PLOS ONE

RESEARCH ARTICLE

Mortality in Switzerland in 2021

Isabella Locatelli*, **Valentin Rousson**

Center for Primary Care and Public Health (Unisanté), University of Lausanne, Lausanne, Switzerland

* isabella.locatelli@unisante.ch

Abstract

Objective

To analyze mortality trends in Switzerland in 2021, the second year of the COVID-19 pandemic.
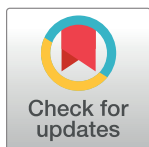
Methods

Using data from the Swiss Federal Statistical Office, we compared mortality in Switzerland in 2021 with that of previous years in terms of standardized weekly deaths, standardized (annual) mortality rates (overall and stratified by age and sex) and life expectancy. The latter is a well-known demographic concept defining the average lifespan of a hypothetical cohort living and dying according to the mortality rates of a given year.

Results

After a favorable first half of the year and a fairly standard second half in terms of mortality in Switzerland, the year 2021 ended with a wave of deaths of moderate intensity related to the 5th wave of COVID-19. Overall, and after a notable increase in mortality in 2020 (+9.2%, 95%CI: +8.0%; +10.3%, compared to 2019, and +5.1%, 95%CI: +4.3%; +6.0%, compared to 2015–19), the pre-pandemic mortality level was approximately recovered in 2021 (+0.8%, 95%CI: -0.3%; +0.8%, compared to 2019, and -2.9%, 95%CI: -3.7%; -2.2%, compared to 2015–19). Life expectancy, after declining by 10 months for men and 6 months for women in 2020 (i.e. men would have lost 10 months and women 6 months had they lived their entire lives with COVID-19 as it was in 2020), returned in 2021 to 2019 levels for women (85.6 years) and regained 2018 levels for men (81.6 years, still -0.3 years from 2019). The age group responsible for the small remaining loss for men was the 50–70 age group, which had similar mortality in 2020 and 2021.

Conclusions

The second year of the COVID-19 pandemic in Switzerland was characterized by an approximate return to pre-pandemic mortality levels, with a faster recovery for women than for men with respect to 2020.

Introduction

The years 2020 and 2021 have seen the global spread of the COVID-19 pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). At the time of writing, more than 500 million cases and more than 6 million deaths due to COVID-19 have been reported worldwide. In Switzerland, the pandemic has caused about 14'000 deaths to date, representing 1600 deaths per million inhabitants (COVID Live - Coronavirus Statistics - Worldometer (worldometers.info)). A key indicator to assess the impact of the pandemic is all-cause mortality [1], a measure that does not suffer from over- or under-reporting and is able to capture both the direct and indirect effects of the pandemic on the population as a whole.

There is now a large literature studying the impact of the pandemic on all-cause mortality during the year 2020 [1–8]. The latter has been evaluated for a large number of countries both from the point of view of the excess mortality (or excess deaths) [1–4] and from the perspective of the loss of life expectancy [5–8]. For Switzerland, an excess mortality of 9.2% has been estimated in 2020, which was significant from the age of 70 for men and 75 for women. The loss of life expectancy was of 10 months for men and 6 months for women [9, 10]. These results were consistent with those, now official, obtained a couple of months later by the Swiss Federal Statistical Office (Espérance de vie | Office fédéral de la statistique (admin.ch)) and with those of a large study on the loss of life expectancy in 29 countries [11].

On the other hand, while a few studies have been published concerning the excess death of (part of) the year 2021 [12, 13], or globally for the period 2020–21 [14], no study has yet, to our knowledge, estimated the life expectancy achieved for the year 2021, nor analyzed the association between age and excess (or under-) mortality that year. The reason is certainly related to the time needed to obtain definitive data on deaths in a given country, and Switzerland is no exception, because part of the deaths are registered with delay by the Offices. We believe however that it is important to have early information on mortality during a pandemic, even if not with the highest precision, and consider that the impact of a second year of pandemic on mortality is a key issue for public health policy. This is why we have been following the weekly updates of deaths published by the Federal Statistical Office (FSO) since the beginning of 2022 and, as the total reported number of death is now supposed to be definitive, we propose in this paper an initial estimate of mortality for 2021.

The objective of this paper was therefore to analyze the change of mortality and life expectancy in Switzerland in 2021 in comparison with the year 2020 and the previous years. We also aimed to compare the mortality and life expectancy changes in men and women and identify the age groups mainly responsible for the observed evolutions and possibly more affected by this second year of pandemic.

Data

We used official data on deaths in Switzerland published by the Swiss FSO for 2000–2021 (last access June 23, 2022). The annual number of deaths, separately for men and women, was available by 1-year age groups (with a last open class of 110+) until year 2020 (Décès selon l'âge et le sexe, 1970-2020 - 1970-2020 | Tableau | Office fédéral de la statistique (admin.ch)), while it was available by 5-years age groups (with a last open class of 90+) for each of the 52 weeks of 2021 (Décès selon la classe d'âge quinquennale, le sexe, la semaine et le canton - 4.1.2021-2.1. 2022 | Tableau | Office fédéral de la statistique (admin.ch)), and by 3 large age groups (0–64, 65–79, 80+) for the entire 2021 (January 1—December 31) (Décès | Office fédéral de la statistique (admin.ch)). By convention, the year 2021 is divided into 52 weeks, the first of which begins on January 4, 2021 and the last of which ends on January 2, 2022. Therefore, for

the annual analysis, we adjusted these weekly deaths to obtain the same reported annual totals for men and women as well as in each of the three age groups (0–64, 65–79, 80+). To facilitate comparisons across all years, we finally excluded 1/366 of deaths in the case of leap years (2000-04-08-12-16-20). Weekly death data were also available for years 2015–21 with a partition in five large age classes (0–19, 20–39, 40–64, 65–79, 80+) (Décès par classe d'âge, semaine et canton - 29.12.2014-27.3.2022 | Tableau | Office fédéral de la statistique (admin.ch)) which have been used for the weekly analysis 2015–21 described below.

The size of the Swiss population as of January 1, 2011–21, stratified by sex and one-year age groups (with a last open class of 105+) was available in the FSO database (Population résidante permanente selon l'âge, le sexe et la catégorie de nationalité, de 2010 à 2020 - 2010-2020 | Tableau | Office fédéral de la statistique (admin.ch)). The size of the Swiss population as of January 1, 2000–21, stratified by sex and one-year age groups (with a last open class of 110+), was also found in the Human Mortality Database (HMD) [15]. Since the difference for the overlapping years were negligible (mean relative difference of 0.01% with no difference exceeding 0.02%), we used HMD source for the years 2000–10 and FSO source for the years 2011–21. Life expectancy for both sexes was also available in the HMD database for the period 2000–20. HMD has been used extensively by demographers because of the standardized methods implemented to produce life tables (from where life expectancies are taken), while concentrating on countries with highest quality data, and is therefore a common reference for mortality research [16]. It was therefore considered as a trustful "gold-standard" to check our data and method.

Methods

Weekly mortality for the years 2015–21 was analyzed using Standardized Weekly Deaths (SWD), with the 5 available age classes (0–19, 20–30, 40–64, 65–79, 80+) and considering population as of January 1, 2021 as the reference. The SWD for a given week and year represents the number of deaths that would have occurred if the age specific mortality rates observed that week and year were applied to the age structure of the reference population. The SWD of week w ($w = 1,...,52$ or 53 depending on the year) and year y ($y = 2015,...,2021$) standardized at January 1 of year s ($s = 2021$) was calculated as follows:

$$d_s^{y,w} = \sum_{k=1}^{5} \frac{D_k^{y,w}}{P_k^y} P_k^s$$

In this formula $D_k^{y,w}$ represents the number of observed deaths for year y, week w and age class k, and P_k^t is the population of age class k as of January 1 of year t.

To compare mortality of 2021 with that of previous years we used one-year of age and sex (directly) Standardized Mortality Rates (SMR) [17, 18]. The SMR for year y ($y = 2000,...,2020$) standardized at January 1 of year s ($s = 2021$) was obtained as follows:

$$m_s^y = \sum_{i=0}^{100+} \sum_{j=M,F} m_{ij}^y \frac{P_{ij}^s}{P^s}.$$

In this formula, $m_{ij}^y = D_{ij}^y / P_{ij}^y$ represent the age and sex specific mortality rate for age i and sex j in year y, D_{ij}^y are deaths in year y, for age i and sex j, P_{ij}^t is the population of age i and sex j of the year t, and P^s the total population of the reference year. Note that the SMR or the reference year $y = s = 2021$ corresponds to the Crude Mortality Rate (CMR) in that year: $m_{21}^{21} = D^{21}/P^{21}$ so that no detailed data on death by age was necessary for that year when calculating a SMR.

SMRs were calculated on the entire population and by sex and 10-year age groups (with a last open class of 90+). Mortality between two years (2020 vs. 2019, 2021 vs. 2019, and 2021 vs. 2020) was compared (globally and for a given sex/age group) using the relative change of SMR expressed in %. The 95% confidence intervals around any relative change of SMR were obtained as in [9] using the method proposed by [19]. To get smoother results that are not overly dependent on what may have happened in a given year, and to allow further comparisons, we also compared the SMR of 2020 and 2021 with the SMR obtained by pooling data from the period 2015–19.

Life expectancy (LE) at birth and at 65 years of age was obtained applying a piecewise exponential model [20] on death (and population) data stratified in 5-year age classes (with a last open class of 90+), i.e. using for all years the degree of age stratification available for 2021. Thus, for this calculation, the mortality rate of age i ($i = 0,\ldots,110$) and sex j ($j = M, F$) in year y ($y = 2000,\ldots,2021$), $\dot{m}_{ij}^y$, was taken equal to the observed mortality rate for the 5-year age class (or the last open class of 90+) that age i belongs to. LE at age x ($x = 0$ and 65) for sex j and year y was then obtained as follows (S1 Appendix):

$$e_{xj}^y = \frac{1}{2} + \sum_{l=x}^{110} \exp\left(-\sum_{i=x}^{l} \dot{m}_{ij}^y \right).$$

For validation we compared LEs at birth for years 2000–20 obtained with our method and data with the ones published by the HMD. We found a mean relative difference of 0.05% with no difference exceeding 0.1%. Life expectancies between two years were then compared using absolute differences expressed in months.

Finally, we calculated an excess death for each of the two years of pandemic, ED^{20} and ED^{21}, as well as for the whole period 2020–21 ($ED^{20}+ED^{21}$), by comparing the number of deaths in 2020 and 2021 to that in 2019, all three standardized to the population as of January 1, 2021:

$$ED^{20} = m_{21}^{20}P^{21} - m_{21}^{19}P^{21},$$

$$ED^{21} = m_{21}^{21}P^{21} - m_{21}^{19}P^{21}.$$

Results

Fig 1 shows the standardized weekly deaths (SWD) for the years 2015–21. This graph highlights the different waves of deaths in the winters from 2015 to 2019, closely matching the waves of influenza incidence (Grippe saisonnière (influenza) (admin.ch)). In 2020, we clearly observe two waves of mortality attributable to COVID-19, where the second wave (in fall-winter 2020) was much higher and broader than the first (in spring 2020). In 2021, after the end of the second wave of COVID-19, we observed low mortality during the first half of the year, due to the absence of an influenza-related mortality wave that year and because the third and fourth waves of COVID-19 in Switzerland (spring and summer waves) had almost no impact on overall mortality. The second half of the year was characterized by a fairly standard mortality level with another moderate wave of mortality at the end of the year, corresponding to the 5th wave of COVID-19 in Switzerland. S1 Fig shows how the 2020 and 2021 mortality waves are related with the COVID-19 incidence waves for the same period in Switzerland (incidence data from the Federal Office of Public Health COVID-19 Suisse | Coronavirus | Dashboard (admin.ch)).

The evolution of the number of deaths, crude mortality rates (CMR), and standardized mortality rates (SMR) between 2000 and 2021 is shown in Fig 2. We see a slightly increasing
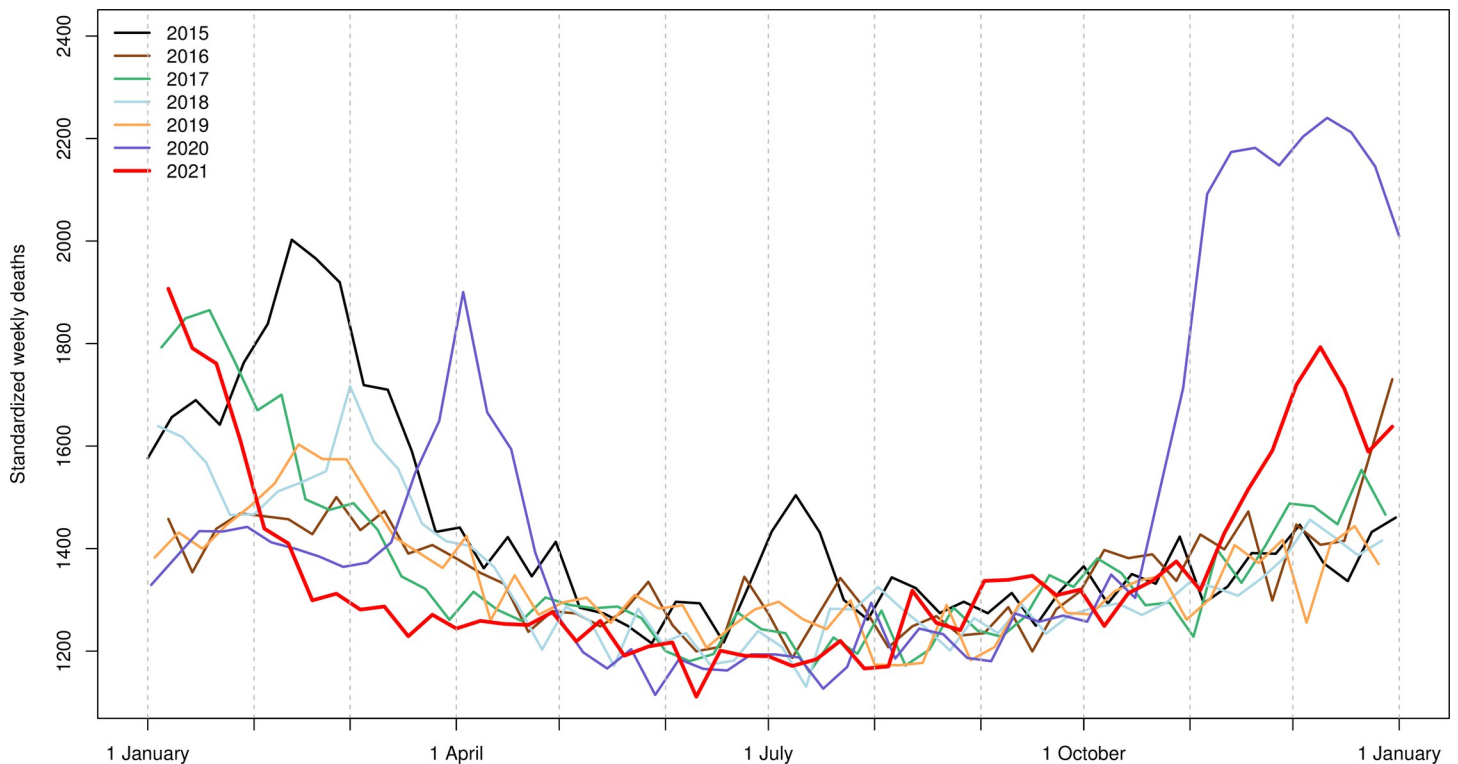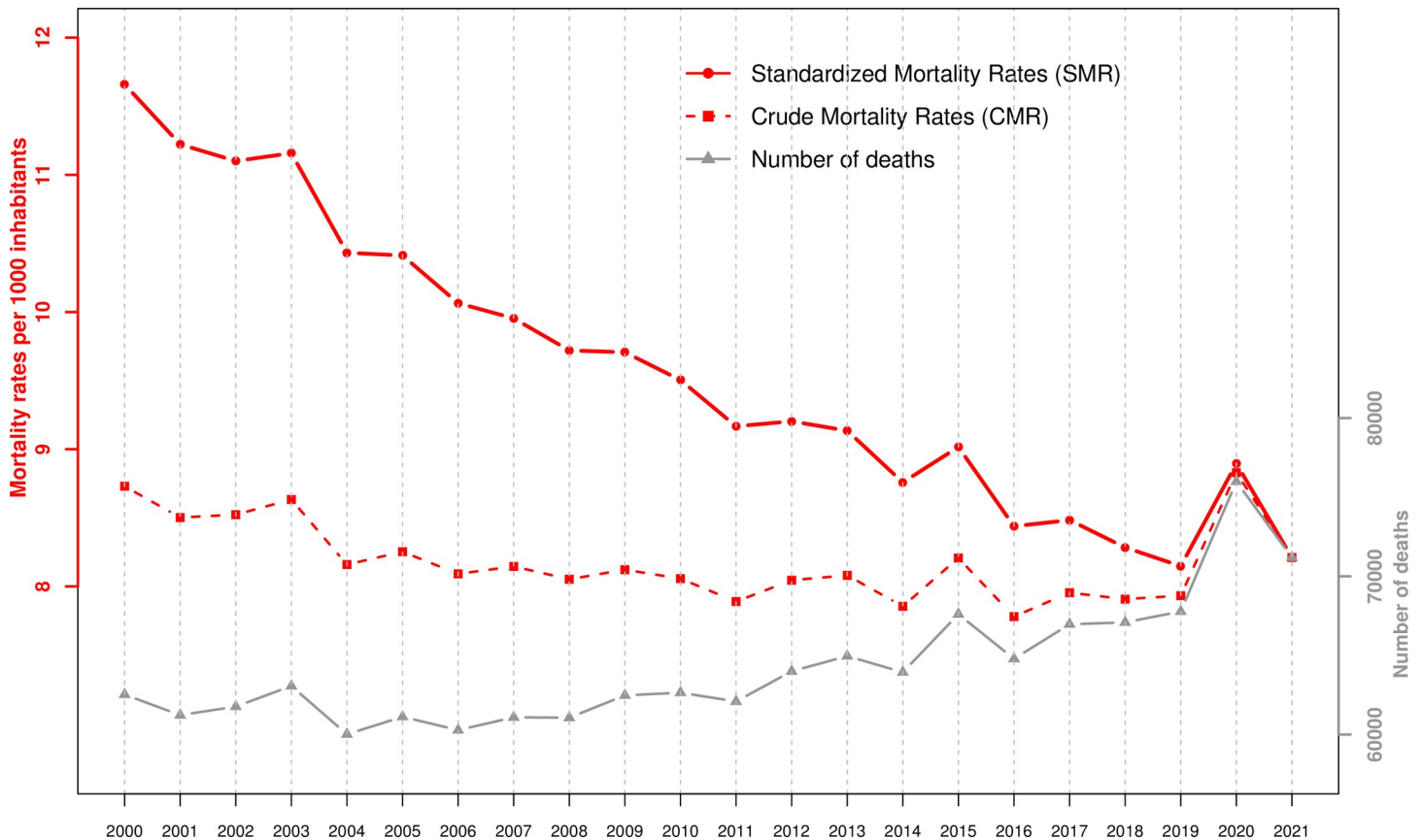
Fig 1. Standardized weekly deaths in Switzerland for the period 2015–21, reference: January 1ˢᵗ 2021 (data from the Swiss Federal Statistical Office).

https://doi.org/10.1371/journal.pone.0274295.g001

trend in the number of deaths and an approximately stable trend in the CMR between 2000 and 2019. The SMRs, on the other hand, have been decreasing steadily during these 20 years, indicating and illustrating a continuous progress regarding mortality. In 2020, all three indicators have increased. The absolute number of deaths increased by 12.1% (9.8% for women and 14.6% for men), the CMR increased by 11.3% (9.1% for women and 13.7% for men), while SMR increased by 9.2% (7.4% for women and 11.0% for men, Table 1), setting a return to the mortality level of the years 2014–15 [9]. This relative difference was largely the same, but in the opposite direction in 2021, bringing mortality back to 2018–19 levels (Fig 2, Table 1). However, whereas women have in 2021 fully recovered to 2019 mortality levels (SMR in 2021 of -0.4%, 95%CI: -1.8%; +1.1% compared to 2019), this was not quite the case for men (SMR in 2021 of +2.0%, 95%CI: +0.4%; +3.5% compared to 2019). Relative to the 2015–19 period, the SMR was 5.1% (95%CI: 4.3%; 6.0%) higher in 2020, while it was 2.9% (95%CI: 2.2%; 3.7%) lower in 2021 (Table 1). The excess death for the period 2020–21 was estimated at a total of 7019 deaths, 6473 for 2020 and 546 for 2021.

Comparing the SMRs between 2019, 2020 and 2021 separately for both sexes and for 10-year age classes (last open class of 90+), we observe that the increased mortality in 2020 (compared to 2019) in age classes over 70 years [9] was almost perfectly counterbalanced by an equally large decrease in 2021 (compared to 2020). As a consequence, in all considered age classes, mortality was not significantly different in 2021 and 2019, with the exception of men aged 60–70, for whom mortality was higher in 2021 (Fig 3), while we also had a (non-significant) trend in this direction for men aged 50–60. These age classes were responsible of the small but significant excess mortality for men in 2021 compared to 2019 (Fig 3).

Life expectancy at birth, which reached 81.9 years for men and 85.6 years for women in 2019 (Table 2) after decades of steady increase (about 3 months/year for men and 2 months/

Fig 2. Number of deaths, crude mortality rates and standardized mortality rates (reference: January 1st 2021) in Switzerland for the period 2000–21 (data from the Swiss Federal Statistical Office and the Human Mortality Database).

year for women), decreased by 10.1 months for men and 5.8 months for women in 2020 reaching 81.0 years for men and 85.1 years for women (Fig 4 and Table 2) [9, 10]. By 2021, this loss has been to a large extent recovered by men, who have returned to the 2018 level (life expectancy in 2021 of 81.6 years) and fully recovered by women (life expectancy in 2021 of 85.6 years). We found similar results for life expectancy at age 65 (Fig 4 and Table 2).

Discussion

The year 2021 was characterized in Switzerland by a first half of the year with unusually low mortality, due to the absence of any COVID-19 or influenza wave, followed by a second half of

Table 1. Summary of changes in standardized mortality rates (SMR) (%) in pandemic years 2020 and 2021 compared to previous years.

	SMR		
	Total	**Men**	**Women**
2020 / 2015–19 (%)	+5.1 (+4.3 ; +6.0)	+6.2 (+5.0 ; +7.4)	+4.1 (+3.0 ; +5.3)
2021 / 2015–19 (%)	-2.9 (-3.7 ; -2.2)	-2.4 (-3.6 ; -1.3)	-3.4 (-4.5 ; -2.3)
2020 / 2019 (%)	+9.2 (+8 ; +10.3)	+11.0 (+9.4 ; +12.6)	+7.4 (+5.9 ; +9.0)
2021 / 2020 (%)	-7.7 (-8.6 ; -6.7)	-8.1 (-9.5 ; -6.8)	-7.3 (-8.6 ; -5.9)
2021 / 2019 (%)	+0.8 (-0.3 ; +1.8)	+2.0 (+0.4 ; +3.5)	-0.4 (-1.8 ; +1.1)
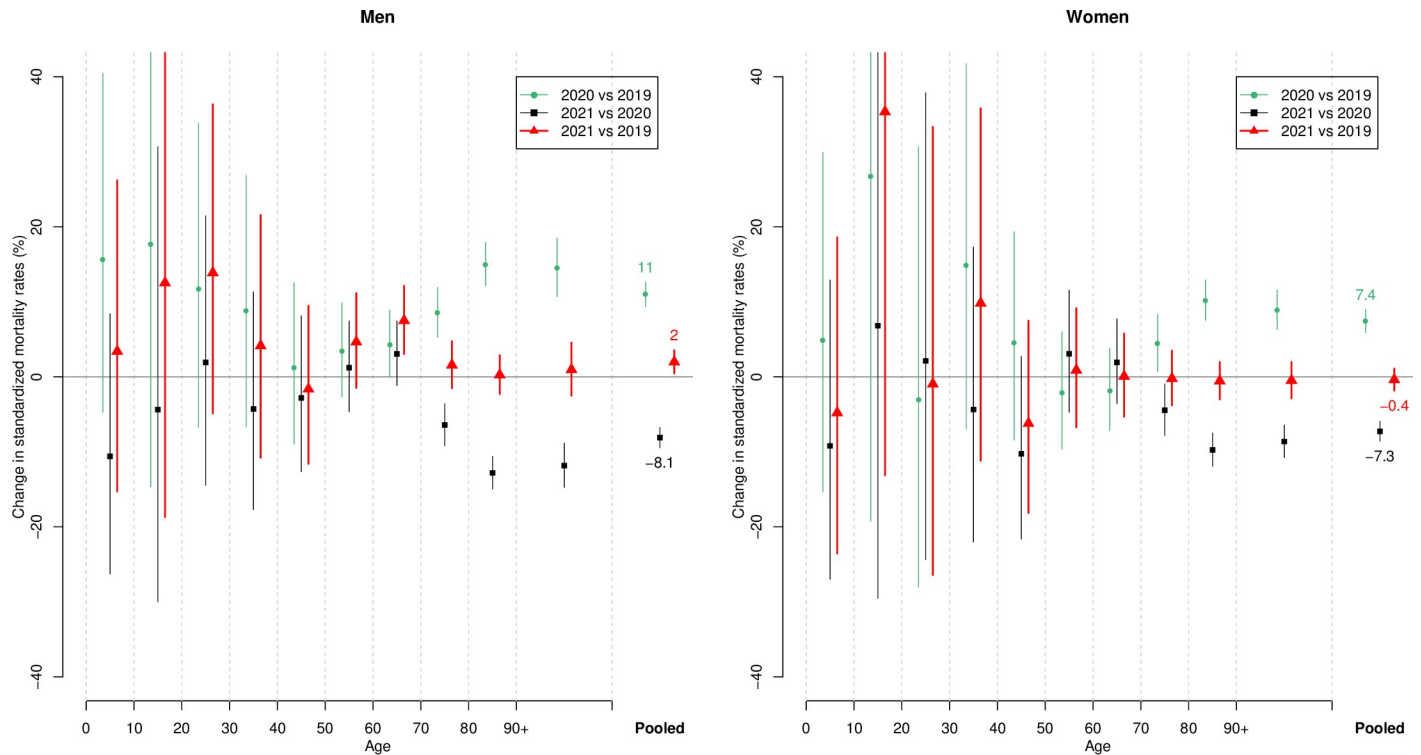
Fig 3. Relative change in standardized mortality rates (reference: January 1ˢᵗ 2021) when comparing 2020 with 2019, and 2021 with 2020 and 2019, in selected age groups, separately for men and women, together with 95% confidence interval (data from the Swiss Federal Statistical Office).

https://doi.org/10.1371/journal.pone.0274295.g003

the year that was quite standard until an unusual end-autumn wave of mortality, corresponding to the 5th wave of COVID-19. Taken as a whole, 2021 marked an approximate return to 2019 mortality levels. After a 9.2% excess mortality in 2020, standardized mortality rates decreased by 7.7% in 2021, bringing the rate approximately back to the pre-pandemic level. Life expectancy, meanwhile, after declining by 10 months for men and 6 months for women in 2020, recovered in 2021 the 2019 levels for women (85.6 years) while returning to 2018 levels for men (81.6 years). In all age groups, mortality was not significantly different in 2021 and 2019, with the exception of men aged 60–70 (and to a lesser and not significant extent, men aged 50–60), who still had an excess mortality in 2021 compared to 2019, and who were indeed responsible for the slightly higher mortality observed for men in 2021 compared to 2019.

Table 2. Summary of changes in life expectancy at birth and 65 years between 2018 and 2021.

	Life expectancy			
	Men		Women	
	At birth	At 65 years	At birth	At 65 years
2018 (years)	81.6	19.8	85.4	22.6
2019 (years)	81.9	19.9	85.6	22.6
2020 (years)	81.0	19.1	85.1	22.2
2021 (years)	81.6	19.7	85.6	22.7
2020–2019 (months)	-10.1	-8.8	-5.8	-5.7
2021–2020 (months)	+7.0	+7.2	+6.0	+5.9
2021–2019 (months)	-3.2	-1.6	+0.3	+0.2

https://doi.org/10.1371/journal.pone.0274295.t002
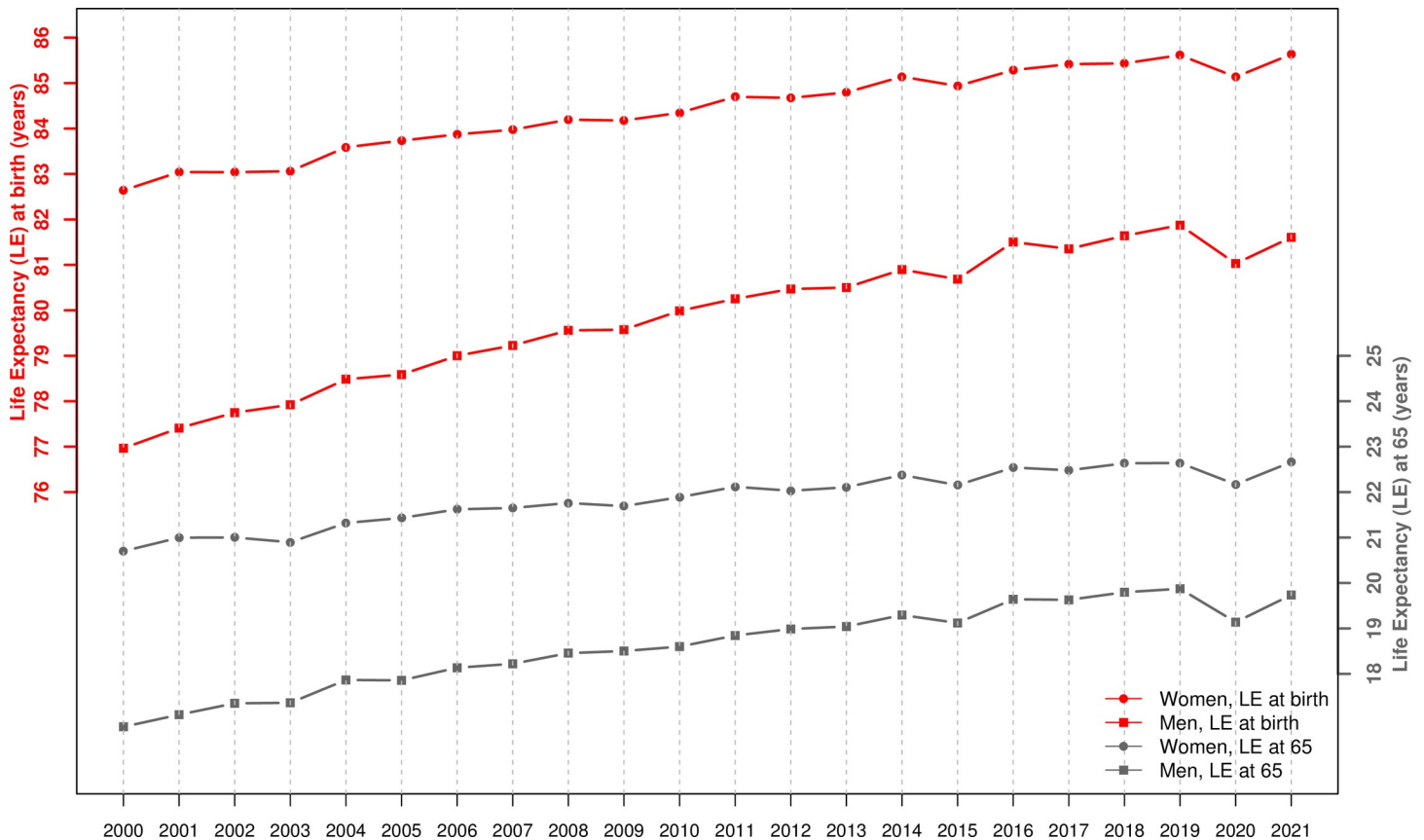
Fig 4. Life expectancy at birth and at 65 years of age in Switzerland for the period 2000–21 for men and women (data from the Swiss Federal Statistical Office and the Human Mortality Database).

We also calculated an estimate of excess deaths based on standardized mortality rates. This indicator captures changes in mortality at different ages adjusting for modifications that occur each year in the size and age structure of the population [17, 18]. Comparing standardized mortality rates in 2020 and 2021 with those in 2019, we estimated an excess of 6473 deaths in 2020 and an excess of 546 deaths in 2021, leading to an excess of 7019 deaths for the 2020–21 period. Our estimate of the excess death for 2020 was consistent with the excess of 6800 deaths estimated by [4] for Switzerland by applying and projecting a Poisson model on weekly deaths for the years 2016–19 stratified by age and sex. It was, however, lower than the excess of 8429 deaths estimated by [12] applying and projecting a negative binomial model on weekly deaths of years 2015–19. Our estimate was also lower than the excess of 8600 deaths estimated via a linear model by [13] for 2020 and the first half of 2021 (considering that the first six months of 2021 had a negative excess of deaths [10, 12]). In addition, our estimate of excess death for the entire 2020–21 period was more than two times lower than the excess of 15500 deaths obtained for Switzerland by a recent analysis of excess mortality for the entire planet [14]. In this paper, the authors estimated the expected mortality for 2020–21 using a global approach over the previous 11 years, weighting six different models, and interpolating the missing information in part of the countries using covariates. We guess that our result is closer to that of [4] because the authors of this study applied their model to age- and sex-stratified deaths, which is roughly equivalent to our standardization. As a complementary analysis, we also estimated the excess deaths for the period 2020–21 by comparing the standardized mortality rates obtained for

these years with those that would be expected based on a continuation of the trend observed in recent years for these rates (Fig 2). However, our results were not the same whether we used ten or twenty years before the pandemic to estimate this trend. Under the first option (linear trend over 2010–19), we estimated an excess of 10496 deaths for the years 2020–21, while the second option (quadratic trend over 2000–19) leaded to an excess of 8015 deaths.

These differences illustrate and confirm the strong dependence of an excess death estimate on the choice of method and time window used to estimate the trends. This is actually the reason why we opted for a factual comparison of mortality after and before the pandemic. In this regard, the question arises as to whether the comparison should be made with respect to 2019, the last year before the pandemic, or rather with respect to a longer time interval, e.g., 2015–19, in order to avoid an excessive impact of the particular conditions in a given year. We performed both comparisons, obtaining a 9.2% increase in mortality in 2020 relative to 2019, versus a 5.1% increase relative to 2015–19. Of these two results, however, we believe that, at least in Switzerland, the former more closely reflects the mortality increase observed in the first pandemic year than the latter. First, 2019 was not a particularly good or bad year in Switzerland, with mortality matching exactly the declining trend observed over the past 10 years. This was not necessarily the case in other countries such as Germany (• Deaths in Germany 1991-2021 | Statista) or Sweden (• Sweden: death rate 2010-2020 | Statista), where mortality in 2019 was notably low, well below the trend. Second, and more importantly, the downward trend in the pre-pandemic years was so strong in Switzerland (see Fig 2) that considering the period 2015–19 as reference amounts to ignoring 2 or 3 years of mortality progress in our comparison.

For the same reason, it may also be advantageous to quantify the impact of a pandemic on mortality in terms of setbacks along the time axis rather than in terms of comparison with a selected year or period or with projections of past trends into the future. Indeed, the setback was the same whether we were looking at standardized rates or life expectancy: both have returned in 2020 to their 2014–16 levels, a five-year setback, while they returned approximately to their 2019 pre-pandemic levels in 2021. Note that a similar phenomenon had been observed for the Spanish flu of 1918. Despite the dramatic loss of life expectancy in 1918 (-10.4 years for men and -8.5 years for women), life expectancy in 1919 (53.7 years for men and 55.9 for women) had largely returned to that of 1917 (54.1 years for men and 57.4 years for women), before the pandemic of Spanish flu [21].

Regarding the choice of scale to compare mortality across years, we believe that life expectancy has several advantages over excess mortality (or excess deaths). First, being measured in months, a loss of life expectancy is easier to interpret than an excess mortality (in %) or an excess deaths (an absolute number which, on its own, is difficult to apprehend without a good knowledge of the context of a given country). Secondly, by giving more weight to the (excess) deaths of the young than to those of the elderly, it recognizes that the former are indeed more dramatic than the latter, an essential point when it comes to assess the severity of a pandemic. The conclusions that can be drawn by using one indicator rather than another can be quite different. For example [12], estimated for Switzerland an excess death about 3 times higher in 1918 (compared to 1917) than in 2020 (compared to 2019). In terms of life expectancy, the ratio between the loss observed in 1918 and that of 2020 is rather 10:1 than 3:1 and, if the two losses are considered in proportion to the (very different) baseline life expectancy of the two periods, the ratio is around 20:1 [8]. The reason for this discrepancy is the different age distribution of the deaths due to the Spanish flu and those caused by COVID-19, the former affecting mostly young people and the latter people over 70. In this regard, it is also interesting to observe that the loss of life expectancy at birth in 2020 (10.1 months for men and 5.8 months for women) corresponds approximately to the loss of life expectancy at age 65 (8.8 months for men and 5.7 months for women).

It may also be useful to recall that the concept of life expectancy calculated in a given year in a given country, as used here and in [5–11], refers to the average life span of a hypothetical cohort of persons who would live and die according to the age and sex specific mortality rates observed in that year in that country. As noted by [22], a comparison of life expectancies of 2020 and 2019 thus informs us on the life lost for a hypothetical cohort of persons who would live their entire lives with a pandemic similar to COVID-19 in 2020. But the life lost to COVID-19 in 2020 for the *actual* population living in Switzerland in that year will be indeed much smaller [23].

One limitation of this study is that it uses mortality data that are not yet totally finalized. Indeed, while the total number of deaths in 2021 is now supposed to be definitive, the age distribution that we have been able to adopt in our analyses is not the most refined possible. Moreover, as the population at the end of 2021 is not yet available, we have calculated the rates by dividing the number of deaths by the population at the beginning of the year, rather than considering the average population at the beginning and end of the year, which would better correspond to the notion of rate. However, as already mentioned, similar calculations for years prior to 2021 have produced almost the same results as those published in HMD. In addition, calculations made early 2021 for 2020 [9] proved to be quite close to those obtained when the finalized data became available (with a final discrepancy in life expectancy of only +0.4 months for men and +0.5 months for women) [10]. Thus, although we do not yet have fully definitive results, there is no doubt that mortality in Switzerland in 2021 has largely returned to its pre-pandemic level. An analysis of the possible reasons responsible for this favorable trend, including vaccination, more experience in treating the disease, improved patient management, harvesting effects, and the emergence of less virulent variants of the virus, is beyond the scope of this study.

In summary and conclusion, in Switzerland, after being notably high in 2020, mortality in 2021 returned to 2019 levels for women and to 2018 levels for men. Thus, while the first year of the COVID-19 pandemic led to a significant increase in mortality, the second year was characterized by an approximate return to pre-pandemic mortality levels, with a faster recovery for women than for men.

Supporting information

S1 Fig. Standardized weekly deaths and COVID-19 weekly incidence in Switzerland for the period 2020–21 (data from the Swiss Federal Statistical Office and the Swiss Federal Office of Public Health).
(TIF)

S1 Appendix. Life expectancy in a piecewise exponential model.
(DOCX)

Author Contributions

Conceptualization: Isabella Locatelli, Valentin Rousson.

Data curation: Isabella Locatelli, Valentin Rousson.

Formal analysis: Isabella Locatelli, Valentin Rousson.

Investigation: Isabella Locatelli, Valentin Rousson.

Methodology: Isabella Locatelli, Valentin Rousson.

Writing – original draft: Isabella Locatelli, Valentin Rousson.

Writing – review & editing: Isabella Locatelli, Valentin Rousson.

References

1. Beaney T, Clarke J, Jain V, et al. (2020). Excess mortality: the gold standard in measuring the impact of COVID-19 worldwide? Journal of the Royal Society of Medicine, 113: 329–334. https://doi.org/10.1177/0141076820956802 PMID: 32910871

2. Woolf SH, Chapman DA, Sabo RT, Zimmerman EB. Excess Deaths From COVID-19 and Other Causes in the US, March 1, 2020, to January 2, 2021 (2021). JAMA, 325:1786–1789. https://doi.org/10.1001/jama.2021.5199 PMID: 33797550

3. Ahmad F, Cisewski J, Minino A, Anderson R (2021). Provisional mortality data–United States, 2020. Morbidity and Mortality Weekly Report, 70: 519–522. https://doi.org/10.15585/mmwr.mm7014e1 PMID: 33830988

4. Islam N, Shkolnikov VM, Acosta RJ et al. (2021) Excess deaths associated with covid-19 pandemic in 2020: age and sex disaggregated time series analysis in 289 high income countries. BMJ 373: n1137 http://dx.doi.org/10.1136/bmj.n1137

5. Aburto JM, Kashyap R, Schöley J, et al. (2021) Estimating the burden of the COVID-19 pandemic on mortality, life expectancy and lifespan inequality in England and Wales: a population-level analysis. J Epidemiol Community Health, 75: 735–740. https://doi.org/10.1136/jech-2020-215505 PMID: 33468602

6. Andrasfay T, Goldman N. (2021) Reductions in 2020 US life expectancy due to COVID-19 and the disproportionate impact on the Black and Latino populations. Proc Natl Acad Sci USA, 2: 118: e2014746118. https://doi.org/10.1073/pnas.2014746118 PMID: 33446511

7. Heuveline P, Tzen M (2021). Beyond deaths per capita: comparative COVID-19 mortality indicators. BMJ Open, 11:e042934. https://doi.org/10.1136/bmjopen-2020-042934 PMID: 33692179

8. Rousson V, Paccaud F, Locatelli I (2022) Comparing the loss of life expectancy at birth during the 2020 and 1918 pandemics in six European countries. Vienna Yearbook Population Research, 22. Available online at https://doi.org/10.1553/populationyearbook2022.dat.7

9. Locatelli I & Rousson V (2021). A first analysis of excess mortality in Switzerland in 2020. Plos One. https://doi.org/10.1371/journal.pone.0253505 PMID: 34138948

10. Locatelli I, Rousson V. Mortality in Switzerland 2020–2021 (2021). Center for Primary Care and Public Health (Unisanté), University of Lausanne, Lausanne (Raisons de Santé: Les Essentiels 35) http://dx.doi.org/10.16908/rds-essentiels/

11. Aburto J, Schöley J, Kashnitzky I, et al. (2021). Quantifying impacts of the COVID-19 pandemic through life expectancy losses: a population-level study of 29 countries. International Journal of Epidemiology, 51: 63–74, https://doi.org/10.1093/ije/dyab207

12. Staub K, Panczak R, Matthes KL, et al. (2022) Historically High Excess Mortality During the COVID-19 Pandemic in Switzerland, Sweden, and Spain. Ann Intern Med, 1:M21–3824. https://doi.org/10.7326/M21-3824 PMID: 35099995

13. Karlinsky A and Kobak D (2021) Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset. eLife; 10:e69336 https://doi.org/10.7554/eLife.69336 PMID: 34190045

14. COVID-19 Excess Mortality Collaborators (2022) Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020–21. THE LANCET https://doi.org/10.1016/S0140-6736(21)02796-3 PMID: 35279232

15. HMD. Human Mortality Database. Max Planck Institute for Demographic Research (Germany), University of California, Berkeley (USA), and French Institute for Demographic Studies (France). Available at www.mortality.org

16. Barbieri M, Wilmoth JR, Shkolnikov VM et al. (2015) Data Resource Profile: The Human Mortality Database (HMD) Int J Epidemiol 1549–56, https://doi.org/10.1093/ije/dyv105 PMID: 26108436

17. Curtin L, Klein R (1995). Direct standardization (age-adjusted death rates). Healthy People 2000 Statistical Notes, 6, 1–10.

18. Fleiss JL, Levin B, Cho Paik M (2003). Statistical methods for rates and proportions. Wiley Series in Probability and Statistics Eds.

19. Fay MP (1999). Approximate confidence intervals for rate ratios from directly standardized rates with sparse data. Communications in Statistics–Theory and Methods, 28, 2141–2160.

20. Friedman M (1982). Piecewise exponential models for survival data with covariates. Annals of Statistics, 10, 101–113.

21. Ansart S, Pelat C, Boelle P-Y et al. (2019) Mortality burden of the 1918–1919 influenza pandemic in Europe. Influenza and Other Respiratory Viruses, 3, 99–106.

22. Goldstein J, Lee R (2020). Demographic perspectives on the mortality of COVID-19 and other epidemics. PNAS, 117(36), 22035–22041. https://doi.org/10.1073/pnas.2006392117 PMID: 32820077

23. Rousson V, Locatelli I (2022). On the impacts of the COVID-19 pandemic on mortality: Lost years or lost days? medRxiv.org