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Descriptive Finding

Population age structure only partially explains the large number of COVID-19 deaths at the oldest ages

Anthony Medford

Sergi Trias-Llimós

Contents

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Anthony Medford[1]

Sergi Trias-Llimós[2]

Abstract

BACKGROUND
To date, any attention paid to the age shape of COVID-19 deaths has been mostly in relation to understanding the differences in case fatality rates between countries.

OBJECTIVE
We explore differences in the age distribution of deaths from COVID-19 among six European countries which have old age structures. We do this by way of a cross-country comparison and put forward some reasons for potential differences.

METHODS
We estimate the distribution of deaths by 10-year age groups and the counterfactual age distribution under the assumption that all populations had the age structure of Italy. For this, we use 10-year age-grouped COVID-19 death counts and the corresponding population exposures for France, Italy, the Netherlands, Germany, Sweden, Spain, and China.

RESULTS
All included European countries experienced a high proportion of deaths at older ages. The relative proportion of deaths at ages above 90 years is lowest in Italy when compared to the other countries in the study despite Italy having the oldest population in Europe.

CONTRIBUTION
Population age structure seems essential for understanding COVID-19-related mortality, but other factors may play an important role, particularly at older ages in European populations.

[1] Syddansk Universitet, Denmark. Email: amedford@sdu.dk.
[2] London School of Hygiene and Tropical Medicine, UK and Center for Demographic Studies, Bellaterra, Spain.

1. Introduction

In December 2019, a number of pneumonia cases of unknown origin emerged in Wuhan City, Hubei province, China. In early January 2020, Chinese scientists discovered a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2; previously known as 2019-nCoV), in these infected patients (Phelan, Katz, and Gostin 2020). The initial outbreak spread rapidly within China and subsequently to most countries across the globe. On March 11, 2020, the World Health Organization declared coronavirus disease 2019 (COVID-19), the disease caused by SARS-CoV-2, to be a pandemic (WHO 2020a).

Despite the variation in symptomatology and health complications from COVID-19, the disease poses a greater risk to individuals at higher ages and those with pre-existing medical conditions. As COVID-19 develops, we are witnessing spikes in hospitalizations and intensive care unit (ICU) admissions in the worst affected countries. The health systems of these countries have been stretched to the limit. Therefore, there has been somewhat of a greater focus on the morbidity impact of the virus, particularly as the availability of intensive care units is being exceeded by the number of critical cases requiring critical care. As the pandemic matures, the number of deaths is rising at an alarming rate. On March 15, 2020, there were about 6,500 deaths globally. Thirteen days later, on March 28, 2020, there were almost 31,000 deaths globally, and on June 8th, 2020, there were more than 400,000 deaths globally, of which more than 184,000 were in Europe (WHO 2020b).

Despite its distinct impact on mortality risk across different population groups, any attention paid to age shapes thus far have been mostly attempts to understand the differences in case fatality rates between countries. Onder, Rezza, and Brusaferro (2020) compare the case fatality rates between Italy and China and noted that, in addition to the older age structure of Italy compared to China, differences in the definition of COVID-19 related deaths and in testing strategies may partly explain the disparities. Dudel et al. (2020) decompose the crude fatality rate into two components: age structure of the diagnosed cases and the age-specific case fatality rates. Dowd et. al (2020) explain differences in case fatality rates by reference to a country's population age structure using Italian and South Korean data. So far, this last study is the only one directly relating age structures of populations and potential COVID-19 outcomes, and it shows important differences in expected deaths in populations with very dissimilar age structures (Dowd et al. 2020). Overall, there has not been a great deal of focus on the age pattern of official COVID-19 deaths in relation to the age structures across European populations.

The aim of this descriptive contribution is to explore whether differences in the age structures of populations account for differences in the age structure of COVID-19 deaths among a selection of European countries: France, Italy, the Netherlands, Germany, Sweden, and Spain. We do this by way of a cross-country comparison in the age patterns of observed COVID-19 death counts and their counterfactual distribution, which we adjusted using Italy's age structure. We include Chinese data for comparison.

2. Data and methods

We use confirmed COVID-19 death counts from the COVID-19 Cases and Deaths by Age Database (COVerAge-DB; Riffe, Acosta et al. 2020) grouped into decennial age groups. The COVerAge-DB collects age- and sex-specific cumulative cases, deaths, and tests from official reports from multiple countries worldwide and for several subpopulations.

We obtained the corresponding populations at risk from the Human Mortality Database for Italy (2017), Spain (2016), the Netherlands (2016), France (2017), Germany (2017), and Sweden (2018). The corresponding data fom China were retrieved from https://www.populationpyramid.net/china/2019/. For each country, we estimated the proportion of deaths for each age group by dividing the number of deaths in each age group by the total number of deaths.

Then, we estimated the counterfactual shares of age-specific deaths in each age group assuming the age-specific distribution of the Italian population. In other words, we estimated what the distribution of deaths by age group would be if all countries are assumed to have the age distribution of the Italian population. For convenience, it makes sense to use Italy as the reference population, but we experimented with different reference populations than Italy (not shown), and the substantive conclusions do not change. Our approach is based on direct standardization techniques (Preston, Heuveline, and Guillot 2001), which we applied using the following formula for each subpopulation:

$$Prop\ deaths_i = \frac{\frac{deaths_i}{population_i} * weights_i}{\sum \frac{deaths_i}{population_i} * weights_i}$$

The *weights* represent the proportion of the population in age group i in the standard population (Italy); *deaths* are the observed COVID-19 deaths; and *population* is the population at risk. We estimated 95% confidence intervals (CI) using a conventional formula for estimating uncertainty around proportions (i.e., prevalence ±1.96 × standard error of prevalence).

3. Results

3.1 Observed deaths distribution

While deaths occur more frequently at higher ages, there are differences both in the observed age distribution and in the estimated counterfactual distribution (Table 1). Deaths in China occur at slightly younger ages than in Europe and are split somewhat more evenly across older ages, with 30% of deaths in age bands 60–69 and 70–79 and 20% of deaths at ages above 80. Above age 80, the proportion of deaths is 58% in Italy; 59–62% in Spain, the Netherlands, and France; 64% in Germany; and 66% in Sweden.

Table 1: COVID-19 death distribution for China, Italy, Spain*, the Netherlands, France, Germany, and Sweden

	China (11 Feb)		Italy (18 May)		Spain* (15 May)		Netherlands (18 May)	
Age	**count**	**Dist'n**	**count**	**Dist'n**	**count**	**Dist'n**	**count**	**Dist'n**
0–9	0	0%	4	0%	2	0%	0	0%
10–19	1	0%	0	0%	5	0%	1	0%
20–29	7	1%	12	0%	23	0%	3	0%
30–39	18	2%	60	0%	63	0%	10	0%
40–49	38	4%	262	1%	201	1%	27	0%
50–59	130	13%	1,081	4%	611	3%	136	2%
60–69	309	30%	3,174	10%	1,695	9%	467	8%
70–79	312	30%	8,337	27%	4,632	24%	1,553	27%
80–89	208	20%	12,387	41%	7,872	41%	2,463	43%
90+			5,015	17%	4,082	21%	1,034	18%
Total	1,023	100%	30,332	100%	19,186	100%	5,694	100%

Table 1: (Continued)

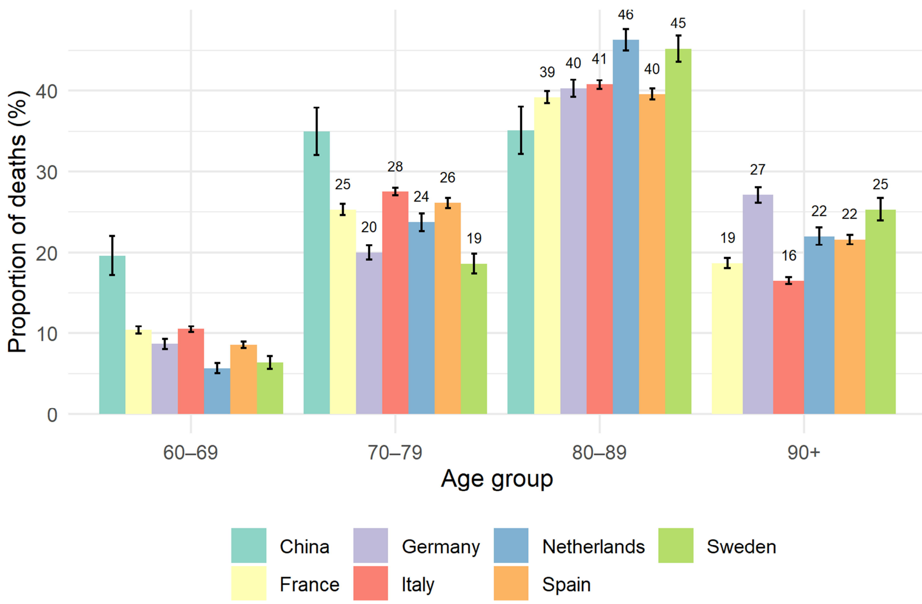
	France (5 May)		Germany (19 May)		Sweden (19 May)	
Age	**count**	**Dist'n**	**count**	**Dist'n**	**count**	**Dist'n**
0–9	2	0%	1	0%	1	0%
10–19	3	0%	1	0%	0	0%
20–29	17	0%	7	0%	8	0%
30–39	68	0%	21	0%	12	0%
40–49	203	1%	60	1%	38	1%
50–59	723	4%	273	3%	117	3%
60–69	1,890	12%	779	10%	272	7%
70–79	3,665	23%	1,789	22%	838	22%
80–89	6,097	38%	3,319	41%	1,529	41%
90+	3,414	21%	1,840	23%	928	25%
Total	16,083	100%	8,090	100%	3,743	100%

*Subsample with age information.

3.2 Age-adjusted death distribution for China, Italy, Spain, the Netherlands, France, Germany, and Sweden

The observed differences between the countries persist after adjustment for age structure of the populations (Figure 1). Notable disparities are observed at the oldest age group (90 and over), with 16.5% (95% CI: 16.1–16.9%) of Italian deaths occurring at those ages. In the other populations, we would expect at least 19% of deaths in those ages if they had the population age structure of Italy. For the age group 80–89, the Netherlands and Sweden accounted for the highest expected number of deaths (45–46%), whereas Spain, Italy, France, and Germany had a lower expected share of deaths at those ages, ranging between 39% and 41%. Finally, for age group 70–79, Italy had the highest expected number of deaths (apart from China), followed by France and Spain.

Figure 1: COVID-19 counterfactual share of mortality by age group adjusting by age structure of Italy. Numbers are shown for the countries and age groups discussed in this paper.



When the results are split by gender, a similar pattern emerges. See the Appendix for the proportion of deaths by male and female. As expected, females account for most of the deaths since women survive to higher ages than men.

4. Discussion

In this paper we showed that a higher share of deaths was observed in the 80–89 age group in Germany and Sweden, as compared to the other included countries: France, Italy, Spain, the Netherlands, and China. At the 90 and over age group, Italy has the lowest proportion of deaths and Sweden the highest. Although Italy has the second oldest population in the world and the oldest in Europe (Eurostat 2017), we observe proportionately fewer deaths there from COVID-19 at the oldest ages (80 and above) than in the other countries in this study, China excepted.

In 2019, the population aged 80 or more in Italy was 7.1%, 5.1% for Sweden, and 4.1% for the Netherlands (Eurostat, online). Therefore, the age structure is only partially predictive of COVID-19 deaths at older ages. General explanations for differences in COVID-19 mortality across countries include variations in the definition of COVID-19 related deaths (Onder, Rezza, and Brusaferro 2020), testing strategies (Onder, Rezza, and Brusaferro 2020), and transmission pathways (Dudel et al. 2020). In the rest of the paper we discuss potential additional explanations behind our results.

While most reported deaths take place in hospitals, significant numbers die at home and in nursing-care facilities. It may be the case that the age shape of deaths depends on how the total death counts are apportioned among these different locations within any given country. Mortality may be higher, for example, in overwhelmed hospitals or understaffed, ill-equipped nursing homes. We suspect that there may be some effects related to the predominant model of healthcare delivery within a country. For example, in the Netherlands there is a high number of nursing-care homes (Molinuevo, and Anderson 2017), whereas in Spain, and especially in Italy, much care is provided at home by children and grandchildren. It is well known that COVID-19 has spread rapidly across multiple nursing homes in the affected countries (Comas-Herrera et al. 2020), and therefore this could have partly explained our findings of an elevated share of mortality in the Netherlands or Sweden as compared to Spain or Italy.

Second, differences may be reflective of different levels of old age frailty between countries. That is, our result of a higher share of COVID-19 deaths in Sweden or Germany as compared to Italy and Spain seem to be in line with their higher all-cause mortality at ages 80 and more, according to available life table data (Human Mortality Database 2020).

Furthermore, the countries with the most robust individuals at a given age group would be less prone to succumb to COVID-19, as COVID-19 deaths are more likely to be associated with cardiovascular and respiratory diseases (Yang et al. 2020). Finally, pre-existing comorbidities (Valderas et al. 2009), which may be more prevalent in some populations relative to others, could be exacerbated by the presence of COVID-19. The reverse may also be the case: COVID-19 could be made more lethal by the presence of underlying medical conditions. This would result in more severe illness and, ultimately, higher deaths in one country versus another.

The age distribution of deaths gives clues to the differential impact of the epidemic across populations. Our results on the estimated age distributions depend critically on data quality and on the comparability of COVID-19 mortality across countries. COVID-19 is a new cause of death, so it is unsurprising that there has been variability around how it is recorded and interpreted. The definition of a death from COVID-19 has evolved over time, and countries have adopted different approaches to coding deaths from COVID-19, which affects comparability. At the time of writing, information from official sources was at times scarce and of variable quality. These issues also affect many causes of death more generally. We assume that the differences in aggregate do not excessively affect comparability.

With the pandemic still ongoing, it may be several months or years before its impact is fully understood. This study was conducted in the midst of the pandemic, where death counts were still increasing. We believe, however, that our findings are reasonably robust. Whilst not shown here, we obtain similar results over time (updating data at different time points) when different reference populations are used in standardization and when males and females are analysed separately (see Appendix).

In summary, the differences in the age patterns of COVID-19 deaths are dependent not only on the age structure of a given population but also on other country-specific factors. While demography plays an important role in shedding light on the age pattern of deaths, other issues are at play. A better grasp of these is crucial to gain a greater insight into the age pattern of COVID-19 deaths.

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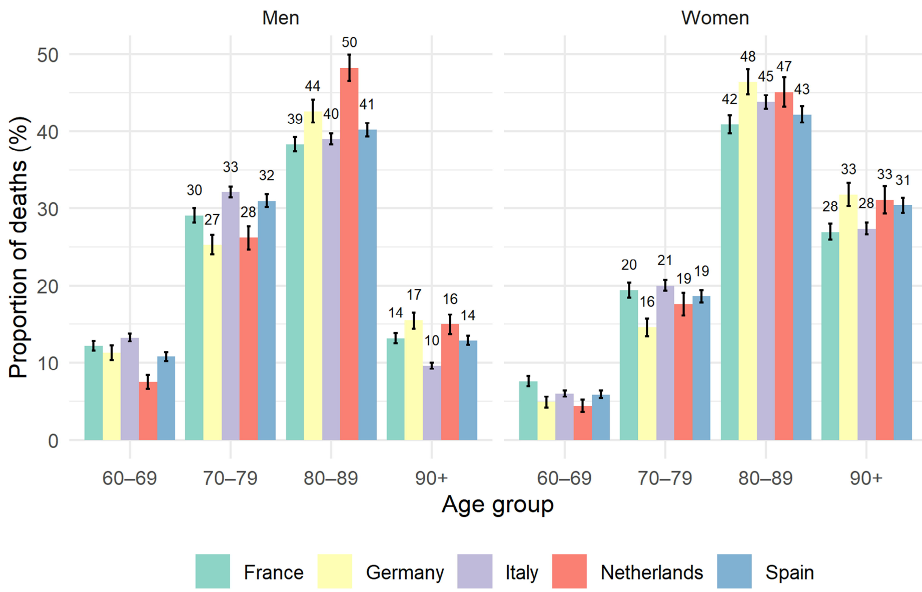
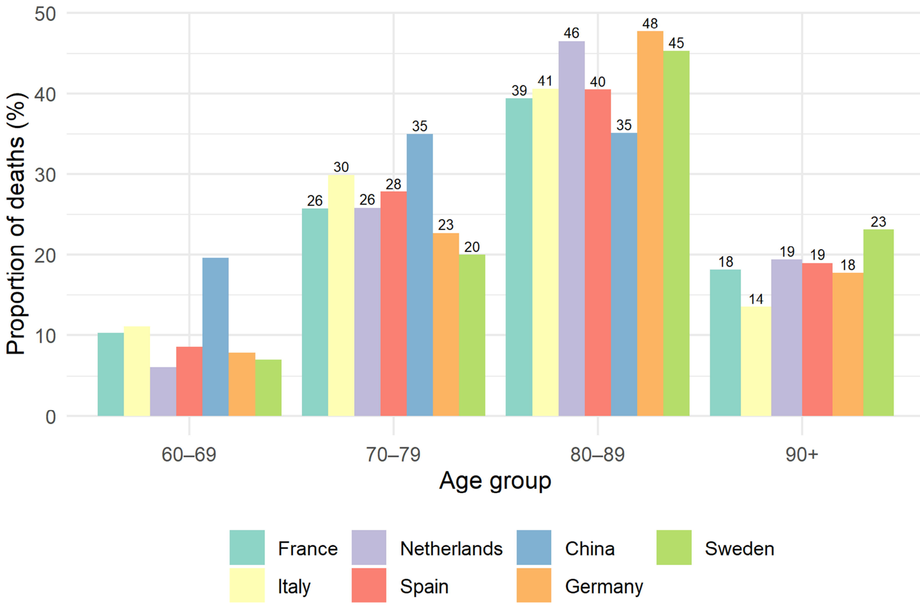
Appendix

Figure A-1: COVID-19 counterfactual share of mortality by age group and sex adjusting by age structure of Italy



Source: COVerAGE-DB (Riffe, Acosta et al. 2020. Available at https://doi.org/10.17605/OSF.IO/MPWJQ) and INED COVID-19 webpage (Available at https://dccovid.site.ined.fr/en/data/).

Figure A-2: COVID-19 counterfactual share of mortality by age group adjusting by age structure of Italy. Data from late April*



* from February 11, 2020 (China), April 7 (Germany), April 20 (Sweden), April 21 (the Netherlands), and April 22 (Spain, Italy, and France).