

The demographic and geographic impact of the COVID pandemic in Bulgaria and Eastern Europe in 2020

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Abstract

Background: The COVID-19 pandemic followed a unique trajectory in Eastern Europe compared to other heavily affected regions, with most countries there only experiencing a major surge of cases and deaths towards the end of 2020 after a relatively uneventful first half of the year. However, the consequences of that surge have not received as much attention as the situation in Western countries. Bulgaria, even though it has been one of the most heavily affected countries, has been one of those neglected cases.

Methods: We use mortality and mobility data from Eurostat, official governmental and other sources to examine the development and impact of the COVID-19 pandemic in Bulgaria and other European countries.

Results: We find a very high level of excess mortality in Eastern European countries measured by several metrics including excess mortality rate (EMR), P-scores and potential years of life lost. By the last metric Eastern Europe emerges as the hardest hit region by the pandemic in Europe in 2020. With a record EMR at $\sim 0.25\%$ and a strikingly large and mostly unique to it mortality rate in the working age demographics, Bulgaria emerges as one of the most affected countries in Eastern Europe. The high excess mortality in Bulgaria correlates with insufficient intensity of testing and with delayed imposition of “lockdown” measures. We also find major geographic and demographic disparities within the country, with considerably lower mortality observed in major cities relative to more remote areas (likely due to disparities in the availability of medical resources). Analysis of the course of the epidemic revealed that individual mobility measures were predictive of the eventual decline in cases and deaths. However, while mobility declined as a result of the imposition of a lockdown, it already trended downwards before such measures were introduced, which resulted in a reduction of deaths independent of the effect of restrictions.

Conclusions: Large excess mortality and high numbers of potential years of life lost are observed as a result of the COVID pandemic in Bulgaria, as well as in several other countries in Eastern Europe. Significant delays in the imposition of stringent mobility-reducing measures combined with a lack of medical resources likely caused a substantial loss of life, including in the working age population.

Introduction

The SARS-CoV-2 virus and COVID-19, the disease it causes¹⁻³, have emerged as the most acute public health emergency in a century. The novel coronavirus spread rapidly before significant efforts at containment were implemented in much of the world, resulting in devastating early outbreaks in the United States and Western Europe, starting in late February and early March of 2020.

Some combination of lockdown measures, imposed in

response to surging infections, voluntary changes in behavior, and the onset of the summer season is thought to have caused the major decline in COVID-19 cases in Europe in the summer of 2020. However, winter in the Southern hemisphere, during which large epidemics developed in South Africa and South America, together with the well-documented seasonality of common-cold coronaviruses⁴, strongly suggested that a major second wave was to be expected in Europe with the arrival of winter⁵, and when it eventually arrived expectation turned into reality.

During the early months of the pandemic, a dichotomy emerged between countries in Western and Eastern Europe (with the possible exception of Russia). Western Europe was heavily affected - by June 2020 official COVID mortality reached 600 to 800 deaths per million (DPM) in countries such as Spain, Italy, the UK, Belgium, France, and Sweden, with excess mortality rates even higher^{6–10}. In contrast, most Eastern European countries registered relatively few deaths, possibly because of much earlier implementation of social distancing measures relative to the development of the outbreak.

This dichotomy disappeared during the second wave at the end of 2020, with both countries in Western and Eastern Europe officially registering a large number of COVID-related fatalities, as well as in some cases considerably larger excess mortality. However, the development of the pandemic in Eastern Europe has so far generally received much less attention than that in the West even though multiple countries in the region were heavily affected by it. We show this using multiple excess mortality measures, which quantify the pandemic-related loss of life and allow for standardized comparisons between countries.

Among Eastern European countries, Bulgaria has emerged as perhaps the most heavily affected by the pandemic as suggested by excess mortality analysis⁶. Here we analyze the development and impact of the pandemic on Bulgaria, in the broader European context, across demographic groups within the country, and for its regional subdivisions, as well as the influence of human mobility changes and government-imposed quarantine measure on the course of the pandemic. We use these analyses to identify correlate factors likely responsible for particularly high unexplained excess mortality in certain settings.

Methodology

Data Sources

All-cause mortality data for European countries, as well as NUTS-3 (Nomenclature of Territorial Units for Statistics) regions in Bulgaria, was obtained from Eurostat^{11,12}. The data presented in the datasets is sex- and age-stratified, with age groups split in increments of 5 years. Since not all countries submit data at the same time and in the same manner, only countries that have consistent weekly data for the period 2015-2020 (inclusive) were analyzed.

Country-level population data at the beginning of 2020 was collected through Eurostat¹³, but was further supplemented by population data from the United Nations' UN-data Data Service¹⁴. We further elaborate on this topic in the subsequent section on Potential Years of Life Lost (PYLL) and Working Years of Life Lost (WYLL) estimates.

Life expectancy values at different ages were obtained from three separate sources. We acquire the full life tables for Bulgaria through the country's National Statistical Institute¹⁵, and for Czechia through the country's Statistical Office¹⁶. Abridged life tables for all European countries

were obtained from the World Health Organization's open data platform¹⁷. This dataset is partitioned by age, in increments of 5 years.

COVID-related mortality and testing data for Bulgaria was collected through the resources available from the Ministry of Health^{18,19}. COVID-related mortality for Czechia was acquired from Czech Ministry of Health official website tracking the pandemic²⁰.

Data Availability

All datasets and associated code can be found at <https://github.com/Mlad-en/COV-BG.git>.

Excess mortality and P-scores

To calculate excess mortality across countries as well as across Bulgarian regions, we analyze the mortality observed between week 10 and 53 of 2020 and compare it to the mean mortality between the same period for the previous five years (2015–2019). We derive this mean both on a weekly and aggregate total basis. We then establish a 95% confidence interval for this mean. This range is used to calculate excess mortality as:

$$\text{Excess Mortality} = \text{Mortality}_{2020} - \text{Mean Mortality}$$

This calculation is done both as a sex- and age-stratified metric, as well as an aggregated total. To normalize excess mortality across countries, we calculate excess mortality per 100,000 people. To do this, we use population data from Eurostat for 2020.

Based on the excess mortality ranges we also compute a P-score value for each country/region. A P-score value is defined as “the percentage difference between the number of deaths in 2020[...] and the average number of deaths in the same period-week or month over the years 2015–2019.”²¹

We calculate the P-score as follows:

$$P := \frac{\text{Mortality}_{2020} - \text{Mean Mortality}}{\text{Mean Mortality}} * 100$$

We also calculate the ratio between excess mortality and official COVID-19-attributed mortality. Due to the demonstrably low testing in Bulgaria²² and other countries, this allows us to estimate under-reported COVID-19 fatalities. We also use the total positive tests per region reported at the end of 2020 to compute a Case Fatality Ratio (CFR) between the total cases and the total COVID-19 fatalities.

Potential Years of Life Lost (PYLL), Aged-Standardized Years of life lost Rate (ASYR), and Working Years of Life Lost (WYLL) estimates

Potential Years of Life Lost (PYLL) is a metric that estimates the burden of disease on a given population by looking at premature mortality. It is derived as the difference

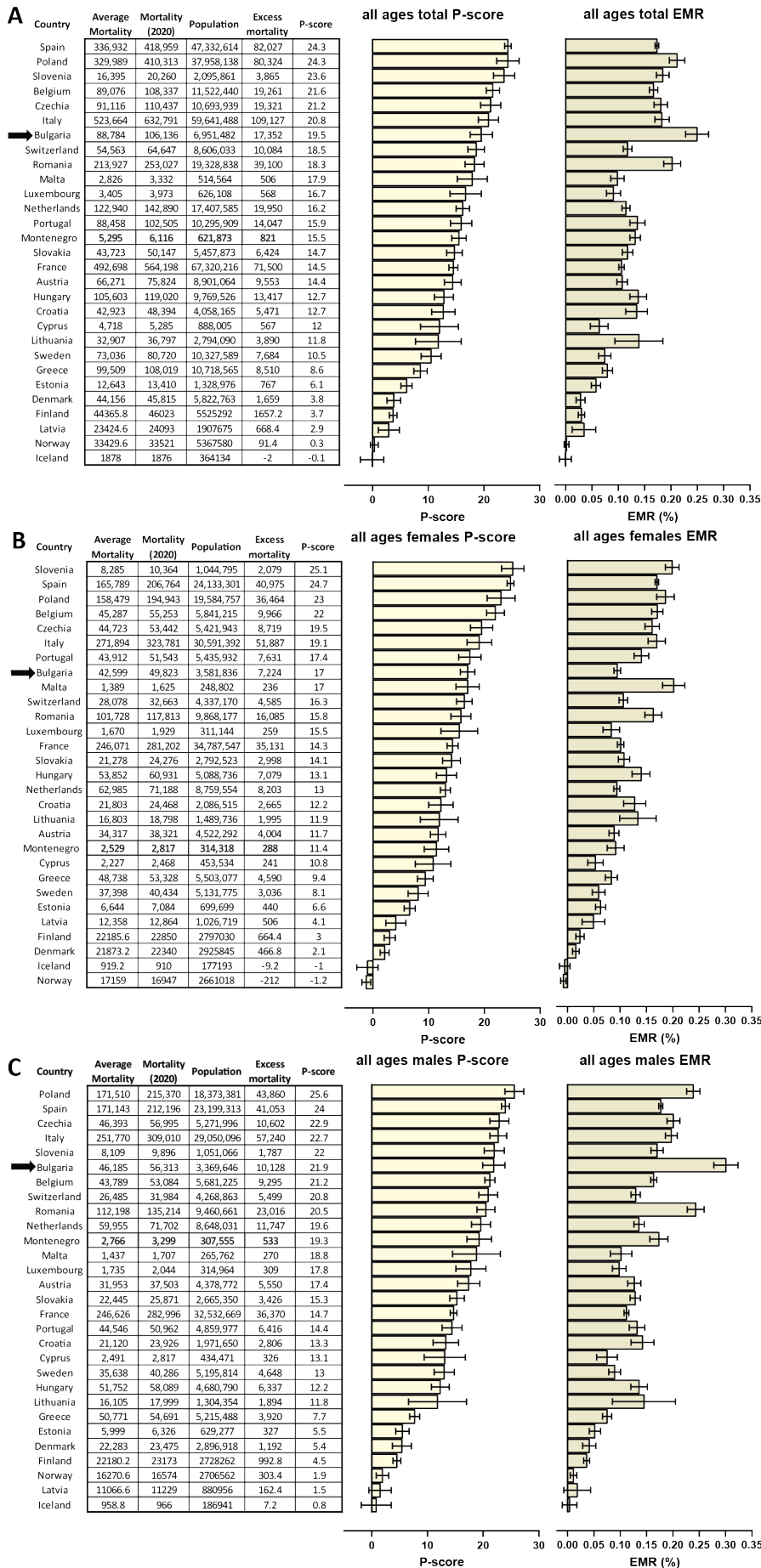


Figure 1: Excess mortality in Bulgaria and other EU countries in 2020. (A) Overall P-scores and excess mortality (in deaths per million; DPM) for all ages in Bulgaria (highlighted in red) and other EU countries; (B) P-scores and excess mortality for females of all ages; (C) P-scores and excess mortality for males of all ages.

	EMR	PFR	EMR/PFR
Austria	0.11	0.07	1.54
Belgium	0.17	0.17	0.99
Bulgaria	0.25	0.11	2.30
Croatia	0.13	0.10	1.40
Czech Republic	0.18	0.11	1.64
Denmark	0.03	0.02	1.28
Estonia	0.06	0.02	3.35
Finland	0.03	0.01	2.95
France	0.11	0.10	1.10
Greece	0.08	0.05	1.76
Hungary	0.14	0.10	1.41
Iceland	0.00	0.01	-0.06
Italy	0.18	0.12	1.47
Latvia	0.04	0.03	1.05
Lithuania	0.14	0.06	2.16
Luxembourg	0.09	0.08	1.14
Malta	0.10	0.04	2.31
Montenegro	0.13	0.11	1.20
Netherlands	0.11	0.07	1.75
Norway	0.00	0.01	0.22
Poland	0.21	0.08	2.81
Portugal	0.14	0.07	2.03
Romania	0.20	0.08	2.47
Slovakia	0.12	0.04	3.00
Slovenia	0.18	0.13	1.43
Spain	0.17	0.11	1.61
Sweden	0.07	0.10	0.78
Switzerland	0.12	0.09	1.32

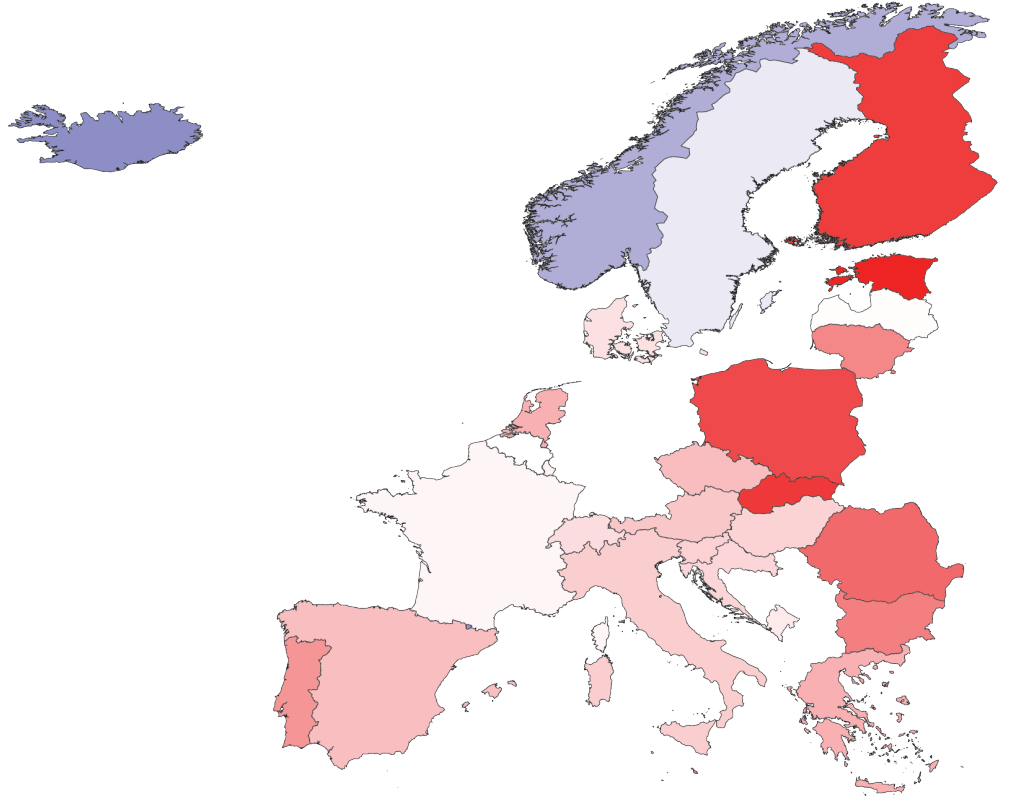


Figure 2: Ratio between excess mortality and official COVID-attributed deaths in European countries in 2020. Note that the high EMR/PFR ratios for 2020 in countries like Finland and Estonia might be an artifact of overall low both excess and COVID-attributed mortality.

between a person’s age at the time died and the expected years of life for people at that age in a given country. As such, the metric attributes more weight to people that have died at a younger age.

We compute the PYLL across countries by taking the positive all-cause excess mortality for all ages groups (in Eurostat they are aggregated at 5 year intervals). We use the abridged life expectancy tables by the WHO (also aggregated at 5 year intervals) and calculate a total and average PYLL value for all countries. To be more precise, for an age interval $[x, x + 4]$ and sex s define by $ED([x, x + 4], s)$ the excess deaths and by $LE([x, x + 4], s)$ the life expectancy. Then the potential years of life lost are computed as

$$PYLL([x, x + 4], s) = ED([x, x + 4], s) * LE([x, x + 4], s).$$

The total PYLL is computed by summing over all age intervals. In our computations we take into account the margin of error for each $ED([x, x + 4], s)$.

A limitation on this approach is the upper-boundary aggregation value for the two datasets. The all-cause mortality dataset’s upper boundary is 90+, while the WHO’s abridged life tables only go up to the 85+ age bracket. To account for this, we attribute the life expectancy of the 85+

age group to the 85-89 mortality group. We have further excluded the 90+ mortality group from our analysis. This is further elaborated on in the Limitations subsection, where we also provide a way of correcting for this exclusion.

Two countries for which we have the exact ages and sex for each reported COVID-19 fatality are Bulgaria and Czechia. We also have full life tables (increments of one year) for both countries provided by their respective statistical institutes. This allows us to compute and compare the PYLLs for each country based on excess mortality data and official data for COVID-19 fatalities.

Finally, we standardize PYLL values across countries by dividing the total sum value by the population and normalizing it per 100,000 people:

$$PYLL_{std} := \frac{PYLL_{total}}{Total\ Country\ Population_{0-89}} * 100,000$$

The data for country-level populations in Eurostat has a similar limitation in the upper boundary of the age distribution (a cut-off at 85+). To mitigate this limitation, we supplement the population data from Eurostat for ages 0-84 with population size data for the 85-89 age group from the UNdata Data Service.

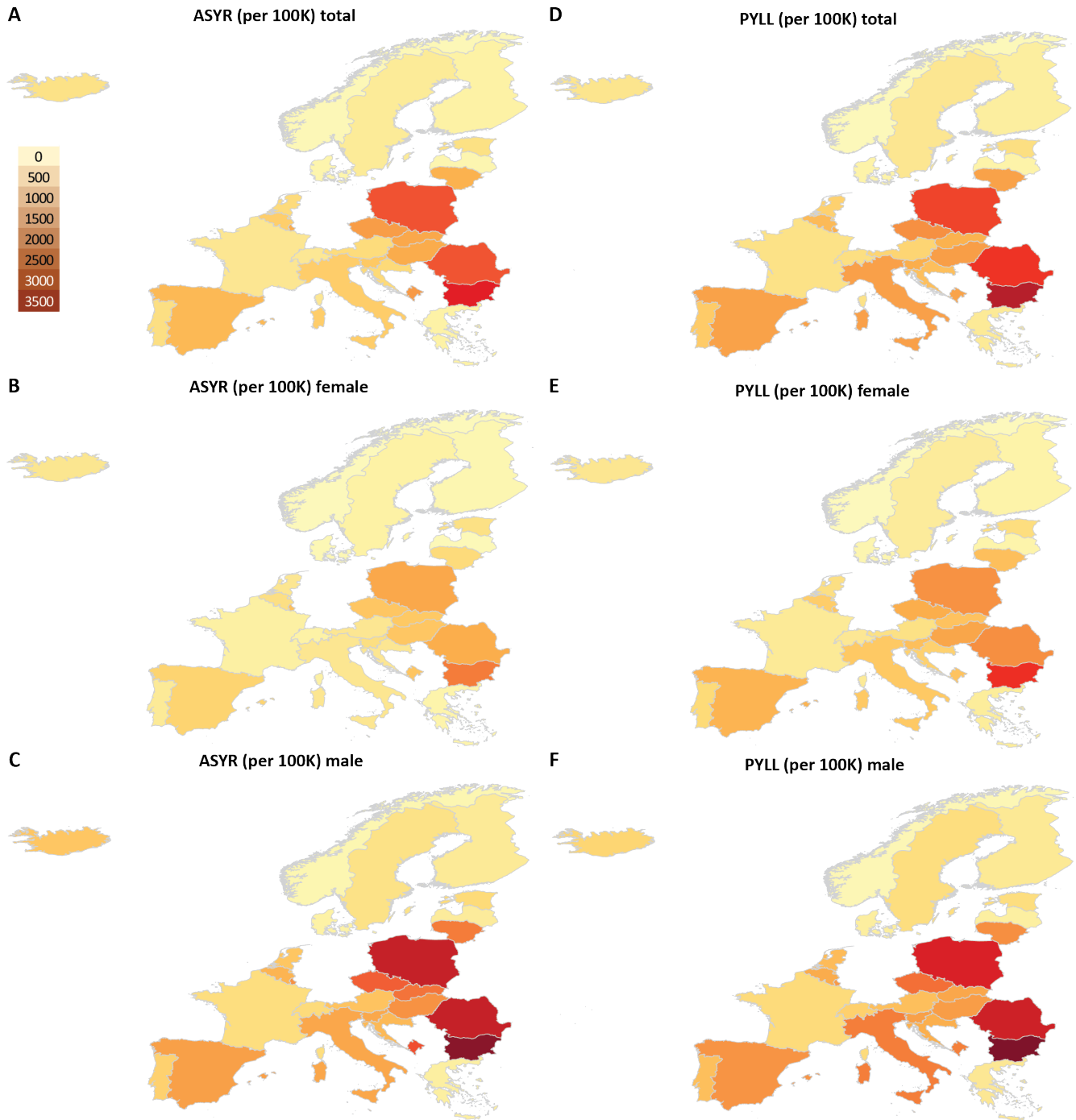


Figure 3: Geographic distribution of excess mortality-based ASYR and PYLL values for European countries in 2020. Shown are the total (per 100K people) values. (A) ASYR values for the whole population; (B) ASYR values for females; (C) ASYR values for males; (D) PYLL values for the whole population; (E) PYLL values for females; (F) PYLL values for males.

To compare the impact of the pandemic across European populations with different age structures we compute the Age-Standardized Years of Life Lost Rate (ASYR)^{23,24}. Let $([x, x + 4], s)$ be an age interval for a sex s in a standard life expectancy table for a given population. Denote by $P([x, x + 4], s)$ the population size of $([x, x + 4], s)$. Define

the PYLL rate for $([x, x + 4], s)$ as

$$\text{PYLL}_{\text{rate}}([x, x + 4], s) := \frac{\text{PYLL}([x, x + 4])}{P([x, x + 4], s)} * 100,000.$$

For the 2013 European Standard Population (ESP) de-

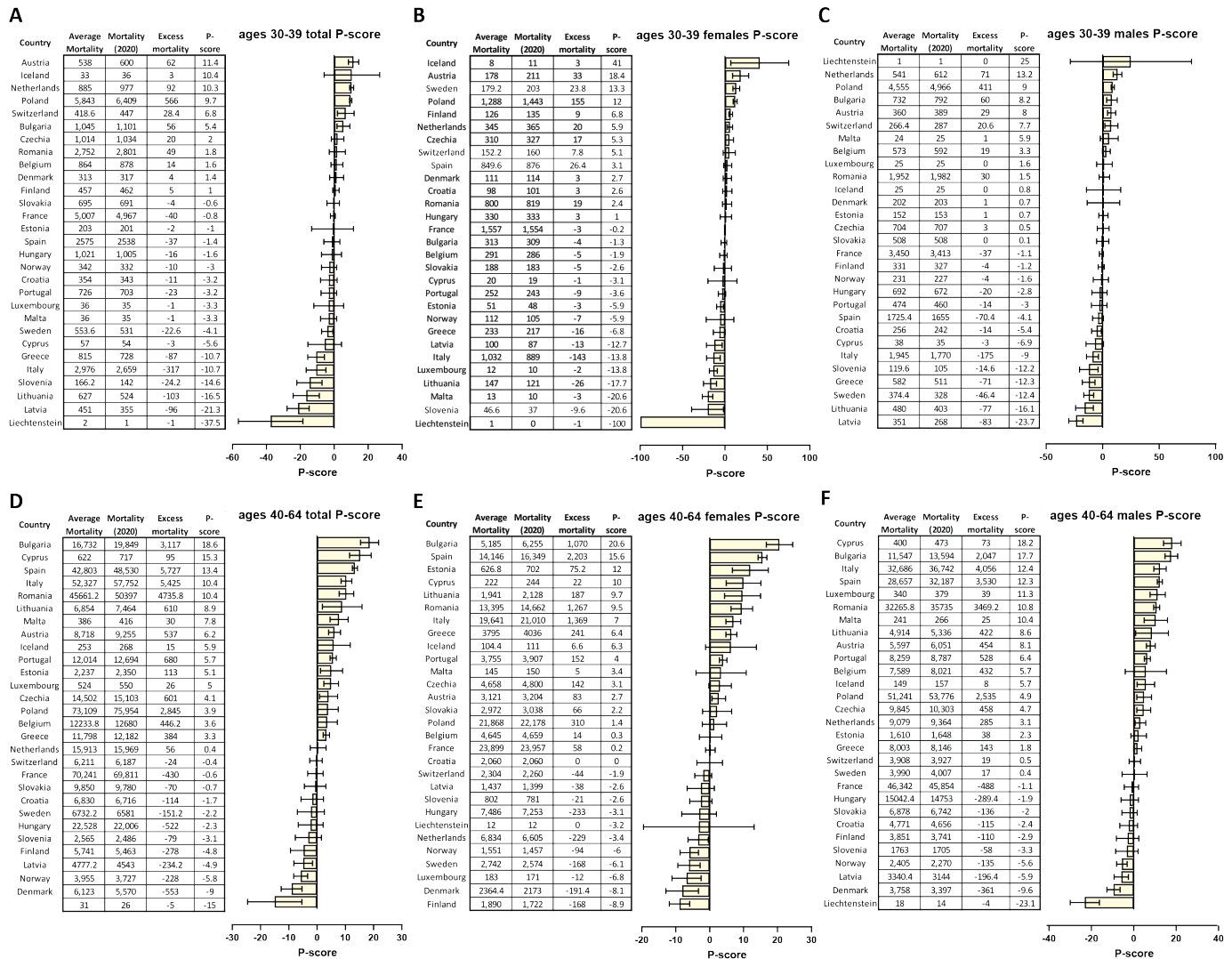


Figure 4: Excess mortality in working age populations in Bulgaria and other EU countries in 2020. (A) P-scores for the overall population in ages 30-39; (B) P-scores for females in ages 30-39; (C) P-scores for males in ages 30-39; (D) P-scores for the overall population in ages 40-64; (E) P-scores for females in ages 40-64; (F) P-scores for males in ages 40-64.

note by $W([x, x + 4], s)$ the weight of $([x, x + 4], s)$ in the standard population. Define

$$\text{ASYR}(s) := \sum \text{PYLL}_{\text{rate}}([x, x + 4], s) * W([x, x + 4], s)$$

where the sum is taken over all age intervals. For a given population of sex s this measure is interpreted as the years of life lost per 100,000 people (of sex s) if the population has the same age distribution as the ESP. ASYR allows for comparison of the pandemic impact on EU countries having different age distributions. Finally, we derive total, average and total standardized WYLL value approximations. To accomplish this, we first assume a common retirement age at 65 and thus exclude excess mortality for all age groups over 65. To calculate the remaining years of working life, we further assume a mean age for each age group, e.g. for the

age interval 60-64 we assume a mean age at 62.5 years. This would leave this group with approximately 2.5 years until retirement. Limitations on this approach are discussed in the subsequent Limitations subsection.

Stringency index and Mobility data

Metrics of population mobility were obtained from the Google COVID-19 Community Mobility Reports²⁵. These datasets contain data on how visits and length of stay at different places change compared to a baseline by generating anonymized metrics from data of Google users who have switched on “Location History” on their mobile devices.

To quantify governmental pandemic-response measures across countries, we used the Oxford COVID-19 Government Response Tracker²⁶, which systematically collects in-

formation on several different common policy responses that governments have taken to mitigate the effects of the pandemic²⁷. This allows a comparison of governmental measures between over 180 countries worldwide.

Limitations

Each of the presented data sources and approaches to analysis have their own limitations. Below we discuss each one in detail.

Limitation of scope

The current time frame that is analyzed creates a hard boundary between week 10 and week 53 of 2020. The exit conditions of different countries at these boundaries, however, are not equal. Some countries experienced subsequent surges in January 2021 and later months. Thus the current research provides a snapshot of the effects of the pandemic up to the end of 2020, not the totality of its effects.

Limitation of Data

All cause mortality figures for 2020 are still provisional for most EU countries, so they are subject to readjustment in future time. Even so, they can provide a good estimate of the effect of COVID-19 in different countries up to this point.

Limitation of Excess mortality and P-scores

Our mean mortality calculations do not account for population changes in the 2015-2019 period. For example, Bulgaria has one of the highest negative growth rates in the world. Between 2015 and 2020 Bulgaria's population has decreased by around 250,000 or approximately 6.5% per year²⁸. The country also has a negative net migration and has seen approximately 25,000 people leave its borders in the last five years²⁹

Since the P-score metric we compute is derived from the excess mortality figures we calculate for each individual country, this metric also suffers from the issues we outline for excess mortality.

Limitations of PYLL/ASYR/WYLL

Since PYLL, ASYR and WYLL data only take into account fatalities, these metrics do not provide information about any worsened quality of life of surviving individuals, reduced life expectancy of these individuals and working capacity. Metrics such as Disability-Adjusted Life Years (DALY), Quality-adjusted life year (QALY) and Healthy Years of Life (HALE) metrics may illuminate further the total disease burden on the European population, however, obtaining the necessary information for these measurements is not yet possible.

As mentioned before, due to data availability limitations from Eurostat in our computations of PYLLs and

ASYRs we excluded the 90+ group. Given that countries like France, Italy and Spain have significant excess mortality in this age group, we also present a computation of the ASYRs including the 90+ age by assuming 4 years of life expectancy (the average life expectancy for the 90+ age group for the European population is 4.74, according to the UN-data Data Service) in Supplementary Tables 4 and 5. This rough approximation gives an upper bound of how large the ASYRs can go. It leads to 5% – 14% and 14% – 22% increase in the ASYRs for the (0 – 89) population of Eastern and Western European countries, respectively, but it does not yield a decrease between the inequalities of the countries from the two groups or any significant change in their ranks (see Fig. 5 and Table 7 in the supplementary sections).

The WYLL measure we present has some additional limitations. The first comes from the assumption that retirement age across European countries is 65. While it is most often assumed as a standard between European countries, there is actually some variation between individual member states³⁰. Furthermore, we assume that the mean age of people who have died in a given age group is the middle of the given range, e.g. for the age group 60-64 - mean age = 62.5. It may well be a fact that a majority of the fatalities are concentrated in the upper part of the age bracket. However, since we do not have data about the different causes of mortality, but rather an aggregate total, we cannot be certain that this trend will hold true for all age groups and across different countries.

Google COVID-19 Community Mobility Reports

Bulgaria is below the EU average when it comes to use of mobile devices in the 16-74 age group. Still, a majority of the population within that group (~64%) utilized mobile devices to access the internet in 2019³¹. However, it is possible that there might be a skew towards the younger half of this age range of users who are supplying data.

Results

Mortality during the COVID pandemic in Bulgaria

We analyzed overall excess mortality patterns in Bulgaria for the year 2020 and compared it to data for other European Union (EU) countries for the same period. We focus on excess mortality rather than officially registered COVID deaths because limited testing and varying standards for official reporting of COVID deaths can result in large disparities between public figures for COVID-related mortality and the actual burden the disease has imposed on the population⁶. While some of the excess deaths are caused by the collapse of healthcare services during peak moments of COVID waves, when a particularly large discrepancy between official COVID deaths and excess deaths is observed, this is likely mostly due to underreporting of COVID deaths due to insufficient testing and other irregularities.

In total, we estimate that 17,352 lives have been lost in Bulgaria in 2020 in excess of the baseline from previous years (Figure 1A). This amounts to an EMR of 2,496 DPM, or $\sim 0.25\%$, for the year and ranks the country as the most highly affected within the EU (Figure 1A; Supplementary Table 1; according to P-scores Spain, Poland and Belgium rank higher). COVID mortality is in most countries higher in males than in females³², and this is also what is observed in Bulgaria and most other EU countries (Figure 1B-C; Supplementary Tables 2-3). For females, an EMR of 2,178 DPM is observed (P-score of 18.79), compared to an EMR of 3,198 DPM for males (P-score of 23.99) across all ages.

These observed EMR values are much higher than the officially reported COVID-attributed population fatality rate (PFR), by a factor of $\sim 2.3\times$. Examination of the EMR/PFR ratios in Europe showed that excess deaths are higher than official COVID death tolls in most countries (Figure 2). However, a clear dichotomy emerges between Eastern and Western Europe, with the EMR/PFR ratio being considerably higher in countries in Eastern Europe such as Bulgaria, Romania, Poland, Slovakia, Lithuania, and others.

These estimates and geographic patterns are in agreement with other recent analyses of excess mortality^{33,34}.

Loss of life as a result of the COVID pandemic

We next examined the impact of the pandemic in terms of years of life lost using the PYLL and ASYR metrics based on excess mortality (Figure 3). Both metrics paint a similar picture, which is also consistent with the raw excess mortality measures.

Using standardized ASYR and PYLL values (per 100,000 population; Supplementary Figures 2A-C and 1), we find that the highest total loss of life among the examined countries occurred in Bulgaria, for both males and females, followed by Romania, Poland, Hungary and Czechia. This higher loss of life burden in Eastern European countries is explained not only by their high EMRs but also by a large numbers of deaths in younger age groups. In Bulgaria and Romania, 28% and 29% of excess deaths, respectively, are of people under the age of 70. In Poland, 13% of the excess deaths are of people in the age interval 65–69 and 42% of the excess deaths are of people under 75. Moreover, 18% of all excess deaths in Bulgaria are of people under the age of 65, in particular in the 40-64 age group (Supplementary Figure 4). Calculation of WYLL values, which show the loss of working years of life, showed Bulgaria to have incurred the highest such loss within the set of examined countries (Figure 2D-E; note that the high total WYLL value for Iceland is possibly an artifact of the small population of the country). In contrast, in countries such as Italy, France and Spain, only 18% – 19% of excess deaths are under 75 years of age. In Italy and Spain, 34% – 35% of the excess deaths are of people older than 90. In France, 46% of excess deaths are of people older than 90. Remarkably, in Greece, one of

the least affected countries in the EU (having a low EMR and P-score), 55% of all excess deaths are of people above 90 and 20% are people under 80.

For Bulgaria, we find an average PYLL value of 13.46 ± 0.11 in total, 12.56 ± 0.03 for males, and 13.68 ± 0.24 per female (Figure 2). Excluding outliers (note that average PYLL values based on excess mortality are very high in countries such as Iceland, Luxembourg due to stochasticity associated with the very low number of excess deaths), these values are generally higher than what is seen in Western Europe. The only three countries with an average PYLL greater than 13 are Bulgaria, Poland, and Romania, compared to values as low as in the 10 to 11 years range for countries such as Denmark, Switzerland and Sweden (Supplementary Table 17). Despite males exhibiting higher mortality due to COVID-19, the average PYLL based on excess deaths in Bulgaria is higher for females (it is also higher for females in several other European countries; Supplementary Figure 3).

Using official COVID-attributed deaths, for Bulgaria we obtain an average of 12.37 years lost for males and 14.01 years lost for females. Based on the official COVID-19 mortality data for Czechia (the other country for which exact data about the age of the diseased is available) we obtain 9.78 and 9.35 for males and females, respectively. In both cases, the estimates we obtain for the average PYLLs from excess mortality and official COVID-19 deaths data are in agreement (note, however, that there are substantial differences between Bulgaria and Czechia in other aspects – for example, the average age of officially registered COVID-19 deaths for women is 71 years in Bulgaria compared to a life expectancy of 78.4 years, while in Czechia, the average age of the female COVID-19 deaths is 80.81, which is very close to the 82.1 life expectancy for women in that country).

These observations suggest that the impact of the pandemic in hard hit in late 2020 countries in Eastern Europe was not only large in absolute terms but also heavily affected younger demographics than in Western Europe.

Demographic-specific mortality patterns in Bulgaria

By the official statistics of the Ministry of Health^{18,19} the average age of a deceased male and female from COVID-19 are 69 and 71, respectively. The leading comorbidity is cardiovascular disease (55%), followed by diabetes (17%), pulmonary disease (12%), obesity (3%), and 30% are listed with no known comorbidity. An overwhelming majority of 94.5% of all 7576 COVID-19 deaths occurred in the hospitals with working age deaths comprising 28% of all COVID-19 deaths. For the working age group females on average died at age 55.9 and males at age 55.7 with 45% of the deceased having a cardiovascular disease.

Data on excess mortality for people under 65 reveals a slightly different picture. The working age group excess deaths are 18.3% of all excess deaths with an average age of the deceased 55.65 ± 0.07 for men and 57.57 ± 0.28 for

women. The reason for the higher average age for women is that our data does not reveal excess deaths in women under 40, whereas in the official statistics 5% of the casualties are in the age interval between 10 and 39.

Next, we examine mortality in Bulgaria within the working age population in detail. Due to the well-documented age-related skew of COVID fatalities, we focused on two subgroups of working age individuals – those in the 30-39 and those in the 40-64 age ranges.

We find no elevated mortality in females in the 30-39 age group, while mortality is elevated in males of the same age bracket, with P-scores of -0.39 and 9.37 , respectively (Figure 4A-C).

In contrast, we find highly elevated excess mortality in both males and females in the 40-64 age group, in which Bulgaria ranks highest in the EU (Figure 4D-F), with P-scores of 17.7 and 20.6 for males and females, respectively. The difference between males and females is remarkable, as, unlike the typical situation, elsewhere in the world in this group in Bulgaria excess mortality measured by P-scores is lower for males than for females. A similar reversal of the usual sex-specific mortality pattern is only also observed in Spain within the EU. We discuss the possible explanation for these observations in subsequent sections.

Regional disparities in COVID pandemic-related mortality in Bulgaria

Following from the observation of considerable disparities between different European regions, we then analyzed regional differences in pandemic impacts within Bulgaria (Figure 5). As a reminder, the overall statistics for Bulgaria are an EMR of 0.25% , P-score of 19.5% , CFR of 3.7% , an EMR/PFR ratio of 2.3 , and a percentage of population tested positive of 2.9% .

The first major such disparity we observe is that between the four most populated provinces and the rest of the country. The excess deaths in these four major regions – Sofia (city), Plovdiv, Varna and Burgas – account for just 34% of all excess deaths even though $\geq 50\%$ of the Bulgarian population lives there. Moverover, Sofia (city), Varna and Burgas have the lowest EMR of all provinces (Figure 5A) and P-scores of up to 20% (Figure 5B). The provinces of Sofia (city) and Burgas also show the two lowest CFR values (Figure 5F).

In contrast, the more peripheral regions are among the most heavily affected. For example, the regions of Vidin and Silistra exhibit some of the highest EMRs – 0.37 and 0.40 , respectively. Vidin also has the second highest CFR (8%). The relatively low P-score of 19% in Vidin is likely a result of already very high pre-pandemic mortality in the region (the region has one of the fastest aging populations in the EU and the death rate there is 22 per 1000 people per year, whereas the death rate for Bulgaria is 15 deaths per 1000 people per year). In Silistra, the EMR/PFR ratio is 3.00 , the second highest in the country and the P-score is 28% . In Kardzhali, the EMR/PFR ratio is 4.00 , the highest in

the country, and the P-score is 24% . With a P-score of 31% and EMR of 0.42 , Smolyan is the hardest hit region in the country. It also has a CFR of 8.9% , which is the highest among all provinces.

These regions also tend to show a lower percentage of the population that has tested positive, despite exhibiting the highest excess mortality (Figure 5E), often high CFRs (Figure 5F), and high EMR/PFR ratios (Figure 5G).

We also find curious disparities in regional patterns of male- and female-specific excess mortality (Figure 5C-D). The highest male excess mortality was observed in Pazardzhik, Gabrovo, Sofia (region) and Smolyan, while the highest female excess mortality is seen in Blagoevgrad, Silistra, Pazardzhik and Targovishte.

Remarkably, only 30% of all excess deaths in the working age group occurred in Sofia (city), Plovdiv, Varna and Burgas. For women in the working age group only 27% of the deaths occurred in those regions. A regional analysis reveals that the regions that with the highest P-scores in this demographic category are Blagoevgrad, Silistra, Pazardzhik, Targovishte, Dobrich, Kardzhali and Kyustendil ranging from 52% to 36% (Figure 5C). Women in the age group $65 - 69$, which includes working women in retirement age, were also heavily affected with an overall P-score of 23.7% and exceptionally high regional P-scores in the provinces of Sliven - 76% , Blagoevgrad - 49.5% , Pazardzhik - 46% , Smolyan - 42% and Kardzhali - 42% (Supplementary Figure 5). We discuss the possible explanations for these observations in the Discussion section.

The trajectory of the pandemic in Bulgaria and the effectiveness of implemented pandemic control measures

Finally, we mapped the trajectory of the pandemic in Bulgaria onto the timeline of imposition of social distancing measures and independent measures of actual changes in societal mobility to understand the relationship between those factors and its development (Figure 6).

The first period of the COVID-19 pandemic in Bulgaria, from March to the end of September, was marked by a slight elevation of the new confirmed cases in the summer, peaking at 242 cases per day towards the end of July. The excess mortality for this period is around 300 people and the official COVID-19 death toll amounts to 820 people, with a daily death rate of up to 10 deaths until the middle of October.

Rapid growth in the number of new confirmed cases started around the end of September, then an explosion of cases occurred in late October, November and the first half of December (Figure 6B). The peak in the 7-day moving average of the number of confirmed cases occurred on November 19th.

Official COVID-19 deaths peaked on December 6th with a 7-day moving average of 140 , or ~ 18 DPM/day; excess deaths started decreasing around the same time (Figure 6C). Excess deaths began diverging from official statistics

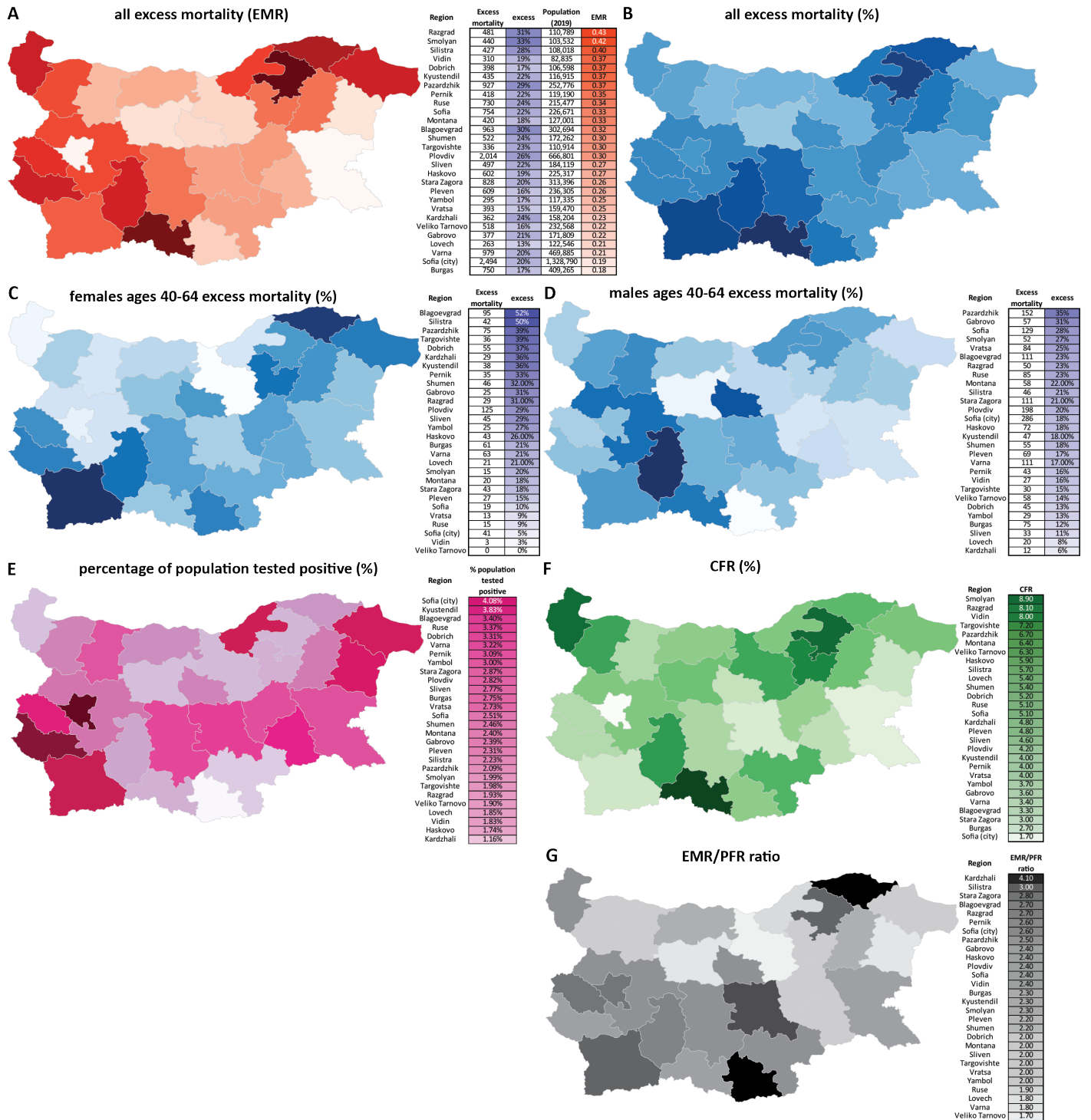


Figure 5: Regional disparities in the impacts of the COVID-19 pandemic in Bulgaria. (A) Overall excess mortality in Bulgarian regions (EMR units); (B) Overall excess mortality in Bulgarian regions (P-score); (C) Excess mortality in working age (40-64) females in Bulgarian regions (P-score); (D) Excess mortality in working age (40-64) males in Bulgarian regions (P-score); (E) Percentage of the population who have tested positive for SARS-CoV-2 in Bulgarian regions; (F) CFR values for Bulgarian regions; (G) Ratio between excess deaths (EMR) and official COVID-19-attributed deaths (PFR).

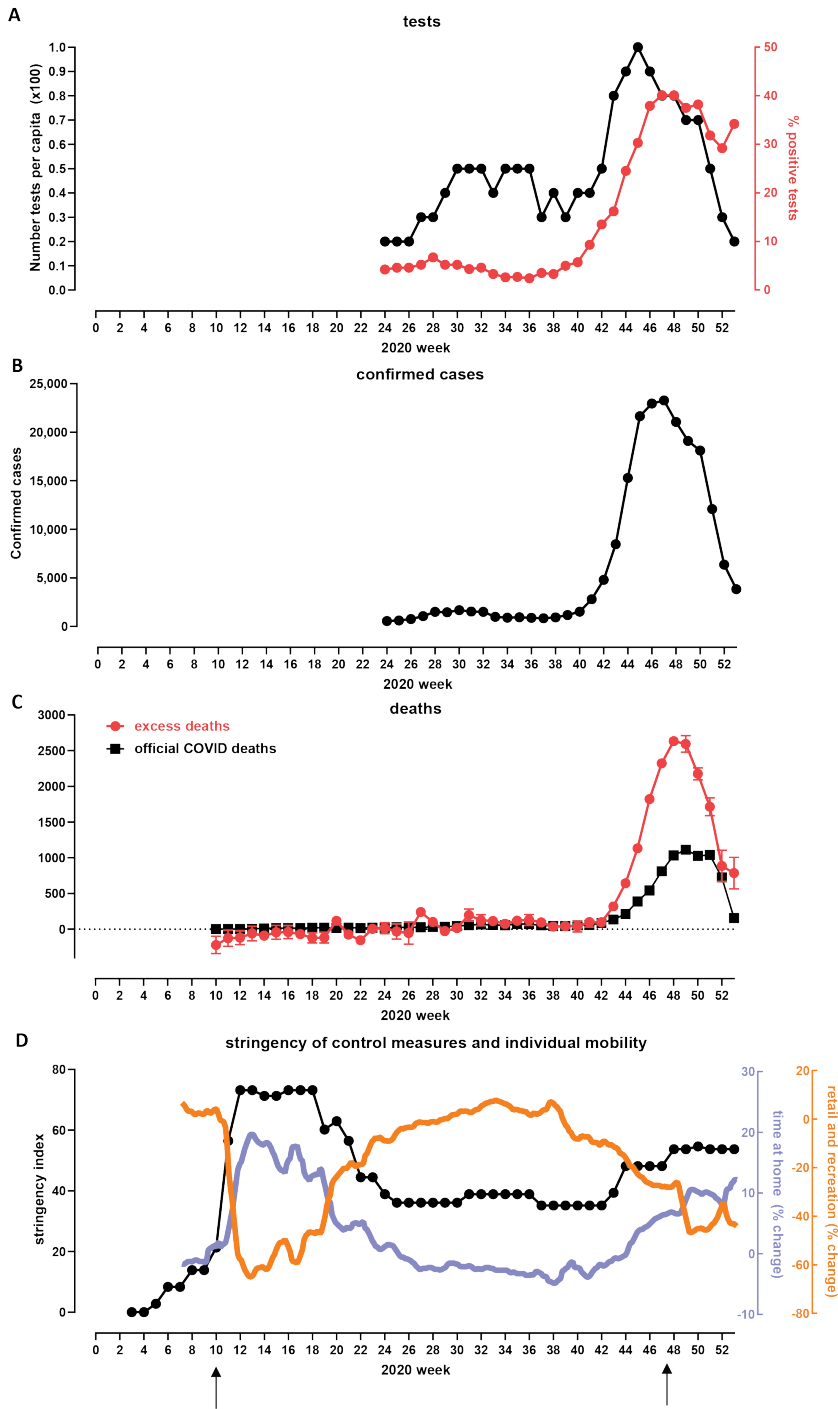


Figure 6: Development of the COVID pandemic in Bulgaria over 2020 and the effectiveness of measures implemented in order to control it. (A) Number of tests conducted and test positivity percentage over the second half of 2020^a. (B) Officially registered COVID cases. Note that rapid antigen tests were only included in statistics starting from December 22nd 2020. (C) Officially registered weekly COVID deaths and overall weekly excess mortality over the course of 2020. (D) Social mobility changes and the timing of imposition of restrictions. Arrows indicate the time of imposition of “lockdown” measures. “Time Home” refers to the change of the number of visitors to residential areas relative to the period before the pandemic. “Time Retail and Recreation” refers to the change of the number of visitors to places of retail and recreation relative to the period before the pandemic. This includes restaurants, cafes, shopping centers, theme parks, museums, movie theatres, libraries.

^aOfficial daily testing data was only made available from 06 Jun 2020 – Open Data Portal (<https://data.egov.bg/data/resourceView/e59f95dd-afde-43af-83c8-ea2916badd19>)

with the start of the Fall surge, in the middle of October, and peaked at ~ 54 DPM/day in the week ending on November 27th. This corresponds to a 112.3% increase in relative age-standardised mortality rates (rASMRs) according to the ONS³⁵; a higher number in Europe in 2020 was observed only in Spain for the week ending on April 3rd at 142.9%.

One of the obvious candidate explanations for the discrepancy between official and excess deaths is insufficient testing³⁶ Indeed, that appears to be the case for Bulgaria.

Test positivity rates peaked $\sim 40\%$ in late November. However, a curious pattern is observed in the number of tests recorded in official statistics, which actually began decreasing while the positivity was still increasing in the month of November (Figure 6A). An explanation for this pattern is that the results of rapid antigen tests were not included in official statistics until late December, and a considerable portion of testing shifted from PCR to antigen tests as the Fall wave developed. This likely accounts for at least some of the discrepancy between recorded and excess deaths.

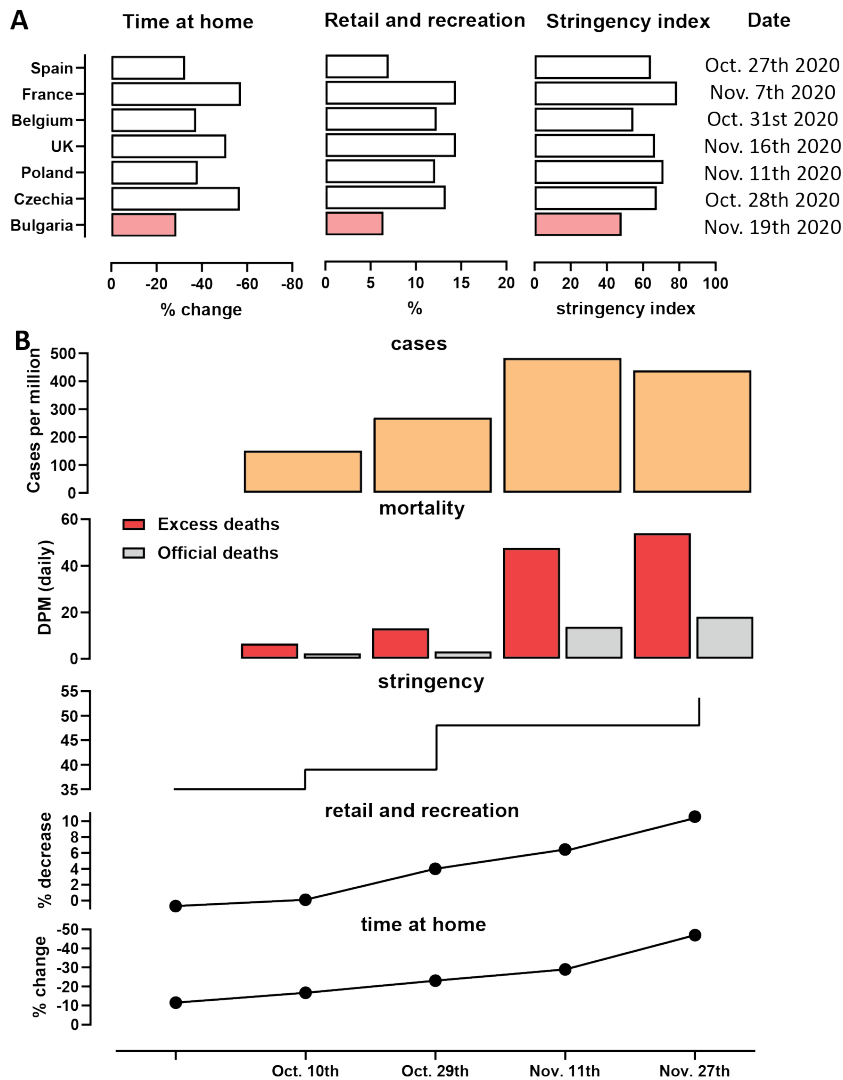


Figure 7: Mobility metrics, stringency of restrictions and mortality and cases at the peak of the late-2020 wave in Bulgaria (A) Google Mobility Data and Stringency Index at the peak of the fall wave in Bulgaria and other EU countries. “Time Home” refers to the change of the number of visitors to residential areas relative to the period before the pandemic. “Time Retail and Recreation” refers to the change of the number of visitors to places of retail and recreation relative to the period before the pandemic. This includes restaurants, cafes, shopping centers, theme parks, museums, movie theatres, libraries. (B) Timeline of imposition of social distancing measures and of reductions in mobility in Bulgaria around the peak of the late-2020 wave. The peak occurred around November 11th 2020, as demonstrated by mortality data, which at any given moment reflects the dynamic of new cases in Bulgaria approximately 2.5 weeks prior to that moment.

We then examined the factors responsible for the Fall surge eventually receding using the stringency index and mobility metrics (see Methods), changes in which have been shown before to be predictive of the trajectory of COVID epidemics^{37–40}.

The stringency index was at 35.19 from mid September until October 29th (Figures 6D and 7B), when the Bulgarian government imposed some new restrictions (high schools and universities moved to remote learning; nightclubs, pubs and bars were closed), which is reflected by an increase in the stringency index to 48.15. No further substantial epidemiological measures were introduced until after the peak of the fall wave – on November 27th, restaurants, bars, malls, schools and gyms were closed. However, the stringency index, though now increased to 53.7%, remained considerably below the levels of restrictions imposed in other European countries (Figure 7A), as no stay-at-home orders or curfews were imposed, non-essential stores and hair-dressing salons remained open, and gatherings of up to 15 people were permitted.

As the peak of restrictions occurred around the time of the peak of excess mortality and thus after the peak of infections, it is likely that restrictions were not the main cause for the eventual decline in cases. Indeed, changes in people’s behavior as reflected in social mobility measures were observed much earlier than the imposition of restrictions, likely due to fear of becoming infected spreading among the population, a pattern previously noted elsewhere in the world⁴¹. The 7-day running average Google mobility data measured on November 19th shows a total decrease of –29% percent of time spent in retail and recreation and a 6.43% increase in time spent at home compared to the baseline (Figures 6D and 7B). However, as with the stringency index, these values are still the lowest among analyzed European countries (Figure 7B), which is likely a contributing factor to the very high excess mortality resulting from the pandemic.

Finally, we examine hospitalization trends in Bulgaria and several other European countries. We find that at their peak on December 12th, hospitalizations in Bulgaria

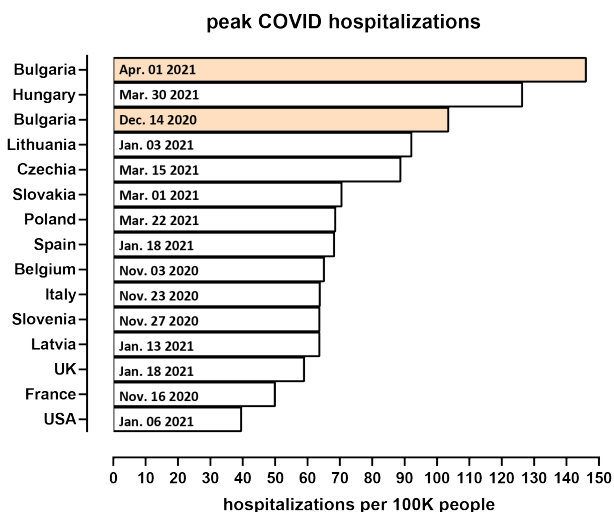


Figure 8: Peak hospitalizations in Bulgaria and other countries.

reached a level of 0.1% of the population, which is one of the highest hospitalization rates up to date (it has since been exceeded by Hungary and by Bulgaria itself during the subsequent March surge; Figure 8).

Discussion

In this survey, we analyze the impact of the COVID-19 pandemic in 2020 in Bulgaria and the broader Eastern European context. After a relatively low level of COVID-19 cases and deaths prior to that, in the concentrated span of less than three months in October, November, and December 2020, Bulgaria recorded the largest (per capita) number of excess deaths among the examined countries. Similar, though somewhat lower, large excess mortality increases were observed in most other countries in Eastern Europe. However, official COVID-19-attributed deaths account for only less than half of the excess deaths.

This discrepancy is likely caused by a combination of multiple factors – COVID-19 cases leading to death that were not reported as such in official statistics, COVID-19 cases resulting in death some time after recovery due to longer-term complications from the disease, and deaths from other causes that increased as a result to the inability of the healthcare system to treat them due to it being overwhelmed by COVID-19 patients. As the disparity between excess deaths and official COVID-19 mortality is very large in the case of Bulgaria – excess deaths amount to $\sim 0.25\%$ of the population while official COVID-19 are at $\sim 0.11\%$, i.e. a $\sim 0.14\%$ difference – and excess mortality is highly temporally concentrated in a short time span of about ten weeks (i.e. the contribution of the latter two factors is unlikely to have been so large in such a brief period), it is most likely that the bulk of excess deaths were caused directly by COVID-19.

Why they were not recorded as such is also probably

due to a multitude of factors. Testing in Bulgaria has been greatly insufficient throughout the pandemic and even more so during the late-2020 surge; in addition to that, the decision to not include rapid antigen tests in public statistics certainly has contributed to the underreporting. Most reported deaths occurred in hospitals, and many of those who could not be hospitalized due to healthcare systems being overwhelmed and died at home were not recorded as having died of COVID. Whether additional social and socio-economic factors could have contributed, as has been suggested to be the case elsewhere in the world⁴², is a subject for future investigations, as is the question of whether the reasons for underreporting are uniform across the more general Eastern European region. Lack of testing on its own in turn has probably contributed to the epidemic growing out of control and leading to such a number of excess deaths.

Another contributing factor to the high mortality rate in Eastern Europe is probably the very high prevalence of cardiovascular diseases in the region⁴³. In Bulgaria over half of the COVID-19 officially reported fatalities are listed with cardiovascular disease as a comorbidity.

Bulgaria also exhibits the most highly elevated working-age excess mortality, and it is also an outlier in terms of working-age excess mortality among females. We also observe significant regional disparities within the different regions in the country in total and in working age sex-specific excess mortality. A possible explanation for the latter is the development of outbreaks at workplaces where mostly women work – for example, garment, textile and shoe factories, which in Bulgaria almost exclusively employ women and which are major sectors of the economy in provinces such as Blagoevgrad, Kardzhali, Smolyan, Sliven, and Kyustendil⁴⁴. Indeed, there were numerous reports about outbreaks in such settings. Analogous causality might be behind regional disparities in working age male-specific excess mortality (Figure 5D). A list of reports about

outbreaks in these regions can be found in our GitHub repository, which includes reports about outbreaks in battery, automotive parts, power transmission, sanitary ceramics, and other factories.

Of note, Spain is another European country with a notable substantial number of working-age female excess deaths. The likely cause in that case is the overrepresentation of middle-aged women among home care workers, who were identified as essential workers early on in the pandemic and were thus affected by it to a greater extent⁴⁵.

Regional disparities in overall excess mortality, in particular the clear dichotomy emerging between the major population centers, in which generally better outcomes are observed, and the more heavily affected peripheral regions, also warrant further investigation. COVID-19 is still often considered a disease that impacts highly populated big cities the most, where disease spread is thought to be facilitated by density; this is due to many of the most notable initial outbreaks affecting well-connected in terms of international travel large metropolitan areas. However, as the pandemic has spread throughout the countries that have not controlled it, it may be the case that previously established regional disparities in healthcare infrastructure are becoming a key factor determining differential outcomes between generally better resourced major cities on one hand, and the less equipped to test, track and treat COVID-19 patients countryside areas. There is evidence that such causation is at play in Bulgaria – many of the heavily affected regions have fewer ICU beds, fewer doctors, and fewer specialists in the most relevant to the treatment of COVID-19 specialties than the capital and a few other major cities (Supplementary Figure 6). For example, Vidin and Silistra have fewer than average hospital beds, Kardzhali has the lowest number of doctors, general practitioners and pulmonologists and the second to last number of ICU beds per capita in the country, and Smolyan has the lowest number of ICU beds (just 9 in total for the whole region) and a generally low number of doctors.

In addition, in some of these regions (e.g. Smolyan, the most heavily impacted in the country) there are purely geographic factors that may have complicated the timely treatment of patients due to the logistic challenges of transporting patients to the regional center (which is where the only ICU units are located) from remote small towns through mountainous terrain while the core city’s health infrastructure is itself under immense stress (as shown in Figure 8, Bulgaria recorded record hospitalization levels during the peaks of the pandemic). Whether similar regional patterns of pandemic-related excess mortality are observed in other areas of Europe will be informative and instructive for minimizing the impact of subsequent COVID-19 waves.

It should also be noted that healthcare disparities possibly play a role on a broader-level^{46–48}, as Eastern Europe’s healthcare systems as a whole are well-documented to be suffering from an outflow of skilled medical labor due to large numbers of doctors and nurses emigrating to Western

Europe in recent years⁴⁹.

However, the main factor behind the very high levels of excess mortality is still most likely the late imposition of restrictions on social mobility and lax governmental efforts at controlling the spread of SARS-CoV-2, as our analysis shows. In Bulgaria these were adopted long after exponential growth in cases had commenced and was clearly going to overwhelm hospital resources, little testing was carried out and insufficient efforts were made to ensure the isolation of infected individuals, and even when restrictions were imposed, they were generally the most lax in Europe; furthermore, the late-2020 epidemic appears to have begun to trend downward due to changes in individual behavior, the onset of which actually preceded the imposition of restrictions by the government. The high levels of excess mortality are probably a natural consequence of following these policies.

Notes

Competing Interests

The authors declare no competing interests.

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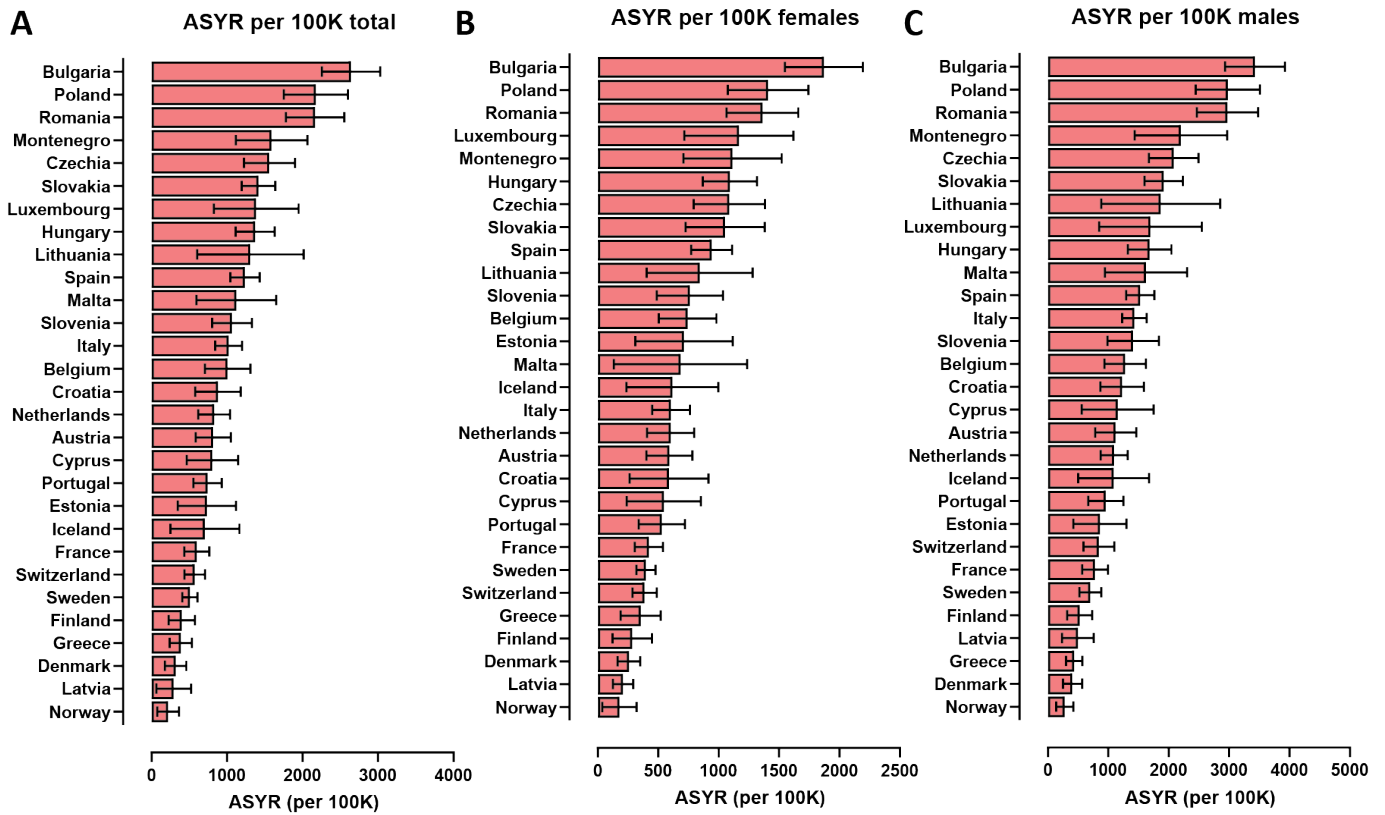
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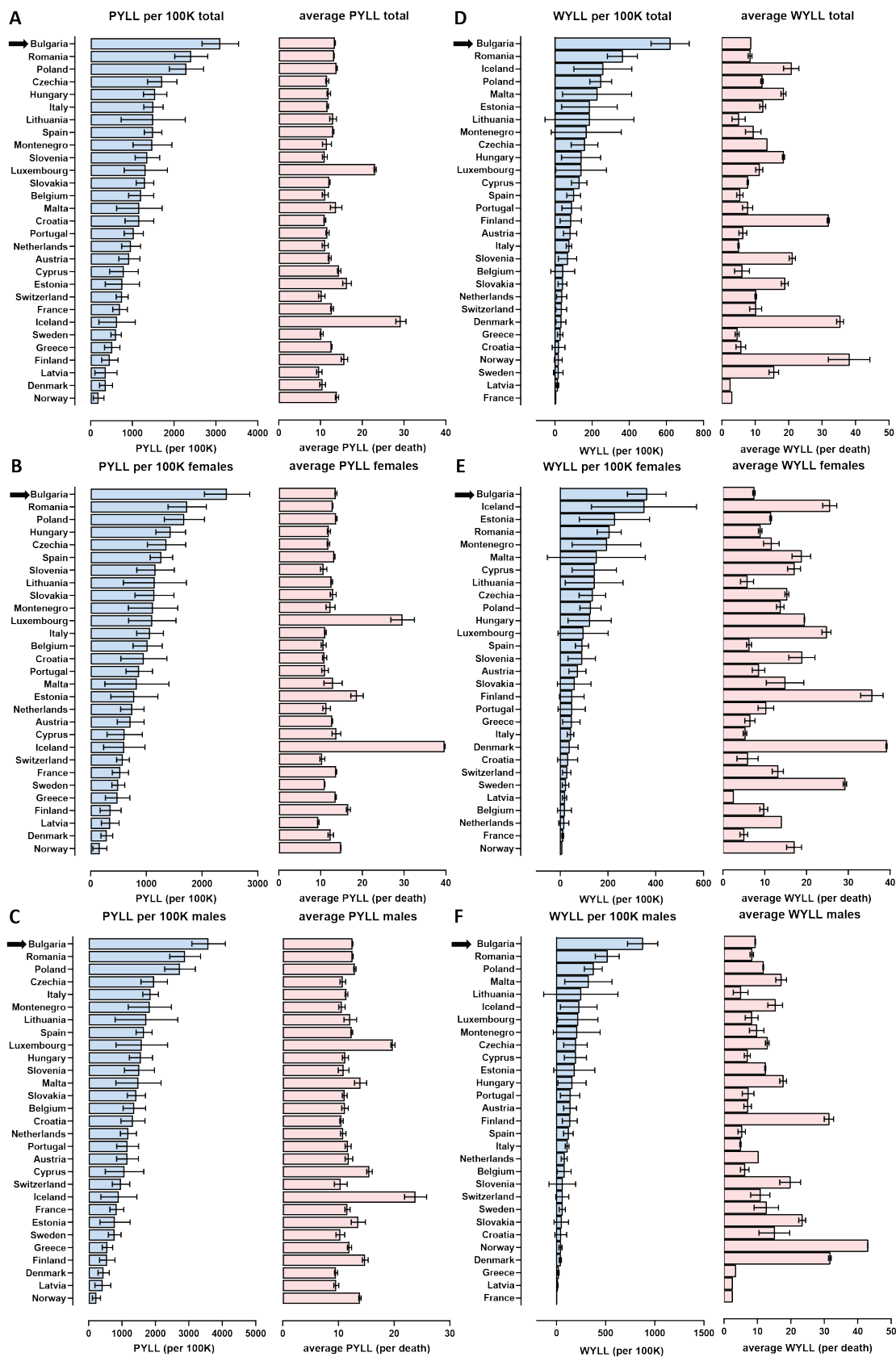
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Supplementary Materials

Supplementary Figures

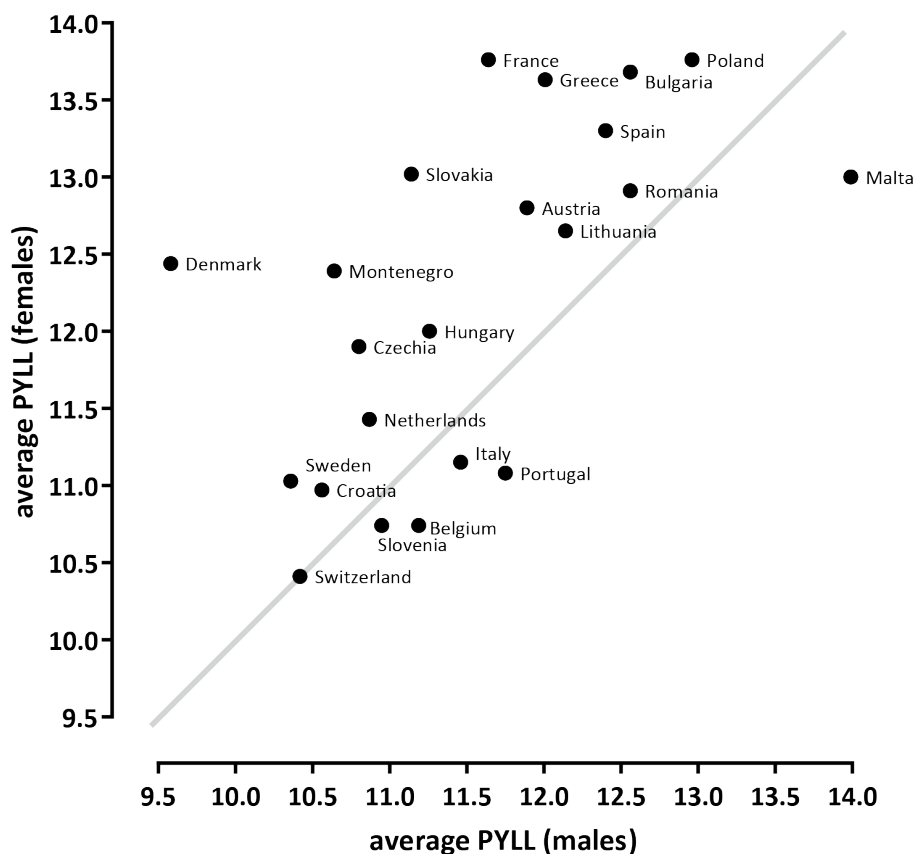


Supplementary Figure 1: Excess mortality-based ASYR values for European countries in 2020. Shown are the total (per 100K people) values. (A) ASYR values for the whole population; (B) ASYR values for females; (C) ASYR values for males.

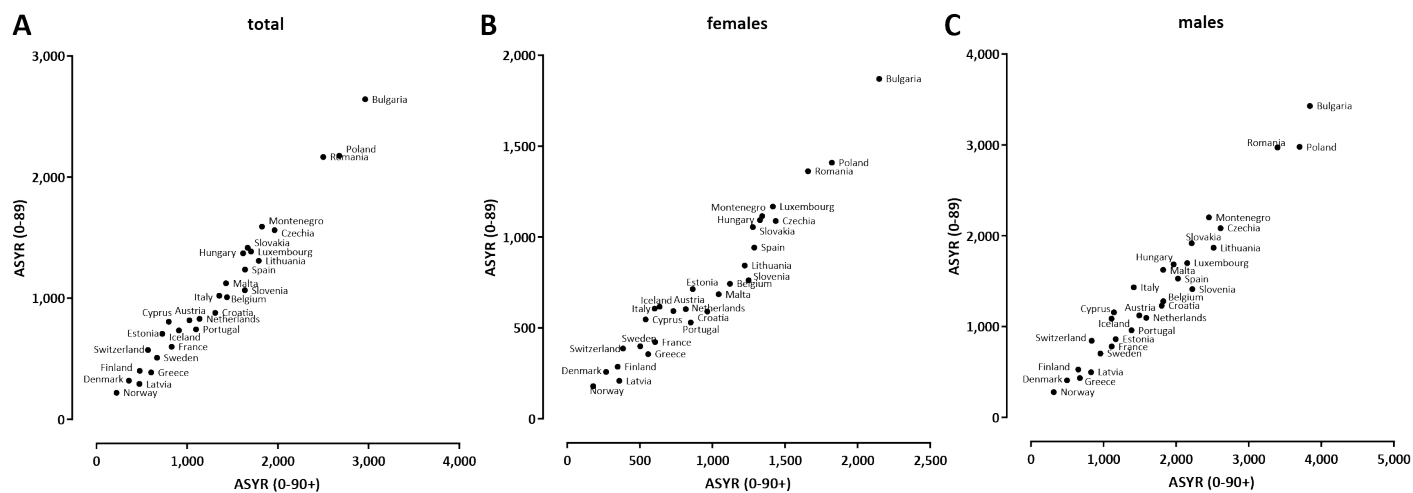


Supplementary Figure 2: Excess mortality-based PYLLs and WYLL values for EU countries in 2020. Shown are the total (per 100K people) and average (per death) values. (A) PYLL values for the whole population; (B) PYLL values for females; (C) PYLL values for males; (D) WYLL values for the whole population; (E) WYLL values for females; (F) WYLL values for males.

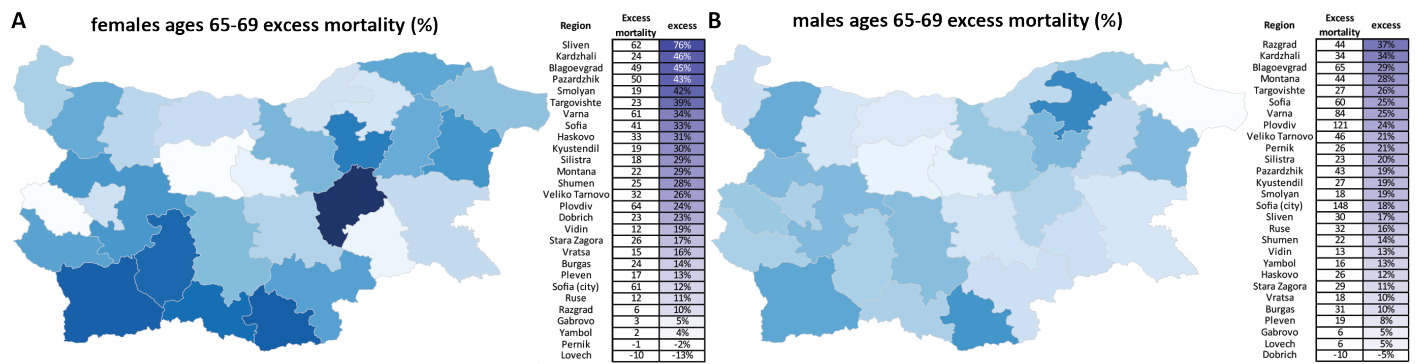
average PYLL males vs. females



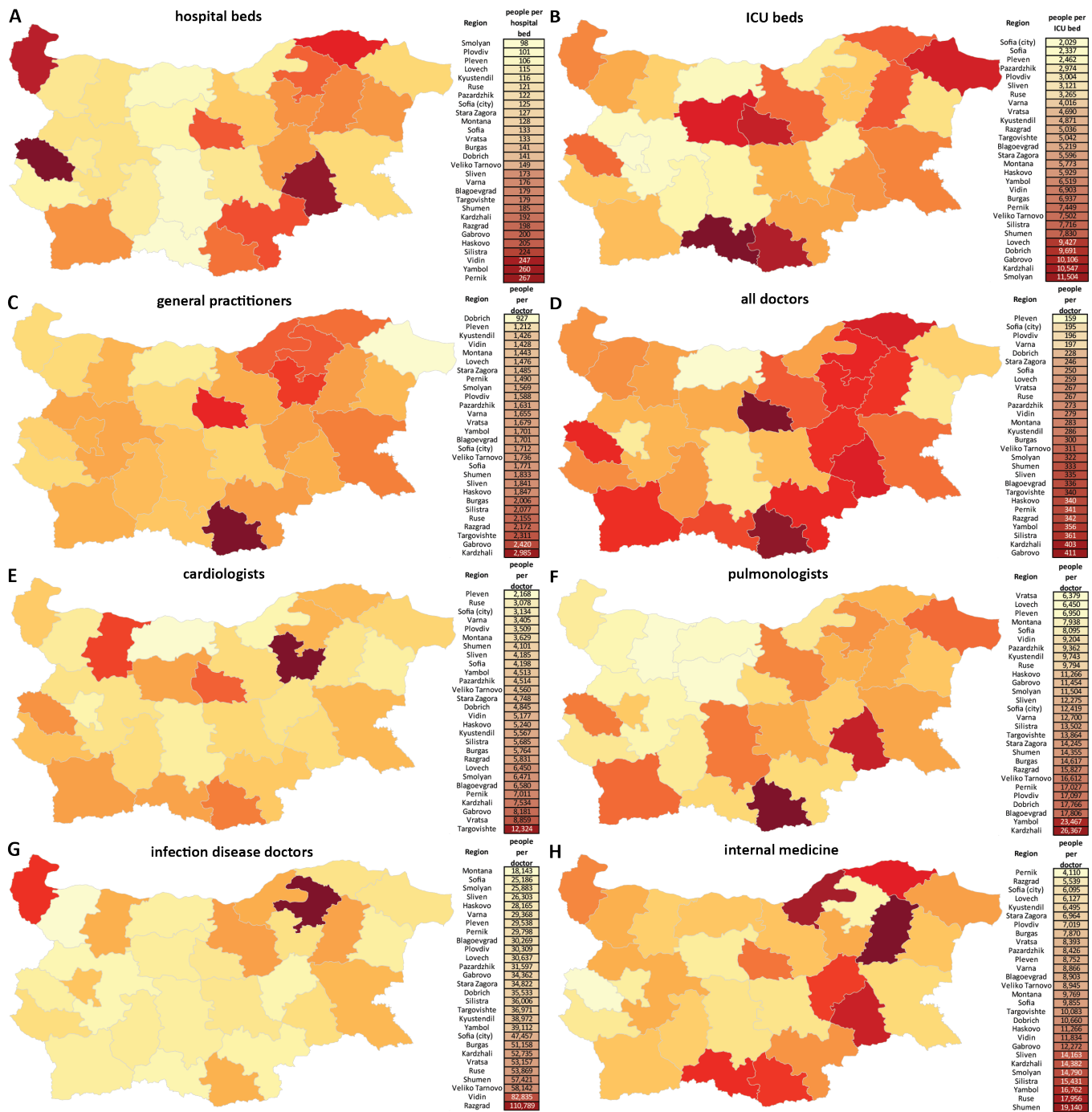
Supplementary Figure 3: Comparison between male- and female-specific average PYLL values in European countries. Shown are the average PYLL values per excess death.



Supplementary Figure 4: ASYR values computed over the 0-89 age range and ASYR values computed over the whole population (with 90+ year-olds included) are consistent. (A) ASYR total; (B) ASYR females; (C) ASYR males.



Supplementary Figure 5: Excess mortality in the 65-69 age range in Bulgarian regions. (A) females, P-scores; (B) males, P-scores.



Supplementary Figure 6: Availability of medical resources in Bulgarian regions. (A) Overall hospital beds (in units of people per bed); (B) ICU beds; (C) Total doctors; (D) General practitioners; (E) Cardiologists; (F) Pulmonologists; (G) Infection disease specialists; (H) Internal medicine specialists. Data from the Bulgarian National Statistical Institute (<https://www.nsi.bg/bg>)

Supplementary Tables

Supplementary Table 1: Total excess mortality in European countries in the year 2020.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	75,824	66,210	64,221	63,508	65,293	65,974	66270.8 (±904.4)	9553.2 (±904.4)	14.4% (±1.5%)	8,901,064	107.3(±10.2)
Belgium	108,337	88,707	87,502	85,674	88,150	86,854	89075.8 (±924.0)	19261.2 (±924.0)	21.6% (±1.2%)	11,522,440	167.2(±8.0)
Bulgaria	106,136	90,281	86,982	85,799	86,927	85,333	88783.6 (±1516.8)	17352.4 (±1516.8)	19.5% (±2.0%)	6,951,482	249.6(±21.8)
Croatia	48,394	43,854	41,876	41,577	42,113	41,011	42923.0 (±839.4)	5471.0 (±839.4)	12.7% (±2.1%)	4,058,165	134.8(±20.7)
Cyprus	5,285	4,703	4,354	4,580	4,612	4,881	4718.0 (±150.4)	567.0 (±150.4)	12.0% (±3.4%)	888,005	63.9(±16.9)
Czechia	110,437	90,266	87,679	87,399	91,120	90,493	91116.2 (±1350.5)	19320.8 (±1350.5)	21.2% (±1.8%)	10,693,939	180.7(±12.6)
Denmark	45,815	43,421	42,791	42,801	44,340	43,482	44156.0 (±498.0)	1659.0 (±498.0)	3.8% (±1.2%)	5,822,763	28.5(±8.5)
Estonia	13,410	12,531	12,444	12,245	12,606	12,316	12642.8 (±116.7)	767.2 (±116.7)	6.1% (±1.0%)	1,328,976	57.7(±8.8)
Finland	46,023	43,422	43,320	42,961	44,135	43,543	44365.8 (±335.2)	1657.2 (±335.2)	3.7% (±0.7%)	5,525,292	30.0(±6.1)
France	564,198	481,159	482,065	477,183	487,298	487,716	492697.8 (±3479.3)	71500.2 (±3479.3)	14.5% (±0.8%)	67,320,216	106.2(±5.2)
Greece	108,019	98,074	95,555	97,129	97,339	99,171	99508.8 (±1041.4)	8510.2 (±1041.4)	8.6% (±1.2%)	10,718,565	79.4(±9.7)
Hungary	119,020	106,102	102,929	102,383	105,154	101,373	105603.4 (±1546.6)	13416.6 (±1546.6)	12.7% (±1.6%)	9,769,526	137.3(±15.9)
Iceland	1,876	1,795	1,900	1,802	1,803	1,890	1878.0 (±40.9)	-2.0 (±40.9)	-0.1% (±2.1%)	364,134	-0.5(±11.2)
Italy	632,791	530,524	505,912	515,251	505,899	507,862	523664.0 (±8215.0)	109127.0 (±8215.0)	20.8% (±1.8%)	59,641,488	183.0(±13.7)
Latvia	24,093	23,484	22,944	23,002	23,295	22,074	23424.6 (±424.7)	668.4 (±424.7)	2.9% (±1.9%)	1,907,675	35.0(±22.3)
Lithuania	36,797	34,588	32,948	31,639	31,353	30,409	32907.4 (±1270.3)	3889.6 (±1270.3)	11.8% (±4.1%)	2,794,090	139.2(±45.5)
Luxembourg	3,973	3,211	3,235	3,399	3,401	3,446	3404.8 (±84.1)	568.2 (±84.1)	16.7% (±2.8%)	626,108	90.8(±13.4)
Malta	3,332	2,727	2,652	2,724	2,864	2,815	2826.0 (±65.4)	506.0 (±65.4)	17.9% (±2.7%)	514,564	98.3(±12.7)
Montenegro	6,116	5,176	5,273	5,067	5,235	5,223	5294.8 (±62.2)	821.2 (±62.2)	15.5% (±1.3%)	621,873	132.1(±10.0)
Netherlands	142,890	119,936	120,124	118,562	121,388	123,017	122939.8 (±1316.7)	19950.2 (±1316.7)	16.2% (±1.2%)	17,407,585	114.6(±7.6)
Norway	33,521	33,242	32,631	32,443	32,568	32,860	33429.6 (±246.6)	91.4 (±246.6)	0.3% (±0.8%)	5,367,580	1.7(±4.6)
Poland	410,313	327,700	315,252	317,038	331,030	327,663	329989.4 (±5560.1)	80323.6 (±5560.1)	24.3% (±2.0%)	37,958,138	211.6(±14.7)
Portugal	102,505	84,405	88,933	85,151	87,890	86,587	88458.0 (±1468.0)	14047.0 (±1468.0)	15.9% (±1.9%)	10,295,909	136.4(±14.3)
Romania	253,027	214,965	208,821	206,011	212,414	205,978	213926.6 (±3118.8)	39100.4 (±3118.8)	18.3% (±1.7%)	19,328,838	202.3(±16.1)
Slovakia	50,147	43,709	42,894	42,097	43,451	42,328	43723.0 (±544.6)	6424.0 (±544.6)	14.7% (±1.4%)	5,457,873	117.7(±10.0)
Slovenia	20,260	16,261	15,705	15,780	16,439	16,185	16394.8 (±248.8)	3865.2 (±248.8)	23.6% (±1.9%)	2,095,861	184.4(±11.9)
Spain	418,959	333,245	328,706	329,693	331,312	327,996	336932.0 (±1656.4)	82027.0 (±1656.4)	24.3% (±0.6%)	47,332,614	173.3(±3.5)
Sweden	80,720	73,779	71,520	71,330	71,438	69,456	73035.8 (±1202.2)	7684.2 (±1202.2)	10.5% (±1.8%)	10,327,589	74.4(±11.6)
Switzerland	64,647	54,313	52,694	52,555	53,485	54,495	54562.8 (±700.5)	10084.2 (±700.5)	18.5% (±1.5%)	8,606,033	117.2(±8.1)

Supplementary Table 2: Excess mortality in European countries in the year 2020 for females (all ages)

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	1,689	1,703	1,701	1,593	1,577	1,623	1663.4 (±46.6)	25.6 (±46.6)	1.5% (±2.7%)	237,161	10.8 (±19.6)
Belgium	2,625	2,379	2,267	2,261	2,325	2,332	2348.0 (±38.6)	277.0 (±38.6)	11.8% (±1.8%)	321,281	86.2 (±12.0)
Bulgaria	3,975	3,292	3,154	3,218	3,186	3,101	3240.6 (±56.0)	734.4 (±56.0)	22.7% (±2.1%)	258,560	284.0 (±21.7)
Croatia	1,466	1,195	1,285	1,314	1,272	1,176	1269.2 (±46.9)	196.8 (±46.9)	15.5% (±4.1%)	142,394	138.2 (±32.9)
Cyprus	120	133	114	117	119	119	123.6 (±5.8)	-3.6 (±5.8)	-2.9% (±4.4%)	23,116	-15.6 (±25.1)
Czechia	3,539	3,556	3,399	3,319	3,318	3,109	3401.8 (±126.7)	137.2 (±126.7)	4.0% (±3.7%)	363,248	37.8 (±34.9)
Denmark	1,385	1,566	1,478	1,319	1,421	1,400	1462.4 (±72.1)	-77.4 (±72.1)	-5.3% (±4.4%)	163,541	-47.3 (±44.1)
Estonia	403	358	372	370	443	335	379.6 (±31.7)	23.4 (±31.7)	6.2% (±8.2%)	45,393	51.5 (±69.9)
Finland	1,224	1,411	1,240	1,295	1,237	1,228	1307.0 (±60.1)	-83.0 (±60.1)	-6.4% (±4.1%)	185,685	-44.7 (±32.4)
France	12,617	11,547	11,628	11,572	11,689	11,608	11827.2 (±42.9)	789.8 (±42.9)	6.7% (±0.4%)	2,067,425	38.2 (±2.1)
Greece	2,204	2,045	1,920	1,913	1,910	1,836	1958.4 (±59.1)	245.6 (±59.1)	12.5% (±3.3%)	323,057	76.0 (±18.3)
Hungary	5,359	4,130	4,062	4,286	4,414	4,421	4344.2 (±127.9)	1014.8 (±127.9)	23.4% (±3.6%)	366,614	276.8 (±34.9)
Iceland	56	52	51	45	41	44	46.6 (±3.7)	9.4 (±3.7)	20.2% (±8.9%)	8,431	111.5 (±43.9)
Italy	11,505	11,506	11,179	10,875	10,296	9,861	10983.4 (±521.1)	521.6 (±521.1)	4.7% (±4.7%)	1,818,274	28.7 (±28.6)
Latvia	720	722	726	771	810	679	755.2 (±39.4)	-35.2 (±39.4)	-4.7% (±4.7%)	65,922	-53.4 (±59.8)
Lithuania	1,055	1,001	970	942	932	934	974.2 (±23.1)	80.8 (±23.1)	8.3% (±2.5%)	92,402	87.4 (±25.0)
Luxembourg	108	101	84	104	89	85	93.4 (±7.3)	14.6 (±7.3)	15.6% (±8.4%)	13,913	104.9 (±52.5)
Malta	87	111	104	82	83	80	95.2 (±11.3)	-8.2 (±11.3)	-8.6% (±9.7%)	14,406	-56.9 (±78.4)
Montenegro	2,817	2,542	2,482	2,390	2,539	2,445	2529.2 (±50.6)	287.8 (±50.6)	11.4% (±2.2%)	314,318	91.6 (±16.1)
Netherlands	3,967	4,120	3,871	3,626	3,580	3,595	3833.6 (±183.6)	133.4 (±183.6)	3.5% (±4.7%)	502,794	26.5 (±36.5)
Norway	897	951	969	932	910	855	941.0 (±34.5)	-44.0 (±34.5)	-4.7% (±3.3%)	138,228	-31.8 (±24.9)
Poland	16,084	12,019	12,246	12,834	13,235	13,509	12997.4 (±496.6)	3086.6 (±496.6)	23.7% (±4.5%)	1,352,561	228.2 (±36.7)
Portugal	2,082	1,829	1,894	1,848	1,782	1,792	1863.4 (±35.4)	218.6 (±35.4)	11.7% (±2.1%)	337,447	64.8 (±10.5)
Romania	9,792	7,001	7,444	7,489	7,890	7,618	7634.0 (±253.3)	2158.0 (±253.3)	28.3% (±4.2%)	670,155	322.0 (±37.8)
Slovakia	2,003	1,546	1,680	1,625	1,751	1,681	1687.8 (±59.8)	315.2 (±59.8)	18.7% (±4.1%)	181,339	173.8 (±33.0)
Slovenia	487	441	403	419	497	471	458.2 (±29.9)	28.8 (±29.9)	6.3% (±6.5%)	68,823	41.8 (±43.5)
Spain	7,597	5,988	6,069	6,115	6,051	6,112	6192.6 (±40.8)	1404.4 (±40.8)	22.7% (±0.8%)	1,271,580	110.4 (±3.3)
Sweden	1,758	2,152	1,928	1,894	1,859	1,678	1943.8 (±133.1)	-185.8 (±133.1)	-9.6% (±5.8%)	272,942	-68.1 (±48.8)
Switzerland	1,172	1,301	1,244	1,206	1,194	1,149	1246.8 (±44.8)	-74.8 (±44.8)	-6.0% (±3.3%)	222,768	-33.6 (±20.1)

Supplementary Table 3: Excess mortality in European countries in the year 2020 for males (all ages)

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	2,889	2,854	2,871	2,629	2,656	2,606	2784.0 (±100.8)	105.0 (±100.8)	3.8% (±3.7%)	213,220	49.2(±47.3)
Belgium	4,569	4,040	4,027	3,922	3,882	3,729	3996.8 (±99.0)	572.2 (±99.0)	14.3% (±2.7%)	302,248	189.3(±32.8)
Bulgaria	7,029	6,059	5,979	5,849	5,835	5,645	5983.0 (±123.9)	1046.0 (±123.9)	17.5% (±2.4%)	205,259	509.6(±60.4)
Croatia	2,962	2,373	2,420	2,450	2,550	2,467	2501.6 (±51.3)	460.4 (±51.3)	18.4% (±2.4%)	124,926	368.5(±41.1)
Cyprus	224	224	186	221	228	221	220.0 (±13.3)	4.0 (±13.3)	1.8% (±5.8%)	21,813	18.3(±61.0)
Czechia	6,826	6,384	6,260	6,005	6,146	5,953	6269.6 (±139.5)	556.4 (±139.5)	8.9% (±2.4%)	315,679	176.3(±44.1)
Denmark	2,145	2,314	2,195	2,089	2,105	2,114	2205.0 (±73.4)	-60.0 (±73.4)	-2.7% (±3.2%)	155,734	-38.5(±47.1)
Estonia	807	695	727	720	723	752	737.8 (±16.0)	69.2 (±16.0)	9.4% (±2.3%)	32,108	215.5(±49.9)
Finland	2,151	2,596	2,514	2,400	2,308	2,199	2438.6 (±124.1)	-287.6 (±124.1)	-11.8% (±4.3%)	171,275	-167.9(±72.4)
France	24,034	23,344	22,913	22,656	22,558	21,980	23116.6 (±392.0)	917.4 (±392.0)	4.0% (±1.8%)	1,835,511	50.0(±21.3)
Greece	4,363	4,223	3,857	3,886	3,800	3,874	4015.2 (±131.8)	347.8 (±131.8)	8.7% (±3.5%)	285,945	121.6(±46.1)
Hungary	8,792	6,525	7,019	6,942	7,332	7,278	7139.2 (±252.5)	1652.8 (±252.5)	23.2% (±4.3%)	277,065	596.5(±91.2)
Iceland	86	78	73	80	69	87	79.8 (±5.4)	6.2 (±5.4)	7.8% (±6.9%)	8,550	72.5(±63.2)
Italy	20,940	19,839	19,094	18,098	17,400	16,617	18608.0 (±1010.2)	2332.0 (±1010.2)	12.5% (±5.8%)	1,652,740	141.1(±61.1)
Latvia	1,368	1,229	1,290	1,305	1,321	1,246	1305.4 (±30.8)	62.6 (±30.8)	4.8% (±2.4%)	43,882	142.7(±70.1)
Lithuania	2,078	1,878	1,734	1,690	1,737	1,752	1795.0 (±55.6)	283.0 (±55.6)	15.8% (±3.5%)	62,138	455.4(±89.5)
Luxembourg	168	136	161	210	160	150	165.8 (±21.9)	2.2 (±21.9)	1.3% (±11.8%)	13,597	16.2(±161.0)
Malta	147	165	141	153	158	153	159.6 (±6.8)	-12.6 (±6.8)	-7.9% (±3.8%)	14,037	-89.8(±48.5)
Montenegro	3,299	2,634	2,791	2,677	2,696	2,778	2765.6 (±52.8)	533.4 (±52.8)	19.3% (±2.2%)	307,555	173.4(±17.2)
Netherlands	5,745	6,058	5,581	5,310	5,309	5,144	5589.2 (±281.4)	155.8 (±281.4)	2.8% (±4.9%)	493,254	31.6(±57.0)
Norway	1,374	1,503	1,460	1,406	1,336	1,295	1432.8 (±67.1)	-58.8 (±67.1)	-4.1% (±4.3%)	137,044	-42.9(±49.0)
Poland	31,063	22,051	22,655	23,212	24,714	25,008	23980.0 (±1010.1)	7083.0 (±1010.1)	29.5% (±5.2%)	1,095,263	646.7(±92.2)
Portugal	4,148	3,524	3,730	3,629	3,660	3,724	3731.0 (±65.8)	417.0 (±65.8)	11.2% (±2.0%)	285,465	146.1(±23.0)
Romania	18,305	12,569	12,817	13,450	14,465	14,171	13771.2 (±646.2)	4533.8 (±646.2)	32.9% (±5.9%)	531,739	852.6(±121.6)
Slovakia	3,753	2,835	3,003	2,973	3,237	3,199	3102.2 (±131.0)	650.8 (±131.0)	21.0% (±4.9%)	148,066	439.5(±88.5)
Slovenia	1,106	798	862	847	960	986	903.4 (±62.2)	202.6 (±62.2)	22.4% (±7.9%)	65,374	309.9(±95.2)
Spain	15,883	13,492	13,126	13,309	13,057	12,782	13394.8 (±209.9)	2488.2 (±209.9)	18.6% (±1.9%)	1,160,179	214.5(±18.1)
Sweden	2,693	3,090	2,830	2,584	2,648	2,421	2780.2 (±200.6)	-87.2 (±200.6)	-3.1% (±6.6%)	267,106	-32.6(±75.1)
Switzerland	2,082	2,137	2,033	1,916	1,943	1,872	2017.0 (±82.7)	65.0 (±82.7)	3.2% (±4.0%)	207,844	31.3(±39.8)

Supplementary Table 4: ASYR values for European countries for the year 2020, for ages 0-89.

ASYR total		ASYR males		ASYR females	
country	ASYR	country	ASYR	country	ASYR
Bulgaria	2642.71 ± 387.64	Bulgaria	3429.04 ± 494.95	Bulgaria	1870.95 ± 322.65
Poland	2176.02 ± 425.24	Poland	2979.2 ± 531.98	Poland	1409.38 ± 333.52
Romania	2166.23 ± 386.11	Romania	2971.23 ± 506.87	Romania	1362.30 ± 297.74
Montenegro	1591.07 ± 474.47	Montenegro	2201.28 ± 765.93	Luxembourg	1167.63 ± 450.58
Czechia	1561.77 ± 338.36	Czechia	2083.52 ± 411.74	Montenegro	1114.90 ± 406.12
Slovakia	1416.99 ± 222.16	Slovakia	1916.80 ± 316.7	Hungary	1093.03 ± 224.89
Luxembourg	1385.34 ± 561.60	Lithuania	1867.11 ± 984.67	Czechia	1088.59 ± 294.64
Hungary	1371.86 ± 257.82	Luxembourg	1698.68 ± 848.55	Slovakia	1054.24 ± 327.81
Lithuania	1308.71 ± 705.12	Hungary	1684.16 ± 360.10	Spain	942.20 ± 169.04
Spain	1237.10 ± 195.03	Malta	1624.29 ± 680.96	Lithuania	842.8 ± 438.91
Malta	1122.81 ± 528.47	Spain	1528.26 ± 232.74	Slovenia	761.89 ± 274.98
Slovenia	1065.83 ± 262.79	Italy	1431.94 ± 203.13	Belgium	743.09 ± 237.88
Italy	1020.91 ± 177.37	Slovenia	1412.31 ± 423.85	Estonia	713.18 ± 403.65
Belgium	1008.50 ± 301.28	Belgium	1278.93 ± 342.72	Malta	684.67 ± 551.42
Croatia	879.37 ± 301.07	Croatia	1229.67 ± 361.12	Iceland	616.88 ± 380.42
Netherlands	830.38 ± 210.23	Cyprus	1155.62 ± 595.19	Italy	605.74 ± 155.89
Austria	818.23 ± 233.29	Austria	1123.27 ± 340.89	Netherlands	603.04 ± 195.17
Cyprus	806.27 ± 339.84	Netherlands	1095.74 ± 222.74	Austria	592.24 ± 189.30
Portugal	742.72 ± 187.97	Iceland	1087.99 ± 587.39	Croatia	589.37 ± 326.44
Estonia	733.79 ± 384.83	Portugal	959.40 ± 291.99	Cyprus	546.61 ± 306.67
Iceland	705.81 ± 457.04	Estonia	861.08 ± 440.19	Portugal	529.72 ± 192.09
France	599.00 ± 165.45	Switzerland	842.88 ± 255.68	France	422.21 ± 117.61
Switzerland	572.07 ± 136.63	France	780.58 ± 213.49	Sweden	398.40 ± 79.04
Sweden	508.34 ± 100.43	Sweden	702.98 ± 179.45	Switzerland	386.31 ± 100.48
Finland	400.07 ± 172.88	Finland	526.50 ± 207.13	Greece	355.06 ± 165.77
Greece	387.31 ± 147.26	Latvia	496.83 ± 261.61	Finland	285.37 ± 162.98
Denmark	319.15 ± 141.77	Greece	433.70 ± 135.00	Denmark	257.42 ± 92.80
Latvia	292.95 ± 229.64	Denmark	408.03 ± 160.00	Latvia	208.70 ± 84.34
Norway	219.82 ± 142.17	Norway	279.00 ± 142.00	Norway	179.47 ± 141.82

Supplementary Table 5: ASYR values for European countries for the year 2020, for ages 0 to 90+.

ASYR total		ASYR males		ASYR females	
country	ASYR	country	ASYR	country	ASYR
Bulgaria	2963.08 ± 423.25	Bulgaria	3842.60 ± 529.63	Bulgaria	2147.98 ± 362.37
Poland	2676.11 ± 479.93	Poland	3700.81 ± 597.50	Poland	1823.31 ± 387.70
Romania	2501.03 ± 430.02	Romania	3396.66 ± 546.60	Romania	1658.84 ± 344.88
Czechia	1963.81 ± 389.01	Czechia	2612.61 ± 476.53	Czechia	1435.77 ± 346.58
Montenegro	1825.12 ± 530.49	Lithuania	2517.08 ± 1058.43	Luxembourg	1416.52 ± 505.13
Lithuania	1789.84 ± 758.74	Montenegro	2451.80 ± 866.94	Montenegro	1342.87 ± 487.51
Luxembourg	1704.25 ± 628.43	Slovenia	2223.7 ± 534.70	Hungary	1326.87 ± 255.44
Slovakia	1666.51 ± 250.84	Slovakia	2213.56 ± 344.59	Spain	1288.61 ± 190.40
Spain	1638.01 ± 220.31	Luxembourg	2152.29 ± 961.87	Slovakia	1277.82 ± 358.38
Slovenia	1635.98 ± 320.95	Spain	2026.51 ± 275.46	Slovenia	1249.83 ± 328.03
Hungary	1616.83 ± 282.59	Hungary	1966.58 ± 380.22	Lithuania	1222.45 ± 495.15
Belgium	1438.89 ± 330.31	Belgium	1822.65 ± 392.28	Belgium	1120.08 ± 268.13
Malta	1427.67 ± 577.51	Malta	1820.27 ± 747.73	Malta	1043.07 ± 606.69
Italy	1354.28 ± 204.22	Croatia	1800.53 ± 448.09	Croatia	965.27 ± 368.26
Croatia	1309.57 ± 352.60	Netherlands	1587.07 ± 291.09	Estonia	863.81 ± 443.5
Netherlands	1136.98 ± 238.97	Austria	1492.68 ± 402.59	Portugal	850.83 ± 238.20
Portugal	1098.04 ± 245.12	Italy	1415.77 ± 200.74	Netherlands	816.38 ± 210.52
Austria	1024.27 ± 276.29	Portugal	1384.46 ± 374.22	Austria	730.49 ± 231.15
Estonia	909.88 ± 451.22	Estonia	1168.07 ± 571.62	Iceland	635.56 ± 436.84
France	829.05 ± 192.34	Cyprus	1142.61 ± 587.28	France	605.05 ± 145.93
Cyprus	796.80 ± 335.12	France	1112.10 ± 247.55	Italy	601.71 ± 154.81
Iceland	725.93 ± 507.83	Iceland	1109.31 ± 639.07	Greece	557.5 ± 228.32
Sweden	667.81 ± 126.16	Sweden	955.58 ± 203.81	Cyprus	539.87 ± 303.08
Greece	604.26 ± 207.60	Switzerland	837.75 ± 252.29	Sweden	503.02 ± 110.52
Switzerland	567.55 ± 134.87	Latvia	826.88 ± 373.38	Switzerland	384.27 ± 99.47
Finland	476.93 ± 198.87	Greece	674.05 ± 198.07	Latvia	357.84 ± 152.71
Latvia	474.65 ± 301.96	Finland	651.73 ± 265.71	Finland	346.96 ± 182.45
Denmark	358.89 ± 151.64	Denmark	496.97 ± 181.88	Denmark	267.38 ± 99.06
Norway	221.17 ± 146.99	Norway	314.10 ± 161.51	Norway	177.81 ± 140.37

Supplementary Table 6: Average PYLL values for European countries for the year 2020.

PYLL total		PYLL males		PYLL females	
country	PYLL	country	PYLL	country	PYLL
Iceland	29.25 ± 1.22	Iceland	23.86 ± 1.99	Iceland	39.71 ± 0.13
Luxembourg	23.08 ± 0.26	Luxembourg	19.79 ± 0.37	Luxembourg	29.63 ± 2.83
Estonia	16.37 ± 1.03	Cyprus	15.58 ± 0.49	Estonia	18.73 ± 1.48
Finland	15.73 ± 0.77	Finland	14.82 ± 0.51	Finland	16.65 ± 0.48
Cyprus	14.48 ± 0.41	Malta	13.99 ± 1.09	Norway	14.92 ± 0.02
Norway	13.95 ± 0.39	Norway	13.88 ± 0.22	Cyprus	13.79 ± 1.04
Poland	13.87 ± 0.18	Estonia	13.58 ± 1.28	France	13.76 ± 0.1
Malta	13.76 ± 1.4	Poland	12.96 ± 0.21	Poland	13.76 ± 0.19
Bulgaria	13.46 ± 0.11	Romania	12.56 ± 0.11	Bulgaria	13.68 ± 0.24
Romania	13.29 ± 0.01	Bulgaria	12.56 ± 0.03	Greece	13.63 ± 0.14
Spain	13.08 ± 0.16	Spain	12.4 ± 0.15	Spain	13.3 ± 0.14
Lithuania	13.04 ± 0.82	Lithuania	12.14 ± 1.14	Slovakia	13.02 ± 0.7
France	12.77 ± 0.33	Greece	12.01 ± 0.38	Malta	13 ± 2.19
Greece	12.68 ± 0.1	Austria	11.89 ± 0.68	Romania	12.91 ± 0.05
Austria	12.21 ± 0.35	Portugal	11.75 ± 0.53	Austria	12.8 ± 0.07
Slovakia	12.17 ± 0.12	France	11.64 ± 0.46	Lithuania	12.65 ± 0.21
Hungary	11.99 ± 0.43	Italy	11.46 ± 0.25	Denmark	12.44 ± 0.66
Italy	11.72 ± 0.21	Hungary	11.26 ± 0.54	Montenegro	12.39 ± 1.07
Portugal	11.69 ± 0.38	Belgium	11.19 ± 0.59	Hungary	12 ± 0.37
Czechia	11.62 ± 0.37	Slovakia	11.14 ± 0.43	Czechia	11.9 ± 0.3
Montenegro	11.57 ± 1.08	Slovenia	10.95 ± 0.97	Netherlands	11.43 ± 0.9
Belgium	11.15 ± 0.72	Netherlands	10.87 ± 0.49	Italy	11.15 ± 0.22
Netherlands	11.14 ± 0.73	Czechia	10.8 ± 0.5	Portugal	11.08 ± 0.79
Croatia	11.06 ± 0.23	Montenegro	10.64 ± 0.58	Sweden	11.03 ± 0.02
Slovenia	11.05 ± 0.6	Croatia	10.56 ± 0.3	Croatia	10.97 ± 0.52
Denmark	10.52 ± 0.68	Switzerland	10.42 ± 1.15	Belgium	10.74 ± 0.6
Switzerland	10.32 ± 0.77	Sweden	10.36 ± 0.78	Slovenia	10.74 ± 0.77
Sweden	10.29 ± 0.37	Latvia	9.63 ± 0.44	Switzerland	10.41 ± 0.59
Latvia	9.71 ± 0.66	Denmark	9.58 ± 0.27	Latvia	9.47 ± 0.18

Supplementary Table 7: Average WYLL values for European countries for the year 2020.

WYLL total		WYLL males		WYLL females	
country	WYLL	country	WYLL	country	WYLL
Norway	38.11 ± 6.23	Norway	43.02 ± 0.02	Denmark	39.15 ± 0.13
Denmark	35.38 ± 1.03	Denmark	31.69 ± 0.41	Finland	35.65 ± 2.69
Finland	31.87 ± 0.33	Finland	31.39 ± 1.39	Sweden	29.18 ± 0.4
Slovenia	21.09 ± 0.92	Slovakia	23.4 ± 1.04	Iceland	25.56 ± 1.69
Iceland	20.78 ± 2.31	Slovenia	19.81 ± 3.12	Luxembourg	24.77 ± 1.09
Slovakia	18.84 ± 1.04	Hungary	17.68 ± 1.01	Hungary	19.5 ± 0.06
Malta	18.47 ± 0.75	Malta	17.08 ± 1.6	Slovenia	18.89 ± 3.14
Hungary	18.43 ± 0.31	Iceland	15.32 ± 2.22	Malta	18.77 ± 2.23
Sweden	15.57 ± 1.43	Croatia	15.07 ± 4.6	Norway	17.03 ± 1.79
Czechia	13.54 ± 0	Czechia	12.96 ± 0.56	Cyprus	17.03 ± 1.54
Estonia	12.25 ± 0.9	Sweden	12.66 ± 3.65	Czechia	15.3 ± 0.47
Poland	12.04 ± 0.37	Estonia	12.37 ± 0.17	Slovakia	14.86 ± 4.48
Luxembourg	11.21 ± 1.06	Poland	11.74 ± 0.1	Netherlands	14.01 ± 0.47
Netherlands	10.17 ± 0.24	Switzerland	10.86 ± 2.88	Poland	13.72 ± 0.89
Switzerland	10.13 ± 1.81	Netherlands	10.26 ± 0.02	Switzerland	13.14 ± 1.34
Montenegro	9.4 ± 2.33	Montenegro	9.77 ± 2.16	Montenegro	11.59 ± 1.85
Bulgaria	8.68 ± 0	Bulgaria	9.35 ± 0.07	Estonia	11.42 ± 0.22
Romania	8.47 ± 0.58	Romania	8.32 ± 0.52	Portugal	10.27 ± 1.86
Cyprus	7.78 ± 0.21	Luxembourg	8.27 ± 1.91	Belgium	9.77 ± 0.95
Portugal	7.73 ± 1.52	Portugal	7.22 ± 1.75	Romania	8.91 ± 0.42
Austria	6.28 ± 1.16	Austria	7.09 ± 1.13	Austria	8.52 ± 1.49
Belgium	6.03 ± 2.23	Cyprus	6.98 ± 0.92	Bulgaria	7.43 ± 0.28
Croatia	5.69 ± 1.44	Belgium	6.2 ± 1.28	Greece	6.46 ± 1.22
Spain	5.42 ± 0.96	Spain	5.3 ± 1.1	Spain	6.25 ± 0.6
Lithuania	5.03 ± 1.97	Lithuania	4.97 ± 2.19	Croatia	5.89 ± 2.53
Italy	5 ± 0.18	Italy	4.93 ± 0.16	Lithuania	5.78 ± 1.57
Greece	4.61 ± 0.6	Greece	3.46 ± 0.32	Italy	5.29 ± 0.42
France	3.04 ± 0.67	France	2.5 ± 0	France	5 ± 0.91
Latvia	2.5 ± 0	Latvia	2.5 ± 0	Latvia	2.5 ± 0

Supplementary Table 8: Excess mortality in European countries in the year 2020, ages 30-39.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	600	538	520	510	560	532	538.4 (±14.9)	61.6 (±14.9)	11.4% (±3.0%)	1,217,932	5.1(±1.2)
Belgium	878	906	836	861	840	799	864.4 (±30.7)	13.6 (±30.7)	1.6% (±3.5%)	1,499,416	0.9(±2.1)
Bulgaria	1,101	1,068	1,065	962	1,032	978	1045.0 (±38.4)	56.0 (±38.4)	5.4% (±3.8%)	956,388	5.9(±4.0)
Croatia	343	391	333	343	344	348	354.2 (±17.7)	-11.2 (±17.7)	-3.2% (±4.6%)	536,215	-2.1(±3.3)
Cyprus	54	60	46	50	58	68	57.2 (±6.7)	-3.2 (±6.7)	-5.6% (±9.9%)	143,651	-2.2(±4.6)
Czechia	1,034	1,066	983	953	991	941	1014.0 (±38.3)	30.0 (±38.3)	2.0% (±3.7%)	1,485,125	1.3(±2.6)
Denmark	317	304	308	294	336	297	312.6 (±13.1)	4.4 (±13.1)	1.4% (±4.1%)	686,808	0.6(±1.9)
Estonia	201	232	249	191	176	163	203.0 (±28.8)	-2.0 (±28.8)	-1.0% (±12.3%)	196,352	-1.0(±14.6)
Finland	462	447	447	440	429	460	457.4 (±8.9)	4.6 (±8.9)	1.0% (±1.9%)	711,550	0.6(±1.3)
France	4,967	5,047	4,843	4,824	4,954	4,927	5007.0 (±70.6)	-40.0 (±70.6)	-0.8% (±1.4%)	8,329,503	-0.5(±0.9)
Greece	728	895	820	753	827	709	815.2 (±56.4)	-87.2 (±56.4)	-10.7% (±5.8%)	1,333,233	-6.5(±4.2)
Hungary	1,005	1,120	994	1,054	941	917	1021.2 (±65.1)	-16.2 (±65.1)	-1.6% (±5.9%)	1,271,926	-1.3(±5.1)
Iceland	36	22	33	41	37	30	32.6 (±5.7)	3.4 (±5.7)	10.4% (±16.4%)	53,461	6.4(±10.6)
Italy	2,659	3,198	3,044	2,865	2,837	2,618	2976.4 (±172.4)	-317.4 (±172.4)	-10.7% (±4.9%)	6,854,632	-4.6(±2.5)
Latvia	355	490	425	480	433	359	451.0 (±40.9)	-96.0 (±40.9)	-21.3% (±6.5%)	268,173	-35.8(±15.3)
Lithuania	524	730	644	563	582	521	627.2 (±63.7)	-103.2 (±63.7)	-16.5% (±7.7%)	359,239	-28.7(±17.7)
Luxembourg	35	34	34	37	36	40	36.2 (±1.9)	-1.2 (±1.9)	-3.3% (±4.8%)	98,584	-1.2(±1.9)
Malta	35	31	43	37	37	33	36.2 (±3.6)	-1.2 (±3.6)	-3.3% (±8.8%)	88,901	-1.3(±4.0)
Netherlands	977	862	858	869	891	867	885.4 (±10.1)	91.6 (±10.1)	10.3% (±1.2%)	2,147,931	4.3(±0.4)
Norway	332	335	359	303	347	328	342.4 (±16.6)	-10.4 (±16.6)	-3.0% (±4.5%)	730,547	-1.4(±2.2)
Poland	6,409	5,764	5,663	5,692	5,773	5,763	5843.0 (±39.3)	566.0 (±39.3)	9.7% (±0.7%)	6,009,458	9.4(±0.7)
Portugal	703	780	685	745	671	670	726.2 (±38.9)	-23.2 (±38.9)	-3.2% (±4.9%)	1,239,016	-1.9(±3.2)
Romania	2,801	2,948	2,703	2,662	2,579	2,495	2751.8 (±134.1)	49.2 (±134.1)	1.8% (±4.7%)	2,694,828	1.8(±5.0)
Slovakia	691	731	693	651	647	679	695.4 (±26.9)	-4.4 (±26.9)	-0.6% (±3.7%)	847,471	-0.5(±3.2)
Slovenia	142	186	173	136	146	162	166.2 (±15.8)	-24.2 (±15.8)	-14.6% (±7.4%)	288,802	-8.4(±5.5)
Spain	2,538	2,740	2,593	2,551	2,415	2,316	2575.0 (±128.4)	-37.0 (±128.4)	-1.4% (±4.7%)	6,103,321	-0.6(±2.1)
Sweden	531	558	548	538	567	501	553.6 (±20.1)	-22.6 (±20.1)	-4.1% (±3.3%)	1,366,489	-1.7(±1.5)
Switzerland	447	428	399	445	379	406	418.6 (±20.2)	28.4 (±20.2)	6.8% (±4.9%)	1,229,176	2.3(±1.7)

Supplementary Table 9: Excess mortality in European countries in the year 2020, ages 30-39, females.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	211	171	165	175	208	156	178.2 (±15.5)	32.8 (±15.5)	18.4% (±9.5%)	601,390	5.5(±2.5)
Belgium	286	301	271	304	284	265	291.4 (±13.7)	-5.4 (±13.7)	-1.9% (±4.4%)	749,098	-0.7(±1.8)
Bulgaria	309	328	296	293	305	299	313.0 (±11.0)	-4.0 (±11.0)	-1.3% (±3.3%)	462,747	-0.9(±2.4)
Croatia	101	110	92	97	94	95	98.4 (±5.6)	2.6 (±5.6)	2.6% (±5.5%)	260,574	1.0(±2.1)
Cyprus	19	21	10	18	21	24	19.6 (±4.2)	-0.6 (±4.2)	-3.1% (±17.1%)	72,453	-0.8(±5.8)
Czechia	327	299	332	280	290	299	310.4 (±15.3)	16.6 (±15.3)	5.3% (±4.9%)	717,952	2.3(±2.1)
Denmark	114	110	105	107	121	104	111.0 (±5.4)	3.0 (±5.4)	2.7% (±4.8%)	337,996	0.9(±1.6)
Estonia	48	42	74	40	48	51	51.0 (±10.7)	-3.0 (±10.7)	-5.9% (±16.3%)	93,659	-3.2(±11.4)
Finland	135	130	121	123	125	125	126.4 (±2.6)	8.6 (±2.6)	6.8% (±2.1%)	344,313	2.5(±0.8)
France	1,554	1,539	1,533	1,512	1,532	1,532	1556.8 (±8.1)	-2.8 (±8.1)	-0.2% (±0.5%)	4,280,714	-0.1(±0.2)
Greece	217	257	254	215	228	202	232.8 (±18.8)	-15.8 (±18.8)	-6.8% (±7.0%)	665,385	-2.4(±2.9)
Hungary	333	334	338	362	285	305	329.6 (±23.6)	3.4 (±23.6)	1.0% (±6.7%)	619,906	0.5(±3.9)
Iceland	11	4	5	9	12	9	7.8 (±2.5)	3.2 (±2.5)	41.0% (±34.2%)	24,653	13.0(±10.1)
Italy	889	1,070	1,062	1,015	995	888	1031.6 (±57.3)	-142.6 (±57.3)	-13.8% (±4.6%)	3,402,902	-4.2(±1.7)
Latvia	87	110	84	118	98	84	99.6 (±12.0)	-12.6 (±12.0)	-12.7% (±9.3%)	130,421	-9.7(±9.2)
Lithuania	121	172	148	145	135	119	147.0 (±15.3)	-26.0 (±15.3)	-17.7% (±7.7%)	170,267	-15.3(±9.0)
Luxembourg	10	10	12	10	13	13	11.6 (±1.2)	-1.6 (±1.2)	-13.8% (±8.1%)	48,912	-3.3(±2.5)
Malta	10	5	18	12	16	12	12.6 (±3.9)	-2.6 (±3.9)	-20.6% (±18.8%)	40,451	-6.4(±9.6)
Netherlands	365	332	359	345	326	330	344.8 (±10.6)	20.2 (±10.6)	5.9% (±3.2%)	1,066,068	1.9(±1.0)
Norway	105	119	109	105	103	106	111.6 (±4.9)	-6.6 (±4.9)	-5.9% (±4.0%)	356,127	-1.9(±1.4)
Poland	1,443	1,235	1,298	1,292	1,306	1,231	1288.4 (±28.5)	154.6 (±28.5)	12.0% (±2.4%)	2,952,254	5.2(±1.0)
Portugal	243	246	254	262	222	252	252.0 (±11.9)	-9.0 (±11.9)	-3.6% (±4.3%)	637,279	-1.4(±1.9)
Romania	819	844	793	795	752	690	799.6 (±45.1)	19.4 (±45.1)	2.4% (±5.4%)	1,300,038	1.5(±3.5)
Slovakia	183	173	229	180	153	184	187.8 (±21.9)	-4.8 (±21.9)	-2.6% (±10.1%)	412,863	-1.2(±5.3)
Slovenia	37	53	46	41	41	44	46.6 (±3.9)	-9.6 (±3.9)	-20.6% (±6.1%)	135,173	-7.1(±2.9)
Spain	876	882	894	853	807	764	849.6 (±42.4)	26.4 (±42.4)	3.1% (±4.9%)	3,060,796	0.9(±1.3)
Sweden	203	182	175	163	184	180	179.2 (±6.6)	23.8 (±6.6)	13.3% (±4.0%)	665,413	3.6(±1.0)
Switzerland	160	161	162	156	129	141	152.2 (±11.2)	7.8 (±11.2)	5.1% (±7.2%)	608,327	1.3(±1.8)

Supplementary Table 10: Excess mortality in European countries in the year 2020, ages 30-39, males.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	389	367	355	335	352	376	360.2 (±12.3)	28.8 (±12.3)	8.0% (±3.6%)	616,542	4.7(±2.0)
Belgium	592	605	565	557	556	534	573.0 (±20.3)	19.0 (±20.3)	3.3% (±3.5%)	750,318	2.5(±2.7)
Bulgaria	792	740	769	669	727	679	732.0 (±33.0)	60.0 (±33.0)	8.2% (±4.7%)	493,641	12.2(±6.6)
Croatia	242	281	241	246	250	253	255.8 (±12.3)	-13.8 (±12.3)	-5.4% (±4.3%)	275,641	-5.0(±4.5)
Cyprus	35	39	36	32	37	44	37.6 (±3.4)	-2.6 (±3.4)	-6.9% (±7.7%)	71,198	-3.7(±4.8)
Czechia	707	767	651	673	701	642	703.6 (±39.4)	3.4 (±39.4)	0.5% (±5.3%)	767,173	0.4(±5.2)
Denmark	203	194	203	187	215	193	201.6 (±8.5)	1.4 (±8.5)	0.7% (±4.1%)	348,812	0.4(±2.4)
Estonia	153	190	175	151	128	112	152.0 (±25.2)	1.0 (±25.2)	0.7% (±14.4%)	102,693	1.0(±24.5)
Finland	327	317	326	317	304	335	331.0 (±9.0)	-4.0 (±9.0)	-1.2% (±2.6%)	367,237	-1.1(±2.5)
France	3,413	3,508	3,310	3,312	3,422	3,395	3450.2 (±65.0)	-37.2 (±65.0)	-1.1% (±1.8%)	4,048,789	-0.9(±1.6)
Greece	511	638	566	538	599	507	582.4 (±40.1)	-71.4 (±40.1)	-12.3% (±5.6%)	667,848	-10.7(±6.0)
Hungary	672	786	656	692	656	612	691.6 (±51.4)	-19.6 (±51.4)	-2.8% (±6.8%)	652,020	-3.0(±7.9)
Iceland	25	18	28	32	25	21	24.8 (±4.4)	0.2 (±4.4)	0.8% (±15.2%)	28,808	0.7(±15.3)
Italy	1,770	2,128	1,982	1,850	1,842	1,730	1944.8 (±119.7)	-174.8 (±119.7)	-9.0% (±5.3%)	3,451,730	-5.1(±3.5)
Latvia	268	380	341	362	335	275	351.4 (±31.2)	-83.4 (±31.2)	-23.7% (±6.3%)	137,752	-60.5(±22.6)
Lithuania	403	558	496	418	447	402	480.2 (±49.8)	-77.2 (±49.8)	-16.1% (±7.9%)	188,972	-40.9(±26.4)
Luxembourg	25	24	22	27	23	27	24.6 (±1.8)	0.4 (±1.8)	1.6% (±6.9%)	49,672	0.8(±3.6)
Malta	25	26	25	25	21	21	23.6 (±1.9)	1.4 (±1.9)	5.9% (±7.9%)	48,450	2.9(±3.9)
Netherlands	612	530	499	524	565	537	540.6 (±18.7)	71.4 (±18.7)	13.2% (±3.8%)	1,081,863	6.6(±1.7)
Norway	227	216	250	198	244	222	230.8 (±16.7)	-3.8 (±16.7)	-1.6% (±6.7%)	374,420	-1.0(±4.4)
Poland	4,966	4,529	4,365	4,400	4,467	4,532	4554.6 (±58.9)	411.4 (±58.9)	9.0% (±1.4%)	3,057,204	13.5(±1.9)
Portugal	460	534	431	483	449	418	474.2 (±36.6)	-14.2 (±36.6)	-3.0% (±6.9%)	601,737	-2.4(±6.1)
Romania	1,982	2,104	1,910	1,867	1,827	1,805	1952.2 (±93.7)	29.8 (±93.7)	1.5% (±4.6%)	1,394,790	2.1(±6.8)
Slovakia	508	558	464	471	494	495	507.6 (±29.1)	0.4 (±29.1)	0.1% (±5.4%)	434,608	0.1(±6.7)
Slovenia	105	133	127	95	105	118	119.6 (±12.3)	-14.6 (±12.3)	-12.2% (±8.2%)	153,629	-9.5(±8.0)
Spain	1,655	1,858	1,699	1,698	1,608	1,552	1725.4 (±91.0)	-70.4 (±91.0)	-4.1% (±4.8%)	3,042,525	-2.3(±3.0)
Sweden	328	376	373	375	383	321	374.4 (±19.8)	-46.4 (±19.8)	-12.4% (±4.4%)	701,076	-6.6(±2.8)
Switzerland	287	267	237	289	250	265	266.4 (±15.3)	20.6 (±15.3)	7.7% (±5.8%)	620,849	3.3(±2.5)

Supplementary Table 11: Excess mortality in European countries in the year 2020, ages 40-64.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	9,255	8,875	8,602	8,347	8,582	8,358	8718.4 (±169.7)	536.6 (±169.7)	6.2% (±2.1%)	3,149,418	17.0(±5.4)
Belgium	12,680	12,880	12,151	11,810	11,712	11,364	12233.8 (±450.3)	446.2 (±450.3)	3.6% (±3.6%)	3,823,073	11.7(±11.7)
Bulgaria	19,849	17,125	16,808	16,204	16,293	15,587	16732.2 (±464.3)	3116.8 (±464.3)	18.6% (±3.2%)	2,483,521	125.5(±18.7)
Croatia	6,716	7,224	6,682	6,640	6,689	6,181	6830.4 (±289.8)	-114.4 (±289.8)	-1.7% (±4.0%)	1,411,276	-8.1(±20.5)
Cyprus	717	631	575	636	591	625	622.0 (±21.1)	95.0 (±21.1)	15.3% (±3.8%)	268,729	35.4(±7.8)
Czechia	15,103	15,183	14,242	14,077	13,957	13,573	14502.4 (±469.6)	600.6 (±469.6)	4.1% (±3.2%)	3,754,028	16.0(±12.5)
Denmark	5,570	6,456	6,210	5,873	5,887	5,599	6122.6 (±260.5)	-552.6 (±260.5)	-9.0% (±3.7%)	1,900,863	-29.1(±13.7)
Estonia	2,350	2,344	2,248	2,182	2,178	2,045	2237.0 (±85.7)	113.0 (±85.7)	5.1% (±3.9%)	439,984	25.7(±19.5)
Finland	5,463	6,078	5,743	5,651	5,564	5,064	5740.8 (±287.6)	-277.8 (±287.6)	-4.8% (±4.6%)	1,745,132	-15.9(±16.5)
France	69,811	72,287	69,972	68,790	67,562	65,552	70241.4 (±1983.8)	-430.4 (±1983.8)	-0.6% (±2.7%)	21,517,650	-2.0(±9.2)
Greece	12,182	11,816	11,530	11,637	11,480	11,419	11798.0 (±122.3)	384.0 (±122.3)	3.3% (±1.1%)	3,797,626	10.1(±3.2)
Hungary	22,006	23,851	22,517	21,719	21,973	20,138	22528.4 (±1054.2)	-522.4 (±1054.2)	-2.3% (±4.4%)	3,474,333	-15.0(±30.3)
Iceland	268	233	236	233	254	277	253.0 (±15.0)	15.0 (±15.0)	5.9% (±5.9%)	111,401	13.5(±13.4)
Italy	57,752	53,841	51,123	51,312	50,453	49,508	52326.6 (±1264.3)	5425.4 (±1264.3)	10.4% (±2.6%)	22,244,774	24.4(±5.7)
Latvia	4,543	4,947	4,680	4,688	4,737	4,346	4777.2 (±169.2)	-234.2 (±169.2)	-4.9% (±3.3%)	653,837	-35.8(±25.9)
Lithuania	7,464	7,520	7,158	6,356	6,265	6,197	6854.4 (±470.9)	609.6 (±470.9)	8.9% (±7.0%)	985,469	61.9(±47.7)
Luxembourg	550	482	517	510	515	527	523.8 (±13.2)	26.2 (±13.2)	5.0% (±2.6%)	217,216	12.1(±6.0)
Malta	416	389	374	374	396	357	386.0 (±11.8)	30.0 (±11.8)	7.8% (±3.2%)	160,331	18.7(±7.4)
Netherlands	15,969	16,399	15,905	15,460	15,357	14,892	15913.0 (±448.9)	56.0 (±448.9)	0.4% (±2.8%)	5,858,292	1.0(±7.6)
Norway	3,727	4,062	3,981	3,819	3,803	3,724	3955.4 (±109.0)	-228.4 (±109.0)	-5.8% (±2.5%)	1,734,716	-13.2(±6.3)
Poland	75,954	76,731	72,326	70,737	70,473	67,728	73109.4 (±2596.1)	2844.6 (±2596.1)	3.9% (±3.6%)	12,856,410	22.1(±20.2)
Portugal	12,694	11,809	11,916	11,794	11,758	11,488	12013.8 (±125.0)	680.2 (±125.0)	5.7% (±1.1%)	3,736,038	18.2(±3.4)
Romania	50,397	45,898	45,219	44,143	44,875	43,323	45661.2 (±778.2)	4735.8 (±778.2)	10.4% (±1.9%)	6,858,653	69.0(±11.4)
Slovakia	9,780	10,409	9,769	9,596	9,570	9,001	9849.8 (±395.7)	-69.8 (±395.7)	-0.7% (±3.8%)	1,918,677	-3.6(±20.6)
Slovenia	2,486	2,739	2,565	2,599	2,456	2,301	2564.8 (±128.6)	-78.8 (±128.6)	-3.1% (±4.6%)	756,559	-10.4(±17.0)
Spain	48,530	42,710	41,641	41,697	41,975	41,862	42803.4 (±337.6)	5726.6 (±337.6)	13.4% (±0.9%)	17,787,666	32.2(±1.9)
Sweden	6,581	7,263	6,687	6,606	6,405	6,064	6732.2 (±344.5)	-151.2 (±344.5)	-2.2% (±4.8%)	3,164,608	-4.8(±10.9)
Switzerland	6,187	6,378	6,040	6,087	6,109	5,874	6211.2 (±142.5)	-24.2 (±142.5)	-0.4% (±2.2%)	3,008,509	-0.8(±4.7)

Supplementary Table 12: Excess mortality in European countries in the year 2020, ages 40-64, females.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	3,204	3,178	3,099	2,981	3,031	3,009	3121.2 (±62.1)	82.8 (±62.1)	2.7% (±2.0%)	1,582,710	5.2(±4.0)
Belgium	4,659	4,894	4,532	4,430	4,525	4,388	4645.0 (±156.7)	14.0 (±156.7)	0.3% (±3.3%)	1,903,120	0.7(±8.3)
Bulgaria	6,255	5,295	5,236	5,129	5,090	4,720	5185.2 (±176.0)	1069.8 (±176.0)	20.6% (±3.9%)	1,243,628	86.0(±14.2)
Croatia	2,060	2,172	1,963	2,059	2,003	1,897	2059.6 (±81.5)	0.4 (±81.5)	0.0% (±3.8%)	713,346	0.1(±11.4)
Cyprus	244	227	193	221	222	222	221.8 (±10.7)	22.2 (±10.7)	10.0% (±5.1%)	136,643	16.2(±7.9)
Czechia	4,800	4,887	4,580	4,467	4,488	4,386	4657.6 (±152.5)	142.4 (±152.5)	3.1% (±3.3%)	1,853,549	7.7(±8.2)
Denmark	2,173	2,519	2,444	2,220	2,250	2,121	2364.4 (±129.5)	-191.4 (±129.5)	-8.1% (±4.8%)	949,220	-20.2(±13.7)
Estonia	702	679	620	626	582	583	626.8 (±31.1)	75.2 (±31.1)	12.0% (±5.3%)	225,466	33.4(±13.7)
Finland	1,722	1,938	1,843	1,879	1,840	1,714	1890.0 (±64.3)	-168.0 (±64.3)	-8.9% (±3.0%)	868,038	-19.4(±7.5)
France	23,957	23,920	23,519	23,589	23,401	22,747	23899.2 (±337.3)	57.8 (±337.3)	0.2% (±1.4%)	11,012,229	0.5(±3.1)
Greece	4,036	3,627	3,794	3,797	3,726	3,679	3795.0 (±57.7)	241.0 (±57.7)	6.4% (±1.6%)	1,965,849	12.3(±2.9)
Hungary	7,253	8,123	7,413	7,240	7,212	6,650	7486.0 (±414.9)	-233.0 (±414.9)	-3.1% (±5.1%)	1,772,947	-13.1(±23.4)
Iceland	111	110	107	85	101	107	104.4 (±7.9)	6.6 (±7.9)	6.3% (±7.5%)	54,332	12.1(±14.6)
Italy	21,010	20,143	19,100	19,191	19,001	18,772	19640.6 (±413.6)	1369.4 (±413.6)	7.0% (±2.2%)	11,306,702	12.1(±3.7)
Latvia	1,399	1,504	1,377	1,392	1,406	1,333	1436.8 (±49.4)	-37.8 (±49.4)	-2.6% (±3.3%)	346,973	-10.9(±14.2)
Lithuania	2,128	2,099	1,955	1,842	1,841	1,782	1940.6 (±98.6)	187.4 (±98.6)	9.7% (±5.3%)	519,477	36.1(±19.0)
Luxembourg	171	166	171	195	181	184	183.4 (±8.9)	-12.4 (±8.9)	-6.8% (±4.3%)	105,793	-11.7(±8.4)
Malta	150	133	134	161	153	128	145.0 (±11.2)	5.0 (±11.2)	3.4% (±7.4%)	76,584	6.5(±14.7)
Netherlands	6,605	7,087	6,838	6,612	6,631	6,315	6834.2 (±225.0)	-229.2 (±225.0)	-3.4% (±3.0%)	2,931,284	-7.8(±7.7)
Norway	1,457	1,608	1,552	1,494	1,514	1,458	1550.8 (±45.1)	-93.8 (±45.1)	-6.0% (±2.7%)	848,170	-11.1(±5.4)
Poland	22,178	23,099	21,517	20,973	21,181	20,375	21868.2 (±801.2)	309.8 (±801.2)	1.4% (±3.6%)	6,529,236	4.7(±12.3)
Portugal	3,907	3,623	3,695	3,744	3,643	3,626	3755.0 (±40.9)	152.0 (±40.9)	4.0% (±1.1%)	1,975,105	7.7(±2.1)
Romania	14,662	13,738	13,374	13,023	13,000	12,374	13395.4 (±396.9)	1266.6 (±396.9)	9.5% (±3.2%)	3,423,435	37.0(±11.6)
Slovakia	3,038	3,168	2,922	2,938	2,920	2,692	2972.0 (±132.1)	66.0 (±132.1)	2.2% (±4.3%)	963,841	6.8(±13.8)
Slovenia	781	822	782	847	792	730	801.8 (±34.7)	-20.8 (±34.7)	-2.6% (±4.0%)	367,879	-5.7(±9.5)
Spain	16,349	13,933	13,524	13,950	13,874	14,055	14146.4 (±158.9)	2202.6 (±158.9)	15.6% (±1.3%)	8,934,587	24.7(±1.7)
Sweden	2,574	2,897	2,695	2,701	2,600	2,584	2741.8 (±97.7)	-167.8 (±97.7)	-6.1% (±3.3%)	1,562,095	-10.7(±6.2)
Switzerland	2,260	2,347	2,271	2,185	2,331	2,188	2303.6 (±60.0)	-43.6 (±60.0)	-1.9% (±2.5%)	1,496,087	-2.9(±4.0)

Supplementary Table 13: Excess mortality in European countries in the year 2020, ages 40-64, males.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	6,051	5,697	5,503	5,366	5,551	5,349	5597.2 (±112.2)	453.8 (±112.2)	8.1% (±2.1%)	1,566,708	29.0(±7.1)
Belgium	8,021	7,986	7,619	7,380	7,187	6,976	7588.8 (±306.8)	432.2 (±306.8)	5.7% (±4.1%)	1,919,953	22.5(±16.0)
Bulgaria	13,594	11,830	11,572	11,075	11,203	10,867	11547.0 (±304.2)	2047.0 (±304.2)	17.7% (±3.0%)	1,239,893	165.1(±24.5)
Croatia	4,656	5,052	4,719	4,581	4,686	4,284	4770.8 (±216.6)	-114.8 (±216.6)	-2.4% (±4.2%)	697,930	-16.4(±31.0)
Cyprus	473	404	382	415	369	403	400.2 (±14.6)	72.8 (±14.6)	18.2% (±4.2%)	132,086	55.1(±11.1)
Czechia	10,303	10,296	9,662	9,610	9,469	9,187	9844.8 (±319.9)	458.2 (±319.9)	4.7% (±3.3%)	1,900,479	24.1(±16.8)
Denmark	3,397	3,937	3,766	3,653	3,637	3,478	3758.2 (±133.4)	-361.2 (±133.4)	-9.6% (±3.1%)	951,643	-38.0(±14.1)
Estonia	1,648	1,665	1,628	1,556	1,596	1,462	1610.2 (±61.1)	37.8 (±61.1)	2.3% (±3.7%)	214,518	17.6(±28.5)
Finland	3,741	4,140	3,900	3,772	3,724	3,350	3850.8 (±225.9)	-109.8 (±225.9)	-2.9% (±5.3%)	877,094	-12.5(±25.7)
France	45,854	48,367	46,453	45,201	44,161	42,805	46342.2 (±1673.3)	-488.2 (±1673.3)	-1.1% (±3.4%)	10,505,421	-4.6(±15.9)
Greece	8,146	8,189	7,736	7,840	7,754	7,740	8003.0 (±151.5)	143.0 (±151.5)	1.8% (±1.9%)	1,831,777	7.8(±8.3)
Hungary	14,753	15,728	15,104	14,479	14,761	13,488	15042.4 (±649.0)	-289.4 (±649.0)	-1.9% (±4.1%)	1,701,386	-17.0(±38.1)
Iceland	157	123	129	148	153	170	148.6 (±14.9)	8.4 (±14.9)	5.7% (±9.7%)	57,069	14.7(±26.1)
Italy	36,742	33,698	32,023	32,121	31,452	30,736	32686.0 (±858.5)	4056.0 (±858.5)	12.4% (±2.9%)	10,938,072	37.1(±7.8)
Latvia	3,144	3,443	3,303	3,296	3,331	3,013	3340.4 (±124.7)	-196.4 (±124.7)	-5.9% (±3.4%)	306,864	-64.0(±40.6)
Lithuania	5,336	5,421	5,203	4,514	4,424	4,415	4913.8 (±375.9)	422.2 (±375.9)	8.6% (±7.7%)	465,992	90.6(±80.7)
Luxembourg	379	316	346	315	334	343	340.4 (±11.5)	38.6 (±11.5)	11.3% (±3.6%)	111,423	34.6(±10.4)
Malta	266	256	240	213	243	229	241.0 (±12.6)	25.0 (±12.6)	10.4% (±5.5%)	83,747	29.9(±15.0)
Netherlands	9,364	9,312	9,067	8,848	8,726	8,577	9078.8 (±226.8)	285.2 (±226.8)	3.1% (±2.5%)	2,927,008	9.7(±7.8)
Norway	2,270	2,454	2,429	2,325	2,289	2,266	2404.6 (±66.1)	-134.6 (±66.1)	-5.6% (±2.5%)	886,546	-15.2(±7.5)
Poland	53,776	53,632	50,809	49,764	49,292	47,353	51241.2 (±1807.7)	2534.8 (±1807.7)	4.9% (±3.5%)	6,327,174	40.1(±28.5)
Portugal	8,787	8,186	8,221	8,050	8,115	7,862	8258.8 (±111.2)	528.2 (±111.2)	6.4% (±1.4%)	1,760,933	30.0(±6.3)
Romania	35,735	32,160	31,845	31,120	31,875	30,949	32265.8 (±411.7)	3469.2 (±411.7)	10.8% (±1.4%)	3,435,218	101.0(±12.0)
Slovakia	6,742	7,241	6,847	6,658	6,650	6,309	6877.8 (±266.7)	-135.8 (±266.7)	-2.0% (±3.6%)	954,836	-14.2(±27.9)
Slovenia	1,705	1,917	1,783	1,752	1,664	1,571	1763.0 (±101.9)	-58.0 (±101.9)	-3.3% (±5.3%)	388,680	-14.9(±26.2)
Spain	32,187	28,777	28,117	27,747	28,101	27,807	28657.0 (±320.6)	3530.0 (±320.6)	12.3% (±1.2%)	8,853,079	39.9(±3.6)
Sweden	4,007	4,366	3,992	3,905	3,805	3,480	3990.4 (±251.2)	16.6 (±251.2)	0.4% (±5.9%)	1,602,513	1.0(±15.7)
Switzerland	3,927	4,031	3,769	3,902	3,778	3,686	3907.6 (±105.7)	19.4 (±105.7)	0.5% (±2.7%)	1,512,422	1.3(±7.0)

Supplementary Table 14: Excess mortality in European countries in the year 2020, ages 65-69.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	4,578	4,557	4,572	4,222	4,233	4,229	4447.4 (±144.6)	130.6 (±144.6)	2.9% (±3.2%)	450,381	29.0(±32.1)
Belgium	7,194	6,419	6,294	6,183	6,207	6,061	6344.8 (±104.5)	849.2 (±104.5)	13.4% (±1.9%)	623,529	136.2(±16.8)
Bulgaria	11,004	9,351	9,133	9,067	9,021	8,746	9223.6 (±170.9)	1780.4 (±170.9)	19.3% (±2.2%)	463,819	383.9(±36.8)
Croatia	4,428	3,568	3,705	3,764	3,822	3,643	3770.8 (±78.1)	657.2 (±78.1)	17.4% (±2.4%)	267,320	245.8(±29.3)
Cyprus	344	357	300	338	347	340	343.6 (±17.0)	0.4 (±17.0)	0.1% (±4.7%)	44,929	0.9(±37.8)
Czechia	10,365	9,940	9,659	9,324	9,464	9,062	9671.4 (±260.8)	693.6 (±260.8)	7.2% (±2.8%)	678,927	102.2(±38.4)
Denmark	3,530	3,880	3,673	3,408	3,526	3,514	3667.4 (±143.2)	-137.4 (±143.2)	-3.7% (±3.7%)	319,275	-43.0(±44.8)
Estonia	1,210	1,053	1,099	1,090	1,166	1,087	1117.4 (±32.4)	92.6 (±32.4)	8.3% (±3.1%)	77,501	119.5(±41.8)
Finland	3,375	4,007	3,754	3,695	3,545	3,427	3745.6 (±172.9)	-370.6 (±172.9)	-9.9% (±4.0%)	356,960	-103.8(±48.4)
France	36,651	34,891	34,541	34,228	34,247	33,588	34943.8 (±376.5)	1707.2 (±376.5)	4.9% (±1.1%)	3,902,936	43.7(±9.7)
Greece	6,567	6,268	5,777	5,799	5,710	5,710	5973.6 (±184.6)	593.4 (±184.6)	9.9% (±3.3%)	609,002	97.4(±30.3)
Hungary	14,151	10,655	11,081	11,228	11,746	11,699	11483.4 (±356.2)	2667.6 (±356.2)	23.2% (±3.7%)	643,679	414.4(±55.4)
Iceland	142	130	124	125	110	131	126.4 (±6.6)	15.6 (±6.6)	12.3% (±5.5%)	16,981	91.9(±38.8)
Italy	32,445	31,345	30,273	28,973	27,696	26,478	29591.4 (±1526.8)	2853.6 (±1526.8)	9.6% (±5.3%)	3,471,014	82.2(±44.0)
Latvia	2,088	1,951	2,016	2,076	2,131	1,925	2060.6 (±67.1)	27.4 (±67.1)	1.3% (±3.2%)	109,804	25.0(±61.1)
Lithuania	3,133	2,879	2,704	2,632	2,669	2,686	2769.2 (±75.3)	363.8 (±75.3)	13.1% (±3.0%)	154,540	235.4(±48.7)
Luxembourg	276	237	245	314	249	235	259.2 (±25.8)	16.8 (±25.8)	6.5% (±9.7%)	27,510	61.1(±93.8)
Malta	234	276	245	235	241	233	254.8 (±13.7)	-20.8 (±13.7)	-8.2% (±4.6%)	28,443	-73.1(±48.1)
Netherlands	9,712	10,178	9,452	8,936	8,889	8,739	9422.8 (±462.4)	289.2 (±462.4)	3.1% (±4.9%)	996,048	29.0(±46.5)
Norway	2,271	2,454	2,429	2,338	2,246	2,150	2373.8 (±99.6)	-102.8 (±99.6)	-4.3% (±3.9%)	275,272	-37.3(±36.1)
Poland	47,147	34,070	34,901	36,046	37,949	38,517	36977.4 (±1499.3)	10169.6 (±1499.3)	27.5% (±5.0%)	2,447,824	415.5(±61.2)
Portugal	6,230	5,353	5,624	5,477	5,442	5,516	5594.4 (±78.0)	635.6 (±78.0)	11.4% (±1.6%)	622,912	102.0(±12.6)
Romania	28,097	19,570	20,261	20,939	22,355	21,789	21405.2 (±881.1)	6691.8 (±881.1)	31.3% (±5.2%)	1,201,894	556.8(±73.3)
Slovakia	5,756	4,381	4,683	4,598	4,988	4,880	4790.0 (±187.1)	966.0 (±187.1)	20.2% (±4.6%)	329,405	293.3(±56.8)
Slovenia	1,593	1,239	1,265	1,266	1,457	1,457	1361.6 (±86.4)	231.4 (±86.4)	17.0% (±7.0%)	134,197	172.4(±64.4)
Spain	23,482	19,480	19,195	19,424	19,108	18,894	19587.4 (±187.5)	3894.6 (±187.5)	19.9% (±1.2%)	2,431,759	160.2(±7.7)
Sweden	4,451	5,242	4,758	4,478	4,507	4,099	4724.0 (±330.4)	-273.0 (±330.4)	-5.8% (±6.1%)	540,048	-50.6(±61.2)
Switzerland	3,254	3,438	3,277	3,122	3,137	3,021	3263.8 (±126.8)	-9.8 (±126.8)	-0.3% (±3.7%)	430,612	-2.3(±29.5)

Supplementary Table 15: Excess mortality in European countries in the year 2020, ages 65-69, females.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	1,689	1,703	1,701	1,593	1,577	1,623	1663.4 (±46.6)	25.6 (±46.6)	1.5% (±2.7%)	237,161	10.8 (±19.6)
Belgium	2,625	2,379	2,267	2,261	2,325	2,332	2348.0 (±38.6)	277.0 (±38.6)	11.8% (±1.8%)	321,281	86.2 (±12.0)
Bulgaria	3,975	3,292	3,154	3,218	3,186	3,101	3240.6 (±56.0)	734.4 (±56.0)	22.7% (±2.1%)	258,560	284.0 (±21.7)
Croatia	1,466	1,195	1,285	1,314	1,272	1,176	1269.2 (±46.9)	196.8 (±46.9)	15.5% (±4.1%)	142,394	138.2 (±32.9)
Cyprus	120	133	114	117	119	119	123.6 (±5.8)	-3.6 (±5.8)	-2.9% (±4.4%)	23,116	-15.6 (±25.1)
Czechia	3,539	3,556	3,399	3,319	3,318	3,109	3401.8 (±126.7)	137.2 (±126.7)	4.0% (±3.7%)	363,248	37.8 (±34.9)
Denmark	1,385	1,566	1,478	1,319	1,421	1,400	1462.4 (±72.1)	-77.4 (±72.1)	-5.3% (±4.4%)	163,541	-47.3 (±44.1)
Estonia	403	358	372	370	443	335	379.6 (±31.7)	23.4 (±31.7)	6.2% (±8.2%)	45,393	51.5 (±69.9)
Finland	1,224	1,411	1,240	1,295	1,237	1,228	1307.0 (±60.1)	-83.0 (±60.1)	-6.4% (±4.1%)	185,685	-44.7 (±32.4)
France	12,617	11,547	11,628	11,572	11,689	11,608	11827.2 (±42.9)	789.8 (±42.9)	6.7% (±0.4%)	2,067,425	38.2 (±2.1)
Greece	2,204	2,045	1,920	1,913	1,910	1,836	1958.4 (±59.1)	245.6 (±59.1)	12.5% (±3.3%)	323,057	76.0 (±18.3)
Hungary	5,359	4,130	4,062	4,286	4,414	4,421	4344.2 (±127.9)	1014.8 (±127.9)	23.4% (±3.6%)	366,614	276.8 (±34.9)
Iceland	56	52	51	45	41	44	46.6 (±3.7)	9.4 (±3.7)	20.2% (±8.9%)	8,431	111.5 (±43.9)
Italy	11,505	11,506	11,179	10,875	10,296	9,861	10983.4 (±521.1)	521.6 (±521.1)	4.7% (±4.7%)	1,818,274	28.7 (±28.6)
Latvia	720	722	726	771	810	679	755.2 (±39.4)	-35.2 (±39.4)	-4.7% (±4.7%)	65,922	-53.4 (±59.8)
Lithuania	1,055	1,001	970	942	932	934	974.2 (±23.1)	80.8 (±23.1)	8.3% (±2.5%)	92,402	87.4 (±25.0)
Luxembourg	108	101	84	104	89	85	93.4 (±7.3)	14.6 (±7.3)	15.6% (±8.4%)	13,913	104.9 (±52.5)
Malta	87	111	104	82	83	80	95.2 (±11.3)	-8.2 (±11.3)	-8.6% (±9.7%)	14,406	-56.9 (±78.4)
Netherlands	3,967	4,120	3,871	3,626	3,580	3,595	3833.6 (±183.6)	133.4 (±183.6)	3.5% (±4.7%)	502,794	26.5 (±36.5)
Norway	897	951	969	932	910	855	941.0 (±34.5)	-44.0 (±34.5)	-4.7% (±3.3%)	138,228	-31.8 (±24.9)
Poland	16,084	12,019	12,246	12,834	13,235	13,509	12997.4 (±496.6)	3086.6 (±496.6)	23.7% (±4.5%)	1,352,561	228.2 (±36.7)
Portugal	2,082	1,829	1,894	1,848	1,782	1,792	1863.4 (±35.4)	218.6 (±35.4)	11.7% (±2.1%)	337,447	64.8 (±10.5)
Romania	9,792	7,001	7,444	7,489	7,890	7,618	7634.0 (±253.3)	2158.0 (±253.3)	28.3% (±4.2%)	670,155	322.0 (±37.8)
Slovakia	2,003	1,546	1,680	1,625	1,751	1,681	1687.8 (±59.8)	315.2 (±59.8)	18.7% (±4.1%)	181,339	173.8 (±33.0)
Slovenia	487	441	403	419	497	471	458.2 (±29.9)	28.8 (±29.9)	6.3% (±6.5%)	68,823	41.8 (±43.5)
Spain	7,597	5,988	6,069	6,115	6,051	6,112	6192.6 (±40.8)	1404.4 (±40.8)	22.7% (±0.8%)	1,271,580	110.4 (±3.3)
Sweden	1,758	2,152	1,928	1,894	1,859	1,678	1943.8 (±133.1)	-185.8 (±133.1)	-9.6% (±5.8%)	272,942	-68.1 (±48.8)
Switzerland	1,172	1,301	1,244	1,206	1,194	1,149	1246.8 (±44.8)	-74.8 (±44.8)	-6.0% (±3.3%)	222,768	-33.6 (±20.1)

Supplementary Table 16: Excess mortality in European countries in the year 2020, ages 65-69, males.

Country	mortality										Excess mortality per 10 ⁵
	2020	2015	2016	2017	2018	2019	Mean Mortality	Excess Mortality	P-score	Population	
Austria	2,889	2,854	2,871	2,629	2,656	2,606	2784.0 (±100.8)	105.0 (±100.8)	3.8% (±3.7%)	213,220	49.2(±47.3)
Belgium	4,569	4,040	4,027	3,922	3,882	3,729	3996.8 (±99.0)	572.2 (±99.0)	14.3% (±2.7%)	302,248	189.3(±32.8)
Bulgaria	7,029	6,059	5,979	5,849	5,835	5,645	5983.0 (±123.9)	1046.0 (±123.9)	17.5% (±2.4%)	205,259	509.6(±60.4)
Croatia	2,962	2,373	2,420	2,450	2,550	2,467	2501.6 (±51.3)	460.4 (±51.3)	18.4% (±2.4%)	124,926	368.5(±41.1)
Cyprus	224	224	186	221	228	221	220.0 (±13.3)	4.0 (±13.3)	1.8% (±5.8%)	21,813	18.3(±61.0)
Czechia	6,826	6,384	6,260	6,005	6,146	5,953	6269.6 (±139.5)	556.4 (±139.5)	8.9% (±2.4%)	315,679	176.3(±44.1)
Denmark	2,145	2,314	2,195	2,089	2,105	2,114	2205.0 (±73.4)	-60.0 (±73.4)	-2.7% (±3.2%)	155,734	-38.5(±47.1)
Estonia	807	695	727	720	723	752	737.8 (±16.0)	69.2 (±16.0)	9.4% (±2.3%)	32,108	215.5(±49.9)
Finland	2,151	2,596	2,514	2,400	2,308	2,199	2438.6 (±124.1)	-287.6 (±124.1)	-11.8% (±4.3%)	171,275	-167.9(±72.4)
France	24,034	23,344	22,913	22,656	22,558	21,980	23116.6 (±392.0)	917.4 (±392.0)	4.0% (±1.8%)	1,835,511	50.0(±21.3)
Greece	4,363	4,223	3,857	3,886	3,800	3,874	4015.2 (±131.8)	347.8 (±131.8)	8.7% (±3.5%)	285,945	121.6(±46.1)
Hungary	8,792	6,525	7,019	6,942	7,332	7,278	7139.2 (±252.5)	1652.8 (±252.5)	23.2% (±4.3%)	277,065	596.5(±91.2)
Iceland	86	78	73	80	69	87	79.8 (±5.4)	6.2 (±5.4)	7.8% (±6.9%)	8,550	72.5(±63.2)
Italy	20,940	19,839	19,094	18,098	17,400	16,617	18608.0 (±1010.2)	2332.0 (±1010.2)	12.5% (±5.8%)	1,652,740	141.1(±61.1)
Latvia	1,368	1,229	1,290	1,305	1,321	1,246	1305.4 (±30.8)	62.6 (±30.8)	4.8% (±2.4%)	43,882	142.7(±70.1)
Lithuania	2,078	1,878	1,734	1,690	1,737	1,752	1795.0 (±55.6)	283.0 (±55.6)	15.8% (±3.5%)	62,138	455.4(±89.5)
Luxembourg	168	136	161	210	160	150	165.8 (±21.9)	2.2 (±21.9)	1.3% (±11.8%)	13,597	16.2(±161.0)
Malta	147	165	141	153	158	153	159.6 (±6.8)	-12.6 (±6.8)	-7.9% (±3.8%)	14,037	-89.8(±48.5)
Netherlands	5,745	6,058	5,581	5,310	5,309	5,144	5589.2 (±281.4)	155.8 (±281.4)	2.8% (±4.9%)	493,254	31.6(±57.0)
Norway	1,374	1,503	1,460	1,406	1,336	1,295	1432.8 (±67.1)	-58.8 (±67.1)	-4.1% (±4.3%)	137,044	-42.9(±49.0)
Poland	31,063	22,051	22,655	23,212	24,714	25,008	23980.0 (±1010.1)	7083.0 (±1010.1)	29.5% (±5.2%)	1,095,263	646.7(±92.2)
Portugal	4,148	3,524	3,730	3,629	3,660	3,724	3731.0 (±65.8)	417.0 (±65.8)	11.2% (±2.0%)	285,465	146.1(±23.0)
Romania	18,305	12,569	12,817	13,450	14,465	14,171	13771.2 (±646.2)	4533.8 (±646.2)	32.9% (±5.9%)	531,739	852.6(±121.6)
Slovakia	3,753	2,835	3,003	2,973	3,237	3,199	3102.2 (±131.0)	650.8 (±131.0)	21.0% (±4.9%)	148,066	439.5(±88.5)
Slovenia	1,106	798	862	847	960	986	903.4 (±62.2)	202.6 (±62.2)	22.4% (±7.9%)	65,374	309.9(±95.2)
Spain	15,883	13,492	13,126	13,309	13,057	12,782	13394.8 (±209.9)	2488.2 (±209.9)	18.6% (±1.9%)	1,160,179	214.5(±18.1)
Sweden	2,693	3,090	2,830	2,584	2,648	2,421	2780.2 (±200.6)	-87.2 (±200.6)	-3.1% (±6.6%)	267,106	-32.6(±75.1)
Switzerland	2,082	2,137	2,033	1,916	1,943	1,872	2017.0 (±82.7)	65.0 (±82.7)	3.2% (±4.0%)	207,844	31.3(±39.8)

Supplementary Table 17: Excess mortality and official COVID-attributed deaths in Bulgarian regions for the year 2020.

region	mortality										COVID deaths	excess/official	pos. cases	CFR
	2020	2015	2016	2017	2018	2019	excess deaths	P-score	deaths					
Blagoevgrad	4,217	3,339	3,174	3,189	3,247	3,201	917.4 (± 52.3)	27.8% ($\pm 2.0\%$)	342	2.7 \pm (0.1)	10,291	3.3		
Burgas	5,261	4,539	4,424	4,483	4,439	4,580	682.4 (± 51.8)	14.9% ($\pm 1.3\%$)	300	2.3 \pm (0.1)	11,263	2.7		
Dobrich	2,765	2,479	2,272	2,365	2,357	2,281	359.0 (± 65.3)	14.9% ($\pm 3.0\%$)	183	2.0 \pm (0.3)	3,526	5.2		
Gabrovo	2,154	1,862	1,768	1,812	1,729	1,679	347.2 (± 55.7)	19.2% ($\pm 3.5\%$)	147	2.4 \pm (0.3)	4,105	3.6		
Haskovo	3,712	3,282	3,116	3,076	3,016	2,974	552.0 (± 93.3)	17.5% ($\pm 3.4\%$)	231	2.4 \pm (0.4)	3,922	5.9		
Kardzhali	1,924	1,546	1,537	1,532	1,535	1,527	358.2 (± 5.5)	22.9% ($\pm 0.5\%$)	88	4.1 \pm (0.0)	1,841	4.8		
Kyustendil	2,405	1,999	2,029	1,974	1,922	1,896	409.0 (± 42.9)	20.5% ($\pm 2.5\%$)	181	2.3 \pm (0.2)	4,473	4		
Lovech	2,321	2,105	2,070	2,057	2,000	2,042	225.4 (± 30.2)	10.8% ($\pm 1.6\%$)	123	1.8 \pm (0.3)	2,264	5.4		
Montana	2,719	2,429	2,345	2,168	2,265	2,213	395.8 (± 81.9)	17.0% ($\pm 3.9\%$)	194	2.0 \pm (0.5)	3,042	6.4		
Pazardzhik	4,136	3,326	3,178	3,204	3,100	3,141	887.8 (± 67.1)	27.3% ($\pm 2.5\%$)	353	2.5 \pm (0.2)	5,287	6.7		
Pernik	2,342	2,003	1,870	1,912	1,896	1,903	383.6 (± 39.7)	19.6% ($\pm 2.4\%$)	146	2.6 \pm (0.3)	3,687	4		
Pleven	4,335	3,892	3,723	3,584	3,674	3,675	560.6 (± 89.1)	14.9% ($\pm 2.7\%$)	260	2.2 \pm (0.3)	5,469	4.8		
Plovdiv	9,905	8,132	7,939	7,654	7,884	7,708	1,882.4 (± 149.9)	23.5% ($\pm 2.3\%$)	793	2.4 \pm (0.2)	18,791	4.2		
Razgrad	2,021	1,580	1,519	1,510	1,564	1,489	464.6 (± 29.9)	29.9% ($\pm 2.5\%$)	173	2.7 \pm (0.2)	2,135	8.1		
Ruse	3,728	3,111	3,002	2,810	3,056	2,938	687.0 (± 91.1)	22.6% ($\pm 3.6\%$)	371	1.9 \pm (0.2)	7,267	5.1		
Shumen	2,691	2,266	2,073	2,087	2,231	2,085	503.4 (± 72.4)	23.0% ($\pm 3.9\%$)	228	2.2 \pm (0.3)	4,246	5.4		
Silistra	1,985	1,663	1,441	1,487	1,590	1,523	409.8 (± 68.5)	26.0% ($\pm 5.2\%$)	138	3.0 \pm (0.5)	2,410	5.7		
Sliven	2,798	2,380	2,269	2,237	2,336	2,195	474.6 (± 58.5)	20.4% ($\pm 2.9\%$)	233	2.0 \pm (0.3)	5,107	4.6		
Smolyan	1,794	1,346	1,341	1,396	1,358	1,307	424.4 (± 25.2)	31.0% ($\pm 2.4\%$)	184	2.3 \pm (0.1)	2,061	8.9		
Sofia	4,178	3,458	3,456	3,419	3,399	3,308	700.4 (± 48.0)	20.1% ($\pm 1.6\%$)	288	2.4 \pm (0.2)	5,698	5.1		
Sofia (city)	15,129	12,899	12,605	12,183	12,459	12,476	2,352.6 (± 203.7)	18.4% ($\pm 1.8\%$)	917	2.6 \pm (0.2)	54,185	1.7		
Stara Zagora	5,046	4,332	4,148	4,185	4,242	4,079	767.2 (± 75.1)	17.9% ($\pm 2.0\%$)	270	2.8 \pm (0.3)	8,996	3		
Targovishte	1,843	1,549	1,513	1,477	1,466	1,460	318.8 (± 29.4)	20.9% ($\pm 2.3\%$)	158	2.0 \pm (0.2)	2,196	7.2		
Varna	5,892	4,985	4,947	4,832	4,946	4,683	905.4 (± 96.8)	18.2% ($\pm 2.3\%$)	508	1.8 \pm (0.2)	15,136	3.4		
Veliko Tarnovo	3,827	3,357	3,293	3,329	3,267	3,226	467.0 (± 40.2)	13.9% ($\pm 1.3\%$)	277	1.7 \pm (0.1)	4,427	6.3		
Vidin	1,933	1,730	1,652	1,539	1,596	1,568	286.4 (± 59.3)	17.4% ($\pm 4.1\%$)	121	2.4 \pm (0.5)	1,519	8		
Vratsa	3,001	2,756	2,582	2,620	2,572	2,499	345.6 (± 74.2)	13.0% ($\pm 3.1\%$)	173	2.0 \pm (0.4)	4,351	4		
Yambol	2,052	1,936	1,696	1,678	1,781	1,677	262.4 (± 86.7)	14.7% ($\pm 5.3\%$)	131	2.0 \pm (0.7)	3,525	3.7		