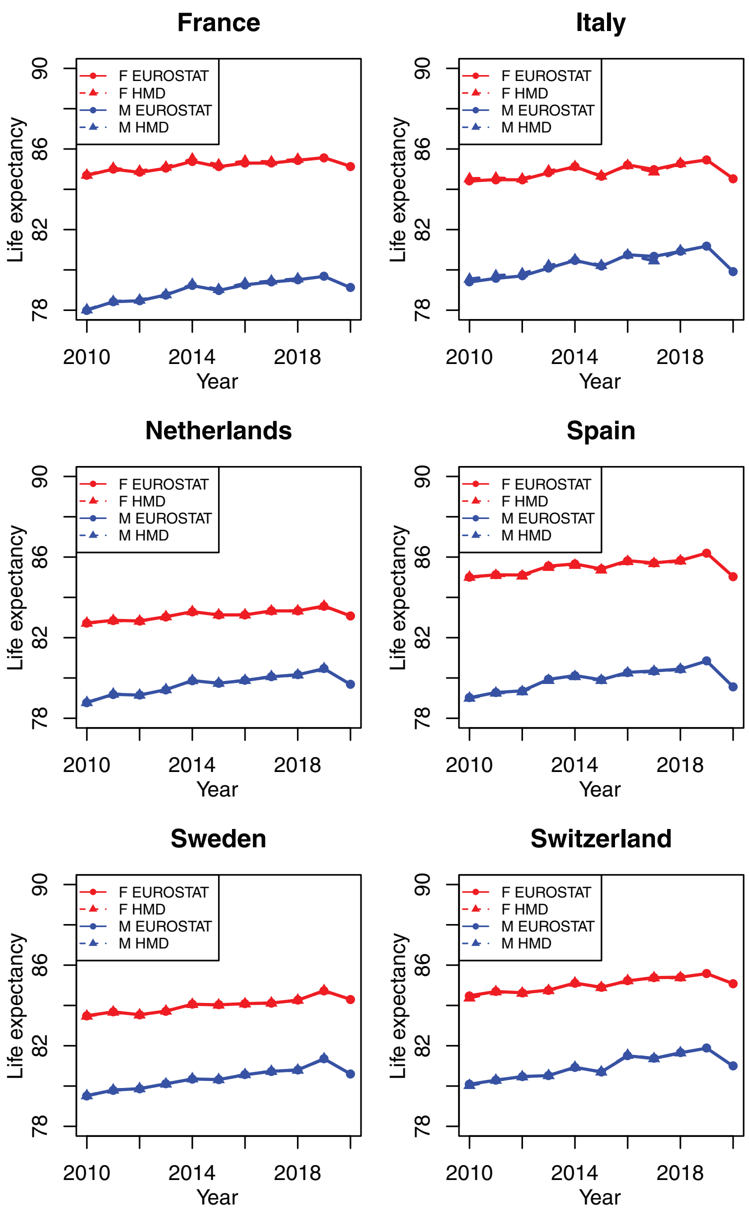
Thus, we implicitly assumed that everybody died before the age of 110. Corresponding estimated life tables for 2020 are provided as Supplementary Material (available at https://doi.org/10.1553/populationyearbook2022.dat.7). Figure 2 shows life expectancies at birth obtained for men and women in the six countries between 2010 and 2020. To check the validity of the method and the reliability of the data, these estimates could be compared with those provided in the HMD for the years 2010–2018 (2019 for the Netherlands and Sweden), which are considered to be the gold standard. As can be seen in Figure 2, the two estimates were very close to each other, with the absolute differences between the two estimates averaging 0.03 years (0.4 months), and with 89% of them being less than one month and 99% of them being less than two months. Similar percentages were found (93% and >99%) when the two estimates of life expectancies at any age between zero and 85 years were compared (no life expectancies at ages over 85 are used in this paper).

For each country and sex, we calculated losses of life expectancy at birth between 2019 and 2020 (based on Eurostat data), and between 1917 and 1918 (based on HMD data). The contributions of the different age groups to these losses between years y_1 and y_2 were calculated using the United Nations (1982, 1985) decomposition method, as advocated by Ponnapalli (2005), which is a compromise between the decomposition methods introduced by Lopez and Ruzicka (1977) and by Arriaga (1984). The contribution of age group $(x, x+n)$ to the total loss was thus calculated as:

$$(e_x^{y_2} - e_x^{y_1})(l_x^{y_2} + l_x^{y_1})/2 - (e_{x+n}^{y_2} - e_{x+n}^{y_1})(l_{x+n}^{y_2} + l_{x+n}^{y_1})/2.$$

The contribution of the last open age group was obtained by the first term of this formula, without subtracting any second term. As an example, we had for Italian women in $y_2 = 1917$ and $y_1 = 1918$ (according to HMD period life tables)

Figure 2:
Life expectancy at birth between 2010 and 2020 estimated using Eurostat data (solid lines) or provided by the Human Mortality Database (HMD, dashed lines) for women (F) and men (M) in six European countries



$e_0^{1917} = 47.41, e_0^{1918} = 28.34, e_5^{1917} = 56.24$ and $e_5^{1918} = 38.10$ while we had $l_0^{1917} = l_0^{1918} = 1, l_5^{1917} = 0.770$ and $l_5^{1918} = 0.646$. The loss of life expectancy at birth in 1918 was thus $47.41 - 28.34 = 19.07$ years, and the contribution of age group 0-5 to that loss was:

$$(47.41 - 28.34)(1 + 1)/2 - (56.24 - 38.10)(0.770 + 0.646)/2 = 6.23.$$

Of note, this example shows that it is possible for the contribution of an age group to be greater than the length n of the corresponding age interval.

4 Results

Distributions of the number of deaths by age for the different years in each country (the d_x of the life tables, which refer to a population size of 100,000) are shown in Figure 3 for women and in Figure 4 for men. As expected, the deaths in 2019 and 2020 were concentrated in the older ages in all countries, with almost no deaths occurring in the younger ages. By contrast, there were many deaths at very young ages in 1917 and 1918, as well as a non-negligible number of deaths among young adults, especially in 1918. In 1917, we can also see the impact of the First World War in the high number of deaths among French and Italian young men.

Our estimates of the decomposition of the loss of life expectancy at birth between 2019 and 2020 and between 1917 and 1918 for women and men in the six countries are provided in Table 1, along with the estimated life expectancies at birth for those years. In all countries and for both sexes, the loss was much larger in 1918 than in 2020. In 2020, it ranged from 0.4 years (for French and Swedish women) to 1.3 years (for Italian and Spanish men). The loss in 2020 was generally slightly larger for men than for women, and averaged 0.8 years over both sexes and the six countries. By contrast, the loss of life expectancy at birth in 1918 ranged from 7.1 or 7.5 years (for French and Italian men) to 12.8 or even 19.1 years (for Spanish and Italian women), with an average of 10.0 years.

Since life expectancy was very different in 1917 and 2019, it might also be sensible to express and compare these losses in terms of percentages. For example, Woolf et al. (2021) used percentages to compare the losses of life expectancy due to COVID-19 in different sub-populations of the USA. In the six countries, the loss in 2020 represented between 0.5% and 1.6% (averaging 0.95%) of life expectancy at birth in 2019. By contrast, the loss in 1918 represented between 14% and 40% (averaging 21%) of life expectancy at birth in 1917. Thus, if we express these losses in years, 1918 (with the Spanish flu) was, on average, 13 times more deadly than 2020 (with COVID-19) in these countries. If we express these losses in percentages, 1918 was as much as 22 times more deadly than 2020. Note that these figures are similar if we exclude from the calculation French and Italian men who actively took part in the First World War.

The contributions of different age groups to the loss of life expectancy at birth in 2020 and 1918 for both sexes in each country are provided in Table 2, using the same

Figure 3:
Distribution of deaths by age (the d_x of the life tables) in 1917, 1918, 2019 and 2020 for women in six European countries

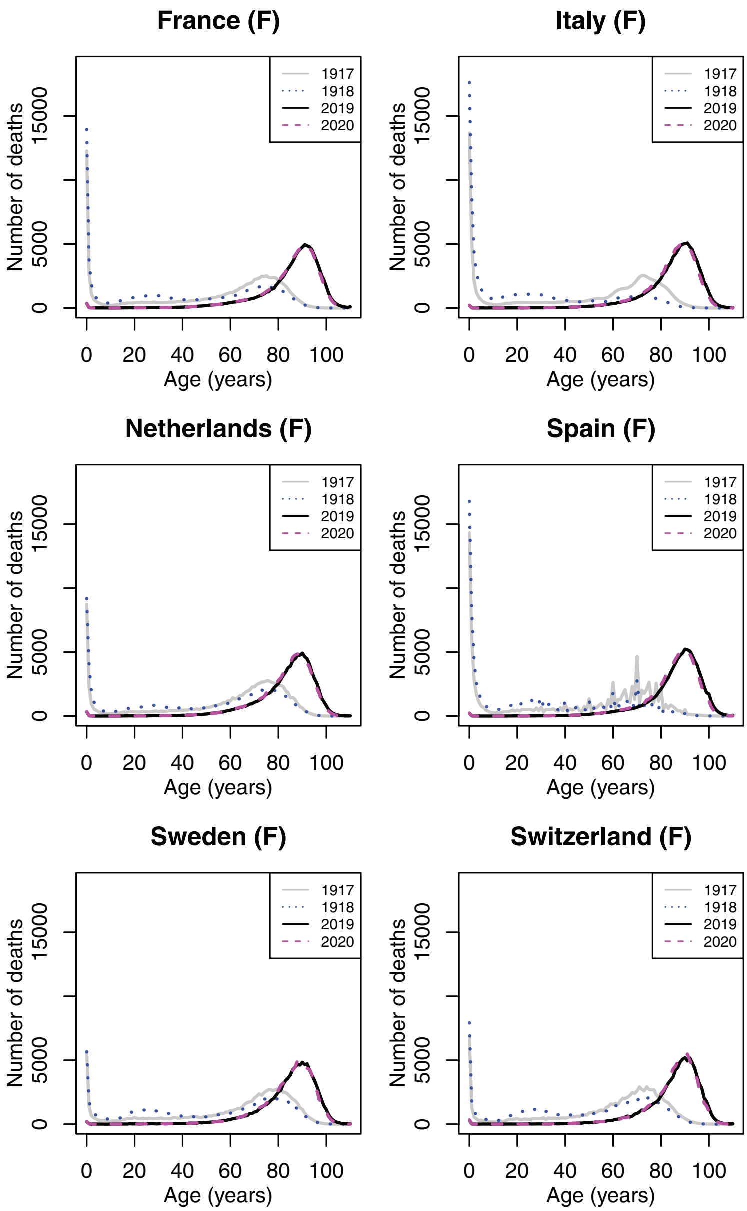


Figure 4:
Distribution of deaths by age (the d_x of the life tables) in 1917, 1918, 2019 and 2020 for men in six European countries

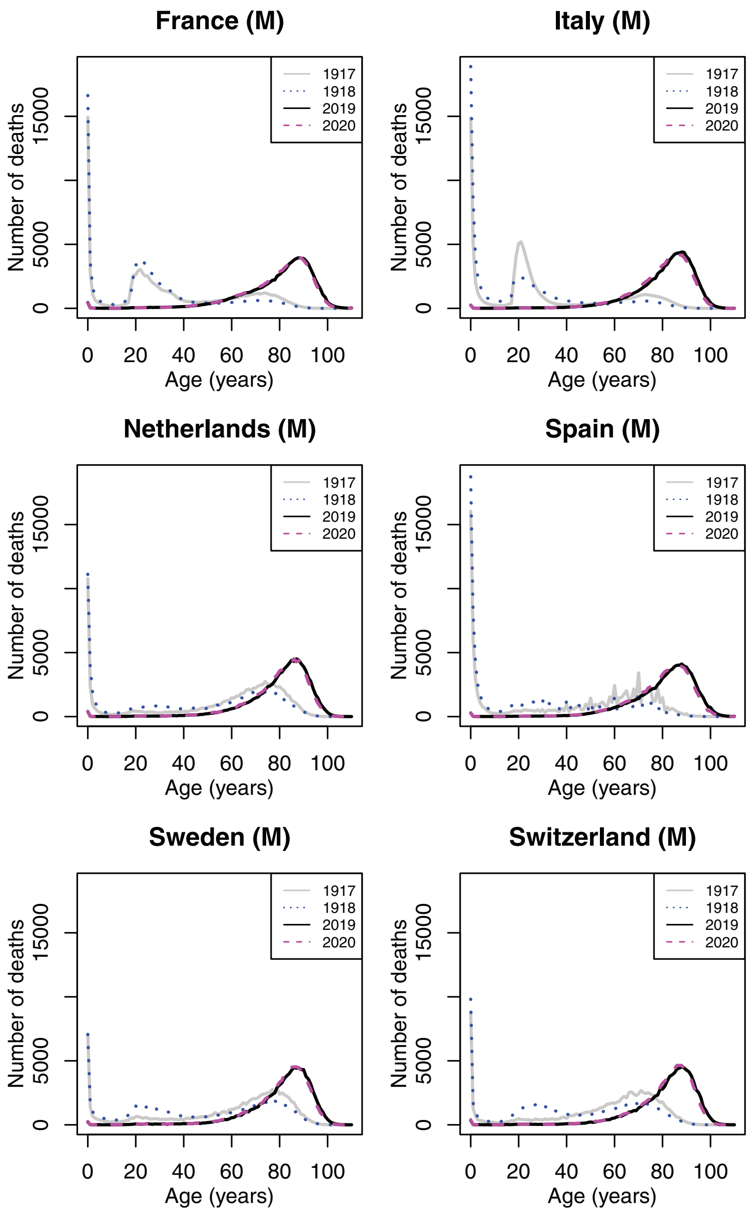


Table 1:
Life expectancy at birth estimated in 1917, 1918, 2019 and 2020, and the corresponding loss (in years and in %) between 1917 and 1918 and between 2019 and 2020 for women (F) and men (M) in six European countries

		Life expectancy				Life expectancy			
				Loss				Loss	
		1917	1918	Abs.	%	2019	2020	Abs.	%
France	F	51.9	43.0	**8.9**	**17.2**	85.6	85.1	**0.4**	**0.5**
	M	35.5	28.4	**7.1**	**20.1**	79.7	79.1	**0.6**	**0.7**
Italy	F	47.4	28.3	**19.1**	**40.2**	85.5	84.5	**0.9**	**1.1**
	M	31.0	23.5	**7.5**	**24.1**	81.2	79.9	**1.3**	**1.6**
Netherlands	F	56.7	48.6	**8.1**	**14.2**	83.6	83.1	**0.5**	**0.6**
	M	54.6	46.6	**8.0**	**14.6**	80.5	79.7	**0.8**	**1.0**
Spain	F	43.6	30.8	**12.8**	**29.3**	86.2	85.0	**1.2**	**1.4**
	M	41.7	29.9	**11.7**	**28.1**	80.8	79.6	**1.3**	**1.6**
Sweden	F	60.1	51.4	**8.7**	**14.5**	84.7	84.3	**0.4**	**0.5**
	M	57.5	48.1	**9.4**	**16.4**	81.3	80.6	**0.8**	**0.9**
Switzerland	F	57.4	48.9	**8.5**	**14.8**	85.6	85.1	**0.5**	**0.6**
	M	54.1	43.8	**10.4**	**19.1**	81.9	81.0	**0.9**	**1.1**

age groups as in Table 4 of Ponnapalli (2005). All but one of these contributions were positive or equal to zero (when rounded to one decimal), meaning that mortality in 2020 was higher than (or equal to) mortality in 2019, and mortality in 1918 was higher than (or equal) mortality in 1917 in all age groups considered. The only exception was the age group 15–25 for Italian men, who made a negative contribution (−1.5 years) to the 1918 loss; which means that among the men in that age group, mortality was lower in 1918 than in 1917 (probably due to different wartime circumstances). The magnitudes of these positive contributions and their distributions across age groups were, however, very different in 2020 than in 1918. In line with Figures 3 and 4, we find that most of the contributions to the 2020 loss came from the older age groups (65–85 and 85+), and that there were almost no contributions by the age groups below 45. In contrast, we observe that most of the contributions to the 1918 loss came from the age groups below 45, and that there was almost no contribution by the age group 85+. We also find that this general pattern was largely repeated for both sexes in each country.

5 Discussion

The COVID-19 pandemic has often been compared to the Spanish flu. For example, He et al. (2020) discussed the epidemiological similarities between the two pandemics in the UK, whereas Agrawal et al. (2021) noted similar trajectories at

Table 2:
Contributions of different age groups to the loss of life expectancy at birth between 1917 and 1918 and between 2019 and 2020 for women (F) and men (M) in six European countries, using the United Nations (1982, 1985) decomposition method. Values rounded to 0.0 are represented with a dot

		Loss 1918–1917								Loss 2020–2019							
		0–5	**5–15**	**15–25**	**25–45**	**45–65**	**65–85**	**85+**	**Total**	**0–5**	**5–15**	**15–25**	**25–45**	**45–65**	**65–85**	**85+**	**Total**
France	F	2.3	1.0	1.9	3.2	0.6	.	.	**8.9**	.	.	.	.	.	0.2	0.2	**0.4**
	M	1.4	0.5	1.6	3.4	0.3	.	.	**7.1**	.	.	.	.	0.1	0.4	0.2	**0.6**
Italy	F	6.2	3.1	3.3	4.8	1.2	0.4	.	**19.1**	.	.	.	.	0.1	0.5	0.4	**0.9**
	M	4.2	1.6	−1.5	2.2	0.8	0.1	.	**7.5**	.	.	.	.	0.2	0.8	0.2	**1.3**
Netherlands	F	2.3	1.1	1.5	2.7	0.5	.	.	**8.1**	.	.	.	.	.	0.3	0.2	**0.5**
	M	2.2	0.8	1.4	3.0	0.6	.	.	**8.0**	.	.	.	.	0.1	0.5	0.2	**0.8**
Spain	F	3.9	1.7	2.2	3.9	0.8	0.2	.	**12.8**	.	.	.	.	0.1	0.6	0.4	**1.2**
	M	3.7	1.2	2.0	3.9	0.8	0.1	.	**11.7**	.	.	.	0.1	0.2	0.8	0.3	**1.3**
Sweden	F	0.9	1.0	2.4	3.6	0.7	0.1	.	**8.7**	.	.	.	.	.	0.3	0.2	**0.4**
	M	0.7	0.8	2.6	4.7	0.6	0.1	.	**9.4**	.	.	.	.	0.1	0.4	0.2	**0.8**
Switzerland	F	1.5	0.7	2.0	3.6	0.5	0.1	.	**8.5**	.	.	.	.	.	0.2	0.3	**0.5**
	M	1.1	0.5	2.7	5.5	0.5	.	.	**10.4**	.	.	.	.	0.1	0.4	0.3	**0.9**

the beginning of each outbreak. It has been estimated that the Spanish flu killed 50–100 million people around the world (2.3 million in Europe) between 1918 and 1920 (Johnson and Mueller, 2002), and thus up to 5% of the global population at that time (0.5% of the population in Europe). By contrast, at the time of writing (according to https://www.worldometers.info/coronavirus/, accessed on June 7, 2022), COVID-19 has officially killed about 6.3 million people around the world (1.8 million in Europe), and thus about 0.08% of the global population (0.2% of the population in Europe).

Comparing these numbers is, however, challenging for a variety of reasons, including the different levels of mortality in the two periods; the unreliable reporting of causes of deaths; and the difficulties associated with accounting for both the direct and the indirect effects of the two pandemics, and for the confounding effects of the First World War. Furthermore, the population structures were profoundly different in the two periods: i.e. the populations were smaller in number and much younger in 1918 than in 2020. In this article, we have attempted to tackle some of these challenges. We compared mortality in 2020 and 1918 by calculating the loss of life expectancy at birth (to avoid the problem of the different population structures) based on all-cause mortality data (to capture both the direct and the indirect effects of the pandemics, and to avoid the problems arising from the unreliable reporting of causes of deaths) in six European countries, including in four countries that did not directly participate in the First World War. We found that in all six countries, the loss of life expectancy at birth and the contributions of the different age groups to that loss were very different in 2020 than in 1918.

The loss of life expectancy at birth was, on average, 13 times (when expressed in years) or even 22 times (when expressed in percentages) larger in 1918 than in 2020. The figures are similar if we include only the four countries that did not directly participate in the First World War. Thus, it may not be an exaggeration to say that in the countries we analyzed, the Spanish flu was about 20 times more deadly in 1918 than COVID-19 was in 2020. Other striking differences between the two pandemics became apparent when we explored the contributions of the different age groups to these losses, as we found that older age groups contributed more in 2020 while younger age groups contributed more in 1918. These results were largely consistent across the six countries, and were in line with previous evidence indicating that the majority of COVID-19 fatalities were among the elderly, while the majority of Spanish flu fatalities were among very young children and young adults (see e.g. Collins, 1931; Simonsen et al., 1998; Taubenberger and Morens, 2006). Thus, the age structure of fatalities was a key difference between the two pandemics.

Our observations are based on period life expectancy at birth, which is one of the indicators that is most frequently used in demography to summarize mortality (Luy et al., 2019). It has the particular feature of giving more weight to deaths at younger than at older ages, and thus reflects the larger number of years lost when a young person dies. As it is a synthetic measure of the mortality that occurs in a given year, it offers a convenient way to compare different calendar years without having to choose an (arbitrary) reference population for standardization. Moreover, using this indicator, a loss of life expectancy observed between two years can also be decomposed into the contributions of different age groups. This exercise would be more difficult using another summary indicator. However, as is the case for other indicators calculated from period life tables, it does not provide information about a “real” cohort of individuals followed from birth to death, but rather about a hypothetical cohort of individuals who lived their entire lives under the mortality conditions observed in a given calendar year. Thus, if a pandemic occurs in that year, period life expectancy at birth will inform us about what would happen if a similar pandemic occurred in each year of these individuals’ lives (Goldstein and Lee, 2020). Hence, unlike analyses using cohort life tables, estimates of loss of life expectancy using period life tables are based on specific assumptions that are not directly transferable to the underlying real populations.

On the other hand, using other indicators to compare mortality across years, such as a standardized mortality rate or a percentage of excess deaths compared to some robust baseline (Ansart et al., 2009; Davies, 2020), can provide another, and often more dramatic picture. For example, Ansart et al. (2009) reported an 86% increase in excess mortality in Europe during the Spanish flu period, which represents an even more dramatic decrease in life expectancy than our estimates indicated. Locatelli and Rousson (2021) reported that in Switzerland, the standardized mortality rate increased 8.8% from 2019 to 2020, which corresponds to a 0.7% decrease in life expectancy at birth. Thus, life expectancy tells only part of the story. See Leser (1955) or Keyfitz and Golini (2009) for further discussions on such mortality comparison measures. This reminds us that the choice of the indicator used to measure the impact of a pandemic is not insignificant. For example, Goldstein and Lee (2020) concluded, in relation to the COVID-19 epidemic in America, that “it is possible to portray the epidemic as unimaginably large – the biggest killer in American history – or small, reducing our remaining life by less than 1 part in 1000.” The results presented in this paper could therefore be challenged by other researchers using other indicators.

While such comparisons might not be relevant in countries not significantly affected by the two pandemics, this was not the case for the six European countries included in this study. According to recent estimates, the share of the respective national population that was killed by the Spanish flu was 0.59% in Sweden, 0.61% in Switzerland, 0.71% in the Netherlands, 0.73% in France, 1.07% in Italy and 1.23% in Spain (Johnson and Mueller, 2002). Moreover, at the end of 2020 – and despite the different protective measures adopted by their respective governments – all of these countries belonged to the first quintile of countries in the world in terms of COVID-19 mortality, with Italy ranked fifth, Spain ninth, France 15th, Switzerland 24th, Sweden 26th and the Netherlands 37th among the 220 countries considered in the Worldometer website (https://www.worldometers.info/coronavirus/, accessed on December 27, 2020). These deaths represented between 0.12% (for Italy) and 0.06% (for the Netherlands) of the population. In the present study, Italy and Spain were also found to be the two countries with the largest life expectancy losses in both 1918 and 2020.

To date, a few mortality analyses for the year 2020 have been fully published in the scientific literature. Based on provisional data, Locatelli and Rousson (2021) reported a loss of life expectancy at birth in Switzerland of 5.3 months for women and 9.7 months for men between 2019 and 2020. These findings are just one month less than our estimates of 0.50 years (6.0 months) for women and 0.89 years (10.7 months) for men. For France, our estimates largely match those published on the Statista website (statista.com/statistics/460418/france-life-expectancy-by-gender/, accessed on August 24, 2021), which reported that life expectancy at birth was 85.6 years (the same as our estimate) for women and 79.8 years (our estimate was 79.7) for men in 2019, and was 85.3 years (our estimate was 85.1) for women and 79.2 years (our estimate was 79.1) for men in 2020. Further useful comparisons can be made by examining Figure 2 in Aburto et al. (2021b), who analyzed mortality data from 29 countries in 2020 based on harmonized data produced from initial five age groups. They found that the loss of life expectancy at birth between 2019 and 2020 was about 1.5 years for Spanish men and women and for Italian men; about one year for Italian women and for Swiss men; and between 0.6 and 0.8 years for Swiss women and for men and women in France, the Netherlands and Sweden. As these findings are close to our values, they further validate our method and data.

One limitation of our analysis is that it was restricted to a single year for both pandemics (2020 for COVID-19, 1918 for the Spanish flu). Note, however, that while the Spanish flu lasted until at least 1920 and consisted of three main waves (Patterson and Pyle, 1991), the peak of mortality in Europe occurred in October-November 1918 (Ansart et al., 2009). Indeed, the HMD data show that life expectancy in 1919 had already returned to 1917 levels in most countries (see also our Figure 1). Moreover, as the COVID-19 pandemic that reached Europe in February-March 2020 is not yet over, the analysis provided here gives an incomplete picture of the impact of COVID-19. It would be interesting to conduct a similar analysis in the future using consolidated mortality data for 2021 and beyond.

Finally, and importantly, our analysis did not consider the impact of the public health measures designed to reduce COVID-19 mortality that were put in place in 2020. While it is indeed very difficult to estimate what would have happened if these measures had not been implemented, it is clear that the public health approaches to managing a pandemic were not the same in 2020 as they were 100 years previously. This limits the potential interpretations of our comparison. Thus, our analysis should be seen primarily as descriptive.

Despite these limitations, and although we were unable to analyze more precisely the nature (e.g. societal or medical) of the mortality impacts of the two pandemics, it is fair to conclude that they were quite different, with COVID-19 killing mostly the elderly and the Spanish flu killing mostly young people, and with the loss of life expectancy being about 13 (or even 22) times larger in 1918 than it was in 2020.

Supplementary material

Available online at https://doi.org/10.1553/populationyearbook2022.dat.7

Supplementary file 1. Estimated life tables by sex for the year 2020, France, Italy, Netherlands, Spain, Sweden, Switzerland

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