Annals of Internal Medicine ORIGINAL RESEARCH

Historically High Excess Mortality During the COVID-19 Pandemic in Switzerland, Sweden, and Spain

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Background: Excess mortality quantifies the overall mortality impact of a pandemic. Mortality data have been accessible for many countries in recent decades, but few continuous data have been available for longer periods.

Objective: To assess the historical dimension of the COVID-19 pandemic in 2020 for 3 countries with reliable death count data over an uninterrupted span of more than 100 years.

Design: Observational study.

Setting: Switzerland, Sweden, and Spain, which were militarily neutral and not involved in combat during either world war and have not been affected by significant changes in their territory since the end of the 19th century.

Participants: Complete populations of these 3 countries.

Measurements: Continuous series of recorded deaths (from all causes) by month from the earliest available year (1877 for Switzerland, 1851 for Sweden, and 1908 for Spain) were jointly modeled with annual age group–specific death and total population counts using negative binomial and multinomial models, which accounted for temporal trends and seasonal variability of prepandemic years. The aim was to estimate the expected number of deaths in a pandemic year for a nonpandemic scenario and the difference in observed and expected deaths aggregated over the year.

Results: In 2020, the number of excess deaths recorded per 100 000 persons was 100 (95% credible interval [CrI], 60 to 135) for Switzerland, 75 (CrI, 40 to 105) for Sweden, and 155 (CrI, 110 to 195) for Spain. In 1918, excess mortality was 6 to 7 times higher. In all 3 countries, the peaks of monthly excess mortality in 2020 were greater than most monthly excess mortality since 1918, including many peaks due to seasonal influenza and heat waves during that period.

Limitation: Historical vital statistics might be affected by minor completeness issues before the beginning of the 20th century.

Conclusion: In 2020, the COVID-19 pandemic led to the second-largest infection-related mortality disaster in Switzerland, Sweden, and Spain since the beginning of the 20th century.

Primary Funding Source: Foundation for Research in Science and the Humanities at the University of Zurich, Swiss National Science Foundation, and National Institute of Allergy and Infectious Diseases.

Ann Intern Med. doi:10.7326/M21-3824 **Annals.org**

For author, article, and disclosure information, see end of text.

This article was published at Annals.org on 1 February 2022.

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Excess mortality compares expected and observed values and is applied temporally as well as regionally. The expected number of deaths is derived from counterfactual thinking (1, 2) and ideally captures what would have happened based on extrapolation of observations from prior years. As such, excess mortality is increasingly being used to quantify the overall effect of the COVID-19 pandemic in 2020 (3), including periods of excess mortality and periods of lower-than-expected mortality.

Europe has experienced several influenza pandemics over the past 140 years, including in 1890, 1918, 1957, 1968, 1977, and 2009 (4). The 1918 influenza pandemic is the best-documented and best-researched pandemic (5) and caused the most deaths, including approximately 2.6 million excess deaths in Europe (6). The 1890 pandemic led to approximately 1 million excess deaths globally (7); although it was referred to as an influenza pandemic, it may also have been caused by a coronavirus (8). The 1957 pandemic led to an estimated 1.1 million excess deaths globally (9).

Estimates of excess mortality can provide information about the burden of mortality related to pandemics, including deaths indirectly linked to them (10). Demographers have used excess mortality since the 1830s to describe monthly and seasonal mortality fluctuations (11, 12). In the 1850s, William Farr used expected versus observed crude death rates to identify places and populations that might benefit from sanitary interventions in England (13). An early application of the concept of excess mortality during a pandemic occurred when Switzerland's federal authorities compared monthly deaths in 1890 with those in adjacent years during the 1890 influenza pandemic (14).

The World Health Organization estimated that at least 3 million global deaths in 2020 were attributable to the COVID-19 pandemic, representing 1.2 million more deaths than officially reported (15). Other global estimates showed that excess mortality substantially exceeded official deaths reported from COVID-19 (1, 15, 16). These estimates reinforced the relevance of excess mortality when examining a pandemic's full mortality burden. However, to date, there have been no studies

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comparing pandemics between countries over longer periods based on uniformly structured data sets analyzed with a common approach.

METHODS

To assess the historical dimensions of the ongoing pandemic, we estimated age-specific, monthly excess deaths from all causes for Switzerland, Sweden, and Spain for 2020 to 2021 and other pandemic periods since the end of the 19th century in chronological order. These 3 countries are particularly well suited for longer-term contextualization of pandemic-related excess mortality based on available continuous data from 100 or more years. First, they were militarily neutral and were not involved in combat during the 2 world wars, and, with the exception of the Spanish Civil War (1936 to 1939), they were not simultaneously affected by war-related excess mortality. Furthermore, collection of vital events and censuses continued without data quality issues such as those expected in countries at war. Second, since the end of the 19th century, these countries have not been affected by significant changes in their territory.

Data Sources

Monthly numbers of deaths from all causes in Switzerland (1877 to 2020) and Sweden (1851 to 2020) were provided by the Swiss Federal Statistical Office and Statistics Sweden and are freely available (17, 18). For Spain, the monthly death figures from 1941 to 2019 were accessible from the Spanish Statistical Office, and data from 1908 to 1940 had to be transcribed from historical reports provided on its website (19). In all 3 countries, the onset of these vital statistics series coincided with the establishment of official national statistical offices. In general, the quality of the historical data series is assessed to be very good and comparable, both over time and between countries (20). Quality concerns about historical mortality data, which affect reporting of causes of death more strongly, generally apply less to death count data. In all 3 countries, there were precise regulations on when and how to officially report a death (21). Minor problems with completeness may be inherent at the end of the 19th century with regard to underregistration in the context of deaths in the first days or weeks of life, at very old ages, and during emigration (22–25); however, these issues are not considered relevant from the first half of the 20th century onward (26). Monthly data covering the first 6 months of 2021 in Switzerland were provided directly by the Swiss Federal Statistical Office. For Spain, provisional monthly death counts for 2020 were provided by the Spanish Statistical Office, and the data for the first 6 months of 2021 were compiled from experimental weekly data provided by the Spanish Statistical Office.

Data on the size and age structure of the population and on deaths were not available at the monthly level for any of the 3 countries. We used yearly data on population size and age structure to account for demographic shifts over time (27). The annual population numbers and annual deaths by age group (in 1-year bands) were obtained from the Human Mortality Database (20). The most recent annual death counts (2021 for Switzerland and 2019 to 2021 for Spain) and population structure (2020 to 2021 for Spain) by age group, which were unavailable in the Human Mortality Database, were obtained from provisional publicly accessible data repositories of the national statistics services of the 3 countries. Yearly deaths by 1-year age groups were grouped into 10-year age bands and combined with relevant population denominators for each country–year–age group stratum. Information on the numbers of officially reported deaths from COVID-19 in all 3 countries since spring 2020 was obtained from the Johns Hopkins Coronavirus Resource Center (28).

Statistical Analysis

We analyzed the continuous series of officially reported deaths from all causes by month from the earliest available year (1877 for Switzerland, 1851 for Sweden, and 1908 for Spain) through the end of 2020 (for Sweden) and June 2021 (for Spain and Switzerland). To estimate the expected values for a given year (for example, 1918) while accounting for uncertainty, we used deaths and total population counts from the 5 prior years (for example, 1913 to 1917). We excluded years with high pandemic mortality (1890, 1918, and 1957) to estimate expected values for the years following these pandemic years. We built a Bayesian model to compute the expected number of deaths by month and age group for each year based on the 5 preceding years, separately for each country. The model included an age-specific intercept, a yearly linear trend, and a periodic component based on a combination of sine and cosine functions (29). Because death counts by age group were only available aggregated by whole calendar years whereas overall death counts were available by month, we considered the model-predicted death counts by month and age group as latent variables. The yearly marginal sums were fitted to yearly death counts by age group with a multinomial likelihood, and the monthly marginal sums were fitted to monthly counts of overall deaths with a negative binomial likelihood (30, 31).

For each year, the model was fitted to the 5 preceding years, and the fitted model was used to predict expected death counts by month and age with a full propagation of uncertainty for the year of interest. We then computed the absolute number of excess deaths as the difference between observed and expected deaths, the absolute number of excess deaths per population as the absolute number of excess deaths scaled by the country population at that time, and the relative excess deaths as the absolute number of excess deaths scaled by the number of expected deaths. We convey uncertainty in the estimates using 95% credible intervals (CrIs), defined as the interval within which the parameter value falls with 95% probability. Statistical inference was conducted with Hamiltonian Monte Carlo techniques available in Stan software. We used normal prior distributions centered at 0 with a standard deviation of 10 for all regression terms and a half-Cauchy distribution with a

Table 1. Characteristics of the 4 Deadliest Pandemics of the Past 140 Years in Switzerland, Sweden, and Spain, by Calendar Year

Calendar Year and Country	Population, *N*	Deaths From All Causes, *n*		COVID-19 Deaths, *n**
		Observed	Expected†	
1890				
Switzerland	2 949 868	61 805	55 700 to 61 100	–
Sweden	4 775 819	81 824	69 300 to 77 000	–
1918				
Switzerland	3 878 360	75 034	47 600 to 53 100	–
Sweden	5 802 022	104 591	73 500 to 84 000	–
Spain	21 300 235	695 758	429 700 to 480 000	–
1957				
Switzerland	5 097 745	51 066	49 300 to 54 700	–
Sweden	7 341 017	73 132	67 800 to 73 000	–
Spain	29 445 865	293 502	264 700 to 296 200	–
2020				
Switzerland	8 605 965	76 195	64 700 to 70 900	7873
Sweden	10 327 496	97 870	86 900 to 93 700	8727
Spain	47 332 613	492 930	400 500 to 441 000	50 837
2021‡				
Switzerland	8 670 302	34 619	33 700 to 37 700	2900
Sweden	10 379 295	–	–	5903
Spain	47 394 223	234 994	210 300 to 238 400	30 046

* Data are from the Johns Hopkins Coronavirus Resource Center.
† Model-predicted number of deaths due to all causes from the 5 preceding years (95% credible interval, rounded to the next 100).
‡ Only the first 6 months of the year were included in the analyses. No age-specific data were available from Sweden for this period.

location parameter of 0 and a scale parameter of 5 for the variance terms.

We conducted several sensitivity analyses (**Supplement Table**, available at Annals.org). We used a simpler version of the model without the age structure and considering only the monthly death counts. We also assessed a time window of 7 years instead of 5 and a window of 7 years excluding the 2 years with the highest and lowest overall mortality. In addition, we assessed the effect of not excluding pandemic years when computing the expected deaths in the subsequent years.

We performed all analyses using R, version 4.1.0 (32), and Stan, version 2.21 (33), interfaced by the cmdstanr package (34). More details about the model are provided in the **Supplement** (available at Annals.org). All code and data are available from the repository at https://github.com/RPanczak/ISPM_excess-mortality.

Role of the Funding Source

The funding sources had no role in the study design or the collection, analysis, or interpretation of the data.

Results

The characteristics (population and deaths from all causes) of the 4 deadliest pandemics of the past 140 years in Switzerland, Sweden, and Spain are shown by calendar year in **Table 1**. Measured by the absolute number of excess deaths per 100 000 persons, 2020 resulted in historic excess mortality in all 3 countries. Of the deadliest pandemic years considered, only 1918 was markedly more severe (**Table 2**). Depending on the measure considered, 2020 reached or slightly exceeded the dimensions of 1890. The other pandemic years (1957, 1968, 1977, and 2009) did not lead to marked excess mortality in the 3 countries.

In 2020, the number of excess deaths recorded per 100 000 persons was 100 (95% CrI, 60 to 135) in Switzerland, 75 (CrI, 40 to 105) in Sweden, and 155 (CrI, 110 to 195) in Spain (**Table 2**). In proportion to the expected number of deaths, this corresponds to a relative excess of 12.5% (CrI, 7.4% to 17.7%) in Switzerland, 8.5% (CrI, 4.5% to 12.6%) in Sweden, and 17.3% (CrI, 11.8% to 23.1%) in Spain. Our estimates of the absolute number of excess deaths from all causes in 2020 are similar to the officially reported number of deaths due to COVID-19 in Switzerland (8429 vs. 7873) and Sweden (7656 vs. 8727) but higher than those in Spain (72 328 vs. 50 837) (**Tables 1** and **2**). We did not find evidence that the first 6 months of 2021 resulted in either lower-than-expected mortality or excess mortality in Switzerland and Spain (these values could not be calculated for Sweden because the data have not been released) (**Table 2**).

Looking back from 2020 by full calendar years (**Figure 1**), only a few years in the first half of the 20th century led to slightly higher absolute numbers of excess deaths per 100 000 persons than in 2020 in all 3 countries. The year 1918 was a major mortality event in the 20th century in all 3 countries: Over the entire year, the number of excess deaths recorded per 100 000 persons was 640 (CrI, 565 to 710) in Switzerland, 445 (CrI, 355 to 535) in Sweden, and 1135 (CrI, 1015 to 1250) in Spain. The number of excess deaths per 100 000 persons was thus 6 to 7 times higher in 1918 than in 2020. If the time

Table 2. Model-Based Estimates of Absolute Excess Deaths, Absolute Excess Deaths Scaled by Population, and Relative Excess Deaths (Compared With Expected Number of Deaths)

Calendar Year and Country	Absolute Excess Deaths (95% CrI), *n*	Absolute Excess Deaths per 100 000 Persons (95% CrI), *n**	Relative Excess Deaths (95% CrI), %†
1890			
Switzerland	3456 (703 to 6118)	115 (25 to 205)	6.0 (1.2 to 11.0)
Sweden	8810 (4871 to 12 573)	185 (100 to 265)	12.1 (6.3 to 18.2)
1918			
Switzerland	24 730 (21 925 to 27 453)	640 (565 to 710)	49.3 (41.3 to 57.7)
Sweden	25 937 (20 597 to 31 087)	445 (355 to 535)	33.1 (24.5 to 42.3)
Spain	241 661 (215 791 to 266 103)	1135 (1015 to 1250)	53.3 (45.0 to 61.9)
1957			
Switzerland	−922 (−3679 to 1804)	−20 (−70 to 35)	−1.7 (−6.7 to 3.7)
Sweden	2760 (101 to 5338)	40 (0 to 75)	4.0 (0.1 to 7.9)
Spain	13 227 (−2659 to 28 783)	45 (−10 to 100)	4.8 (−0.9 to 10.9)
2020			
Switzerland	8429 (5253 to 11 449)	100 (60 to 135)	12.5 (7.4 to 17.7)‡
Sweden	7656 (4199 to 10 984)	75 (40 to 105)	8.5 (4.5 to 12.6)‡
Spain	72 328 (51 942 to 92 409)	155 (110 to 195)	17.3 (11.8 to 23.1)‡
2021§			
Switzerland	−1002 (−3087 to 957)	−10 (−35 to 10)	−2.7 (−8.2 to 2.8)
Sweden	–	–	–
Spain	10 867 (−3423 to 24 715)	25 (−5 to 50)	5.0 (−1.4 to 11.8)

CrI = credible interval.
* Absolute number of excess deaths scaled by country population.
† Absolute number of excess deaths scaled by the number of expected deaths.
‡ Based on 8000 posterior samples, the probability that the relative number of deaths in 2020 was larger than in 1957 is 100% for Switzerland, 94.3% for Sweden, and 99.9% for Spain.
§ Only the first 6 months of the year were included in the analyses. No age-specific data were available from Sweden for this period.

scale is focused to the monthly level (**Supplement Figure 1**, available at Annals.org), the peaks of monthly excess mortality in all 3 countries in 2020 were greater than most monthly excess mortality since 1918, including many peaks due to seasonal influenza and heat waves during that period.

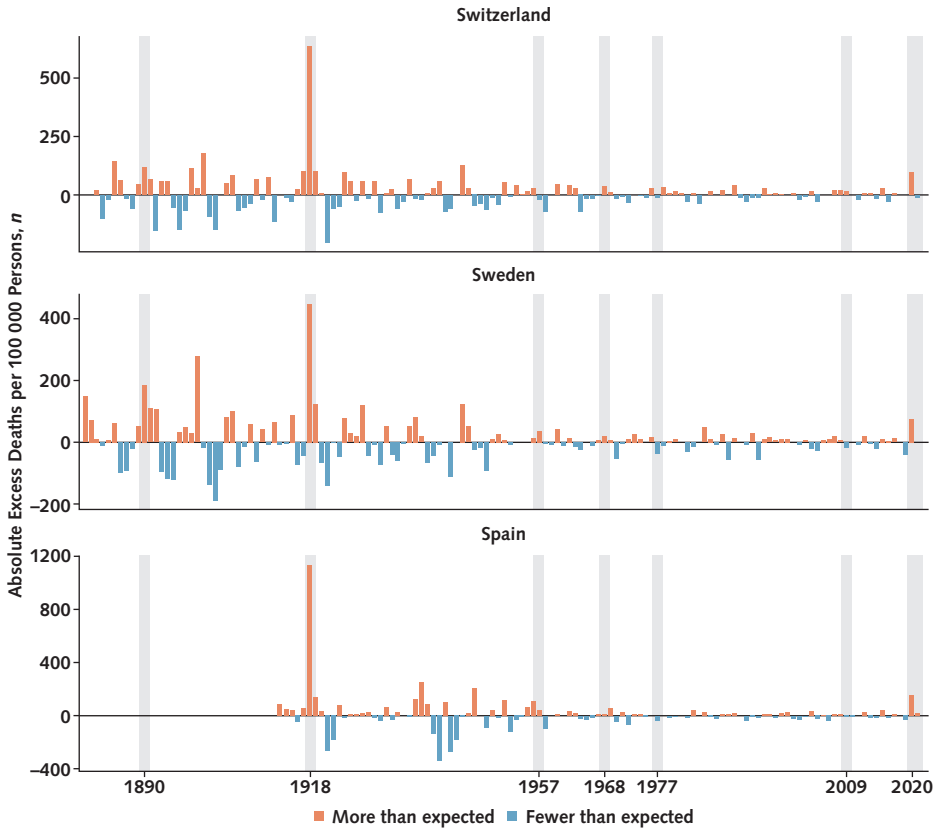
Our detailed analysis of the 4 deadliest pandemic years (1890, 1918, 1957, and 2020) over the past 140 years revealed that the 1890 influenza pandemic led to marked excess mortality in Sweden and Switzerland during January only (**Figure 2**; **Supplement Figure 2**, available at Annals.org). The 1957 influenza pandemic led to only moderate excess mortality in the last 2 to 4 months of the year in all 3 countries. In contrast, excess mortality was very high in the autumn during the 1918 influenza pandemic in all 3 countries, particularly Spain. In Switzerland, there were 2 waves between July and December 1918, and in Sweden and Spain, there were significant single waves in the last quarter of 1918. **Supplement Figure 3** (available at Annals.org) presents the difference in estimates of expected deaths in the years after the 1918 pandemic depending on whether death counts from 1918 were incorporated in subsequent projections of expected deaths. The COVID-19 pandemic in 2020 consisted of 2 waves that affected the 3 countries differently depending on the time of year. Although excess mortality was higher during the spring wave than the autumn wave in Spain, the opposite was observed in Switzerland. Sweden recorded similar excess mortality in spring and autumn of 2020. In Spain and Switzerland, excess mortality was still recorded in January 2021. In Switzerland, this was followed by slightly lower-than-expected mortality in February before the values returned to the expected range. **Supplement Figure 4** (available at Annals.org) shows the difference in estimates of expected deaths during the first 6 months of 2021 depending on whether deaths from 2020 were incorporated.

The number of annual excess deaths per 100 000 persons by age group (**Figure 3**) revealed different patterns for the 4 deadliest pandemic years. In 1890, Switzerland and Sweden had the highest number of excess deaths per 100 000 persons in the 50-year and older age groups in an increasing manner, though with large CrIs due to small numbers of deaths in the older age groups. The 1957 influenza pandemic and the 2020 COVID-19 pandemic showed an age-specific pattern similar to the one in 1890. In contrast, although the age groups above 50 years were heavily affected in Spain and Switzerland during the 1918 pandemic, young adults aged 20 to 40 years were also disproportionately affected in all 3 countries.

DISCUSSION

Because Switzerland, Sweden, and Spain were militarily neutral and were not involved in combat during either world war, they are rare cases in which monthly statistics on deaths from all causes are available for more than 100 years with no major interference. During the COVID-19 pandemic in 2020, these 3 countries recorded monthly peaks of excess all-cause mortality that were greater than most monthly excess mortality since the

Figure 1. Yearly numbers of excess deaths from all causes per 100 000 persons in Switzerland, Sweden, and Spain.



The numbers are displayed as differences between observed and expected values (based on 5 years before a given pandemic year and accounting for trends in all-cause mortality). The gray shading indicates pandemic years. The *y*-axes have different scales for each country.

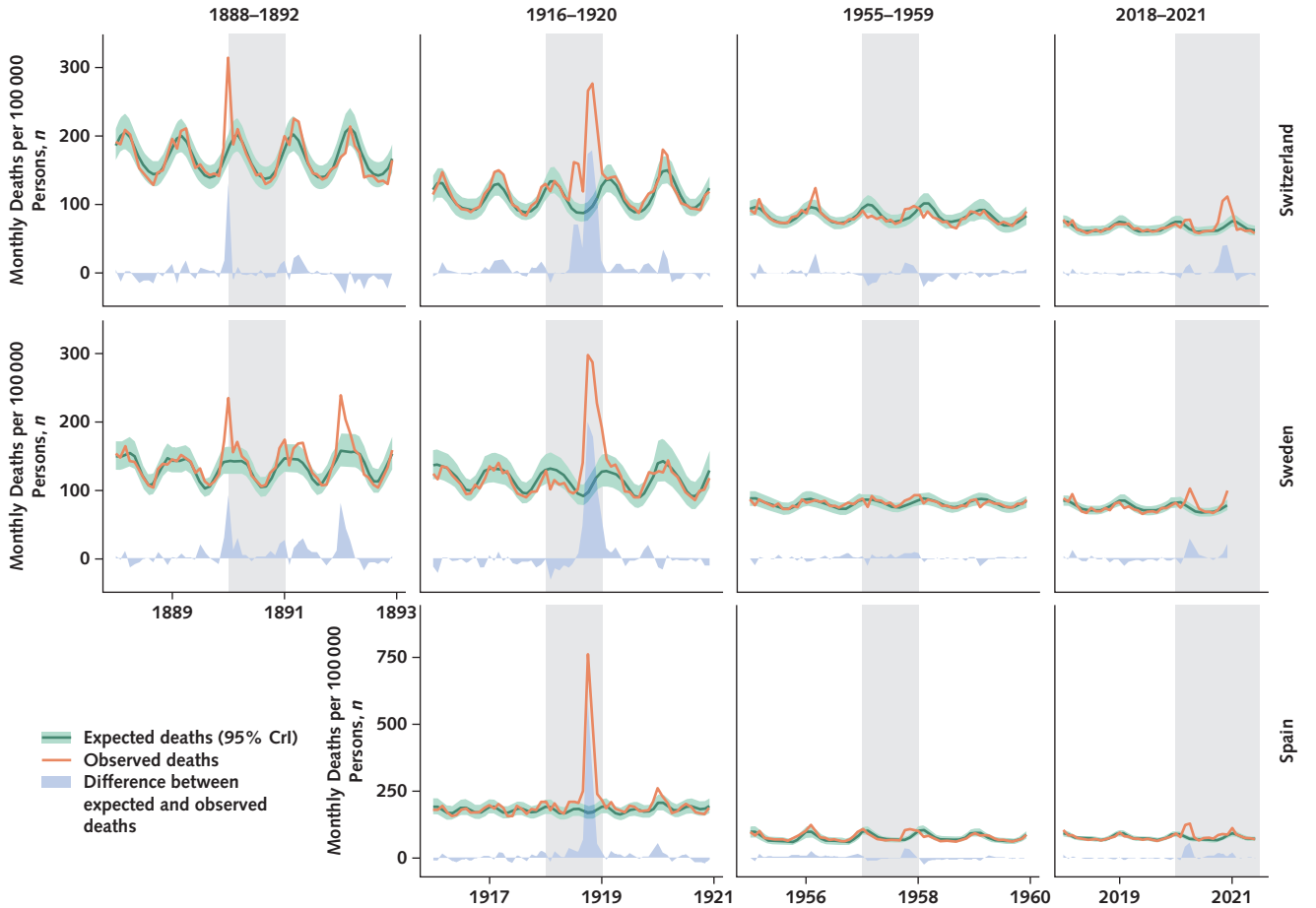
1918 influenza pandemic, including many peaks due to seasonal influenza and heat waves during that period. This emphasizes the historical dimension of the COVID-19 pandemic. In terms of age groups affected, 1918 stands out from the other pandemic years, as young adults aged 20 to 40 years were disproportionately affected by excess mortality.

Our analysis of excess mortality in these 3 countries during 2020 confirms previous studies that either made comparisons across countries (3, 35–37) or analyzed data separately for these countries (38–40). Although our estimates of excess deaths in 2020 are in good agreement with officially reported excess deaths from all 3 countries, there may be minor discrepancies in the absolute and relative excess mortality compared with other recent publications (1, 35), potentially due to methodological differences (for example, considering full calendar years vs. finer time resolutions [41]). Our estimates of excess deaths in 2020 in Switzerland and Sweden are similar to officially reported data on COVID-19 deaths. We estimated a higher number of excess deaths in 2020 than the officially reported number of COVID-19 deaths in Spain, possibly due to underreporting of COVID-19 deaths as recently proposed (42) or an increase in deaths from other causes.

Our study is unique in that it analyzed a continuous series of monthly death data spanning more than 100 years, including 2020 to 2021. The concept of excess mortality has frequently been used to assess the overall effect of historical pandemics, including comparisons across countries for specific pandemics (9, 43–46) and historical comparisons of different pandemics within individual countries (47, 48). Recently, 2 studies compared excess mortality in 2020 versus 1918 for New York City (49) and the United Kingdom (50), and a third study that was similar to ours used weekly data and focused exclusively on Sweden (39). Our findings are consistent with those of these earlier studies.

Our findings are also consistent with those in an earlier article examining the historical patterns of pandemic influenza in the 3 countries we studied (51). In terms of mortality, the 1918 pandemic remains unparalleled, although it should be noted that during the 1890 and 1957 pandemics, there was limited use of nonpharmaceutical interventions, in contrast to 1918 and 2020 (51). Excess mortality in 2020 might have been even higher if not for strong public health interventions worldwide (52). Early estimates suggest that vaccination prevented approximately 470 000 deaths in persons aged 60 years or older across 33 European countries between December

Figure 2. Detailed analysis of the deadliest pandemic years (1890, 1918, 1957, and 2020–2021) in Switzerland, Sweden, and Spain.



Data from Sweden were not yet available for 2021. The dark green lines and light green shading indicate expected monthly deaths from all causes with 95% CrIs based on the previous 5 years (excluding pandemic years themselves), the orange lines indicate the observed monthly deaths, and the blue shading shows the difference between the two (corresponding to monthly excess deaths). All numbers are scaled by population. The gray shading indicates pandemic years. The *y*-axes have different scales for each country. CrI = credible interval.

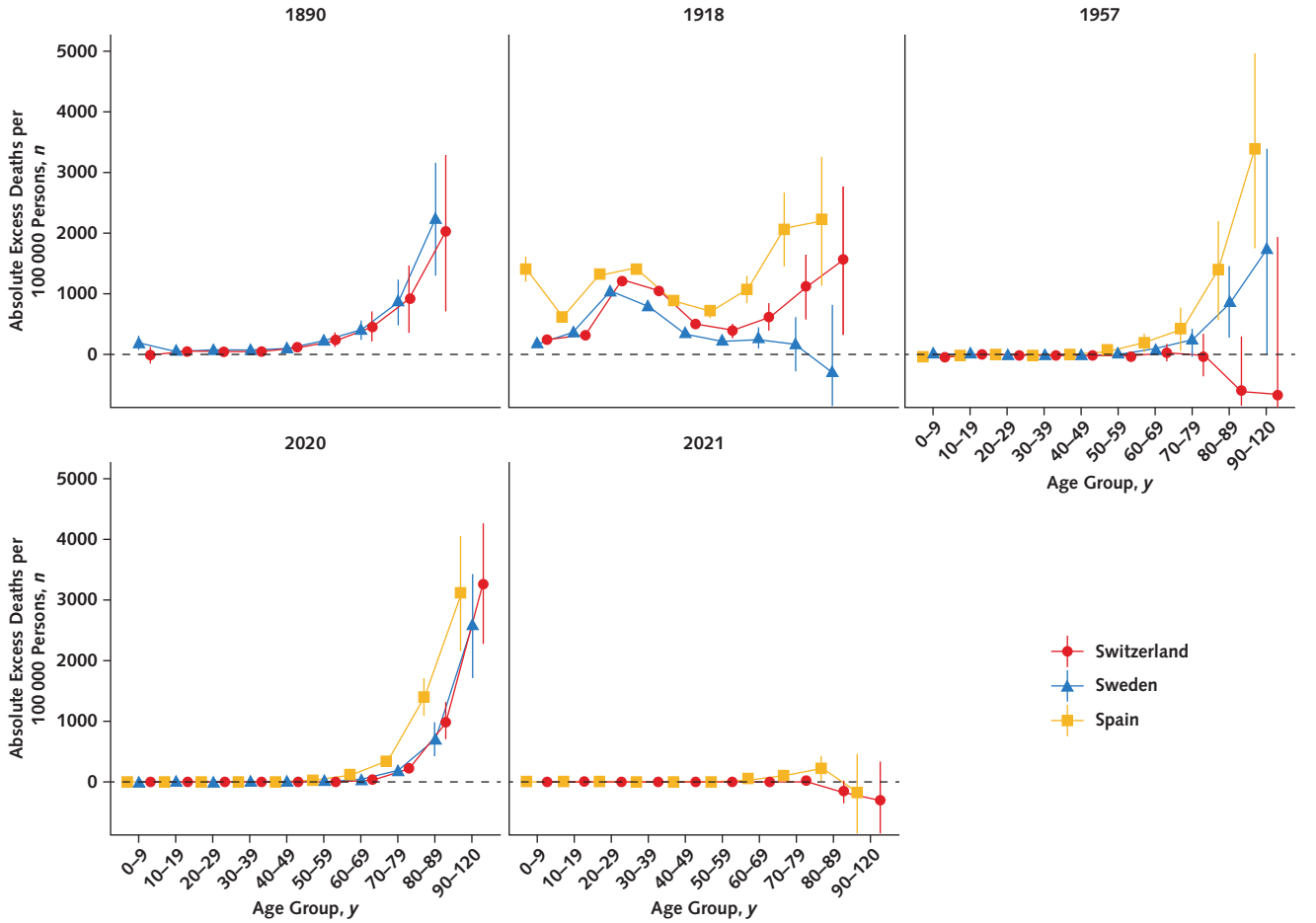
2019 and November 2021 (53). Because the COVID-19 pandemic is ongoing, a more conclusive assessment will have to wait.

Geographic variation seems to be a general feature of pandemics, as previously observed in 1890 (54), 1918 (6), 1957 (9), 1968 (55), and 2009 (56). In our analysis, Spain was the hardest-hit of the 3 countries in 1918, 1957, and 2020, even after differences in population size and age were accounted for. A general north–south gradient in excess mortality was found across Europe in the 1918 pandemic, although the reasons are uncertain (6). Other studies that focused on Spain in 1918 also offer no explanation for why the country was hit comparatively hard at the time (57, 58).

Another feature of the 1918 pandemic was the high mortality among young adults, which had not been observed before and has not been seen since. The reasons for this are still not clear, but preexisting age cohort–specific, cross-protective immunity from past pandemics has been suggested (59). The different age-specific patterns of excess mortality in 1918 and 2020 translated to substantial differences in life-years lost, even though prepandemic life expectancy was clearly lower before 1918 compared with before 2020. In 1917, the mean remaining life expectancy was about 45 years for persons having reached age 20 years in all 3 countries, compared with 65 years just before 2020 (20); for persons aged 50 years, the remaining life expectancy was about 20 years just before 1918 and 35 years just before 2020 (20). When multiplying age-specific expected life-years by the estimated number of excess deaths by age and relating them to the total population size in a "back of the envelope" calculation, we arrived at crude estimates of about 6000 (for Sweden) to 15 000 (for Spain) life-years lost per 1 million persons in 2020, compared with 19 million (for Sweden) to 40 million (for Spain) in 1918. Thus, for all 3 countries, the number of life-years lost was approximately 30 times greater in the 1918 pandemic than the 2020 pandemic.

Our analysis also shows that pandemic years are not the only peaks in excess mortality. Other events also led to increased excess deaths between 1890 and 2020. For

Figure 3. Excess deaths from all causes per 100 000 persons, with 95% credible intervals, by age group for the deadliest pandemic years (1890, 1918, 1957, and 2020–2021) in Switzerland, Sweden, and Spain.



The 90-to-120-year age group is not shown before 1957 because of the very low number of events. Data from Sweden were not yet available for 2021.

example, there were later waves immediately after the actual pandemic years (as seen in 1891 to 1894 and in 1920) (60). Seasonal influenza has also repeatedly led to noticeable peaks in all 3 countries (39, 61). In Spain, the civil war (1936 to 1939) must also be noted, but its mortality impact, though likely substantial, is difficult to assess (62), both because the official death figures might be underestimated (63) and because it is methodologically difficult to estimate the counterfactual mortality in the absence of the war over several years.

Our work also raises a methodological question: Should severe pandemic years be included in calculations of expected values for subsequent years (which we did not do)? This depends on whether one wants to give a clear counterfactual meaning to the term "expected." If it is meant to describe what would be observed without a pandemic, then expected mortality estimates for a pandemic's second year should not factor in deaths from the first year. We show that, for the years after 1918, this decision makes a difference (**Supplement Figure 3**). This decision becomes more complicated for longer-term comparisons involving countries where deaths increased sharply over several years during the world wars.

During the 2009 influenza pandemic and especially during the ongoing COVID-19 pandemic, public and scientific interest in prior pandemics increased markedly (64). However, comparisons with prior pandemics must be made with caution because there are important differences (59). Living conditions have changed substantially over time, and the viruses responsible for each pandemic had different biological and epidemiologic characteristics, including mortality patterns (59). However, there are also significant parallels between the pandemics of 1918 and 2020, such as authorities' hesitant and decentralized management of subsequent waves, as recently described for Switzerland (65).

Looking beyond the 3 studied countries to other European countries shows that excess mortality in 2020 was not inevitable. For example, Finland, Norway, and Denmark did not report excess mortality in 2020 (35). The exact reasons for these differences have yet to be investigated, not only for 2020 but also for 1918, where there are still relatively few cross-national studies (6).

However, the type, duration, and strength of governmental, public health, and direct infection control interventions, as well as ecological, geographic, and cultural factors, might have played roles worthy of further study.

Our study has limitations. First, it was geographically limited due to available data. Few countries have complete series of monthly death data spanning more than 100 years and were militarily neutral during both world wars. Moreover, monthly death numbers by sex, age, and cause were not available until the 1960s, although our methods partially accounted for this. Second, there are limitations to data quality, especially for older vital statistics from before the 20th century, including underreporting in the youngest and oldest age groups and due to emigration. Furthermore, according to the statistical services of the 3 countries, the data from 2020 and 2021 must still be considered provisional and could theoretically change. Third, current analyses of the COVID-19 pandemic show that not all regions in these 3 countries were affected equally (66). Aggregation at the country level may hide regional nuances that are potentially important (67). Fourth, the 95% CrIs from our models are relatively large, reflecting the uncertainty in the data. Finally, focusing on deaths does not account for other direct or indirect health, societal, or economic consequences during pandemic periods (68). It is estimated that long-term effects of coronavirus infection in convalescent persons (long COVID) in all age groups will continue to be a burden for some time, not only in the clinic (69).

In conclusion, our results describe the historical dimensions of the COVID-19 pandemic and its overall mortality impact in 2020 in 3 countries with reliable population and mortality records over more than 100 years. Our findings suggest that the pandemic led to the second-largest mortality disaster driven by a viral infection in more than 100 years in the 3 countries we studied, second only to the 1918 influenza pandemic. Only time will tell what the long-term effect of the COVID-19 pandemic will be.

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Note: Ethics approval was not required for the reuse of these publicly available and highly aggregated demographic data at the national level.

Acknowledgment: The authors thank Thomas E. Ewing, Oliver Grübner, Miguel Hernán, Olivia Keiser, Kiko Llaneras, Graham Mooney, Alfredo Morabia, Frank Rühli, Tommy Bengtsson, Diego Ramiro, Hampton Gaddy, Philippe Wanner, and Dominik Ullmann for helpful comments and support and Kristin Marie Bivens for editorial support. Calculations were performed on UBELIX (www.id.unibe.ch/hpc), the high-performance computing cluster at the University of Bern.

Grant Support: By the Foundation for Research in Science and the Humanities at the University of Zurich (grant STWF-21-011 to Drs. Staub and Floris). Dr. Panczak was supported by the National Institute of Allergy and Infectious Diseases (grant 5U01-AI069924-05). Dr. Riou was supported by the Swiss National Science Foundation (grant 189498).

Disclosures: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M21-3824.

Reproducible Research Statement: *Study protocol:* Not available. *Statistical code and data set:* Available at https://github.com/RPanczak/ISPM_excess-mortality.

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Author contributions are available at Annals.org.

Previous Posting: An earlier version of this manuscript was posted as a preprint on medRxiv on 13 August 2021. doi:10.1101/2021.08.12.21261825

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