The effect of Covid-19 on premature mortality. The case of USA, Italy and France

Stefano Mazzuco
Department of Statistical Sciences, University of Padova
Via Cesare Battisti 241, 35121 Padova, Italy
email: stefano.mazzuco@unipd.it

October 30, 2023

Abstract

The recent Covid–19 outbreak severely impacted on longevity of many countries. However, mortality has several components (infant, premature, old age) and it is not yet clear how such impact is distributed across them. We therefore analyse the evolution of both premature and senescent mortality by means of a mixture model, which can distinguish the different components. This model is applied to regional data on mortality in Italy and France from 2015 to 2021 and to US states from 2015 to 2020. The main finding is that Covid-19 severely impacted also the premature mortality, not the senescent one, in all the considered countries.

keywords: premature mortality, longevity, Covid-19, Italy

1 Introduction

The recent Covid–19 pandemic had a severe impact on mortality levels in several countries. This has been shown by many scholars, among them Aburto et al. (2022) and Mazzuco and Campostrini (2022) show such impact in term of life expectancy drop. However, life expectancy is just a summary measure of age–specific mortality, which is made up of several components. Zanotto et al. (2021), moving from Lexis (1878) and Pearson (1897), define a three-components model where infant mortality and premature mortality are distinguished from senescent or old age mortality.

We can therefore wonder how these different components have been differently affected by the pandemic. While we can expect that on the one hand, the effect on infant mortality has been negligible and, on the other hand, the effect on senescent mortality has been quite relevant, it is less clear what can be said on premature mortality, even though some results (see Islam et al., 2021; Ugarte et al., 2022) have been already presented using the Years of Life Lost (YLL) measure. The aim of this paper is to find how both premature and senescent mortality has evolved in the last years in Italy, France and USA and how the Covid-19 shock modified their trend. We use data from regional life tables in Italy and France and from state–level life tables in USA and apply the model proposed by Mazzuco et al. (2021).

2 Modelling premature and senescent mortality with a mixture model

Measurement of premature mortality has been discussed by Mazzuco et al. (2021). The starting point is the mixture model proposed by Zanotto et al. (2021) where the age distribution of death of a life table is fitted by a mixture distribution as follows:

$$
\begin{aligned}
d(x) &= \eta \cdot f_I(x) + \qquad (1)\\
&+ (1-\eta)\cdot\alpha\cdot f_m(x,\xi_m,\omega_m,\lambda_m) + \\
&+ (1-\eta)\cdot(1-\alpha)\cdot f_M(x,\xi_M,\omega_M,\lambda_M) \qquad (2)
\end{aligned}
$$

where $f_I(x)$ is a half–normal capturing the infant mortality component, whereas $f_M(x)$ and $f_m(x)$ are two skew–normal distribution, capturing the senescent and premature mortality components, respectively. Mazzuco et al. (2021) proposed to modify the (1) by grouping some comparable populations and assume that all of them have the same senescent mortality curve, while premature mortality curve varies across populations. In order to do that, a hierarchical model is defined, premature mortality coefficients are allowed to vary across populations, while senescent mortality ones remain fixed, according the formula[1]

$$
d_j(x) = \alpha_j \cdot f_j^m(x,\mu_j^m,\sigma_j^m,\gamma_j^m) + (1-\alpha_j)\cdot f^M(x,\mu^M,\sigma^M,\gamma^M). \qquad (3)
$$

The main issue of this method is the arbitrariness with which countries are grouped together, keeping in mind that the estimate of the extent of premature mortality in one country can significantly vary with different composition of the group it belongs to. In our case, we are dealing with regions (for Italy and France) or states (for US), and we can expect that sub-national heterogeneity is lower than cross–country variability, thus reducing the impact of different grouping.

[1] Infant mortality component is disregarded and model has been fitted only on death occurring at age 5 and higher.

2.1 Data

Data comes from Italian National Institute of Statistics (Italy), the French Human Mortality Database (France) Bonnet (2020); Bonnet and d'Abis (2022) and CDC Centers for Disease Control and Prevention, National Center for Health Statistics (2023). Model (3) is run for every year for each country. For Italy and France, regions have been grouped on hte base of life expectancy at birth: regions which life expectancy was below the median value have been grouped together whereas the regions with a life expectancy above the median constitutes the ohter group. As for US states, 5 groups have been created using the quintiles of life expectancy at birth. It is worth noting that regions or state can change their group from one year and the other. This happens, for example, to Lombardy that in 2020 is moved to a high mortality group because severely hit by the pandemic.

In order to correlate the change in premature mortality with the intensity of the recent pandemic, Covid deaht rate by US states have been taken from CDC Centers for Disease Control and Prevention, COVID-19 Response (2023).

3 Preliminary results

We have preliminary results for Italian regions, USA states and French regions (male population). Table 1 show that the location paremeter of senescent mortality was slightly growing in Italy, then significantly dropped, a decline that is comparable to that of life expectancy as showed by Aburto et al. (2022) and Mazzuco and Campostrini (2022). Tables 2, 3 and 4 reports the estimates for parameters α_j of model (3), that can be interpreted as the share of premature deaths. From these tables it appears that the Covid pandemic also affected the premature mortality component: in Italy premature mortality rises in 2020 in Lombardia, Emilia Romagna and Piemonte (regions more severely hit by the first wave) while a significant drop can be noticed in Campania e Sicilia, a likely indirect effect of lockdown measures. In 2021 other regions show a significant rise of preamture mortality, Campania, Sicilia and Molise. As for USA states we only have information up to 2020. In figure 1 the change in the share of preamture deaths from 2019 to 2020 is plotted with the Covid death rate of 2020. This plot shows that the states that had been more severely hit by the pandemic also show the highest rise in premature mortality. In France[2] we notice a particular high rise of premature mortality in Île de France and Rhône-Alpes regions in 2020.

All in all, the evidence is that while certainly old age mortality has been significantly impacted by the pandemic, premature mortality has also been affected. These preliminary results will be complemented by analyses on other countries, e. g. Sweden and UK. When data on 2022 will be also available, the estimated share of premature mortality will be also correlated with reginal vaccination coverage.

References

Aburto, J. M., I. Kashnitsky, J. Schöley, L. Zhang, C. Rahal, T. Missov, M. C. Mills, J. B. Dowd, and R. Kashyap (2022). Quantifying impacts of the covid-19 pandemic through life-expectancy losses: a population-level study of 29 countries. *International Journal of Epidemiology 51*(1), 63–74.

[2]Estimates for female population will be avaialable soon.

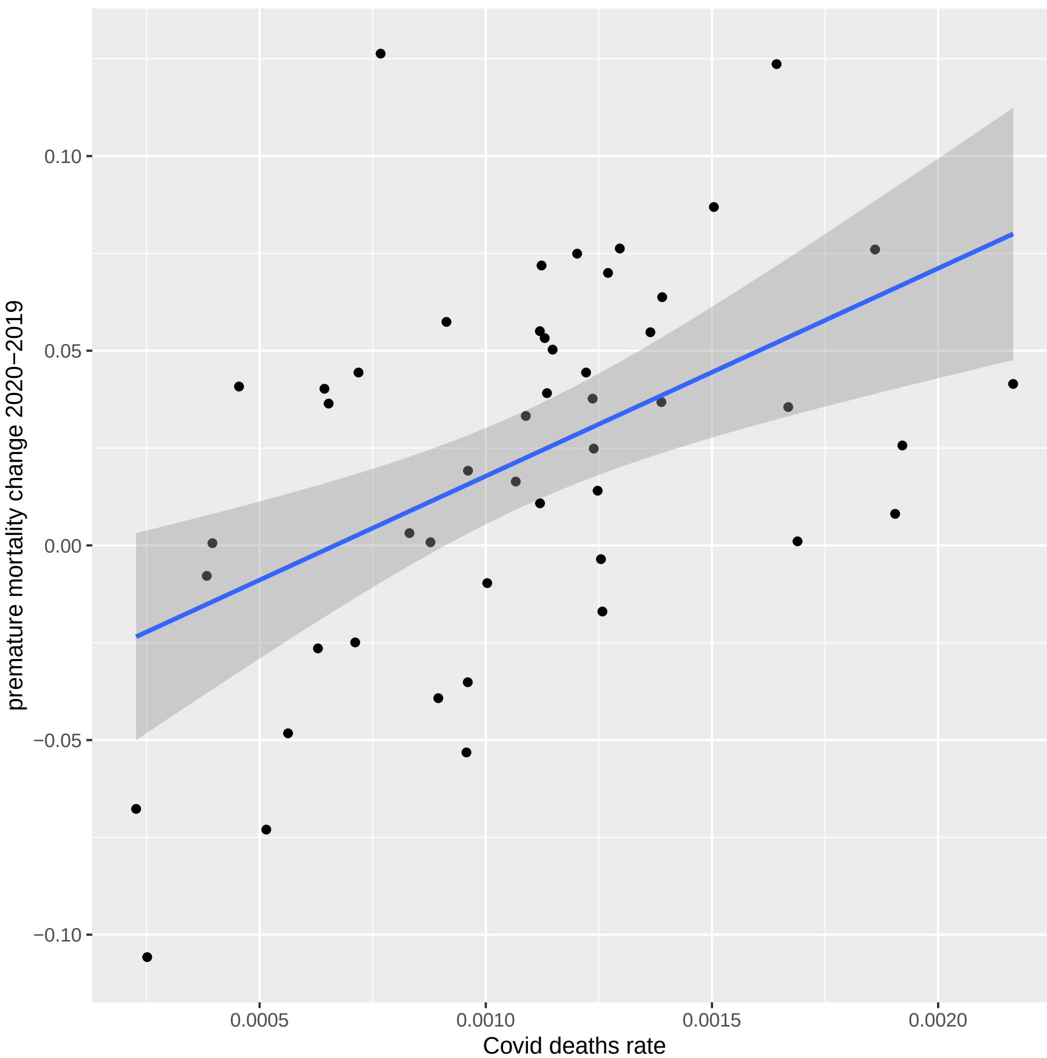

Figure 1: Premature mortality change (2019-2020) and Covid mortality in US states

Bonnet, F. (2020). Computations of French lifetables by department, 1901–2014. *Demographic Research 42*(26), 741–762.

Bonnet, F. and H. d'Abis (2022). The french human mortality database.

Centers for Disease Control and Prevention, COVID-19 Response (2023). Weekly united states covid-19 cases and deaths by state. version date: February 16, 2023.

Centers for Disease Control and Prevention, National Center for Health Statistics (2023). Mortality 1999-2020 on cdc wonder online database, released in 2021. Data are from the Multiple Cause of Death Files, 1999-2020, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program.

Islam, N., D. A. Jdanov, V. M. Shkolnikov, K. Khunti, I. Kawachi, M. White, S. Lewington, and B. Lacey (2021). Effects of covid-19 pandemic on life expectancy and premature mortality in 2020: time series analysis in 37 countries. *BMJ 375*.

Lexis, W. (1878). Sur la durée normale de la vie humaine et sur la théorie de la stabilité des rapports statistiques [on the normal human lifespan and the theory of the stability of the statistical ratios]. *Annales de Démographie Internationale 2*(6-7), 447–460.

Mazzuco, S. and S. Campostrini (2022, 01). Life expectancy drop in 2020. estimates based on human mortality database. *PLOS ONE 17*(1), 1–6.

Mazzuco, S., M. Suhrcke, and L. Zanotto (2021). How to measure premature mortality? a proposal combining "relativ" and "absolute" approaches. *Population Health Metrics 19*(41).

Pearson, K. (1897). *The Chances of Death and Other Studies in Evolution*, Volume I. Edward Arnold.

Ugarte, M. P., S. Achilleos, A. Quattrocchi, J. Gabel, O. Kolokotroni, C. Constantinou, N. Nicolaou, J. M. Rodriguez-Llanes, Q. Huang, O. Verstiuk, N. Pidmurniak, J. W. Tao, B. Burström, P. Klepac, I. Erzen, M. Chong, M. Barron, T. P. Hagen, Z. Kalmatayeva, K. Davletov, I. Zucker, Z. Kaufman, M. Kereselidze, and L. K. and (2022). Premature mortality attributable to covid-19: potential years of life lost in 17 countries around the world, january–august 2020. *BMC Public Health 22*(54).

Zanotto, L., V. Canudas-Romo, and S. Mazzuco (2021). A mixture-function mortality model: illustration of the evolution of premature mortality. *European Journal of Population 37*, 1–27.

4 Appendix

Year	Location		Scale	
	Low	High	Low	High
2015	85.17	85.73	8.71	8.57
2016	85.89	86.22	8.64	8.63
2017	85.42	86.13	8.63	8.50
2018	85.78	86.61	8.75	8.46
2019	85.99	86.89	8.70	8.26
2020	84.91	85.61	8.85	8.58
2021	85.09	85.65	8.90	8.85

Table 1: Old age longevity: location and scale (compression) parameters for Italian regions (low and high mortality groups)

	2015	2016	2017	2018	2019	2020	2021
Abruzzo	0.09	0.10	0.10	0.16	0.15	0.15	0.09
Basilicata	0.11	0.12	0.11	0.10	0.12	0.09	0.10
Calabria	0.15	0.14	0.16	0.12	0.15	0.11	0.18
Campania	0.29	0.29	0.27	0.26	0.25	0.24	0.29
Emilia-Romagna	0.10	0.10	0.10	0.11	0.14	0.15	0.10
Friuli-Venezia Giulia	0.12	0.12	0.11	0.14	0.13	0.12	0.13
Lazio	0.11	0.14	0.11	0.10	0.10	0.16	0.17
Liguria	0.10	0.11	0.10	0.11	0.10	0.14	0.17
Lombardia	0.12	0.10	0.10	0.14	0.14	0.20	0.12
Marche	0.09	0.09	0.09	0.09	0.10	0.09	0.09
Molise	0.10	0.12	0.11	0.11	0.10	0.10	0.18
Piemonte	0.11	0.11	0.10	0.11	0.11	0.18	0.10
Puglia	0.16	0.14	0.09	0.09	0.09	0.09	0.14
Sardegna	0.10	0.12	0.12	0.10	0.10	0.10	0.10
Sicilia	0.20	0.22	0.21	0.20	0.21	0.13	0.24
Toscana	0.10	0.09	0.10	0.11	0.13	0.09	0.09
Trentino-Alto Adige	0.08	0.09	0.08	0.09	0.09	0.10	0.07
Umbria	0.09	0.09	0.09	0.09	0.09	0.08	0.08
Valle d'Aosta	0.15	0.12	0.12	0.14	0.13	0.17	0.10
Veneto	0.10	0.10	0.10	0.11	0.12	0.10	0.08

Table 2: Share of premature mortality estimates (parameter α_j in (3)) for Italian regions

	2015	2016	2017	2018	2019	2020
Alaska	0.28	0.28	0.22	0.25	0.26	0.26
Alabama	0.39	0.38	0.37	0.39	0.36	0.45
Arkansas	0.40	0.37	0.38	0.38	0.38	0.39
Arizona	0.20	0.20	0.19	0.19	0.21	0.26
California	0.18	0.20	0.18	0.18	0.18	0.22
Colorado	0.23	0.26	0.23	0.22	0.24	0.19
Connecticut	0.18	0.20	0.20	0.19	0.21	0.25
District of Columbia	0.26	0.28	0.26	0.26	0.27	0.35
Delaware	0.23	0.25	0.24	0.24	0.20	0.24
Florida	0.19	0.20	0.19	0.19	0.25	0.28
Georgia	0.38	0.36	0.36	0.36	0.33	0.38
Hawaii	0.15	0.15	0.16	0.16	0.17	0.46
Iowa	0.31	0.27	0.27	0.29	0.30	0.30
Idaho	0.27	0.28	0.27	0.24	0.28	0.24
Illinois	0.24	0.28	0.26	0.23	0.25	0.29
Indiana	0.28	0.29	0.30	0.40	0.30	0.37
Kansas	0.28	0.35	0.30	0.32	0.33	0.34
Kentucky	0.39	0.41	0.39	0.40	0.41	0.42
Louisiana	0.32	0.32	0.33	0.33	0.31	0.44
Massachusetts	0.24	0.25	0.25	0.26	0.24	0.25
Maryland	0.20	0.25	0.22	0.22	0.23	0.25
Maine	0.30	0.29	0.28	0.29	0.32	0.22
Michigan	0.31	0.31	0.31	0.32	0.30	0.36
Minnesota	0.20	0.23	0.23	0.24	0.25	0.24
Missouri	0.36	0.35	0.38	0.27	0.35	0.40
Mississippi	0.46	0.43	0.44	0.41	0.45	0.53
Montana	0.25	0.27	0.26	0.23	0.29	0.25
North Carolina	0.35	0.33	0.34	0.33	0.31	0.31
North Dakota	0.28	0.26	0.24	0.24	0.23	0.25
Nebraska	0.25	0.26	0.26	0.24	0.30	0.30
New Hampshire	0.25	0.21	0.22	0.22	0.27	0.22
New Jersey	0.22	0.25	0.23	0.25	0.23	0.27
New Mexico	0.24	0.24	0.24	0.23	0.23	0.31
Nevada	0.32	0.35	0.35	0.29	0.29	0.33
New York	0.19	0.20	0.18	0.19	0.19	0.23
Ohio	0.26	0.27	0.28	0.29	0.28	0.41
Oklahoma	0.37	0.35	0.36	0.37	0.37	0.44
Oregon	0.29	0.23	0.24	0.23	0.26	0.25
Pennsylvania	0.28	0.27	0.29	0.28	0.30	0.28
Rhode Island	0.23	0.25	0.20	0.29	0.23	0.23
South Carolina	0.28	0.27	0.26	0.26	0.25	0.31
South Dakota	0.19	0.25	0.22	0.21	0.27	0.28
Tennessee	0.35	0.36	0.35	0.35	0.36	0.39
Texas	0.31	0.34	0.30	0.29	0.32	0.36
Utah	0.24	0.21	0.19	0.20	0.23	0.27
Virginia	0.26	0.27	0.24	0.26	0.29	0.26
Vermont	0.29	0.20	0.20	0.19	0.28	0.21
Washington	0.28	0.29	0.29	0.28	0.30	0.23
Wisconsin	0.36	0.46	0.43	0.46	0.40	0.46
West Virginia	0.44	0.44	0.44	0.43	0.48	0.45
Wyoming	0.25	0.24	0.23	0.38	0.24	0.29

Table 3: Share of premature mortality estimates (parameter α_j in (3)) for US states

	2015	2016	2017	2018	2019	2020	2021
Île de France	0.18	0.16	0.15	0.23	0.17	0.28	0.18
Centre-Val de Loire	0.25	0.22	0.18	0.30	0.26	0.21	0.25
Bourgogne	0.20	0.19	0.19	0.18	0.19	0.21	0.22
Franche-Comté	0.16	0.20	0.17	0.17	0.17	0.24	0.23
Basse Normandie	0.20	0.20	0.19	0.20	0.19	0.19	0.24
Haute Normandie	0.24	0.25	0.23	0.23	0.25	0.25	0.36
Nord Pas de Calais	0.40	0.43	0.39	0.38	0.38	0.43	0.48
Picardie	0.31	0.35	0.30	0.31	0.30	0.40	0.43
Alsace	0.32	0.26	0.30	0.32	0.30	0.27	0.29
Champagne-Ardenne	0.23	0.25	0.23	0.23	0.23	0.34	0.36
Lorraine	0.25	0.28	0.27	0.22	0.22	0.36	0.35
Pays de la Loire	0.24	0.20	0.20	0.26	0.22	0.18	0.19
Bretagne	0.19	0.21	0.19	0.21	0.20	0.18	0.21
Aquitaine	0.22	0.18	0.18	0.24	0.21	0.16	0.19
Limousin	0.19	0.19	0.21	0.19	0.18	0.19	0.28
Poitou-Charentes	0.22	0.17	0.20	0.26	0.21	0.18	0.21
Languedoc-Roussilon	0.24	0.21	0.20	0.28	0.22	0.19	0.20
Midi-Pyrénées	0.18	0.16	0.16	0.24	0.17	0.14	0.15
Auvergne	0.37	0.25	0.46	0.22	0.46	0.50	0.49
Rhône-Alpes	0.19	0.16	0.16	0.23	0.18	0.24	0.16
Provence-Alpe-Côte d'Azur	0.22	0.18	0.18	0.25	0.20	0.18	0.26
Corse	0.30	0.44	0.46	0.41	0.35	0.38	0.54

Table 4: Share of premature mortality estimates (parameter α_j in (3)) for French regions (male population)