



# Effects of covid-19 pandemic on life expectancy and premature mortality in 2020: time series analysis in 37 countries

Nazrul Islam,<sup>1</sup> Dmitri A Jdanov,<sup>2,3</sup> Vladimir M Shkolnikov,<sup>2,3</sup> Kamlesh Khunti,<sup>4,5</sup> Ichiro Kawachi,<sup>6</sup> Martin White,<sup>7</sup> Sarah Lewington,<sup>1,8</sup> Ben Lacey<sup>1</sup>

For numbered affiliations see end of the article

Correspondence to: N Islam nazrul.islam@ndph.ox.ac.uk (ORCID 0000-0003-3982-4325)

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## ABSTRACT OBJECTIVE

To estimate the changes in life expectancy and years of life lost in 2020 associated with the covid-19 pandemic.

## DESIGN

Time series analysis.

## SETTING

37 upper-middle and high income countries or regions with reliable and complete mortality data.

## PARTICIPANTS

Annual all cause mortality data from the Human Mortality Database for 2005-20, harmonised and disaggregated by age and sex.

## MAIN OUTCOME MEASURES

Reduction in life expectancy was estimated as the difference between observed and expected life expectancy in 2020 using the Lee-Carter model. Excess years of life lost were estimated as the difference between the observed and expected years of life lost in 2020 using the World Health Organization standard life table.

## RESULTS

Reduction in life expectancy in men and women was observed in all the countries studied except New Zealand, Taiwan, and Norway, where there was a gain in life expectancy in 2020. No evidence was found of

a change in life expectancy in Denmark, Iceland, and South Korea. The highest reduction in life expectancy was observed in Russia (men: -2.33, 95% confidence interval -2.50 to -2.17; women: -2.14, -2.25 to -2.03), the United States (men: -2.27, -2.39 to -2.15; women: -1.61, -1.70 to -1.51), Bulgaria (men: -1.96, -2.11 to -1.81; women: -1.37, -1.74 to -1.01), Lithuania (men: -1.83, -2.07 to -1.59; women: -1.21, -1.36 to -1.05), Chile (men: -1.64, -1.97 to -1.32; women: -0.88, -1.28 to -0.50), and Spain (men: -1.35, -1.53 to -1.18; women: -1.13, -1.37 to -0.90). Years of life lost in 2020 were higher than expected in all countries except Taiwan, New Zealand, Norway, Iceland, Denmark, and South Korea. In the remaining 31 countries, more than 222 million years of life were lost in 2020, which is 28.1 million (95% confidence interval 26.8m to 29.5m) years of life lost more than expected (17.3 million (16.8m to 17.8m) in men and 10.8 million (10.4m to 11.3m) in women). The highest excess years of life lost per 100 000 population were observed in Bulgaria (men: 7260, 95% confidence interval 6820 to 7710; women: 3730, 2740 to 4730), Russia (men: 7020, 6550 to 7480; women: 4760, 4530 to 4990), Lithuania (men: 5430, 4750 to 6070; women: 2640, 2310 to 2980), the US (men: 4350, 4170 to 4530; women: 2430, 2320 to 2550), Poland (men: 3830, 3540 to 4120; women: 1830, 1630 to 2040), and Hungary (men: 2770, 2490 to 3040; women: 1920, 1590 to 2240). The excess years of life lost were relatively low in people younger than 65 years, except in Russia, Bulgaria, Lithuania, and the US where the excess years of life lost was >2000 per 100 000.

## CONCLUSION

More than 28 million excess years of life were lost in 2020 in 31 countries, with a higher rate in men than women. Excess years of life lost associated with the covid-19 pandemic in 2020 were more than five times higher than those associated with the seasonal influenza epidemic in 2015.

## Introduction

Since the emergence of SARS-CoV-2, health policy measures employed to minimise the impact of the covid-19 pandemic have varied substantially across countries and jurisdictions.<sup>1-7</sup> These policy measures have affected many social and economic determinants of health,<sup>8-11</sup> including accessibility to healthcare services.<sup>12-15</sup> The overall impact of the pandemic and its associated policy measures therefore have implications for mortality beyond deaths with covid-19—the accuracy and completeness of which has been questioned in many countries and jurisdictions.<sup>2 16</sup>

## WHAT IS ALREADY KNOWN ON THIS TOPIC

Reported numbers of deaths with covid-19 are subject to changes within and across countries as well as some degrees of delays, inaccuracy, and incompleteness

Excess deaths (difference between observed and expected numbers of deaths from all causes) allows the assessment of the full impact of the pandemic, including the direct effect on deaths with covid-19, and the indirect effect of the pandemic on deaths from other diseases

Estimation of excess deaths does not, however, consider the age at death, and therefore does not quantify the impact of the pandemic on premature deaths as years of life lost (YLL)

## WHAT THIS STUDY ADDS

In 2020, life expectancy was lower and YLL higher than expected in all countries except New Zealand, Taiwan, Iceland, South Korea, Denmark, and Norway—in the remaining 31 countries, >28 million excess years of life were lost

Highest reduction in life expectancy in 2020 was observed in Russia (men, -2.33 years; women, -2.14), the US (men, -2.27; women, -1.61), Bulgaria (men -1.96; women, -1.37), Lithuania (men, -1.83; women, -1.21), Chile (men, -1.64; women, -0.88), and Spain (men, -1.35; women, -1.13)

Excess YLL rates associated with the covid-19 pandemic in 2020 were more than five times higher than those associated with the seasonal influenza epidemic in 2015

Data on all cause mortality are considered more reliable indicators of the impact of the covid-19 pandemic because they are less sensitive to coding errors, competing risks, and the potential for misclassification in designating the cause of deaths, and as such enable comparisons between countries.<sup>17-21</sup> We have previously reported a large difference between reported deaths with covid-19 and estimated excess deaths associated with the covid-19 pandemic in 2020.<sup>22</sup> Previous studies have used historical baseline mortality data over the recent past to estimate the expected number of deaths in 2020 and provide the basis for estimating excess deaths (observed minus expected deaths), which capture both the direct (deaths with covid-19) and the indirect (deaths from other causes) effects of the pandemic and associated policy measures.<sup>18-22</sup> Although using excess deaths has been considered the ideal method for measuring the impact of the pandemic,<sup>15</sup> this metric does not take into account age at death. When people die at an older age, they lose fewer years of remaining life.<sup>23-24</sup> Analysis of life expectancy and years of life lost (YLL) provide a more nuanced estimation of premature mortality at population level. Life expectancy, a widely used metric of mortality, is an indication of how long on average people can expect to survive if the age specific mortality rates of that year remain constant for the remainder of their life.<sup>25-26</sup> YLL takes into account the age distributions of mortality by giving greater weights to deaths that occur at younger ages.<sup>24</sup> An important difference exists between life expectancy and YLL. Whereas life expectancy is a standardised measure based on a hypothetical life table cohort, YLL is calculated from the numbers of deaths observed in real populations. Therefore, life expectancy depends solely on mortality, and YLL (even after dividing by population size) depends on both the mortality and the age structure of the population.

Previous studies have reported the effects of the pandemic on reduction in life expectancy in the United States,<sup>27-28</sup> England and Wales,<sup>29</sup> and Spain,<sup>26</sup> largely based on partial data in 2020. Earlier studies have reported the YLL based on deaths with covid-19 only.<sup>23-30-32</sup> This method has several limitations because deaths with covid-19 were reported to have varying degrees of accuracy and incompleteness<sup>2-16</sup>; covid-19 mortality data are often not disaggregated by age and sex, which are required for the calculation of YLL<sup>2</sup>; and the impact of the pandemic and its associated policy measures on deaths from other causes are not captured.<sup>15-22</sup> A recent study by Aburto and colleagues examined changes in life expectancy between 2019 and 2020 in 29 developed countries and provided important information on differences between countries, including the best and the worst performers.<sup>33</sup> However, this study was based on preliminary death statistics for reported countries and did not include data from Canada, Israel, Latvia, Luxembourg, New Zealand, Russia, South Korea, and Taiwan. The study did not report on the change in YLL either.

Most earlier studies compared life expectancy or YLL in 2020 with that in 2019 or an average of the most recent few years, which might lead to incorrect conclusions (see supplementary file).

In this study, we report the changes in life expectancy at birth and excess YLL from all causes in 2020 by comparing the observed life expectancy and YLL in 2020 with those that would be expected based on historical trends in 2005-19 in 37 high income countries.

## Methods

### Study design and eligibility

This study is a time series analysis of annual data on all cause mortality obtained from 37 upper-middle and high income countries with reliable, valid, and complete mortality data between 2005 and 2020 disaggregated by age and sex.

### Source of data

We obtained data from the Human Mortality Database, in which mortality and population data from authoritative national agencies are collated and standardised. The database is maintained by the Department of Demography at the University of California, Berkeley, US and the Max Planck Institute for Demographic Research, Rostock, Germany.<sup>34-35</sup> Mortality data for 2020 were obtained from the Short-term Mortality Fluctuations data series (a new extension of the Human Mortality Database).<sup>36</sup> For the purposes of this study, we required annual mortality data to be disaggregated by age groups (<1, 1-4, 5-9, . . . 90-95, and ≥100) and sex.

Data for 2020 were available for 37 countries: Austria, Belgium, Bulgaria, Canada, Chile, Croatia, Czech Republic, Denmark, England and Wales, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, New Zealand, Northern Ireland, Norway, Poland, Portugal, Russia, Scotland, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, and the US. Details on the source and the methodology for collection and standardisation of data from each of these countries or regions have been published previously.<sup>36-38</sup> In many countries, age groups originally available in Short-term Mortality Fluctuations data differed somewhat from the required granular age scale in this study. In six countries (Canada, Israel, Germany, New Zealand, South Korea, and the US) Short-term Mortality Fluctuations data included relatively coarse age groups (see supplementary file).

### Statistical analysis

#### *Calculation of life expectancy and YLL in 2020 and 2015*

Whenever possible, we used annual estimates from the Human Mortality Database based on official data (see supplementary file). Using the available data series in the Human Mortality Database starting from 2005, we employed the Lee-Carter model<sup>39</sup> to extrapolate

annual death rates, which consequently serve as the input to estimate age specific population exposures and expected death counts under the assumption of zero migration. Expected age specific death rates were predicted separately for men and women. We obtained expected death counts and population exposures for both men and women by summing the data for each. We used the forecasted population exposures and observed death counts from the Short-term Mortality Fluctuations data series to calculate observed death rates for countries where annual estimates for 2020 were not available from the Human Mortality Database.

Before calculating observed age specific death rates, we standardised the death counts from Short-term Mortality Fluctuations according to the International Organization for Standardization 8601-2004 guidelines<sup>36</sup> and adjusted for incomplete weekly death statistics in 2020. The age and sex specific adjustment coefficients for incompleteness were calculated using the average annual ratio of the Short-term Mortality Fluctuations data (ie, sum of weekly death counts) to annual death counts during the past five years.

In the absence of detailed mortality data by granular age groups, especially at young ages (eg, <1, 1-4 years) and old ages (eg, 85-89, 90-94 years) for 2020 in Short-term Mortality Fluctuations, we split aggregated age groups using distribution of forecasted death counts from the Human Mortality Database (fig 1). Details of the methodology have been published previously.<sup>36</sup> We checked the accuracy of life expectancy estimates depending on granular or broad age intervals in the Short-term Mortality Fluctuations data and found only small deviations, even for broad age scales (see supplementary file for details of the methodology, including sensitivity analysis, and supplementary figures S1 and S2). For 2015 data, we used annual death counts and population exposures by five year age groups from the Human Mortality Database.

We derived life expectancy from abridged life tables, which were constructed using standard life table methodology.<sup>40-41</sup> The supplementary file provides details of the methodology.

To attribute an equal lifetime loss produced by a death at the same age across the countries,<sup>42-43</sup> we calculated the YLL from the World Health Organization standard life table using the methodology developed by the Global Burden of Disease, Injuries and Risk Factor study.<sup>43-44</sup> The equation in figure 2 was used to estimate the YLL.

#### *Calculation of changes in life expectancy at birth and YLL in 2015 and 2020*

Within each country, sex, and age groups, the reduction in life expectancy was calculated as the difference between the observed and expected life expectancy in 2020. The expected life expectancy for 2020 was based on Lee-Carter forecasting using observed 2005-19 data.<sup>39</sup> Similarly, the expected YLL was computed for 2020, and excess YLL was calculated as the difference between observed and expected YLL within each country, sex, and age group. The sum of the excess YLL across the age groups, separately by sex, was used to estimate country specific total excess YLL and excess YLL (per 100 000 population) in 2020. As recommended, the excess YLL estimates were rounded to three significant digits to avoid spurious accuracy.

We estimated statistical uncertainty using a bootstrap method. Following a standard demographic approach, we did not calculate confidence intervals for life expectancy and YLL at the national level. Thus, we considered the mortality forecast as the only source of statistical uncertainty. The confidence intervals were based on the sample of 5000 iterations generated: firstly, we derived a distribution of age specific forecasted mortality rates and then we generated a random set of age specific death rates and calculated our variables of interest (life expectancy, YLL, and changes in life expectancy and YLL in 2020). The 2.5th quantile and the 97.5th quantile of the bootstrap distribution for each statistic were used as the 95% confidence intervals. The procedure was applied independently to each country and sex strata.

Our reference period for predicting mortality in 2020 is longer than the period of 2015-19 used in several earlier studies. The period 2015-19 includes substantial increases in mortality during the winters of 2015, 2017, and 2018 that contributed to an attenuation of the mortality improvements in many developed countries in these years.<sup>45-47</sup> Consequently, the choice of 2015-19 as a reference period might result in artificially increased baseline mortality levels and underestimation of losses in life expectancy and excess YLLs in 2020.

To put our findings into context, we also calculated the change in life expectancy and the YLL associated with the seasonal influenza epidemic in 2015 following the same methodology using data between 2000 and 2014 as the reference period. We chose 2015 as a comparator to 2020 because in 2015 the 37 countries under study experienced the smallest average annual

$$\hat{D}_y^{STMF}(x, x+a) = D_y^{STMF}(x, x+b) \cdot \frac{D_y(x, x+a)}{D_y(x, x+b)}$$

Where  $D_y^{STMF}(x, x+b)$  denotes number of deaths in age interval  $[x, x+b)$  in the Short-term Mortality Fluctuations (STMF);  $D_y(x, x+a)$  is forecasted number of deaths in age interval  $[x, x+a)$  in year  $y$ , and  $D_y(x, x+b)$  is forecasted number of deaths in age interval  $[x, x+b)$  in year  $y$ , estimated using information from the Human Mortality Database

**Fig 1 | Equation for splitting aggregated age groups using distribution of forecasted death counts in the Human Mortality Database**

$$YLL_{c,s,a,t} = D_{c,s,a,t} \times SLE_a$$

Where  $D_{c,s,a,t}$  is number of deaths in country  $c$ , sex  $s$ , age  $a$ , and calendar year  $t$ , and  $SLE_a$  is the World Health Organization global health estimates standard life expectancy at age  $a$ <sup>43</sup>

Fig 2 | Equation used to estimate years of life lost (YLL)

improvement in mortality among all years between 2005 and 2019, coinciding with a noticeable increase in mortality during winter.<sup>45 48 49</sup>

#### *Decomposition of life expectancy losses in the US, Lithuania, Poland, and Spain*

Earlier research<sup>25 33</sup> including our preliminary analysis showed the highest life expectancy losses in the US compared with other OECD (Organisation for Economic Co-operation and Development) countries in 2020. Our previous study on excess mortality, however, reported the highest excess crude death rates in Lithuania, Poland, Spain, Hungary, Italy, Belgium, Slovenia, England and Wales, and Czech Republic, followed by the US.<sup>22</sup> To explain these important discrepancies, we conducted an exploratory decomposition analysis of the life expectancy losses of 2020 in the US, and three countries with highest excess crude death rates in 2020 (Lithuania, Poland, and Spain) using the Andreev-Arriaga-Pressat method.<sup>50-53</sup>

Statistical analyses were done using R (version 4.1.0) in RStudio. The Lee-Carter forecast was performed using the R package *demography*.<sup>54</sup>

#### **Patient and public involvement**

Patients and the public were not involved in this study because of the ongoing covid-19 pandemic.

### **Results**

#### **Changes in life expectancy in 2020**

In all the countries between 2005 and 2019, an increasing trend was observed in life expectancy at birth, both in men and women (supplementary figure S3). However, most countries showed a reduction in life expectancy in 2020, with the largest overall reduction in life expectancy at birth (in years) in Russia (−2.32, 95% confidence interval −2.55 to −2.11), the US (1.98, −2.16 to 1.82), Bulgaria (−1.75, −2.09 to −1.41), Lithuania (−1.61, −1.92 to −1.29), and Poland (−1.36, −1.55 to −1.17). Reductions in life expectancy in Italy, Spain, and England and Wales were −1.35 (−1.72 to −0.99), −1.27 (−1.57 to −0.99), and −1.02 (−1.27 to −0.78), respectively. In contrast, a gain in life expectancy was observed in New Zealand (0.66, 0.41 to 0.89) and Taiwan (0.35, 0.14 to 0.54); no evidence was found of a change in life expectancy in South Korea (0.11, −0.09 to 0.30), Norway (0.07, −0.03 to 0.17), or Denmark (−0.09, −0.24 to 0.06) (fig 3).

In all countries but Luxembourg, men had a higher reduction in life expectancy at birth than women. The reduction in life expectancy in men was highest in Russia (−2.33, −2.50 to −2.17), the US (−2.27, −2.39 to −2.15), Bulgaria (−1.96, −2.11 to −1.81), Lithuania (−1.83, −2.07 to −1.59), and Chile (−1.64, −1.97 to −1.32). In

women, the reduction in life expectancy was highest in Russia (−2.14, −2.25 to −2.03), the US (−1.61, −1.70 to −1.51), Bulgaria (−1.37, −1.74 to −1.01), Lithuania (−1.21, −1.36 to −1.05), and Spain (−1.13, −1.37 to −0.90) (fig 3 and supplementary table S2).

#### **Changes in years of life lost in 2020**

Years of life lost declined in most countries in both men and women between 2005 and 2019, except Canada, Greece, Scotland, Taiwan, and the US (fig 4). The observed YLL in 2020 was higher than expected in all countries except Taiwan and New Zealand, where there was a reduction in YLL, and Iceland, South Korea, Denmark, and Norway, where there was no evidence of a change in YLL in 2020. In the remaining 31 countries, more than 222 million (130 million in men and 92.6 million in women) years of life were lost in 2020, which is 28.1 million (95% confidence interval 26.8m to 29.5m) YLL higher than expected. The excess YLL in men and women were 17.3 million (16.8m to 17.8m) and 10.8 million (10.4m to 11.3m), respectively.

In men and women combined, excess YLL (per 100 000) were highest in Russia (5810, 95% confidence interval 5280 to 6340), Bulgaria (5440, 4460 to 6420), Lithuania (3940, 3200 to 4680), the US (3380, 3160 to 3610), and Poland (2800, 2430 to 3170), with a higher rate in men than women. The highest excess YLL per 100 000 in men were observed in Bulgaria (7260, 6820 to 7710), Russia (7020, 6550 to 7480), Lithuania (5430, 4750 to 6070), the US (4350, 4170 to 4530), and Poland (3830, 3540 to 4120); excess YLL in women were highest in Russia (4760, 4530 to 4990), Bulgaria (3730, 2740 to 4730), Lithuania (2640, 2310 to 2980), the US (2430, 2320 to 2550), and Hungary (1920, 1590 to 2240) (fig 5 and supplementary table S3).

Supplementary figure S4 shows the trend of YLL during 2005-20 by age and sex. Figure 6 shows the excess YLL in 2020 by age and sex. In general, excess YLL increased with age, both in men and women. However, Finland, Iceland, New Zealand, South Korea, and Taiwan had lower than expected YLL in the elderly population (≥80 years). These countries had a small increase, or a decrease, in YLL in other age groups as well (fig 6). Excess YLL rate was generally lower in people younger than 65 years, except in Russia (3290, 2780 to 3810), Bulgaria (2650, 2220 to 3070), Lithuania (2580, 1790 to 3410), and the US (2390, 2280 to 2510), with excess YLL rate >2000 per 100 000. The ratio of YLL rate between people aged <65 and ≥65 years was 0.2 or higher in Estonia, Canada, Scotland, the US, Lithuania, and Chile (see supplementary table S4).



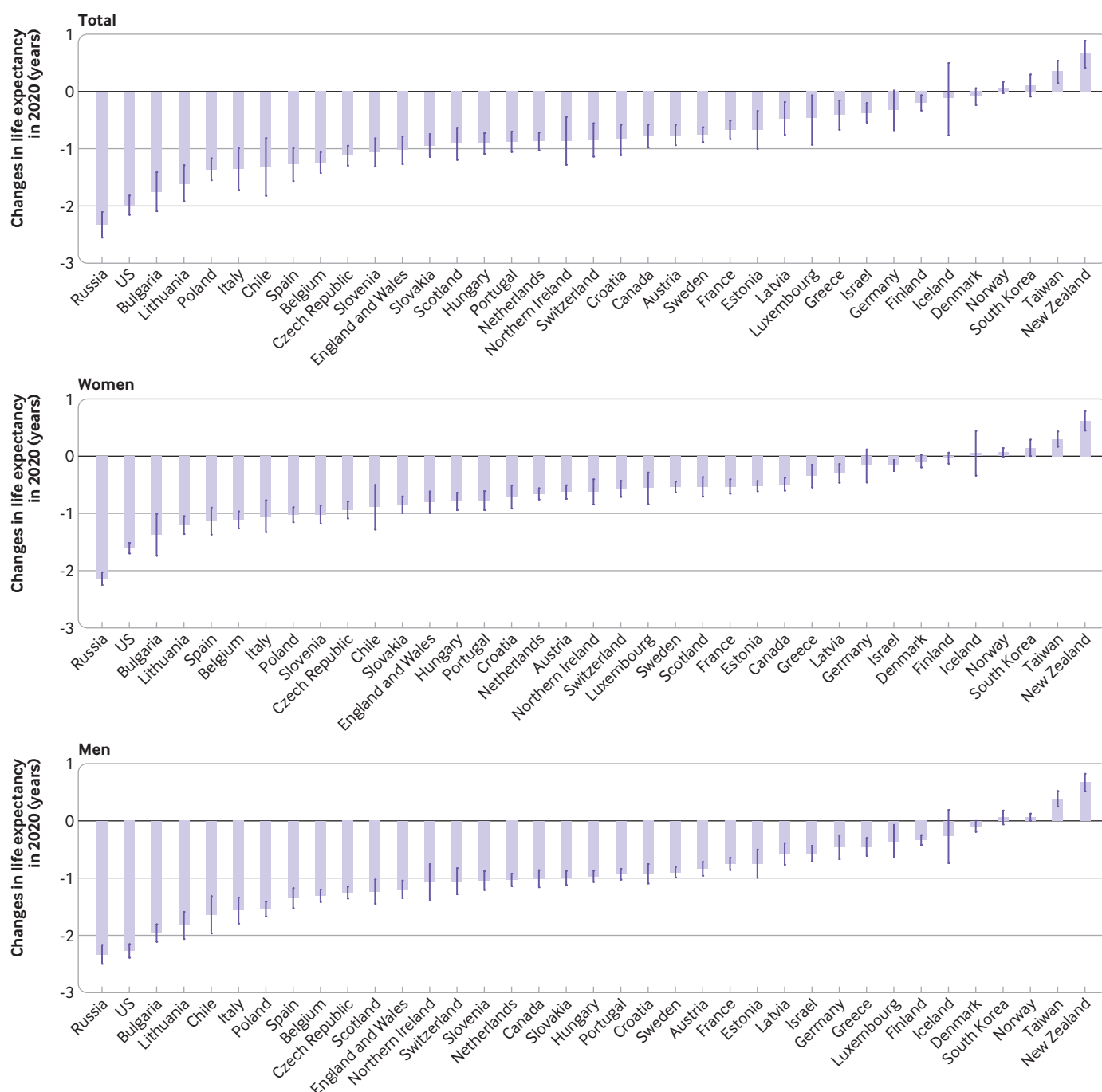


Fig 3 | Changes in life expectancy at birth associated with covid-19 pandemic in 2020. Change is calculated as the difference between observed and expected life expectancy, estimated using the Lee-Carter model<sup>39</sup>

#### Age components of life expectancy losses in US and comparator countries, 2020

Figure 7 shows age components of the life expectancy losses in the US, Lithuania, Poland, and Spain in men and women produced by differences between the observed and expected age specific death rates by age intervals 0-14, 15-54, 55-64, 65-74, and  $\geq 75$ . In the US and Lithuania it appears that mortality excess in people younger than 65 years, particularly among men, was responsible for a high proportion of the total losses in life expectancy: the respective values for men and women were 62% and 42% in the US and

58% and 44% in Lithuania. Corresponding values in Poland were 27% and 8% and in Spain were 26% and 15%. These two countries, especially Spain, showed an expected pattern, with the dominating role of older ages as a driver of losses in life expectancy.

#### Changes in life expectancy and years of life lost: covid-19 (2020) v influenza epidemic (2015)

Most countries experienced a reduction in life expectancy in 2015, but the reduction in 2020 was substantially greater than that in 2015. Most countries had excess YLL during the seasonal influenza epidemic

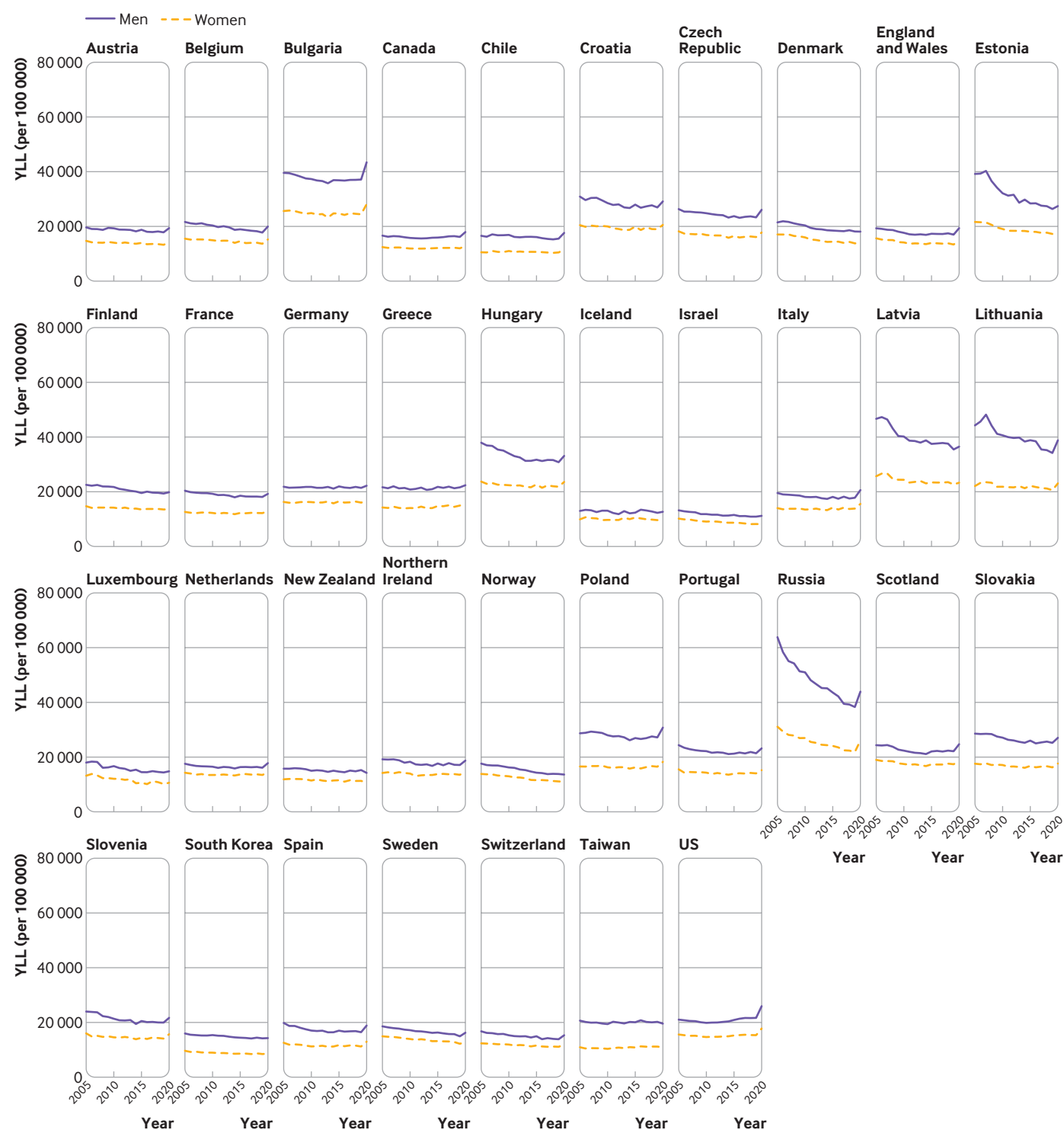


Fig 4 | Years of life lost (YLL) per 100 000 during 2005-20

in 2015, except Chile, Estonia, Luxembourg, Latvia, Finland, New Zealand, Russia, and Taiwan (fig 8 and fig 9). The rate of excess YLL was, however, much higher in most countries during the covid-19 pandemic in 2020 compared with the seasonal influenza epidemic in 2015. Overall, the excess YLL in the 37 countries was 5.5 times higher during the covid-19 pandemic (2510 per 100 000, 95% confidence interval 2390 to 2630 per 100 000) in 2020 than the excess YLL associated

with the seasonal influenza epidemic in 2015 (458, 325 to 592), with an absolute difference of 2050 years of life lost per 100 000.

### Discussion

In this global comparative study of 37 countries, a reduction in life expectancy was found in men and women in all countries except New Zealand, Taiwan, and Norway, where there was a gain in life expectancy

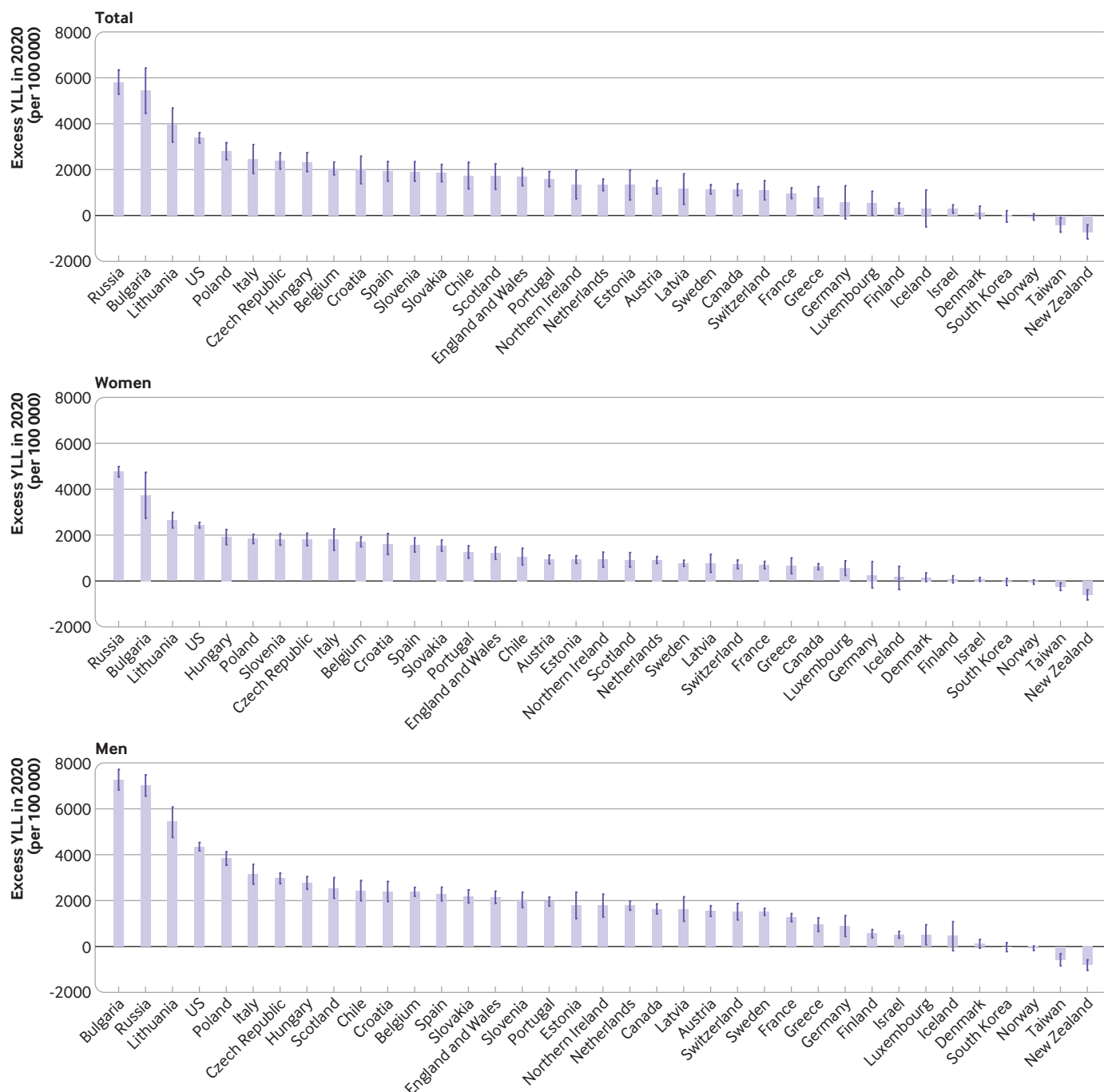


Fig 5 | Excess years of life lost (YLL) in 2020 (per 100 000). Change is calculated as the difference between observed and expected life expectancy estimated using Lee-Carter model<sup>39</sup>

in 2020. We found no evidence of a change in life expectancy in 2020 in Denmark, Iceland, and South Korea. The highest reduction in life expectancy in men was observed in Russia, the US, Bulgaria, Lithuania, and Chile; the highest reduction in women was observed in Russia, the US, Bulgaria, Lithuania, and Spain. Years of life lost were higher than expected in all countries except Taiwan, New Zealand, Iceland, Denmark, South Korea, and Norway. In the remaining 31 countries, about 28 million excess years of life were lost in 2020 (17 million in men and 11 million in women). The highest excess YLL in both men and

women were observed in Russia, Bulgaria, Lithuania, the US, and Poland. The excess YLL rate was relatively low in people younger than 65 years, except in Russia, the US, Lithuania, and Bulgaria. The excess YLL rates associated with the covid-19 pandemic in 2020 were more than five times higher than those associated with the seasonal influenza epidemic in 2015.

#### Comparison with previous literature

Country specific estimates of life expectancy, largely based on partial data in 2020, have been reported for the US,<sup>27 28</sup> England and Wales,<sup>29</sup> and Spain.<sup>26</sup>

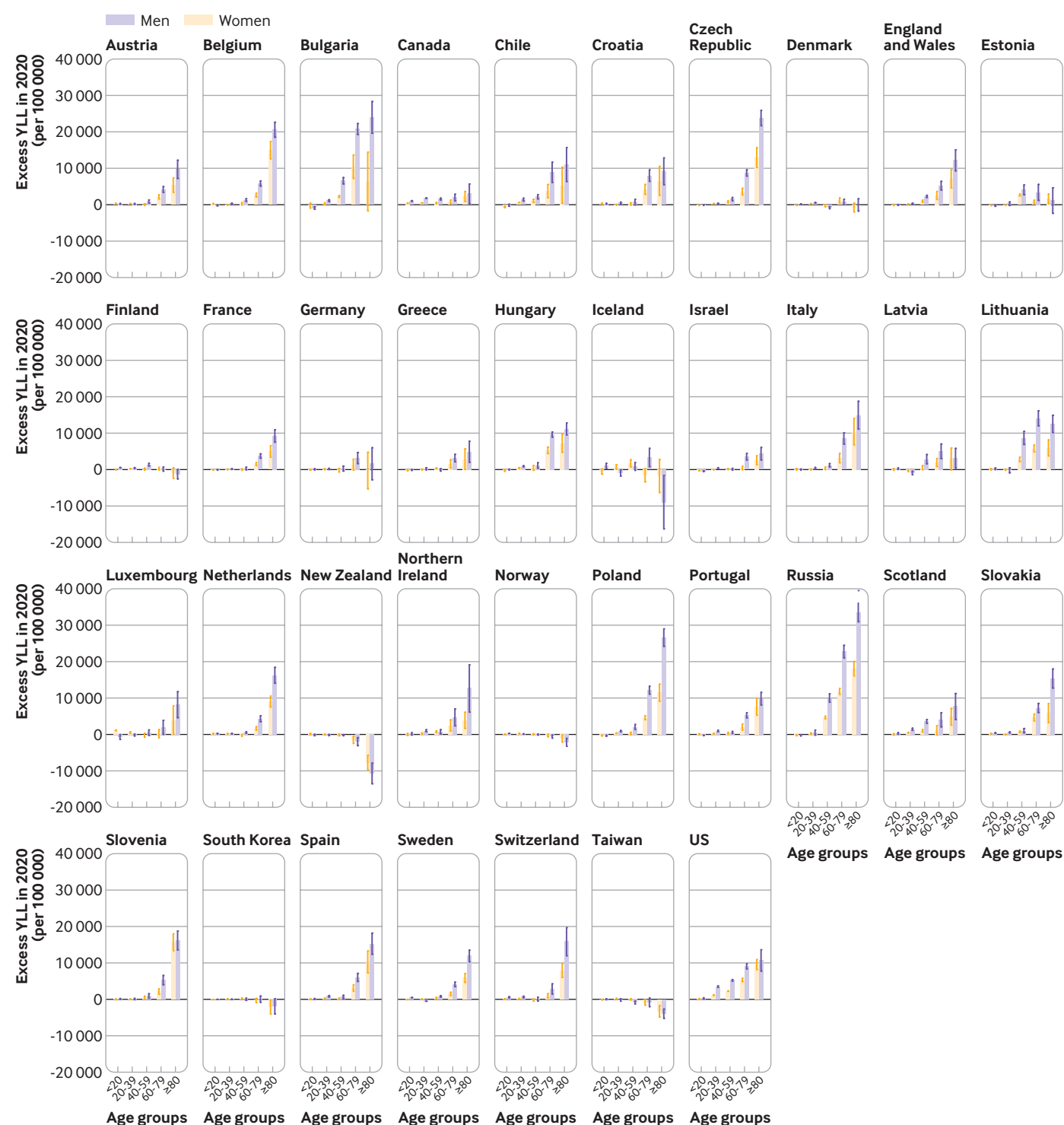


Fig 6 | Excess years of life lost (YLL) (per 100 000) by age and sex in 2020

In the US, the trajectory of life expectancy at birth during 2010-20 reported in our study is similar to that reported by the Centers for Disease Control and Prevention (CDC).<sup>27</sup> Drawing on data from the first half of 2020, this study reported a life expectancy of 77.8 years in the US,<sup>27</sup> whereas the estimated life expectancy at birth in our study was 77.4 years. Similarly, our estimates of life expectancy at birth were 74.6 years in men and 80.3 years in women, which

was slightly lower than those reported in the CDC study (75.1 and 80.5 years, respectively).<sup>27</sup> These differences could be due to a varying timeline used to estimate life expectancy—the CDC study used data up to June 2020, whereas we used data for the full year. Moreover, our earlier study showed that the excess death rates in the younger age groups (15-64 years) increased during the latter months in 2020 (especially during October-December).<sup>22</sup>



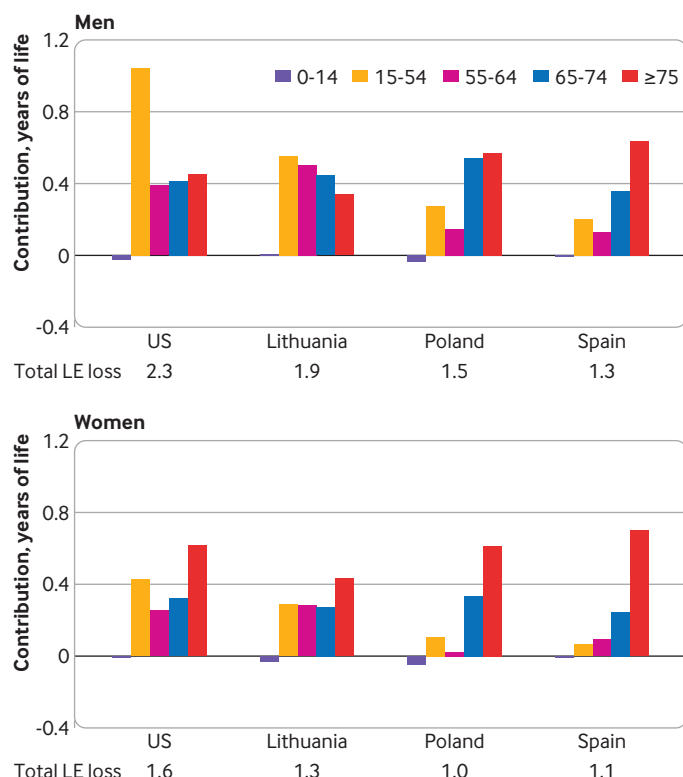


Fig 7 | Age group components of difference between observed and expected life expectancy (LE) in 2020 among men and women in the United States and three comparator countries with the highest excess crude death rates in 2020. \*Highest excess death rates according to Islam et al.<sup>22</sup> The life table decomposition analysis was conducted using the Andreev-Arriaga-Pressat method.<sup>450 51-53</sup>

In Aburto and colleagues' study of England and Wales, using data up to the 47th week (ending 20 November) of 2020, the estimated life expectancy was 82.6 years in women and 78.7 years in men.<sup>29</sup> These findings are almost identical to the estimates from our study (82.7 and 78.7 years, respectively).

Using data up to 5 July 2020, a previous study reported an estimated life expectancy of 79.5 and 85.0 years in men and women, respectively, in Spain in 2020.<sup>26</sup> These estimates are almost identical to those from our study (79.6 and 85.0 years in men and women, respectively).

Multi-country life expectancy estimates and analyses of life expectancy losses across countries have recently been published.<sup>55</sup> In particular, the Eurostat has published preliminary estimates of life expectancy at birth for member countries of the European Union. Comparison between these estimates and our estimates was possible for 26 countries. For 21 countries, the differences were 0.1 years or lower (in both men and women), which is attributable to different methods for building abridged life tables and some remaining incompleteness of mortality data. The largest deviations (0.3 years) were seen in the small populations of Iceland, Latvia, and Luxembourg as well as Finland. However, the updated life expectancy estimates by Statistics Finland are similar to our estimates.<sup>56</sup>

A previous analysis reported the change in life expectancy across 29 developed countries.<sup>33</sup> Our

analysis includes eight additional countries. We were able to include data from Canada, Israel, South Korea, New Zealand, Luxembourg, and Latvia because we applied a more efficient procedure for estimation of the detailed mortality age distributions that fully exploited all available data from the Human Mortality Database. Taiwan was included because updates to Short-term Mortality Fluctuations allowed us to fill former data gaps. Russia was included because Russian data for 2020 has recently been included in Short-term Mortality Fluctuations. Data for these additional eight countries allowed us to observe most of the range of losses in life expectancy in developed countries as well as to highlight the favourable situation in New Zealand, Taiwan, and South Korea. For the subset of 29 countries present in both the studies, the life expectancy losses are in a good agreement with a Spearman's correlation coefficient of 0.94 between the two rankings.

Most of the studies that reported on YLL used deaths with covid-19 to estimate potential YLL.<sup>23 30-32</sup> One earlier study examined the change in YLL due to excess deaths from all causes in 19 developed countries.<sup>23</sup> All these studies, however, used country specific remaining life expectancies, and in this sense the estimated YLL are not comparable across the countries. Since deaths with covid-19 might result in an underestimation or, in some cases, overestimation of the overall impact of the pandemic on deaths and YLL, our estimates are not directly comparable to these estimates. One study estimated 20.5 million YLL in 81 countries based on projected deaths with covid-19,<sup>23</sup> whereas our study estimated 28.1 million YLL in only 31 countries. These findings suggest a substantial underestimation of the overall impact on premature mortality if the estimates are based solely on deaths with covid-19 or when the estimation of YLL uses country specific life tables, or both. Moreover, covid-19 mortality data are often not disaggregated by age at the levels (eg, five year age categories) required for an accurate estimation of life expectancy and premature deaths.

With a much lower reported number of deaths with covid-19 (n=1613) in Lithuania, the estimated excess YLL were higher than in most of the countries (except Bulgaria and Hungary), as were the estimated excess deaths in a previous study.<sup>22</sup> Our study found that the additional years of life lost associated with the covid-19 pandemic in 2020 were higher than those associated with the seasonal influenza epidemic in 2015, which is consistent with a previous report.<sup>32</sup> Our finding of comparable or lower than expected YLL in 2020 in Taiwan, New Zealand, Iceland, and South Korea could be attributed to the successful pandemic elimination policies of these countries, including evidence based population health interventions.<sup>57-62</sup> Taiwan and New Zealand also had lower than expected YLL during the seasonal influenza epidemic in 2015. Exploring the precise reasons for this is beyond the scope of this study but could potentially be related to policy interventions, including seasonal influenza vaccine coverage and systemic resilience of the public health policy instruments.<sup>3 63</sup> Public health policy

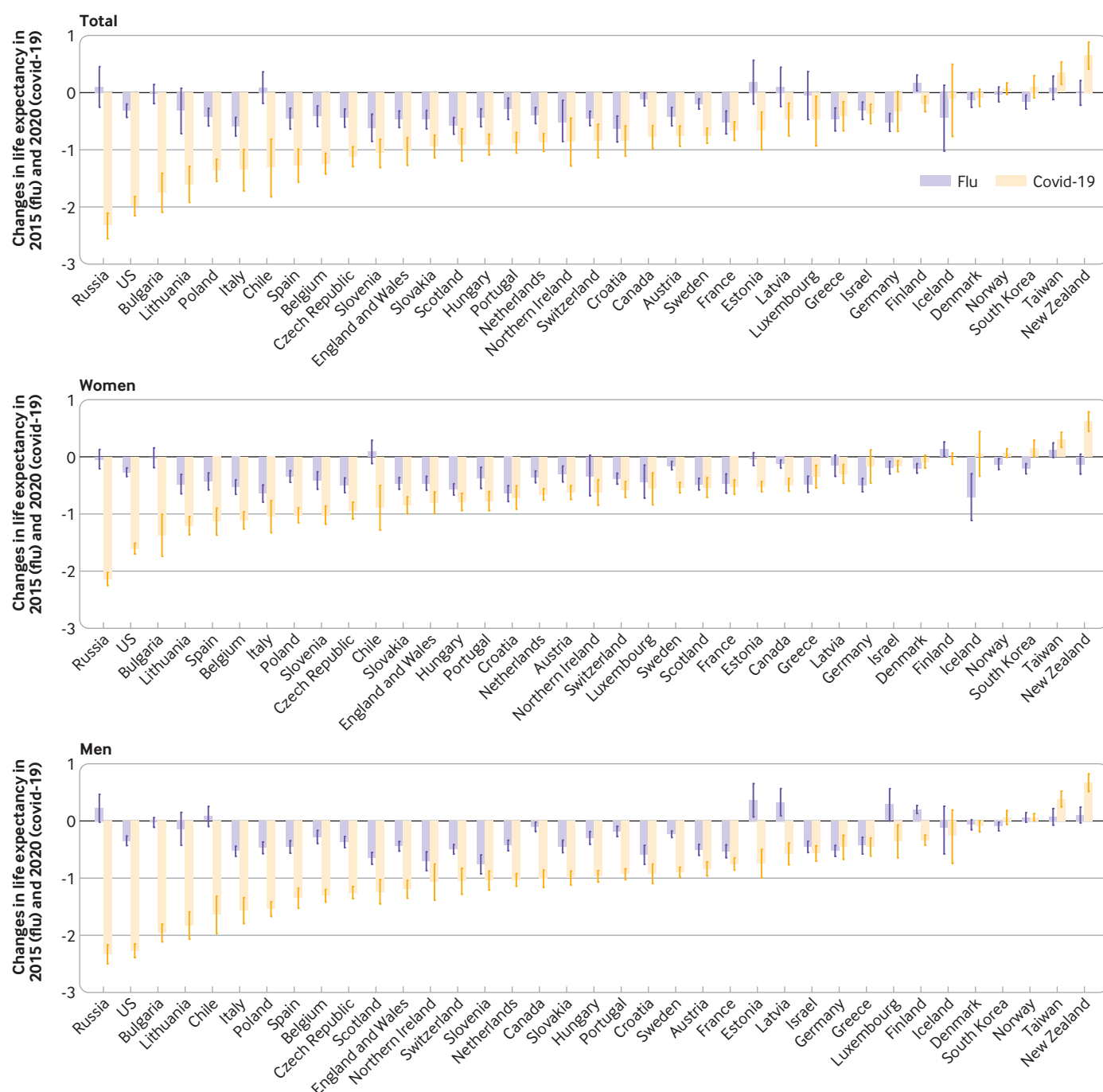


Fig 8 | Changes in life expectancy during covid-19 pandemic in 2020 compared with seasonal influenza epidemic in 2015

interventions aimed at reducing the transmission of SARS-CoV-2<sup>1</sup> might have had other indirect effects (eg, a reduction in deaths from other causes, such as influenza and other respiratory infections, air pollution, road traffic incidents) contributing to an overall reduction in YLL in 2020.

#### Strengths and limitations of this study

In addition to using the two major public health measures reflecting prematurity of death and accounting for trends, a key strength of our study was use of validated and standardised mortality data from authoritative national agencies to ensure comparability

across countries and time. Rather than relying on deaths with covid-19, we used all cause mortality data in our analysis, which are less sensitive to coding error and misclassification in attributing the cause of deaths. We also estimated the expected YLL based on 15 years of historical data and applied a validated analytical approach that enables a more effective use of available data from the Human Mortality Database, which in turn allowed us to include more countries in the analysis. Rather than using an arbitrary age threshold, we used WHO standard life expectancy to enable international comparison of YLL following the standard methodology in the Global Burden of

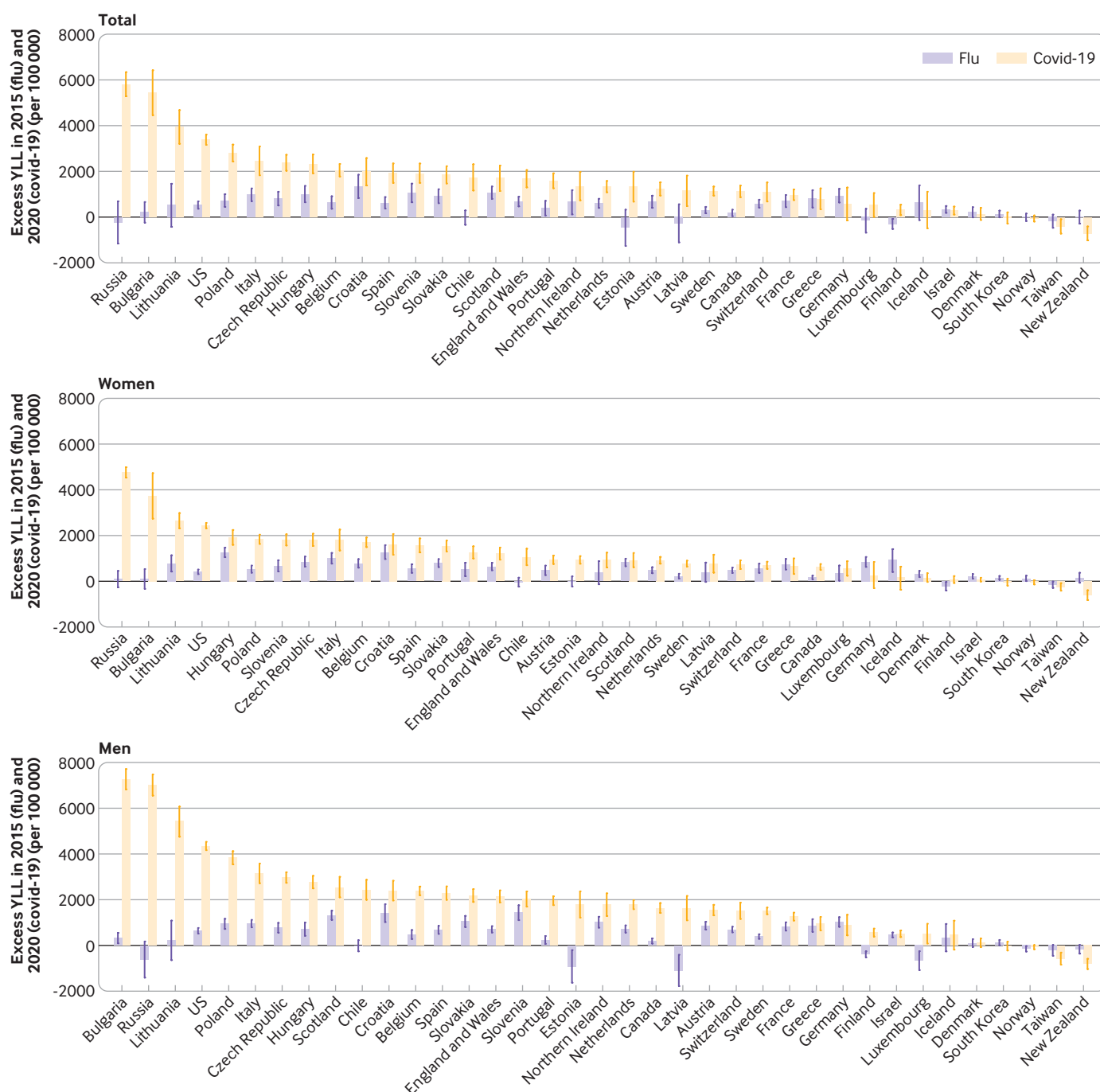


Fig 9 | Changes in years of life lost (YLL) (per 100 000) during covid-19 pandemic in 2020 compared with seasonal influenza epidemic in 2015

Disease, Injuries and Risk Factor study.<sup>43 44</sup> Our study does, however, have some limitations. Firstly, our study was restricted to countries with reliable data for the whole study period of 2000-20. Therefore, we did not include most countries from Asia, Africa, and Latin America. Our assumption of a no migration for population projection, when applicable, might not be generalisable to analyses at subnational levels. We also could not examine the variation in excess YLL by other critically important factors, such as socioeconomic status and race or ethnicity.<sup>64-71</sup> Previous studies also reported regional variability in reduction in life expectancy, such as in Spain,<sup>26</sup> but

we did not have detailed regional data to examine this important heterogeneity. Our study only reports the extent of premature lives lost in 2020. As of October 2021, however, the covid-19 pandemic is not yet over, and therefore future studies should estimate the long term burden of the pandemic.

#### Policy implications and future directions

Our findings extend the existing literature on the direct and indirect effects of the covid-19 pandemic and associated policy measures.<sup>22</sup> Our results strongly justify a more nuanced estimation of the lives lost beyond excess mortality. For example, with a similar

burden of excess deaths per 100 000 in Spain and the US (161 and 160, respectively),<sup>22</sup> excess YLL (per 100 000) was substantially higher in the US (3400) than in Spain (1900), indicating higher numbers of deaths at younger ages in the US compared with Spain.<sup>22</sup> Indeed, the ratio of YLL rate in people aged <65 and ≥65 years at death was 0.29 in the US, whereas it was only 0.07 in Spain. Despite a lower excess death rate than Lithuania, Poland, and Spain,<sup>22</sup> the reduction in life expectancy in the US was higher than in these three countries. A full examination of this phenomenon is beyond the scope of the current study. Nevertheless, the decomposition analysis of the life expectancy losses in these four countries reveals particularly large contributions to the reduction of life expectancy from increases in mortality at ages younger than 65 years in the US. However, our analyses were not able to identify whether these excess deaths were directly caused by SARS-CoV-2 or were related to other causes of deaths. The highest reduction in life expectancy, and highest increase in YLL, largely occurred in countries where the baseline life expectancy was relatively low. Therefore, baseline health status could have contributed to these results. Widespread ethnic inequality in the US, as reported previously, might have contributed to high YLL in the US.<sup>25</sup> Future studies should conduct an in-depth examination to disentangle these factors.

Our findings of a comparable or lower than expected YLL in Taiwan, New Zealand, Denmark, Iceland, Norway, and South Korea underscore the importance of successful viral suppression and elimination policies, including targeted and population based public health policy interventions.<sup>57-62</sup> A comprehensive pandemic preparedness aimed at more resilient health systems could be key to tackling the impact of future pandemics.<sup>3 63</sup> Quantifying the effects of specific policy interventions on the reduction of premature deaths will help inform future policy intervention. As many of the effects of the pandemic might take a longer time frame to have a measurable effect on human lives, continuous and timely monitoring of excess YLL would help identify the sources of excess mortality and excess YLL in population subgroups.<sup>72</sup>

#### AUTHOR AFFILIATIONS

<sup>1</sup>Clinical Trial Service Unit and Epidemiological Studies Unit (CTSU), Nuffield Department of Population Health, Big Data Institute, University of Oxford, Oxford, UK

<sup>2</sup>Max Planck Institute for Demographic Research, Rostock, Germany

<sup>3</sup>International Laboratory for Population and Health, National Research University Higher School of Economics, Moscow, Russian Federation

<sup>4</sup>Diabetes Research Centre, University of Leicester, Leicester, UK

<sup>5</sup>NIHR Applied Research Collaboration—East Midlands, Leicester General Hospital, Leicester, UK

<sup>6</sup>Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Harvard University, Boston, MA, USA

<sup>7</sup>MRC Epidemiology Unit, University of Cambridge, Cambridge, UK

<sup>8</sup>MRC Population Health Research Unit, Nuffield Department of Population Health, University of Oxford, Oxford, UK

**Contributors:** NI conceived the study with input from the coauthors. MW, SL, and BL are the co-senior authors. NI and DAJ conducted the statistical analysis. NI wrote the first draft. All the authors provided critical scholarly feedback on the manuscript. All the co-authors

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**Competing interests:** All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/doi\\_disclosure.pdf](http://www.icmje.org/doi_disclosure.pdf) and declare: NI, SL, and VMS are the members of the WHO-UN DESA Technical Advisory Group on Covid-19 mortality assessment. NI, SL, and BL are employed by the Clinical Trial Service Unit and Epidemiological Studies Unit, which receives research grants from industry that are governed by University of Oxford contracts that protect its independence and has a staff policy of not taking personal payments from industry; further details can be found at [www.ndph.ox.ac.uk/files/about/ndph-independence-of-research-policy-jun-20.pdf](http://www.ndph.ox.ac.uk/files/about/ndph-independence-of-research-policy-jun-20.pdf). SL reports grants from the Medical Research Council (MRC), and research funding from the US Centers for Disease Control and Prevention Foundation (with support from Amgen) unrelated to this study. MW reports research funding from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council, Medical Research Council, National Institute for Health Research, and Wellcome Trust unrelated to this study. KK is a member of the UK Scientific Advisory Group for Emergency (SAGE), and Independent SAGE; no support from any organisation for the submitted work.

**Ethical approval:** Not required.

**Data sharing:** All the data used in this study are publicly available and properly cited. However, we plan to add the analytical codes available on a publicly available repository for reproducibility. More guided instruction to get access to the data for transparency and reproducibility will be provided on request made to the corresponding author at [nazrul.islam@ndph.ox.ac.uk](mailto:nazrul.islam@ndph.ox.ac.uk)

The study guarantors (NI and DAJ) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

**Dissemination to participants and related patient and public communities:** We will disseminate the findings to members of the public through press releases, institutional websites, and repositories, as well as personal communications, and social communication platforms. We also plan to write a BMJ Opinion article to describe it in more general terms for the members of the public.

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**Supplementary information:** additional information, tables, and figures

# Effects of Covid-19 pandemic on life expectancy and premature mortality in 2020: time series analysis in 37 countries

## Supplementary Materials

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## Supplemental data availability

We used data from the Human Mortality Database (HMD, [www.mortality.org](http://www.mortality.org)). For 2015, all calculations are based on annual data series that are available at the finest detail level: by one-year age group and open age interval 110+. Nevertheless, we used a 5-year age groups scale with an open age interval of 100+ (i.e., <1, 1-4, 5-9, ..., 95-99, 100+) for the sake of comparability to 2020 estimates.

For 2020, we used annual series in all cases where respective data were available (see Table S1). Belgium, Denmark, Finland, Norway, Portugal, and Russia had such extended data series. Data for the remaining 31 countries were completed using weekly death counts from the Short-Term Mortality Fluctuations data series (STMF, [www.mortality.org](http://www.mortality.org)) and population exposures based on Lee-Carter forecast as described in the Methods section. The standardized STMF data is available only by a broad age group 0-14, 15-64, 65-74, 75-84, 85+. Nevertheless, the STMF also provides the original death counts classified (in many cases) using more detailed age groups. Note, the age scale in the original data varies across countries (see Table S1, last column).

Most of the countries are using 5-year age groups but with the first age group from 0–4, instead of 0, and 1–4. Infant mortality is crucially important by the life table calculation. There are also six countries – Canada, Germany, Israel, New Zealand, South Korea, and the USA – with broad age groups (Table S1). There is no method for ungrouping coarsely aggregated data designed for the specific case of weekly death counts with elevated mortality due to pandemics.

The pattern of the COVID-19 deaths is very consistent across different settings in age groups below 65. [1] but excess mortality is often disproportionally concentrated at the old ages.[2,3] Thus, aggregated age groups were split using proportions from annual forecasted age-specific death counts (see details in the Methods section). To check the sensitivity of results to using the aggregated data, we do the following check.

First, we tested the importance of the first (infant mortality) and last age groups. For this analysis, we calculated life tables using five countries (England and Wales, France, Italy, Russia, and Scotland) with detailed data including infant mortality. Then, we aggregated the data in the first two age groups (<1 and 1–4) into one age group of 0–4, and made an open age interval of 90+. Using our standard method, we re-distributed aggregated age groups and re-calculated the life tables.

The difference in the estimated life expectancy produced by these two methods is presented in Figure S1, which shows that the difference between these two approaches was <0.01 for all ages below 80. Therefore, our approach of ungrouping coarsely aggregated data is robust.

Second, we tested the robustness of our methods for coarse age groups reported in Canada, Germany, Israel, New Zealand, South Korea, and the USA (Table S1). For this analysis, we used original data from the other 31 countries that had data by 5-year groups, and calculated the life tables. Then, we aggregated the data according to the age groups of the six countries with coarse age groups, and applied our method of ungrouping to re-calculate the life tables.

The boxplot (Figure S2) shows that the maximum difference produced by data aggregation is below 0.2 with the median close to zero; third and second quartiles are within the range of  $\pm 0.1$ . As expected, the biggest differences are observed in case of using most aggregated age scale (New Zealand, age groups 0-64, 65-79, 80+). At the same time, using age group 0-29 (age scale Germany) has only minor influence on life expectancy. Thus, the 2020 life expectancies calculated from STMF mortality data by aggregated age groups are virtually the same compared to LEs calculated from the originally granular STMF data.

### Supplementary methods: calculation of life expectancy

First, we converted the death rates,  ${}_n m_x$ , into probabilities of death,  ${}_n q_x$ . Here, index  $n$  refers to the length of the interval,  $x$  denotes the beginning of the age interval. For example,  ${}_n q_x$  denotes probability of death in age interval  $[x, x + n)$ .

Let,  ${}_n a_x$  be the average number of years lived within the age interval  $[x, x + n)$  for people dying at that age. We assume that  $a_x = \frac{n}{2}$  for all single-year ages except age 0 (see below). We then compute  ${}_n q_x$  from  ${}_n m_x$  and  ${}_n a_x$  according to the formula,

$${}_n q_x = \frac{{}_n m_x}{1 + (1 - {}_n a_x) \cdot {}_n m_x} \quad (1)$$

for  $x = 0, 1, 5, 10, \dots, 95$ . For the open age interval (100+), we set  ${}_{\infty} a_{100} = \frac{1}{{}_{\infty} m_{100}}$  and  ${}_{\infty} q_{100} = 1$ .

For infants <1 year of age, we used the formulas for  $a_0$  suggested by Preston *et al.*, [4] which are adapted from the Coale-Demeny model life tables. [5] Thus, if  $m_0 \geq 0.107$ :

$$a_0 = \begin{cases} 0.350 & \text{for women} \\ 0.330 & \text{for men} \end{cases} \quad (2)$$

On the other hand, if  $m_0 < 0.107$ :

$$a_0 = \begin{cases} 0.053 + 2.800 \cdot m_0 & \text{for women} \\ 0.045 + 2.684 \cdot m_0 & \text{for men} \end{cases} \quad (3)$$

To complete the life table calculation, let  ${}_n p_x$  be the probability of surviving from age  $x$  to  $x + n$ . Therefore,

$${}_n p_x = 1 - {}_n q_x \quad (4)$$

for all ages  $x$ . Let the radix (the starting number of new-borns) of the life table be  $l_0 = 100,000$ . Then, the number of survivors (out of 100,000) at age  $x$  is

$$l_x = l_0 \cdot \prod_{i=0}^{x-1} {}_1 p_i \quad (5)$$

The distribution of deaths by age in the life-table population is

$${}_n d_x = l_x \cdot {}_n q_x \quad (6)$$

for  $x = 0, 1, 5, \dots, 95$ . For the open age category,  ${}_{\infty} d_{100} = l_{100}$ .

The person-years lived by the life-table population in the age interval  $[x, x + n)$  are

$${}_n L_x = l_x - (1 - {}_n a_x) \cdot {}_n d_x \quad (7)$$

for  $x = 0, 1, 5, \dots, 95$ . For the open age category,  ${}_{\infty} L_{100} = l_{100} \cdot a_{100}$ . The person-years remaining for individuals of age  $x$  equal



$$T_x = \sum_{i=x}^{95} L_i + {}_{\infty}L_{100} \quad (8)$$

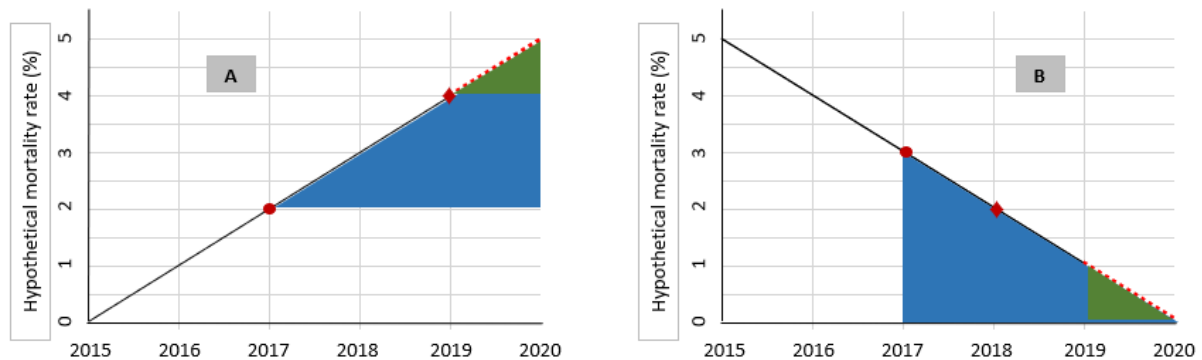
for  $x = 0, 1, 5, \dots, 95$ . Remaining life expectancy at age  $x$  is

$$e_x = \frac{T_x}{l_x} \quad (9)$$

for  $x = 0, 1, 5, \dots, 95$ .

Confidence intervals for the forecasted life expectancy and YLL were calculated using the approach proposed by Chiang.[6] This approach requires known distribution of age-specific probabilities of death. We derived these distributions using confidence intervals for mortality rates returned by Lee-Carter forecast. For the Lee-Carter forecast and calculation respective confidence limits for mortality rates we used R package demography.

## Panel-I: Graphical presentation of potential incorrect conclusion on excess mortality in the context of an increasing or decreasing trend



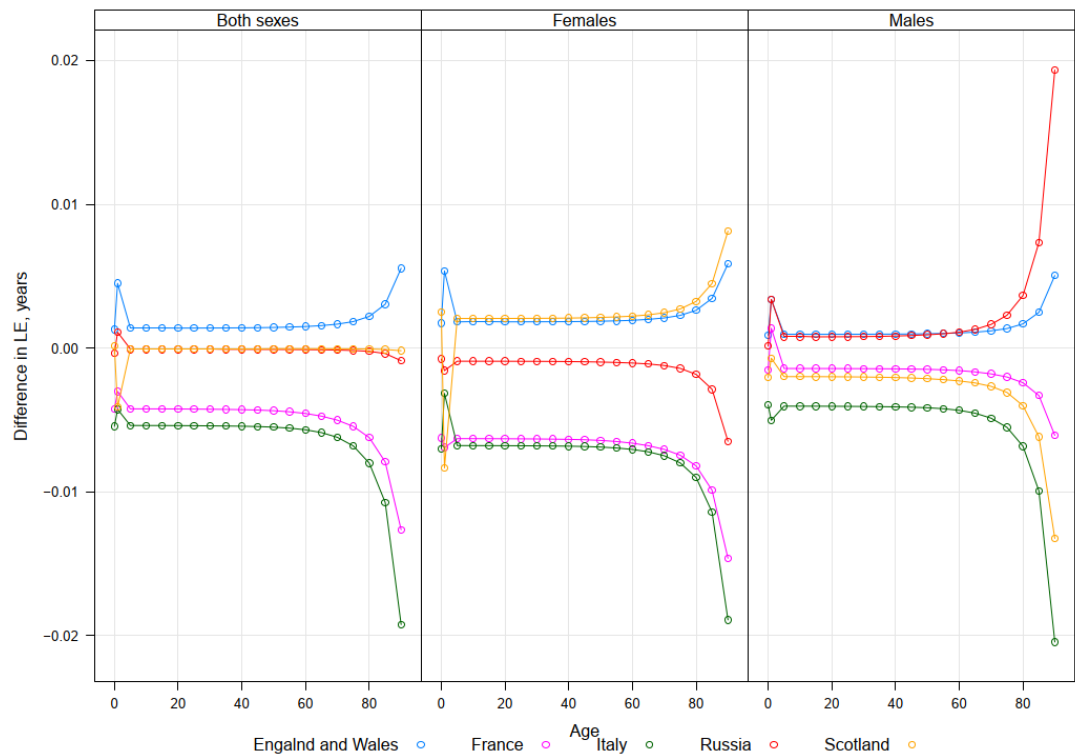
**Panel I:** (A) shows an increasing trend of a hypothetical mortality rate (%) from 0 to 4 between 2015 and 2019. Therefore, the most reasonable 'expected' value in 2020 will be approximately 5 (red dotted line). However, if the observed value in 2020 is  $>2$  but  $<5$  (in the blue or green shaded area), and if we compare this with the 2015-2019 average value of 2, we will incorrectly conclude that the observed value in 2020 was higher than the expected. If the observed value in 2020 is  $>4$  but  $<5$  (green-shaded area), we may incorrectly conclude that the observed was higher than expected if we compared with the 2019 value of 4. An analogous example of a decreasing trend is shown in (B). The reasonable expected value in 2020 is 0 (red dotted line), while the 2015-2019 average is 3. Therefore, any observed value of  $>0$  &  $<3$  would lead to an incorrect conclusion that there was a decrease in 2020. Similarly, any observed value  $>0$  &  $<1$  would lead to an incorrect conclusion that there was a decrease in 2020 if we compared this with the 2019 estimate of 1. Both of these examples illustrate how we can make an incorrect conclusion if we ignore the recent temporal trend (e.g., a gradual improvement in life expectancy over the last decades).

Supplementary Table S1. Data availability in the Human Mortality Database as of August 2021

Country	Last year in the HMD core	STMF age scale in 2020
Austria	2019	0-4, 5-9, ..., 85-89, 90+
Belgium	2020	0-4, 5-9, ..., 85-89, 90+
Bulgaria	2017	0-4, 5-9, ..., 85-89, 90+
Canada	2018	0-44, 45-64, 65-84, 85+
Chile	2017	0-4, 5-9, ..., 85-89, 90-94, 95+
Croatia	2019	0-4, 5-9, ..., 85-89, 90+
Czech Republic	2019	0-4, 5-9, ..., 85-89, 90+
Denmark	2020	0-4, 5-9, ..., 85-89, 90-94, 95-99, 100+
England and Wales	2018	0, 1-4, 5-9, ..., 85-89, 90+
Estonia	2019	0-4, 5-9, ..., 85-89, 90+
Finland	2020	0-4, 5-9, ..., 85-89, 90+
France	2019	0, 1-4, 5-9, ..., 85-89, 90-94, 95+
Germany	2017	0-29, 30-34, 35-39, ..., 90-94, 95+
Greece	2019	0-4, 5-9, ..., 85-89, 90+
Hungary	2019	0-4, 5-9, ..., 85-89, 90+
Iceland	2018	0-4, 5-9, ..., 85-89, 90+
Israel	2019	0-19, 20-29, ..., , 70-79, 80+
Italy	2018	0, 1-4, 5-9,..., 95-99, 100
Latvia	2019	0-4, 5-9, ..., 85-89, 90+
Lithuania	2019	0-4, 5-9, ..., 85-89, 90+
Luxembourg	2019	0-4, 5-9, ..., 85-89, 90+
Northern Ireland	2018	0-4, 5-9, ..., 85-89, 90+
Netherlands	2019	0-4, 5-9, ..., 85-89, 90+
New Zealand	2019	0-64, 65-79, 80+
Norway	2020	0-4, 5-9, ..., 85-89, 90-94, 95-99, 100+
Poland	2019	0-4, 5-9, ..., 85-89, 90+
Portugal	2020	0-4, 5-9, ..., 85-89, 90+
Russia	2020	0, 1-4, 5-9,..., 90-94, 95+
South Korea	2018	0,15,65,75,85
Scotland	2018	0, 1-4, 5-9,..., 90-94, 95+
Slovakia	2019	0-4, 5-9, ..., 85-89, 90+
Slovenia	2019	0-4, 5-9, ..., 85-89, 90+
Spain	2018	0-4, 5-9, ..., 85-89, 90+
Sweden	2019	0-4, 5-9, ..., 85-89, 90+
Switzerland	2018	0-4, 5-9, ..., 85-89, 90+
Taiwan	2019	0-4, 5-9, ..., 85-89, 90-94, 95-99, 100+
USA	2019	0, 1-4, 5-14, 15-24,...,75-84,85+

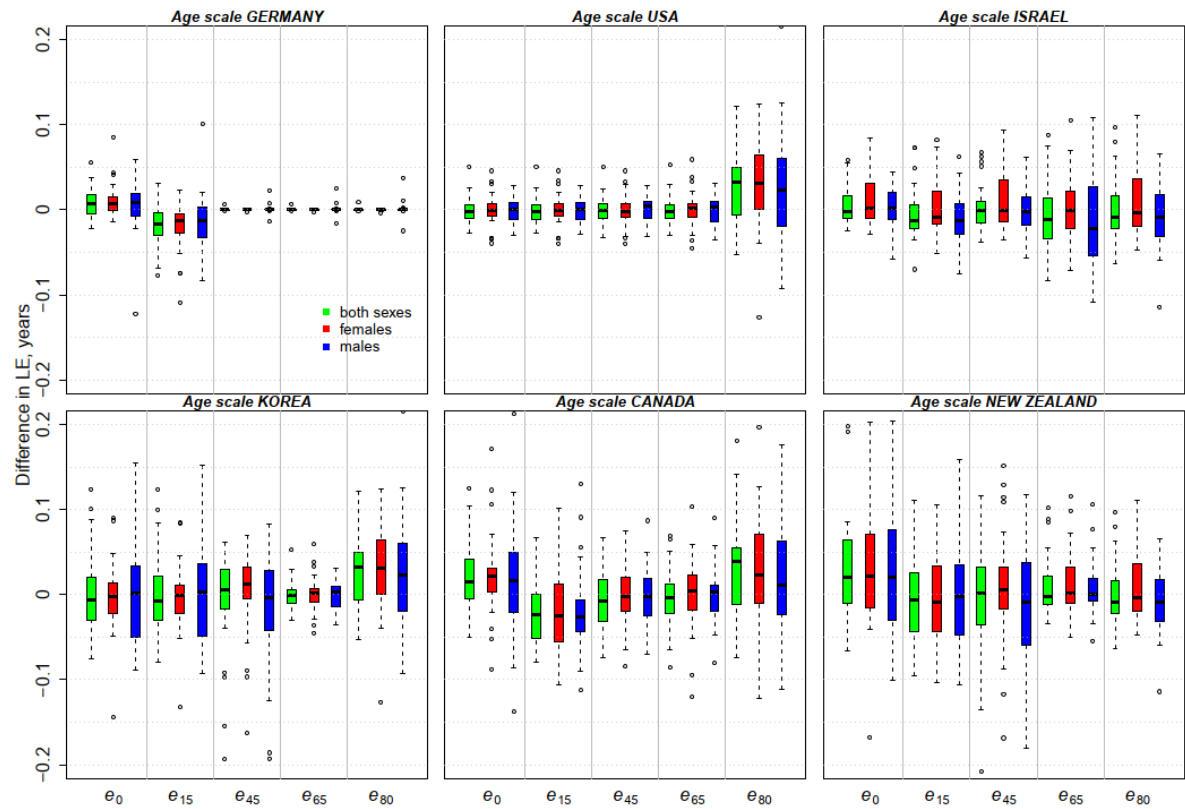
HMD core: Human mortality core database ([www.mortality.org](http://www.mortality.org)). STMF: Short-Term Mortality Fluctuations data series (STMF, [www.mortality.org](http://www.mortality.org))

Supplementary Figure S1. The difference in life expectancy in 2020 by age between estimates based on original granular STMF data and estimates based on (first aggregated and then) re-distributed death counts for five countries with detailed original data.



Notes: Original granular age groups: 0, 1-4, 5-9, 10-14, ..., 100+  
 Simulated age scale: 0-4, ..., 84-85, 90+

Supplementary Figure S2. The difference in life expectancy in 2020 at ages 0, 15, 45, and 80 calculated using original granular data and life expectancy based on (first coarsely aggregated and then) re-distributed death counts.



Notes: Simulated age scales are named after countries that use them (see Table S1).

Calculations on STMF data for 31 countries with the originally granular data in STMF: Austria, Belgium, Bulgaria, Chile, Croatia, Czechia, Denmark, England and Wales, Estonia, Finland, France, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Northern Ireland, Netherlands, Norway, Poland, Portugal, Russia, Scotland, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan.



Supplementary Table S2: Observed, expected and changes in life expectancy in 2020 in 37 high income countries

Country	Sex	Observed	Expected (95% CI)	Difference (95% CI)
Austria	Total	81.32	82.08 (81.9 to 82.26)	-0.76 (-0.94 to -0.59)
Austria	Female	83.7	84.33 (84.21 to 84.45)	-0.62 (-0.75 to -0.51)
Austria	Male	78.91	79.75 (79.62 to 79.87)	-0.84 (-0.96 to -0.72)
Belgium	Total	80.78	82.02 (81.84 to 82.2)	-1.24 (-1.42 to -1.06)
Belgium	Female	83.03	84.14 (83.99 to 84.29)	-1.11 (-1.26 to -0.96)
Belgium	Male	78.52	79.82 (79.72 to 79.93)	-1.31 (-1.42 to -1.2)
Bulgaria	Total	73.53	75.28 (74.94 to 75.62)	-1.75 (-2.09 to -1.41)
Bulgaria	Female	77.42	78.79 (78.42 to 79.16)	-1.37 (-1.74 to -1.01)
Bulgaria	Male	69.91	71.87 (71.72 to 72.03)	-1.96 (-2.11 to -1.81)
Canada	Total	81.61	82.38 (82.18 to 82.58)	-0.77 (-0.98 to -0.58)
Canada	Female	83.89	84.38 (84.27 to 84.49)	-0.49 (-0.6 to -0.38)
Canada	Male	79.34	80.35 (80.2 to 80.5)	-1.01 (-1.16 to -0.86)
Switzerland	Total	83.06	83.91 (83.62 to 84.2)	-0.84 (-1.14 to -0.55)
Switzerland	Female	85.04	85.61 (85.47 to 85.75)	-0.57 (-0.71 to -0.43)
Switzerland	Male	81.04	82.09 (81.87 to 82.32)	-1.05 (-1.28 to -0.83)
Chile	Total	80.08	81.39 (80.9 to 81.9)	-1.31 (-1.82 to -0.81)
Chile	Female	83.05	83.94 (83.56 to 84.34)	-0.88 (-1.28 to -0.5)
Chile	Male	77.03	78.67 (78.34 to 78.99)	-1.64 (-1.97 to -1.32)
Czech Republic	Total	78.33	79.45 (79.27 to 79.62)	-1.12 (-1.3 to -0.95)
Czech Republic	Female	81.36	82.29 (82.15 to 82.44)	-0.94 (-1.09 to -0.79)
Czech Republic	Male	75.33	76.58 (76.48 to 76.69)	-1.26 (-1.36 to -1.15)
Germany	Total	81.02	81.35 (81.01 to 81.7)	-0.33 (-0.68 to 0.02)
Germany	Female	83.43	83.6 (83.31 to 83.89)	-0.17 (-0.46 to 0.12)
Germany	Male	78.62	79.08 (78.87 to 79.29)	-0.46 (-0.67 to -0.25)
Denmark	Total	81.55	81.64 (81.49 to 81.79)	-0.09 (-0.24 to 0.06)
Denmark	Female	83.51	83.6 (83.48 to 83.71)	-0.09 (-0.2 to 0.03)
Denmark	Male	79.58	79.68 (79.58 to 79.77)	-0.09 (-0.19 to 0)
England & Wales	Total	80.63	81.65 (81.41 to 81.9)	-1.02 (-1.27 to -0.78)
England & Wales	Female	82.62	83.42 (83.24 to 83.62)	-0.8 (-0.99 to -0.62)
England & Wales	Male	78.65	79.85 (79.69 to 80)	-1.2 (-1.35 to -1.04)
Spain	Total	82.29	83.56 (83.28 to 83.85)	-1.27 (-1.57 to -0.99)
Spain	Female	85.01	86.13 (85.9 to 86.38)	-1.13 (-1.37 to -0.9)
Spain	Male	79.55	80.9 (80.73 to 81.08)	-1.35 (-1.53 to -1.18)
Estonia	Total	78.47	79.13 (78.81 to 79.47)	-0.66 (-1 to -0.34)
Estonia	Female	82.45	82.97 (82.88 to 83.06)	-0.52 (-0.61 to -0.43)
Estonia	Male	74.1	74.85 (74.6 to 75.1)	-0.75 (-1 to -0.5)
Finland	Total	81.85	82.05 (81.92 to 82.19)	-0.2 (-0.33 to -0.07)
Finland	Female	84.62	84.66 (84.56 to 84.76)	-0.03 (-0.13 to 0.06)
Finland	Male	79.07	79.41 (79.32 to 79.49)	-0.34 (-0.42 to -0.25)
France	Total	82.23	82.9 (82.74 to 83.07)	-0.67 (-0.84 to -0.51)
France	Female	85.18	85.71 (85.58 to 85.84)	-0.53 (-0.66 to -0.4)

France	Male	79.2	79.95 (79.84 to 80.06)	-0.75 (-0.86 to -0.64)
Greece	Total	81.2	81.61 (81.36 to 81.87)	-0.41 (-0.67 to -0.16)
Greece	Female	83.74	84.08 (83.89 to 84.29)	-0.34 (-0.55 to -0.15)
Greece	Male	78.63	79.09 (78.93 to 79.25)	-0.46 (-0.61 to -0.3)
Croatia	Total	77.77	78.61 (78.35 to 78.88)	-0.84 (-1.11 to -0.58)
Croatia	Female	80.88	81.59 (81.39 to 81.79)	-0.72 (-0.92 to -0.51)
Croatia	Male	74.66	75.58 (75.42 to 75.76)	-0.92 (-1.09 to -0.75)
Hungary	Total	75.73	76.64 (76.46 to 76.82)	-0.91 (-1.09 to -0.73)
Hungary	Female	79.03	79.82 (79.67 to 79.97)	-0.79 (-0.94 to -0.64)
Hungary	Male	72.32	73.29 (73.19 to 73.39)	-0.97 (-1.07 to -0.87)
Iceland	Total	82.85	82.95 (82.35 to 83.61)	-0.11 (-0.77 to 0.5)
Iceland	Female	84.41	84.36 (83.97 to 84.75)	0.05 (-0.34 to 0.44)
Iceland	Male	81.33	81.59 (81.13 to 82.07)	-0.26 (-0.74 to 0.19)
Israel	Total	82.76	83.13 (82.96 to 83.3)	-0.37 (-0.54 to -0.2)
Israel	Female	84.77	84.93 (84.84 to 85.03)	-0.16 (-0.26 to -0.07)
Israel	Male	80.66	81.23 (81.09 to 81.36)	-0.57 (-0.7 to -0.43)
Italy	Total	82.15	83.49 (83.14 to 83.87)	-1.35 (-1.72 to -0.99)
Italy	Female	84.45	85.5 (85.22 to 85.78)	-1.05 (-1.33 to -0.77)
Italy	Male	79.78	81.34 (81.12 to 81.57)	-1.56 (-1.8 to -1.34)
South Korea	Total	83.73	83.62 (83.43 to 83.82)	0.11 (-0.09 to 0.3)
South Korea	Female	86.59	86.45 (86.3 to 86.59)	0.14 (0 to 0.29)
South Korea	Male	80.63	80.57 (80.45 to 80.7)	0.06 (-0.06 to 0.18)
Lithuania	Total	75.08	76.69 (76.37 to 77)	-1.61 (-1.92 to -1.29)
Lithuania	Female	80.02	81.22 (81.06 to 81.38)	-1.21 (-1.36 to -1.05)
Lithuania	Male	70.05	71.87 (71.64 to 72.11)	-1.83 (-2.07 to -1.59)
Luxembourg	Total	82.07	82.53 (82.13 to 83)	-0.46 (-0.93 to -0.07)
Luxembourg	Female	84.35	84.9 (84.64 to 85.19)	-0.55 (-0.84 to -0.28)
Luxembourg	Male	79.81	80.17 (79.88 to 80.46)	-0.35 (-0.64 to -0.07)
Latvia	Total	75.43	75.9 (75.61 to 76.18)	-0.47 (-0.76 to -0.18)
Latvia	Female	79.94	80.24 (80.07 to 80.4)	-0.3 (-0.46 to -0.14)
Latvia	Male	70.61	71.19 (71 to 71.38)	-0.58 (-0.77 to -0.39)
Northern Ireland	Total	80.14	81 (80.59 to 81.43)	-0.86 (-1.28 to -0.45)
Northern Ireland	Female	82.02	82.64 (82.42 to 82.87)	-0.62 (-0.85 to -0.4)
Northern Ireland	Male	78.23	79.3 (78.99 to 79.62)	-1.07 (-1.39 to -0.76)
Netherlands	Total	81.36	82.23 (82.07 to 82.38)	-0.87 (-1.03 to -0.72)
Netherlands	Female	83.03	83.69 (83.59 to 83.79)	-0.66 (-0.76 to -0.56)
Netherlands	Male	79.67	80.7 (80.59 to 80.81)	-1.03 (-1.14 to -0.92)
Norway	Total	83.2	83.13 (83.03 to 83.23)	0.07 (-0.03 to 0.17)
Norway	Female	84.87	84.81 (84.73 to 84.88)	0.07 (-0.01 to 0.14)
Norway	Male	81.5	81.43 (81.37 to 81.49)	0.06 (0.00 to 0.13)
New Zealand	Total	82.68	82.02 (81.79 to 82.26)	0.66 (0.41 to 0.89)
New Zealand	Female	84.44	83.82 (83.65 to 83.99)	0.62 (0.45 to 0.79)
New Zealand	Male	80.86	80.19 (80.04 to 80.35)	0.67 (0.51 to 0.82)
Poland	Total	76.76	78.12 (77.93 to 78.31)	-1.36 (-1.55 to -1.17)
Poland	Female	80.88	81.9 (81.77 to 82.03)	-1.02 (-1.16 to -0.89)
Poland	Male	72.76	74.3 (74.17 to 74.43)	-1.54 (-1.67 to -1.41)

Portugal	Total	81.04	81.92 (81.74 to 82.1)	-0.88 (-1.06 to -0.7)
Portugal	Female	83.98	84.75 (84.58 to 84.92)	-0.78 (-0.94 to -0.61)
Portugal	Male	77.93	78.86 (78.77 to 78.96)	-0.93 (-1.03 to -0.84)
Russia	Total	71.48	73.8 (73.59 to 74.04)	-2.32 (-2.55 to -2.11)
Russia	Female	76.36	78.5 (78.39 to 78.61)	-2.14 (-2.25 to -2.03)
Russia	Male	66.45	68.78 (68.62 to 68.95)	-2.33 (-2.5 to -2.17)
Scotland	Total	78.45	79.36 (79.09 to 79.65)	-0.91 (-1.2 to -0.63)
Scotland	Female	80.72	81.26 (81.09 to 81.43)	-0.54 (-0.71 to -0.36)
Scotland	Male	76.18	77.42 (77.2 to 77.63)	-1.24 (-1.45 to -1.03)
Slovakia	Total	76.97	77.92 (77.72 to 78.11)	-0.94 (-1.14 to -0.75)
Slovakia	Female	80.36	81.21 (81.07 to 81.36)	-0.85 (-1.00 to -0.70)
Slovakia	Male	73.53	74.53 (74.4 to 74.65)	-1.00 (-1.12 to -0.88)
Slovenia	Total	80.55	81.61 (81.37 to 81.86)	-1.06 (-1.31 to -0.82)
Slovenia	Female	83.39	84.41 (84.25 to 84.57)	-1.02 (-1.18 to -0.86)
Slovenia	Male	77.76	78.8 (78.64 to 78.97)	-1.04 (-1.21 to -0.88)
Sweden	Total	82.46	83.21 (83.08 to 83.34)	-0.75 (-0.88 to -0.62)
Sweden	Female	84.31	84.85 (84.75 to 84.94)	-0.54 (-0.63 to -0.45)
Sweden	Male	80.66	81.56 (81.47 to 81.64)	-0.90 (-0.99 to -0.81)
Taiwan	Total	81.18	80.83 (80.64 to 81.04)	0.35 (0.14 to 0.54)
Taiwan	Female	84.34	84.05 (83.91 to 84.18)	0.3 (0.17 to 0.43)
Taiwan	Male	78.13	77.75 (77.61 to 77.88)	0.38 (0.25 to 0.52)
United States	Total	77.28	79.27 (79.1 to 79.44)	-1.98 (-2.16 to -1.82)
United States	Female	80.21	81.82 (81.73 to 81.91)	-1.61 (-1.7 to -1.51)
United States	Male	74.44	76.71 (76.59 to 76.83)	-2.27 (-2.39 to -2.15)

Supplementary Table S3: Observed, expected and changes in the years of life lost (per 100,000) in 2020 in 37 high income countries

Country	Sex	Observed	Expected (95% CI)	Difference (95% CI)
Austria	Total	16700	15500 (15200 to 15800)	1230 (941 to 1520)
Austria	Female	14200	13200 (13000 to 13400)	936 (755 to 1130)
Austria	Male	19400	17800 (17600 to 18100)	1540 (1310 to 1780)
Belgium	Total	17600	15500 (15200 to 15800)	2040 (1770 to 2330)
Belgium	Female	15300	13500 (13300 to 13800)	1710 (1490 to 1920)
Belgium	Male	20000	17600 (17400 to 17800)	2390 (2190 to 2580)
Bulgaria	Total	35500	30100 (29100 to 31000)	5440 (4460 to 6420)
Bulgaria	Female	28100	24400 (23400 to 25400)	3730 (2740 to 4730)
Bulgaria	Male	43400	36100 (35600 to 36500)	7260 (6820 to 7710)
Canada	Total	15400	14200 (14000 to 14500)	1120 (870 to 1380)
Canada	Female	12800	12200 (12100 to 12300)	625 (496 to 754)
Canada	Male	17900	16300 (16100 to 16500)	1640 (1420 to 1850)
Switzerland	Total	13500	12400 (12000 to 12900)	1110 (682 to 1520)
Switzerland	Female	11800	11100 (10900 to 11300)	723 (537 to 914)
Switzerland	Male	15300	13800 (13400 to 14100)	1520 (1160 to 1870)
Chile	Total	14500	12800 (12200 to 13300)	1740 (1160 to 2310)
Chile	Female	11500	10400 (10100 to 10800)	1060 (701 to 1430)
Chile	Male	17600	15200 (14700 to 15600)	2430 (1990 to 2870)
Czech Republic	Total	21900	19500 (19100 to 19800)	2380 (2020 to 2730)
Czech Republic	Female	17800	16000 (15700 to 16200)	1810 (1540 to 2080)
Czech Republic	Male	26100	23100 (22900 to 23300)	2970 (2740 to 3200)
Germany	Total	19300	18700 (18000 to 19400)	570 (-146 to 1290)
Germany	Female	16400	16200 (15600 to 16700)	256 (-303 to 847)
Germany	Male	22200	21300 (20800 to 21700)	893 (438 to 1340)
Denmark	Total	16000	15800 (15500 to 16100)	138 (-126 to 407)
Denmark	Female	13800	13700 (13500 to 13900)	160 (-29 to 350)
Denmark	Male	18100	18000 (17800 to 18200)	115 (-76 to 303)
England & Wales	Total	17100	15400 (15000 to 15800)	1670 (1300 to 2060)
England & Wales	Female	14800	13600 (13400 to 13900)	1210 (944 to 1470)
England & Wales	Male	19300	17200 (16900 to 17500)	2140 (1880 to 2410)
Spain	Total	15800	13900 (13500 to 14300)	1920 (1500 to 2340)
Spain	Female	13000	11400 (11100 to 11700)	1560 (1260 to 1870)
Spain	Male	18800	16500 (16200 to 16800)	2280 (1990 to 2580)
Estonia	Total	22400	21100 (20400 to 21700)	1330 (676 to 1980)
Estonia	Female	17900	16900 (16800 to 17100)	933 (766 to 1100)
Estonia	Male	27400	25600 (25100 to 26200)	1790 (1220 to 2370)
Finland	Total	16700	16400 (16100 to 16600)	315 (84 to 545)
Finland	Female	13600	13500 (13400 to 13700)	74 (-77 to 228)
Finland	Male	19800	19300 (19100 to 19400)	561 (385 to 737)
France	Total	15900	15000 (14700 to 15200)	971 (743 to 1210)
France	Female	12800	12100 (12000 to 12300)	700 (540 to 856)

France	Male	19200	18000 (17800 to 18200)	1260 (1090 to 1430)
Greece	Total	18900	18100 (17700 to 18600)	796 (340 to 1260)
Greece	Female	15600	15000 (14600 to 15300)	649 (318 to 1000)
Greece	Male	22400	21400 (21100 to 21700)	954 (655 to 1250)
Croatia	Total	24700	22700 (22100 to 23300)	1980 (1380 to 2580)
Croatia	Female	20600	19000 (18500 to 19400)	1600 (1160 to 2070)
Croatia	Male	29100	26700 (26300 to 27200)	2400 (1960 to 2830)
Hungary	Total	28100	25800 (25400 to 26200)	2320 (1910 to 2740)
Hungary	Female	23600	21700 (21300 to 22000)	1920 (1590 to 2240)
Hungary	Male	33100	30300 (30100 to 30600)	2770 (2490 to 3040)
Iceland	Total	11400	11000 (10200 to 11800)	309 (-492 to 1110)
Iceland	Female	9970	9810 (9330 to 10300)	162 (-372 to 641)
Iceland	Male	12700	12200 (11600 to 12900)	455 (-186 to 1080)
Israel	Total	9660	9370 (9200 to 9550)	288 (110 to 462)
Israel	Female	8150	8080 (8000 to 8160)	71 (-11 to 154)
Israel	Male	11200	10700 (10500 to 10800)	510 (365 to 655)
Italy	Total	18000	15500 (14900 to 16200)	2460 (1830 to 3090)
Italy	Female	15500	13700 (13300 to 14200)	1800 (1340 to 2260)
Italy	Male	20600	17400 (17000 to 17900)	3150 (2720 to 3580)
South Korea	Total	11400	11500 (11200 to 11700)	-37 (-284 to 210)
South Korea	Female	8600	8640 (8490 to 8790)	-43 (-194 to 109)
South Korea	Male	14300	14300 (14100 to 14500)	-31 (-223 to 162)
Lithuania	Total	30400	26500 (25700 to 27200)	3940 (3200 to 4680)
Lithuania	Female	23100	20400 (20100 to 20800)	2640 (2310 to 2980)
Lithuania	Male	38800	33400 (32700 to 34000)	5430 (4750 to 6070)
Luxembourg	Total	12700	12200 (11700 to 12700)	531 (8 to 1050)
Luxembourg	Female	10600	10100 (9740 to 10400)	568 (241 to 877)
Luxembourg	Male	14800	14300 (13900 to 14700)	507 (83 to 947)
Latvia	Total	29400	28200 (27600 to 28900)	1150 (481 to 1810)
Latvia	Female	23300	22500 (22100 to 22900)	768 (376 to 1160)
Latvia	Male	36500	34900 (34300 to 35400)	1620 (1100 to 2170)
Northern Ireland	Total	16700	15300 (14700 to 15900)	1350 (733 to 1980)
Northern Ireland	Female	14700	13800 (13500 to 14100)	932 (604 to 1250)
Northern Ireland	Male	18700	16900 (16400 to 17400)	1780 (1290 to 2280)
Netherlands	Total	16100	14700 (14500 to 15000)	1330 (1090 to 1580)
Netherlands	Female	14400	13500 (13300 to 13600)	924 (768 to 1070)
Netherlands	Male	17800	16000 (15800 to 16200)	1780 (1580 to 1980)
Norway	Total	12300	12400 (12200 to 12500)	-61 (-197 to 74)
Norway	Female	11000	11000 (10900 to 11100)	-47 (-140 to 47)
Norway	Male	13600	13700 (13600 to 13800)	-75 (-169 to 16)
New Zealand	Total	12400	13100 (12800 to 13400)	-713 (-1020 to -408)
New Zealand	Female	10600	11200 (11000 to 11500)	-609 (-824 to -391)
New Zealand	Male	14200	15000 (14800 to 15300)	-807 (-1030 to -583)
Poland	Total	24300	21500 (21100 to 21900)	2800 (2430 to 3170)
Poland	Female	18300	16400 (16200 to 16600)	1830 (1630 to 2040)
Poland	Male	30800	26900 (26700 to 27200)	3830 (3540 to 4120)



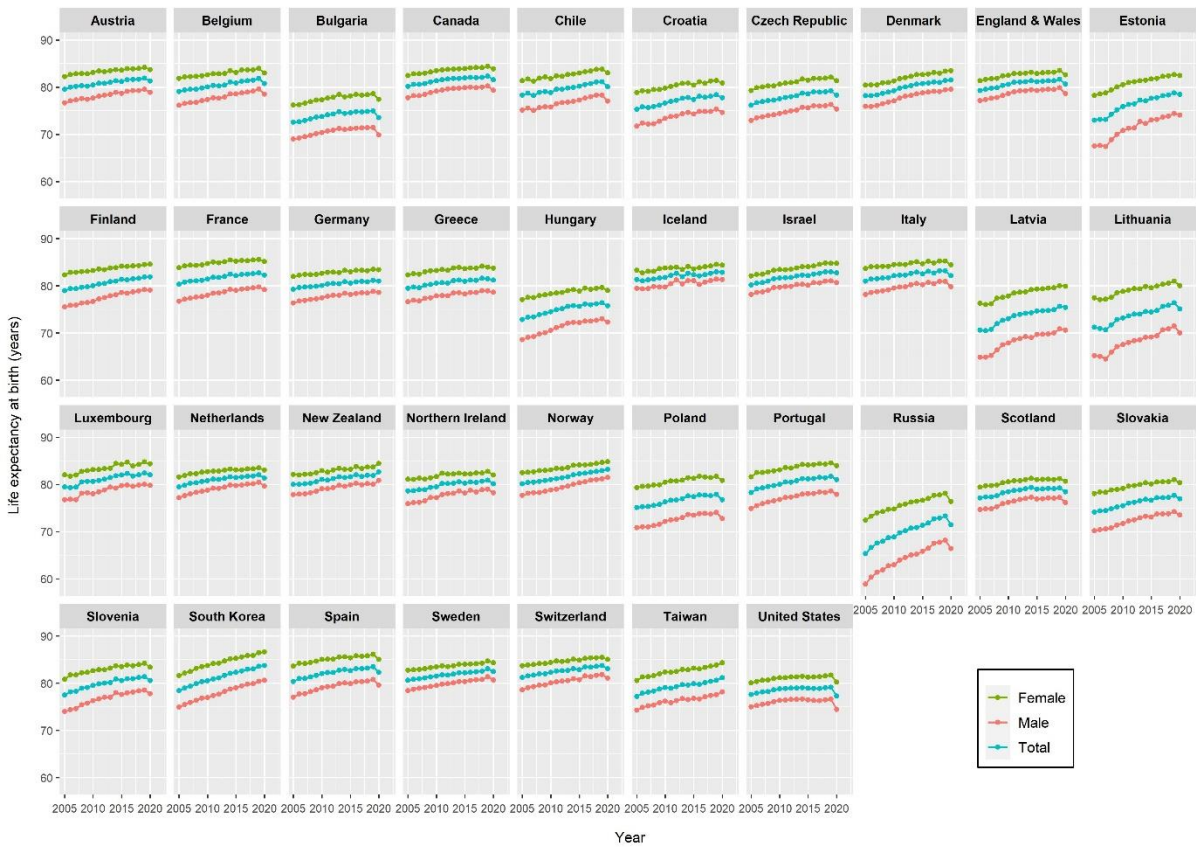
Portugal	Total	19000	17400 (17100 to 17700)	1590 (1260 to 1920)
Portugal	Female	15200	14000 (13700 to 14200)	1260 (995 to 1530)
Portugal	Male	23200	21200 (21000 to 21400)	1950 (1760 to 2150)
Russia	Total	34300	28500 (28000 to 29100)	5810 (5280 to 6340)
Russia	Female	26000	21300 (21100 to 21500)	4760 (4530 to 4990)
Russia	Male	43900	36900 (36400 to 37400)	7020 (6550 to 7480)
Scotland	Total	21500	19800 (19200 to 20400)	1710 (1140 to 2260)
Scotland	Female	18500	17500 (17200 to 17800)	925 (613 to 1240)
Scotland	Male	24700	22100 (21700 to 22600)	2540 (2100 to 3000)
Slovakia	Total	22200	20400 (20000 to 20800)	1850 (1470 to 2230)
Slovakia	Female	17600	16100 (15900 to 16300)	1540 (1300 to 1780)
Slovakia	Male	27100	24900 (24600 to 25200)	2180 (1900 to 2460)
Slovenia	Total	18700	16800 (16300 to 17200)	1910 (1500 to 2340)
Slovenia	Female	15700	13900 (13600 to 14100)	1810 (1560 to 2060)
Slovenia	Male	21700	19700 (19300 to 20000)	2020 (1690 to 2360)
Sweden	Total	14500	13400 (13200 to 13600)	1140 (938 to 1340)
Sweden	Female	12800	12100 (11900 to 12200)	772 (640 to 901)
Sweden	Male	16200	14700 (14600 to 14900)	1510 (1360 to 1660)
Taiwan	Total	15200	15600 (15300 to 15900)	-410 (-722 to -92)
Taiwan	Female	10900	11200 (11000 to 11300)	-247 (-413 to -81)
Taiwan	Male	19600	20100 (19900 to 20400)	-572 (-842 to -312)
United States	Total	21800	18400 (18200 to 18600)	3380 (3160 to 3610)
United States	Female	17800	15300 (15200 to 15500)	2430 (2320 to 2550)
United States	Male	25900	21600 (21400 to 21800)	4350 (4170 to 4530)

Supplementary Table S4: Years of life lost per 100,000 in people <65 compared with people ≥65 years

Country/ region	Total		Female		Male	
	<65y	≥65y	<65y	≥65y	<65y	≥65y
Russia	3290 (2780 to 3810)	19600 (17800 to 21500)	2340 (2180 to 2520)	14900 (14000 to 15900)	4290 (3830 to 4740)	29000 (27300 to 30800)
Bulgaria	2650 (2220 to 3070)	15600 (11300 to 20000)	1650 (1430 to 1860)	9960 (6110 to 13900)	3630 (3260 to 3990)	24000 (22000 to 25800)
Lithuania	2580 (1790 to 3410)	9400 (7770 to 11100)	1440 (1150 to 1720)	6330 (5280 to 7350)	3740 (2990 to 4490)	15400 (14100 to 16900)
United States	2390 (2280 to 2510)	8260 (7040 to 9510)	1430 (1380 to 1480)	6910 (6300 to 7470)	3350 (3250 to 3450)	9940 (8900 to 11000)
Estonia	1340 (750 to 1930)	1300 (-863 to 3510)	931 (832 to 1030)	941 (349 to 1550)	1750 (1200 to 2310)	2020 (-190 to 4240)
Scotland	1310 (954 to 1670)	3380 (956 to 5840)	617 (413 to 826)	2100 (762 to 3430)	2010 (1720 to 2310)	4940 (2810 to 7000)
Chile	1160 (733 to 1620)	5760 (2310 to 9200)	646 (386 to 909)	3640 (1640 to 5710)	1680 (1320 to 2040)	8560 (5760 to 11400)
Canada	1020 (892 to 1150)	1600 (298 to 2920)	472 (403 to 540)	1270 (626 to 1900)	1560 (1450 to 1680)	2000 (814 to 3150)
Hungary	808 (445 to 1180)	8430 (6990 to 9820)	427 (178 to 678)	6750 (5600 to 7940)	1190 (913 to 1470)	11200 (10300 to 12000)
Poland	777 (477 to 1080)	12000 (10500 to 13500)	232 (113 to 353)	7830 (7000 to 8670)	1320 (1040 to 1580)	18200 (17000 to 19400)
England & Wales	749 (567 to 929)	5700 (3750 to 7630)	472 (353 to 592)	4170 (2940 to 5510)	1030 (891 to 1160)	7500 (6070 to 8910)
Northern Ireland	681 (345 to 1020)	4650 (1310 to 7890)	411 (268 to 557)	3310 (1620 to 4940)	953 (652 to 1260)	6290 (3500 to 9180)
Czech Republic	658 (427 to 893)	9280 (7800 to 10700)	405 (287 to 520)	6560 (5420 to 7710)	904 (706 to 1110)	13000 (12100 to 14000)
Italy	613 (301 to 908)	8560 (6000 to 11100)	288 (107 to 477)	6210 (4460 to 7930)	936 (692 to 1180)	11600 (9770 to 13400)
Slovakia	602 (329 to 873)	8100 (6260 to 9930)	411 (305 to 514)	6170 (4990 to 7360)	794 (554 to 1040)	11000 (9490 to 12500)
Iceland	571 (-150 to 1260)	-1220 (-4910 to 2710)	571 (127 to 1020)	-2050 (-4280 to 190)	566 (35.2 to 1100)	-241 (-3340 to 2800)
Latvia	555 (-114 to 1190)	3480 (1400 to 5600)	292 (35.7 to 541)	2160 (792 to 3510)	833 (274 to 1400)	6200 (4430 to 7920)
Spain	539 (293 to 775)	7510 (5590 to 9400)	328 (236 to 421)	5970 (4600 to 7330)	749 (530 to 963)	9520 (8130 to 10900)
Portugal	531 (373 to 689)	5300 (3930 to 6670)	271 (170 to 372)	4330 (3260 to 5410)	804 (684 to 926)	6660 (5820 to 7520)
Croatia	518 (159 to 873)	7490 (4930 to 10100)	341 (195 to 487)	5560 (3810 to 7320)	695 (378 to 1020)	10300 (8420 to 12300)
Finland	429 (251 to 610)	-84.6 (-890 to 716)	59.9 (-39.6 to 162)	120 (-408 to 651)	785 (640 to 937)	-345 (-990 to 283)
Austria	359 (142 to 581)	4930 (3700 to 6180)	183 (81.9 to 281)	3730 (2900 to 4560)	536 (338 to 737)	6510 (5550 to 7480)
Belgium	358 (173 to 534)	9110 (7880 to 10300)	106 (-4.47 to 216)	7670 (6730 to 8600)	606 (460 to 749)	10900 (10100 to 11800)
Sweden	224 (122 to 329)	4800 (3920 to 5700)	114 (37.6 to 192)	3170 (2610 to 3700)	333 (258 to 406)	6680 (5960 to 7390)
Netherlands	217 (85.5 to 348)	5940 (4770 to 7130)	-3.51 (-93.2 to 92.5)	4450 (3860 to 5080)	442 (344 to 539)	7790 (6780 to 8770)
Slovenia	209 (-98.2 to 510)	8600 (6880 to 10300)	94.7 (-25.7 to 220)	7480 (6470 to 8490)	322 (47.8 to 597)	10100 (8650 to 11600)
Switzerland	199 (-76.3 to 467)	5030 (3180 to 6860)	13.4 (-113 to 142)	3460 (2710 to 4230)	394 (161 to 631)	7010 (5280 to 8730)
Luxembourg	156	2730	201	2490	120	3060

	(-291 to 599)	(228 to 5210)	(-27.8 to 436)	(877 to 3990)	(-256 to 497)	(1040 to 5140)
South Korea	108	-839	198	-1180	22.6	-382
Greece	(-58.3 to 275)	(-2130 to 482)	(122 to 274)	(-1990 to -359)	(-126 to 175)	(-1450 to 695)
	107	3190	143	2240	74.6	4400
Germany	(-55 to 270)	(1230 to 5190)	(84.7 to 202)	(788 to 3600)	(-78.1 to 230)	(3040 to 5750)
	82.8	2300	-48.3	1200	210	3710
France	(-248 to 419)	(-599 to 5310)	(-237 to 135)	(-1040 to 3500)	(-64 to 493)	(1790 to 5720)
	81.4	4390	24.8	2990	142	6250
Norway	(-57.4 to 230)	(3390 to 5370)	(-42.2 to 92.9)	(2330 to 3680)	(15.5 to 272)	(5490 to 6990)
	43.2	-551	62.1	-514	25.2	-593
Israel	(-42.2 to 132)	(-1210 to 106)	(-2.24 to 130)	(-927 to -95.6)	(-30 to 80.7)	(-1100 to -96.4)
	-17.1	2540	-93.7	1160	59.1	4250
New Zealand	(-121 to 88.3)	(1310 to 3780)	(-137 to -48.9)	(585 to 1730)	(-32.8 to 153)	(3160 to 5340)
	-108	-3930	-28.3	-3520	-179	-4360
Taiwan	(-282 to 58.7)	(-5720 to -2170)	(-153 to 97.5)	(-4610 to -2370)	(-295 to -62.9)	(-5710 to -3020)
	-110	-2070	62.7	-1820	-279	-2360
	(-368 to 128)	(-3620 to -570)	(-44.1 to 165)	(-2660 to -931)	(-496 to -54.2)	(-3630 to -1100)

Supplementary Figure S3: Life expectancy at birth, 2005-2020



## Supplementary Figure S4: Years of life lost (per 100,000) by age and sex, 2005-2020

Fig. S4(A): Men

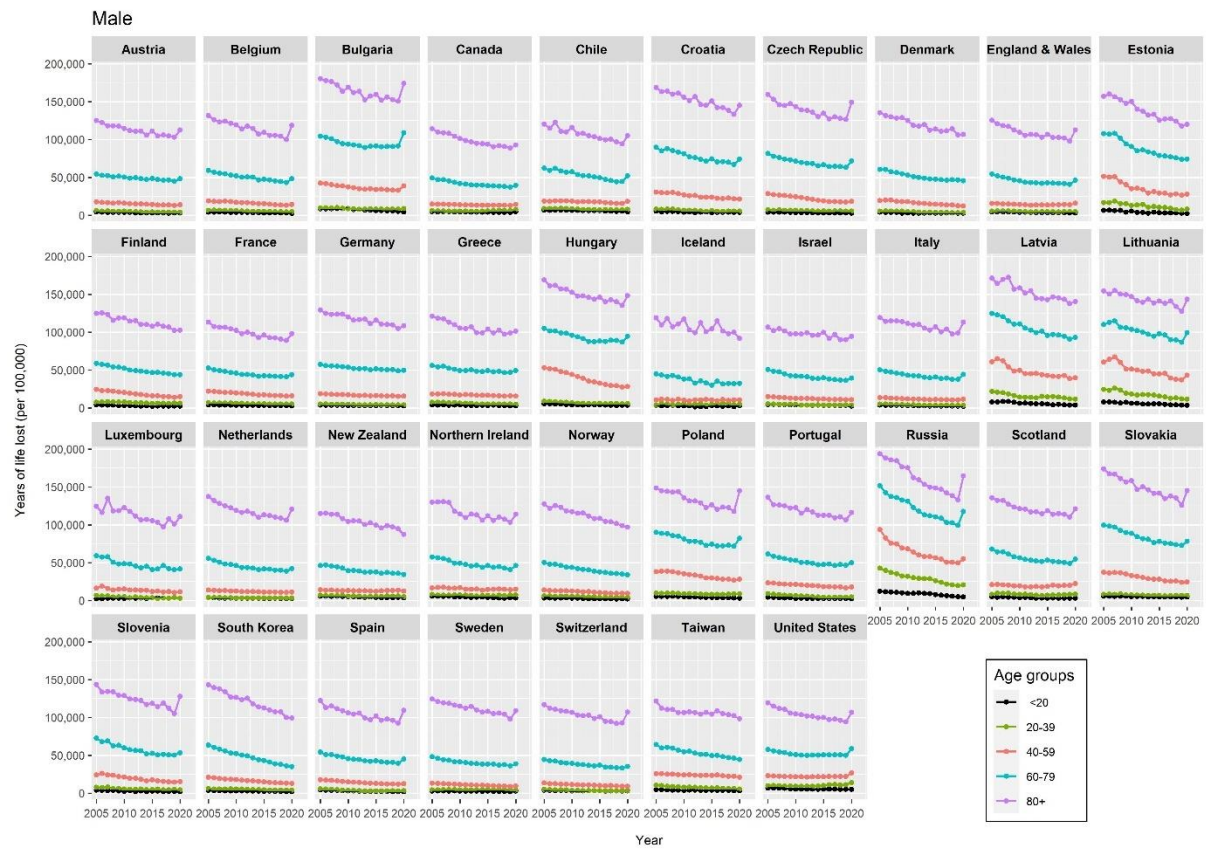
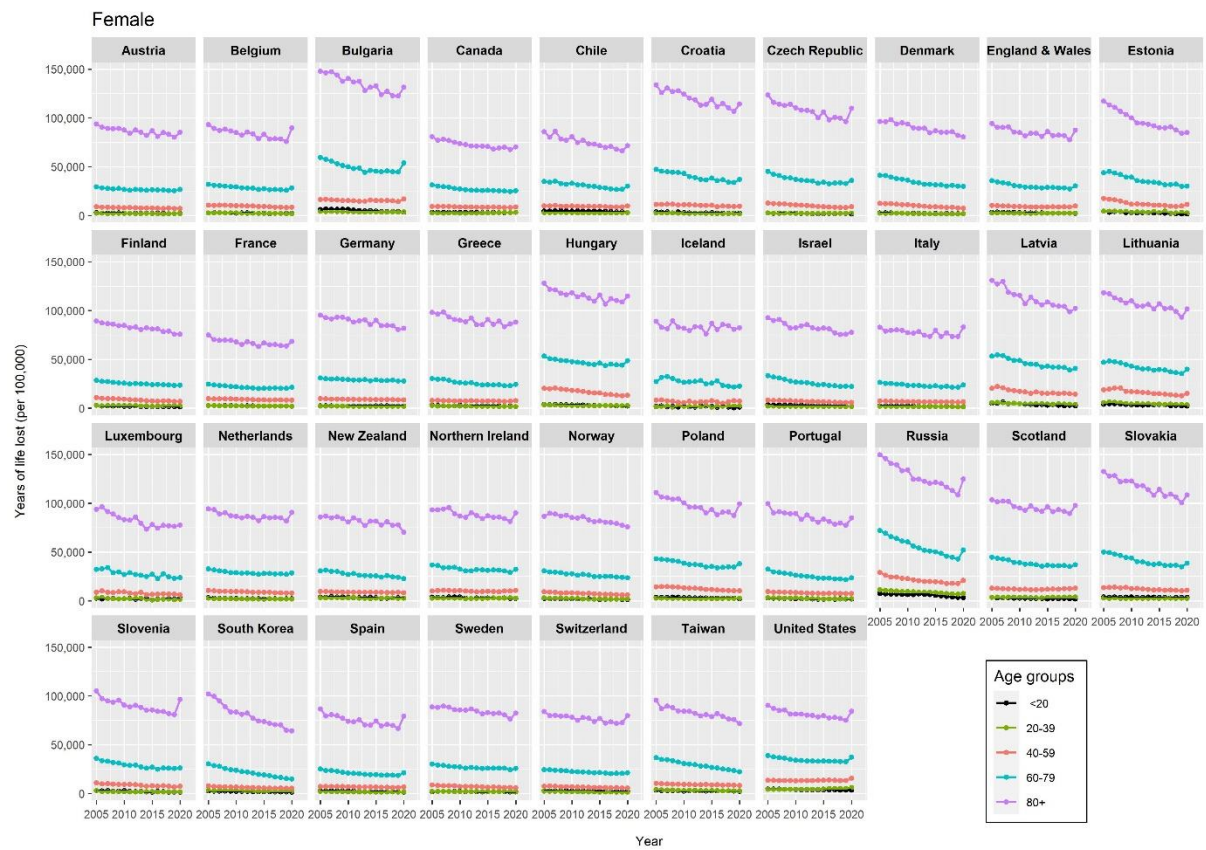


Fig. S4(B): Women



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